TECHNICAL PART

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY

PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
1	16.02.2021	16.02.2021	For Issue	AK/PT/HK	RKS	RKS/MN
0	21.01.2021	21.01.2021	For Issue	AK/PT/HK	RKS	RKS/MN
P	25.11.2020	25.11.2020	PRELIMINARY	AK/PT/HK	RKS	RKS/MN

SUBJECT: SUPPLY OF BASIC DESIGN , DETAILED ENGINEERING, PROCUREMENT, SUPPLY, FABRICATION, INSPECTION BY THIRD PARTY INSPECTION AGENCY (TPI) AS APPLICABLE, EXPEDITING, INSURANCE, TRANSPORTATION OF ALL EQUIPMENT / MATERIALS TO WORK SITE, STORAGE, CONSTRUCTION AND ERECTION OF ALL CIVIL STRUCTURE , MECHANICAL, ELECTRICAL AND INSTRUMENTATION WORKS, ASSEMBLY AND INSTALLATION, OBTAINING ALL NECESSARY STATUTORY APPROVALS, TESTING, MECHANICAL COMPLETION, PRE-COMMISSIONING, COMMISSIONING, PERFORMANCE GUARANTEE TEST RUN INCLUDING TOTAL PROJECT MANAGEMENT AND HANDING OVER OF 425 MTPD AMMONIMUM NITRATE (AN) MELT PLANT ALONG WITH ASSOCIATED FACILITIES AT RCF, TROMBAY ON A LUMP-SUM TURNKEY BASIS ON SINGLE POINT RESPONSIBILITY.

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3	PROCESS DESCRIPTION	PC185/E-1/P-II/1.0
4	DESIGN BASIS PROCESS	PC185/E-1/P-II/1.0
5	CONTRACTOR'S SCOPE OF WORK	PC185/E-1/P-II/1.0
6	PERFORMANCE GUARANTEE TEST RUN	PC185/E-1/P-II/1.0
7	BLOCK DIAGRAM	PC185/E-1/P-II/1.0
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14	CONSTRUCTION/ERECTION, PRE-COMMISSIONING & START-UP	PC185/E-1/P-II/16
15	DRAWINGS & DOCUMENTS SCHEDULE	PC185/E-1/P-II/17
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LIST OF ATTACHMENTS

Sl. No.	DESCRIPTION	DOCUMENT NO.
1	PERFORMANCE TEST	

PROCESS DATA SHEET & PROCESS DESCRIPTION FOR

NEW AMMONIA NITRATE (AN) MELT PLANT AT RCF TROMBAY

PLANT: AMMONIUM NITRATE MELT
JOB NO: PC-185

PREPARED BY

PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

1.0 INTRODUCTION:

M/s Rashtriya Chemicals and Fertilizers Ltd(RCF) is engaged for past five decades in production & marketing of various nitrogenous/phosphatic fertilizers & industrial chemicals at Trombay & Thal plants. Ammonium Nitrate is one of the important industrial products of RCF.

RCF intends to set up a new AN melt plant at RCF Trombay of same capacity as that of existing AN melt plant. The existing facilities like tanker loading station etc. shall be integrated with the new plant. Accordingly, RCF has engaged services of PDIL for preparation of Detailed Feasibility Report(DFR).

2.0 Project Description

2.1 Main Plant

The proposed project shall consist of a 425 MTPD 100% w/w single stream AN Melt plant which would use existing offsites & utility facilities: The Plant is expected to be on stream for 330 days per year.

2.2 Cooling water & DM Water supply and distribution

Other requirement of process water is as make up to DM plant, utility water, etc. The requirement shall be fulfilled by using the existing facility. All off-site and utilities inside battery limit of new AN melt plant shall be in bidders scope.

Clean condensate recovered in AN Melt plant, if any shall be recycled.

2.3 Steam & Power supply and distribution

Required steam and power shall also be supplied from the existing facility and provision has been considered for the same. All off-site and utilities inside battery limit of new AN melt plant shall be in bidders scope

Steam System

Steam is used mainly for the following purposes:

- Process use (Chemical reaction, stripping steam etc.)
- As heating medium for steam heated exchangers
- Steam tracing/flushing of lines.

Power System

Power is used in the complex for following main purposes:

- For driving motors to run various rotating machinery (pumps, compressors, blowers, etc.)
- For meeting the power demand of instruments
- For operating electric heaters (like instrument air dryer heater, electric tracing of lines if specified, etc.)
- For plant lighting and other miscellaneous purposes, etc.

2.4 Instrument Air Facilities

The normal instrument air requirement for the plant will be met from existing Process Air compressor. All off-site and utilities inside battery limit of new AN melt plant shall be in bidders scope.

2.5 Fire Fighting System

Fire-fighting system under the battery limit shall be in the scope of the BIDDER. Fire-fighting system including firewater storage, pumps etc. shall be provided from the existing facility which will be adequate to meet the requirement of proposed plant. Provision has been made for firewater ring and other fire & safety equipments. The fire pump automatically starts when continuous drop of pressure is detected in the fire water network.

2.6 AN Melt Tanker Loading Facility

All precautions as per latest regulations including PESO rules & regulation and AN Rule-2012 shall be considered for the manufacturing and storage for sale. It is envisaged that ammonium nitrate melt shall be transported through road tankers. Existing tanker loading system shall be used for handling product sale.

2.7 Process & Utility Hookup

Provision has to be made for existing process and utility facilities hook up with new AN plant.

2.8 Auxiliary Facilities

Bidder to consider the following facilities under this head.

- Safety
- Plant Buildings
- Furniture & Fittings (Plant)
- Plant Lab
- Control room
- Welfare facilities

3.0 PROCESS DESCRIPTION

3.1 Ammonium Nitrate Melt Plant

The technology and the licenser for the proposed project has not been finalized. We are open to absorb any technology and licenser based on the following factors:

a. Saving on energy
b. Flexibility
c. Investment reduction
d. Safety
e. Layout
f. Highly ecologic process
g. High quality product etc.
h. Process efficiency
i. Proven performance with supporting documentary evidence.

4.0 DESIGN BASIS PROCESS

4.1 General

The design basis of the proposed AN Melt project at Trombay, Maharashtra, will be based on various factors. The Ammonium Nitrate Solution Plant consists of single stream 425 MTPD as 100% by weight Ammonium Nitrate.

4.2 Raw Material Specification:

a) Nitric Acid

SN	Nitric Acid	Specification Range
1	HNO3 content	57-59%
2	HNO2 content	Max 500 ppm
3	Pressure	8 to 9.0 kg/cm2 (at Battery limit)
4	Temperature	35- 40^{0}C
5	Cl- content	Max 20 ppm
6	Availability	can be made available as per the requirement

b) Ammonia

SN	Ammonia	Specification Range
1	State	Liquid
2	NH3	99.80% Purity
3	H2O content max.	0.2% max
4	Oil content max.	Max 5 ppm
5	Pressure	18-20 Kg/cm^2 (at Battery limit)
6	Temperature	-20 to +15^{0}C
7	Availability	can be made available as per the requirement

4.3 Utility conditions

a) Make-up water : Source-1 (STP)

Parameter	Unit	Source -1 (STP)
pH		6.6 - 7.2
Chloride	Mg/lit. as Cl.	15-20
Silica	Mg/lit. as SiO_2	1-5
Total Hardness	Mg/lit as $CaCO_3$	4-6
Calcium Hardness	Mg/lit as $CaCO_3$	2-6
Magnesium Hardness	Mg/lit as $CaCO_3$	1-4
Total Dissolved solids	Mg/lit.	40-60
Conductivity	Micro mhos	80-90
Free Chlorine	ppm	0.1 -0.2
Pressure	Kg/Cm2	2-3

b) Make-up Water: Source-2 (MCGM)

Parameter	Unit	Source-2 (MCGM)
pH		6.8-7.2
Chloride	Mg/lit. as Cl.	10-20
Silica	Mg/lit. as SiO_2	5-10
Total Hardness	Mg/lit as $CaCO_3$	30-60
Calcium Hardness	Mg/lit as $CaCO_3$	20-30
Magnesium Hardness	Mg/lit as $CaCO_3$	10-30
Total Dissolved solids	Mg/lit.	50-100
Conductivity	Micro mhos	80-120
Free Chlorine	ppm	0.1-.0.2
Pressure	Kg/Cm2	0.5 to 2.5

c) DM Water

Sr. No.	DM water	
1	Pressure	6-7 Kg/cm^2

d) Power

Sr. No.	Power		
1	Frequency:	50 Hz	
2	Voltage:	440 V	3.3 KV
3	Phases:	3 phase	

e) Instrument air

Sr. No.	Instrument air:	(at battery limit)
1	Pressure	5.5 to 6.0 Kg/cm2 Gauge
2	Dew point: ^{0}C	-15 to -30

f) Cooling water(Existing cooling tower shall be used)

Sr. No.	Cooling Water	
1	Supply Pressure	3.5 to 4.5 kg/cm2
2	Supply Temperature	30 - 33 ^{0}C
3	Return Temperature	40 - 43 ^{0}C

g) LP Steam

Sr. No.	Low Pressure Steam	12 Ata
1	Pressure	10-12 Kg/cm2
2	Temperature	180 – 205 ^{0}C

h) MP Steam

Sr. No.	Medium Pressure Steam	20 Ata
1	Pressure	19-20 Kg/cm^2
2	Temperature	210 ^{0}C

4.4 Climatic and other site conditions:

1. Location: RCF, Trombay Unit, Chembur.
2. Nearest Airport/railway Station: Mumbai / Chunabhatti
3. GPS co-ordinates : (a) Latitude N 19.0

   : (b) Longitude E 72.8
4. Altitude : 5 Meter above MSL

5. Wind Load : As per IS: 875 – 1987 Part III

6. Earthquake Zone : Zone III, IS: 1893-2002

7. AMBIENT AIR TEMPERATURE:

7.1. Maximum : 45º C

7.2. Minimum : 7º C

7.3. Design air temp : 50 º C

8. RELATIVE HUMIDITY :

8.1. Maximum : 100 %

8.2. Minimum : 74%

8.3. Design : 85%

9. Wind Direction : South West to North East

10. WIND SPEED :

10.1. Annual mean Speed : 40-60 Km/hr.

10.2. Maximum mean speed : 152 Km/hr.

10.3. Design wind speed: 160 Km/hr.

11. RAIN FALL :

11.1. Annual Average : 2500mm

11.2. Highest : 3900mm

11.3. Heaviest Rain fall in 24hours: 360 mm

11.4. Design : 150mm in 1hour

5.0 LSTK Contractor SCOPE OF WORK

LSTK contractor will be single point responsible for execution of this project. Scope of work of LSTK contractor shall include:

- Detailed Engineering, procurement, inspection and expediting, construction and pre-commissioning & commissioning.
- Procurement all balance equipment & machinery, electrical and instrument bulk material etc.

- Logistics including marine transport and Insurance Charges from FOB vendor port to RCF, Trombay site.
- All plant buildings
- Topo survey, Soil investigation survey
- Land development/Land leveling
- Route survey for super ODC equipment
- Inspection and expediting services by posting necessary specialists at the Vendors / Fabrication shops.
- Construction and erection
- Project Management with monitoring, Scheduling and reporting
- Arrangement for expatriate supervisory personnel including vendor's specialist during erection, start up and commissioning.

6.0 GUARANTEE PARAMETER

6.1 Plant Capacity

Capacity of the plant (MTPD)	425	based on 100% w/w AN Melt
Stream days	330 days	based on 24 hrs per day
Overall Plant Turn Down Ratio	50 % (minimum)	

The rated capacity of new AN melt plant is **425 MTPD.** The plant shall have a built-in additional capacity and operating margin of 10% over and above the designed capacity of the plant. However, process guarantee shall be for the production of 425 MTPD of AN melt product only.

6.2 Guaranteed Product Specification

Specification	Value
AN Concentration	85 wt% minimum
State	Liquid
Temperature	90^0 C (minimum)
pH	4.5 to 5.5

ANNEXURE-II

PERFORMANCE & GUARANTEE TEST RUN

FOR

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY

PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
1	16.02.2021	16.02.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
0	10.02.2021	10.02.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
P	09.12.2020	09.12.2020	PRELIMINARY	AK/PT/HK	RKS	RKS/MN

1.0 PERFORMANCE GUARANTEES:

LSTK Contractor shall guarantee performance of AN melt plant as specified in this Clause under the following heads:

Failure to meet capacity of the plant or quality of the AN melt shall be breach of contract requiring corrective action by LSTK contractor irrespective of the cost involved.

1.1 Conditions for Guarantees:

For proving the performance guarantees, the following shall be provided by Owner to the LSTK Contractor:

1.1.1 Raw materials and utilities in sufficient quantities conforming to the range of specifications supplied to LSTK Contractor by Owner and used as the design basis for AN melt plant.

1.1.2 AN MELT PLANT are operated under the direction and supervision of LSTK Contractor as defined in operating manuals to be supplied by LSTK Contractor/process licensors.

1.1.3 Consumption of raw material and utilities shall be measured and calculated as per figures indicated by various calibrated instruments. The guaranteed figures shall be inclusive of all instrument tolerances. All measurement instrumentation shall be part of the system/ plant installed by the LSTK Contractor and no special instrumentation for the purpose of guarantee tests shall be required.

1.2 AN melt plant

LSTK Contractor shall guarantee performance of AN melt plant for the following:

1. Sustained Load Test Guarantee
2. Capacity of AN melt plant
3. Quality of AN melt (as specified in Section-2)
4. Total Works cost
5. Noise level
6. Gaseous/liquid effluents

1.3 Works Cost

1.3.1 Basis of Works cost

The works cost will be calculated on the basis of the guaranteed raw material & utility consumption figures as well as unit prices indicated in the Table below. The Bidder shall Guaranteed works cost shall be computed based on cost of each item and guaranteed specified consumption.

All Guaranteed peak Consumptions including power & raw material and Cost shall be indicated in **below mentioned table. Bidder shall indicate expected peak consumption**

figures in technical bid for the items specified them in guarantee figures. The same shall be considered for technical evaluation purpose.

TABLE

Sl. No.	Raw Material/ Utilities	Unit Price in Rs.	Consumption per day (24 hrs) for required capacity as per Specification	Total Works Cost Rs. per day (24 hrs)
a	b	c	d	e=c x d
AN MELT PLANT: Bidder shall furnish the following with reference to the Technical NIT:				
A.	**Raw material**			
1.	Ammonia 100%	Rs. 26,650 per MT	Bidder to specify in MT/day	
2.	Nitric Acid 100%	Rs. 11,230 per MT	Bidder to specify in MT/day	
Sub-Total for Raw material "A" (1+2)				
B.	**Utilities**			
1.	DM Water	Rs 185/M^3	Bidder to specify in m^3/day	
2.	Cooling Water	Rs 90/ M^3	Bidder to specify in m^3/day	
Sub-Total for Utilities "B" (1+2)				
C.	Steam (3.5-5 bar a)	Rs. 2650 per MT	Bidder to specify in MT/day	
D.	Electrical Power, kWh	7.5 per Kwh	Bidder to specify in KWh/day	
Total Works Cost per day i.e. A+B+C+D :				

Notes

1: The above unit prices are indicative and may change at a later date. Revision, if any will be intimated to CONTRACTORS.

2. Raw material mentioned above are the items normally required for AN MELT plant. Bidder shall consider those items/raw material/utilities which shall be applicable for the system offered by him.

3. Bidder to indicate the peak consumption of utilities and raw material consumption in the AN Melt Plant.

1.3.2 Variation in Works cost

Adjustment to guaranteed WORKS COST shall be made in the event OWNER changes, in a manner mutually agreed with CONTRACTOR. For the purpose of performance evaluation, guaranteed works cost & actual works cost during Performance Test shall be worked out for commercial implication as mentioned in Commercial Tender document.

1.4 Noise Level:

LSTK contractor shall guarantee the noise level. Noise level for standard design shall not exceed 85dB at 1m distance from each source in work areas.

1.5 Gaseous/liquid effluents:

The contractor shall guarantee that the gaseous/liquid effluents from the AN melt plant shall not exceed the limits defined by CPCB/ State Pollution control board, whichever is more stringent.

1.6 Sustained Load Test Guarantee:

The contractor guarantees that the Sustained Load test described in this clause will be successfully completed. During the Sustained Load Test, the contractor will demonstrate that the AN MELT PLANT operate for a minimum of 15 days at an aggregate output of min. 95% of the rated capacity of 425 MTPD.

If the contractor fails to achieve any of the requirements of this test, contractor shall remedy the Works to achieve the above guarantee, in a reasonable time frame, in consultation with Owner.

2.0 PERFORMANCE TESTS:

Performance tests shall consist mainly of two categories as follows:

i) Functional test

ii) Performance guarantee test

2.1 Functional test:

The functional test shall be part of the Contractor's commissioning program. These tests shall be performed prior to offering the plant for Performance guarantee Test and Reliability Test. The plant shall be ready in all respects prior to commencement of the functional test. The individual functional test shall be demonstrated by the CONTRACTOR and witnessed by the OWNER.

Functional test shall broadly cover, but not be limited to, the demonstration of satisfactory functioning of the followings:

a) Alarm, trip, remote/manual operation, process and safety interlocks, emergency shutdown of the system/ equipment in the plant.
b) Automatic operation of the system controls, bumpless changeover of Auto/ manual control and proper maintenance of the controlled variables within the desired band.
c) Normal start-up & shutdown sequence of the Unit.
d) Fail safe shutdown in the event of total power failure.
e) Plant turndown min. 50% of design capacity without affecting the AN melt quality.

2.2 Performance guarantee test:

LSTK Contractor shall prove the performance guarantees tests of the AN melt plants separately as specified in this clause under the following headlines:

A. Sustained Load Test

B. Guarantee Test

2.2.1 Sustained Load Test:

After Mechanical Completion has occurred, LSTK Contractor shall commence the Commissioning operations of AN melt Plant. After Plant has been commissioned and at least near rated daily capacity has been achieved, LSTK Contractor's authorised representative shall give notice in writing to Owner that Plant is ready for a sustained load test. On receipt of this notice, but not later than 15 days after the notice, Owner shall conduct the sustained load test under the direct supervision of LSTK Contractor for a consecutive period of 15 days or less at the discretion of the Owner. The sustained load test of the composite plant shall be deemed to have been completed if the Plant produces an average of not less than 95% of the daily rated capacity. If, during the sustained load test, there are interruptions due to reasons not attributable to the obligations and responsibilities of LSTK Contractor, periods of such interruptions shall be included and regarded as days of operation at min. 95% of design capacities or actual load prior to interruptions whichever is lower. The cumulative period of such interruptions shall be limited to a maximum of 3 days. In case the cumulative period of such interruptions exceeds 3 days, SLT shall be repeated by the LSTK Contractor. Owner shall have option to reduce the period of sustained load test of 15 days. LSTK Contractor shall endeavour to complete the sustained load test within a reasonable period after Mechanical completion, but shall complete the same in any case within 120 days from Mechanical completion. If, during the sustained load test, corrective measures are required and involve procurement of new items of Equipment or modification

of items of Equipment which require longer period for delivery than covered by the 120 days period, the period shall be suitably adjusted as agreed with Owner. However, design engineering and placement of orders shall be completed within 120 days from Mechanical completion. On satisfactory completion of the sustained load test, the results achieved shall be tabulated and jointly signed by LSTK Contractor's and Owner's representatives within ten days of completing the sustained load test. During the sustained load test, no standby items of Equipment shall be used in parallel for completing the test.

Contractor shall also demonstrate for a period of 24 hrs, minimum turndown capacity without sacrificing product quality.

2.2.2 A. Notice of Guarantee Test:

On successful completion of the sustained load test, LSTK Contractor shall give notice in writing for commencing the guarantee test. On receipt of the notice, but not later than 15 days after the notice, Owner shall conduct the guarantee test under the direction and supervision of LSTK Contractor. During the guarantee test, no stand by items of Equipment shall be used in parallel for proving the guarantee. The range of operating conditions shall be within the design conditions.

B. Guarantee Test:

After the system has been stabilized by the contractor during sustain load test runs, the contractor shall conduct a performance guarantee test run for the package systems after successful commissioning of the plants. The procedure for performance testing shall be submitted to the Owner for review & approval. The duration for the performance guarantee test run shall be 72 hours continuous operation of the plant. During the above test run, the guaranteed parameters as per specified in para 1.0 above tender document shall be demonstrated.

In the event of failure of performance test run, contractor shall carry out necessary modification at his own expense to meet the guarantees.

The LSTK Contractor shall within 30 days from the beginning of the 1st guarantee test shall give a full and detailed statement in writing to OWNER. The statement shall contain the detailed description and corrective measures which LSTK Contractor intends to take and the time required for the same to be completed and a repeat guarantee test to be made. LSTK contractor shall wherever possible shall carry out such corrective measures and repeat the guarantee test within the shortest possible time, but not later than 180 days from the beginning of the first guarantee test unless otherwise agreed with Owner.

If the contractor fails to achieve any of the requirements of this test, contractor shall remedy the Works to achieve the above guarantee, in a reasonable time frame, in consultation with Owner.

C. Measurements during Guarantee Test:

For determination of the average performance achieved during the guarantee test, all inputs and outputs shall be measured through appropriate meters specified and installed in plant by LSTK Contractor and jointly calibrated and certified to be correct by LSTK Contractor and Owner. No metering tolerances shall be allowed. LSTK Contractor shall have all measurements and records certified by Owner during the test.

D. Inconsistent Measurements:

If any measurement is demonstrably inconsistent with the bulk of the data, or is otherwise suspected to be incorrect, then the data will be adjusted, to achieve consistency and correctness in accordance with generally accepted engineering principles and practice as mutually agreed by Owner and LSTK Contractor. No other adjustments shall be made on the measurements and data recorded during the guarantee test.

2.3 Deviations from Specifications:

In the event that any condition is not in accordance with conditions specified or referred to in Contract and are prejudicial to LSTK Contractor or Owner as demonstrated by LSTK Contractor or Owner, Owner and LSTK Contractor shall mutually, reasonably, and in good faith negotiate an adjustment to the performance guarantees. Any such adjustments to the performance guarantees shall be made utilising the same methods of calculation as were used in establishing the original performance guarantees to the extent such methods continue to be applicable in accordance with good engineering principles and practice.

2.4 Guarantee Test Results:

Within a reasonable period of time but not later than 15 working days from the completion of the guarantee test, Contractor shall determine the results thereof and if in LSTK Contractor's judgement, the performance guarantees have been achieved, submits its calculations and report to Owner for Owner's acceptance. Owner will review the report, calculations and the supporting data and accept the same in writing, if the results are in accordance with the provisions of this Section. In case, Owner does not accept the performance guarantee results, Owner shall indicate in writing to LSTK Contractor in what respect the performance guarantees have not been met, within 15 working days of receipt of the report by Owner from the LSTK Contractor. In the event of rejection of Guarantee

test results by Owner, LSTK Contractor shall take immediate actions to set right as per the provisions of the contract and repeat guarantee test to the satisfaction of the owner.

NITRIC ACID

B.L

STEAM

STEAM EJECTOR

COOLING WATER IN

EJECTOR CONDENSER

PROCESS STEAM CONDENSER

COOLING WATER OUT

AMMONIA EVAPORATOR

AMMONIA FILTER

LIQUID AMMONIA

AMMONIA FILTER

CONDENSATES NETWORK

AMMONIA RE-EVAPORATOR

B.L

AMMONIA HEATER

MTR REACTOR

REACTOR STEAM SCRUBBER

REACTOR VESSEL

PS SCRUBBER MIXER

PS SCRUBBER PUMPS

SECOND SCRUBBER

SECOND SCRUBBER MIXER

SECOND SCRUBBER PUMP

FLUSH DRUM

REACTOR MIXER

ANS CIRCULATING PUMPS

CONCENTRATED ANS VESSEL

CONCENTRATED ANS PUMPS

EMERGENCY WATER VESSEL

CLEAN CONDENSATES VESSEL

CLEAN CONDENSATES PUMPS

DIRTY CONDENSATES VESSEL

DIRTY CONDENSATES PUMPS

Not in AN melt vendor's scope. Existing storage shall be used.

ANS STORAGE TANKS

ANS STORAGE PUMPS

ANS STORAGE HEATER

AN SOLUTION 95%

B.L

AN SOLUTION 95%

B.L

P	16.10.20	PRELIMINARY ISSUE	KS	AK	RKS
REV.	DATE	DESCRIPTION	PPD.	CKD.	APPD.

CLIENT: RASHTRIYA CHEMICALS & FERTILIZERS LTD

REV. P

SHEET: 1 OF 1

SCALE: N/A

TITLE: P & I DIAGRAM
BLOCK FLOW DIAGRAM

DRG. NO.

PLANT: RCF TROMBAY

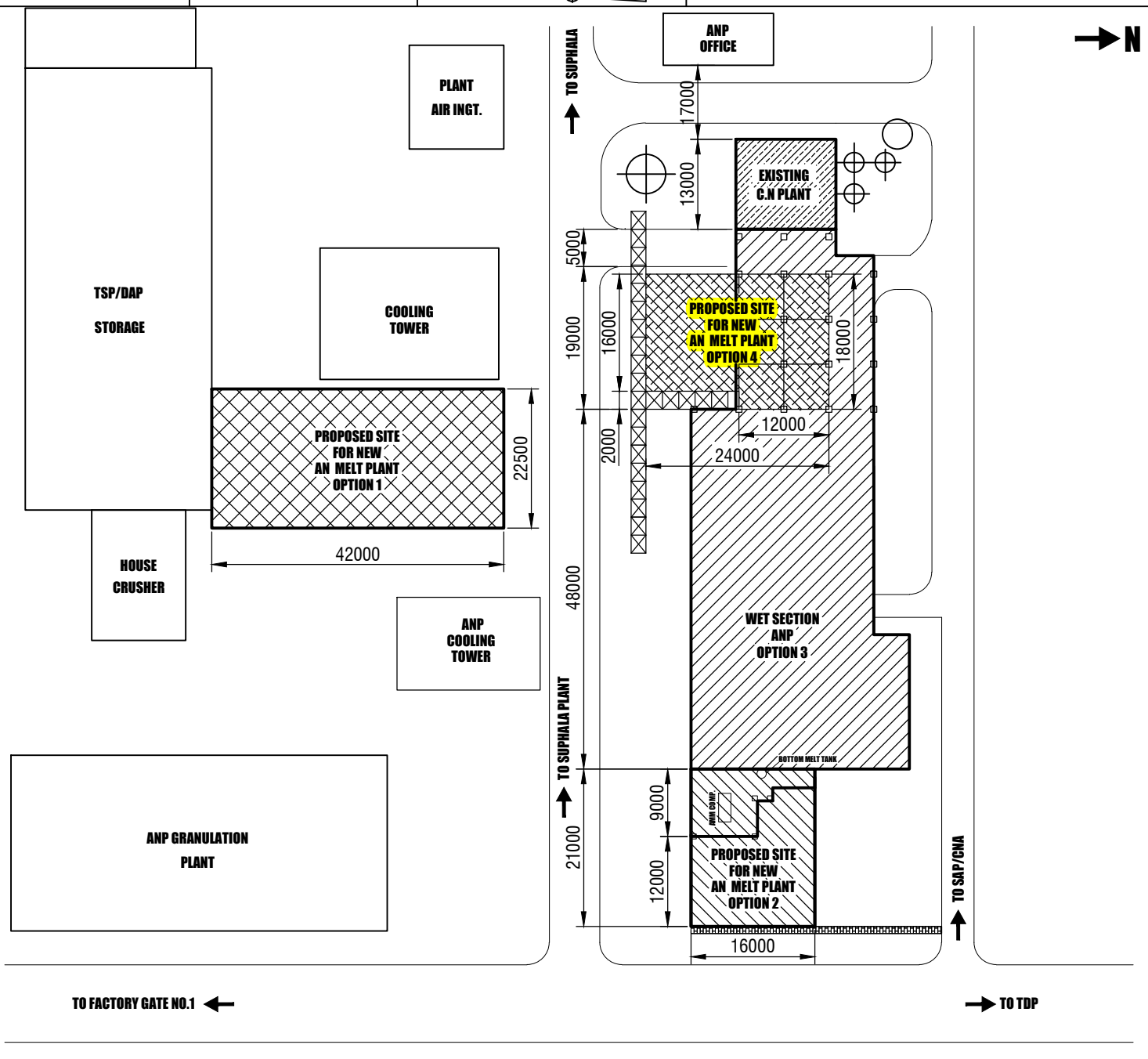
PROJECT: NEW AN MELT PLANT

FORMAT: A1

PROJECTS & DEVELOPMENT INDIA LIMITED

A3 SEAT.DWG 15 October 2020 17:26:01

23.4 x 33.1 Inch



SN	DRN	DATE	REVISION	APR.
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-

NOTES :-

1. ALL DIMENSIONS ARE IN MM. UNLESS STATED.
2. THIS IS REFERENCE DRAWING ONLY.

NO.	DESCRIPTION	QTY.	MATERIAL
-	-	-	-
-	-	-	-
-	-	-	-

RASHTRIYA CHEMICALS & FERTILIZERS LTD.
CHEMBUR, MUMBAI-400 074.

DRN.	Daya Na Kolte	TROMBAY UNIT
CHD.	RMD	PLANT: ANP
SUB.		TITLE:- PROPOSED SITE FOR NEW AN MELT PLANT
DATE	28.10.2020	

DO NOT SCALE THE DRAWING.	CERTIFIED BY	APPROVED	SCALE	DRAWING NO	REV.	
	SECTION HEAD		NTS	12-H-064	00	A3

JOB NO. 175/20

LOCATION

REV. 0 DRG.NO:- 12-H-064 PROJECTION CRITICAL DIMENSIONS AND POINTS FOR INSPECTION - *

SECTION – 7

DESIGN PHILOSOPHY-STATIC EQUIPMENT

FOR

(NEW AMMONIUM NITRATE MELT PLANT)

PLANT: RCF TROMBAY

PROJECT: AMMONIUM NITRATE MELT PLANT RCF, TROMBAY

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3.0	TECHNICAL REQUIREMENT
4.0	FABRICATION
5.0	INSPECTION & TESTING
6.0	PICKLING AND PASSIVATION
7.0	PAINTING
8.0	INSULATION
9.0	SPARE PARTS
10.0	DOCUMENTATION
11.0	VENDOR LIST

LIST OF ATTACHMENTS

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2.	INSPECTION (GUIDELINES)	ANNEXURE - 2
3.	VESSEL TOLERANCE	PDS:PV-001
4.	PROJECTION OF NOZZLES	PDS:PV-002
5.	NAME PLATE FOR VESSEL	PDS:PV-003
6.	SKIRT SUPPORT FOR VERTICAL VESSEL	PDS:PV-301
7.	LIFTING LUG	PDS:PV-302
8.	PIPE DAVIT	PDS:PV-303
9.	NAME PLATE FOR HEAT EXCHANGER	HE-321
10.	LUG SUPPORT FOR VERTICAL VESSEL	PDS:SR-300
11.	SUPPORT SADDLE FOR HORIZONTAL VESSEL	PDS:SR-302
12.	BRACKET SUPPORT FOR VERTICAL VESSEL	PDS:SR-304

1. 0 Design Criteria

1.1 This document defines the design philosophy to be applied to the design (Mechanical), procurement, fabrication, construction/erection, insulation, painting, Pickling & Passivation (for SS equipments), inspection and testing of static equipment i.e. Pressure Vessels, Heat Exchangers,filters, Vessel Internals e.t.c for Ammonium Nitrate Plant for the M/s RCF TROMBAY in accordance with this specification, standards specification, codes and other attachment etc. listed in bid document.

1.2 The equipment shall be designed & constructed as per the latest edition of the following codes and standards:

Code**	**Description**
ASME Section VIII Div 1	Rules for construction of Unfired Pressure Vessels
TEMA 'R' / API 660	Standards of Tubular Exchangers Manufacturer's Association / For Shell & Tube Heat Exchanger
HEI	Heat Exchanger Institute standards for steam surface condensers and steam jet ejectors
API 650	Welded Steel Tanks for Oil Storage
API 661	Air Cooled Heat Exchangers
API 662	Plate type Heat Exchangers
API 941	Steels for Hydrogen Service at Elevated Temperature & Pressure
API-934-A	Materials and Fabrication Requirements for 2-1/4Cr-1Mo & 3Cr-1Mo Steel Heavy Wall Pressure Vessels for High Temperature, High Pressure Hydrogen Service
API-934-C	Materials and Fabrication of 1 1/4Cr-1/2Mo Steel Heavy Wall Pressure Vessels for High-pressure Hydrogen Service Operating at or Below 825 °F (441 °C)
API 605	Metallic gaskets for raised face pipe flanges & flanged Connections(Double jacketed corrugated & Spiral wound)
EJMA *	Standard of Expansion Joint Manufacturers Association
ASME Section II A & B/ ASTM	Materials Specifications
ASME Section II PART C	Specification for welding rod, electrode & filler metal
ASME SEC II PART D	Material Properties
ASME Section V	Non-destructive Examination
ASME X	Fiber-Reinforced Plastic Pressure Vessels
BS EN 13121	GRP Tanks & vessel
ASME Section IX	Welding Qualification
ASME B 16.5	For Flanges
ASME B 16.47	For large diameter flanges

ASME B 16.20	For Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral Wound, and Jacketed
ANSI	Pipes, Flanges, Fittings and Valves
IS: 875 / SITE DATA	For wind load consideration
IS: 1893 (Part 4) & IS: 1893 (Part 1) / SITE DATA	For seismic design consideration
BS 4994	Design & Construction of vessel & Tanks in Reinforced Plastics
IS:4682 (Part-1) with Amendment No. 3	Code of Practice for Rubber Lining of Vessels & Equipment for Chemical Process
Factory Act, 1948 BS CP 3003 (Part 1)	Factory Act & State Govt factory rules Code of Practice on lining of Vessels and equipment for Chemical Process.
PESO	Petroleum And Explosives Safety Organisation

*- Except for heat exchangers, while for heat exchangers the expansion bellows shall be designed as per TEMA standard.

**Any conflicts between documents, including regulations and codes, shall be brought to the Purchaser's attention for resolution.

NOTES:

1. LSTK Contractor may select DIN, BS or any other well known international materials as substituted materials to ASTM/ASME ones, if they are equivalent or superior to ASTM / ASME ones. The chemical & mechanical properties of such equivalent or superior offered materials preferably comparison w.r.t. ASTM materials shall be furnished along the bid. LSTK Contractor shall also submit the references of past supplies of similar type of equipment w.r.t. the proposed materials offered by them in their bid.

2. Process licensors guidelines / standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

3. Specifications of all critical equipments including those specified by the process licensor shall be furnished in the technical bid.

1.3 Complete mechanical design of Equipment as per latest code /standard of construction shall be the responsibility of the LSTK Contractor. Strict compliance with the requirement of codes/equipment specification & any other referred document shall be ensured. In addition, all statutory rules& regulations (PESO, IBR e.t.c) shall also be complied with.

1.4 Design conditions for all equipment shall be as per technical Specification and Material specification. Minimum required thickness is calculated based on design parameters considering different types of loadings including effect of static head of liquid column. Equipment shall also be designed for hydrostatic condition. Final thickness is decided giving due consideration for corrosion allowance, tolerance e.t.c.

1.5 Design pressure shall be at the top of vertical vessel or at the highest point of horizontal vessel. The design pressure at any lower point shall be determined by adding the maximum operating liquid head and any pressure gradient within the vessel.

1.6 Wind analysis shall be performed as per IS-875 (Latest Edition).Wind forces shall be increased by 20% (over & above design code requirement) to cater the effect of piping system, platforms and ladders etc. Vertical vessels with height/diameter ratio equal to or greater than 10 shall be analyzed for vibration due to vortex shedding when critical wind speed does not exceed 30m/s. For guidelines of Dynamic Wind Analysis refer Annexure-I.

Wind velocity shall be 160 km/hr for analysis.

1.7 Seismic analysis shall be performed by Response spectrum method (RSM) considering **seismic zone-IV** as per IS-1893 part-1 & IS-1893 Part 4 (Latest edition).

1.8 All carbon steel (CS) & low alloy steel (LAS) pressure parts shall have 3 mm corrosion allowance unless specified otherwise.

1.9 All internals CS/ LAS parts including low temperature materials shall have at least 1.5 mm corrosion allowance on either side unless otherwise specified.

1.10 Design of supports and anchor bolts shall be performed for compressive and tensile loading. In no case shall diameter of anchor bolts be less than M24 for skirt support and M16 for other type of support.

1.11 Each Lifting lug shall be designed with shock factor 2.

1.12 Hydro testing of equipment shall be as per UG-99b of ASME Sec VIII Div-1. In order to safeguard against the risk of brittle fracture during hydrostatic test metal temperature during hydrostatic test be maintained at least 30°F (17°C) above the minimum design metal temperature, but need not exceed 120°F(48°C). Design pressure for each nozzle shall be sum of maximum allowable working pressure and static head of corresponding nozzles.

1.13 Maximum Allowable Working Pressure (MAWP) is the maximum gauge pressure at the top of a completed vessel, which is obtained from the calculations for every element of the vessel based on the actual thickness in the corroded condition. Supplier shall calculate the MAWP of each vessel, and the calculation shall be included in design calculations. MAWP shall not be assumed to be the same as the design pressure except for cases where MAWP cannot be determined by calculation to the applicable code. Accordingly calculate hydro test pressure as per UG-99b

1.14 Bolt of size M 48 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner. The bolts shall have an extra threaded length at one end of approximately 1 bolt diameter, and shall be provided with threaded protection caps. Hex nuts shall have suitable holes for manual tightening. The requisite no. of hydraulic stud-tensioner device with necessary adopters/insertions based on varying sizes of studs shall be supplied by bidder as per mechanical design of the equipment.

1.15 Orientation of longitudinal seams and position of circumferential seams shall be clearly marked in the fabrication drawing. Nozzles, support and other attachments shall be located clear of welded joints.

1.16 All process equipments shall be supplied with Nitrogen filled. In case of equipment assembled and welded at site, it shall be filled with N2 after testing at site. Dry Nitrogen shall be filled at a pressure of 0.5 Kg/cm2g and equipment shall be fitted with a pressure gauge and valve.

1.17 Bidder shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.

1.18 Bidder shall stand Performance Guarantee of equipment as per respective technical specifications/Process Data sheets.

1.19 Design conditions for all equipment shall be in accordance with the process data Sheets/specification .However, in any case design pressure shall not be lower than 10% over the maximum anticipated operating pressure and design temperature should be 25°C higher than the maximum anticipated operating temperature for all equipment unless otherwise specified.

1.20 Basic allowable stresses for shell, heads and other components etc.of vessels and shell, roof, etc. of tanks shall be the values specified in the design code.
Maximum allowable “tensile stress” and “compressive stress” shall be as per UG-23 of ASME Sec VIII Div -1. These stresses may be increased by 20% for earthquake & wind combination case in line with UG-23 (d).

1.21 All blind flanges and man way covers weighing 35kgs or more shall be fitted with handling Facilities such as davits.

1.22 As a General rule all nozzle attachment to shell/head shall be set in type.

1.23 As a minimum requirement, all vessels, Exchanger, Tanks e.t.c shall be spot radiographed.

1.24 Forces and moments acting on nozzles shall be considered in the equipment design.

1.25 LSTK Contractor shall mark tangent lines, the position of the main axis and the centre of gravity for orientation in a clearly identifiable and permanent way on the vessel. Centre of gravity shall be clearly marked.

1.26 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings. For welding the stud on tray decks and support beams, use of stud welding gun with suitable flux is acceptable. In manually welding of studs, care should be taken to minimize the weld spatter and the outside diameter of the weld so that it should not foul with tray deck or washer. For stud welding, proper welding procedure shall be established. Torque required for welding failure shall be higher than the torque required for failure of the stud.

1.27 A proposed Welding Procedure Specification (WPS) shall be submitted to approved inspection agency for approval. On approval, a Procedure Qualification Test (PQT) shall be conducted which shall be witnessed by approved inspection agency. On acceptance of all tests as per ASME Section IX, a final WPS along with Procedure Qualification Record (PQR) shall be submitted. Production welding shall start only after approval of final WPS/PQR and qualification of welders as per ASME Section IX, approved inspection agency may accept previously qualified WPS/PQR at his sole discretion.

1.28 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible

1.29 Gas or Carbon arc welding shall not be used.

1.30 Welding electrodes of composition similar to Internals material shall be used except austenitic electrodes of higher chromium and nickel content such as AWS A5.4, ASME SFA 5.4 class E309 and E310 may be used for 12-Cr stainless steel. For dissimilar material welding, electrode composition shall be similar to nobler material being welded. Following electrodes shall be used unless specified otherwise:

E 7018	for all CS materials
E 308	for all SS 304 to SS 304
E 308L	for all SS 304L to SS 304L
E 309 MoL	For SS 410S to SS 410S, SS to CS, SS 410S to SS 304, 304L, 316, 316L
E 316	For all SS 316
E 316L	For all SS 316L
E Ni – Cu7	For Monel to Monel and Monel to CS/SS

1.31 All parts fabricated shall be smooth, true, clean and free from burrs, grease and dents. Openings for passage of workman must have exposed edges rounded.

1.32 All support rings, bolting bars, beams support brackets and other components which are integral and therefore welded to the column shell inside, shall be supplied and installed by column fabricator.

1.33 Total draw-off trays shall be designed for zero leakage construction and may be seal welded (if required) at site to attain zero leakage.

1.34 Seal welds shall have a throat thickness at least equal to the specified Corrosion allowance.

1.35 All stainless steel tray assemblies/internals and their components (e.g. Bubble caps, valves etc.) shall be pickled and Passivated. Pickling and Passivation shall be as per ASTM 380.

1.36 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.

1.37 For equipment coming under the purview of Static and Mobile Pressure Vessel rules, it shall be LSTK Contractor responsibility to get complete approval from Chief Controller of Explosives,

PESO e.t.c, pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.

1.38 For equipment coming under the purview of Indian Boiler Regulations, it shall be LSTK Contractor responsibility to get approval from IBR authorities pertaining to design, drawings, material of construction, fabrication, inspection and testing etc.

1.39 In case of conflict between this specification and other specification, codes and data sheets. It shall be referred to PMC/ Owner for clarification and the decision of PMC/ Owner shall be final & binding on contractor without any cost & delivery implications. However, it shall be resolved considering the most stringent in the following order.

- Statutory requirement
- Requirement specified in this specification
- Process data sheet/ P&ID
- Applicable codes & standards

1.4 REGULATIONS

Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations such as Indian Boiler Regulation, PESO and Department of Explosives, Nagpur, India together with Local by Laws for the state including statutory requirements as applicable. Static and Mobile Pressure Vessel (SMPV) rules as applicable shall also be complied with.

PUBLICATIONS:

NACE MR 0103	Materials Resistant to Sulphide Stress Cracking in Corrosive Petroleum Refining Environments
NACE MR 0175 / ISO 15156	Petroleum and natural gas industries - Materials for use in H2S containing environments in oil and gas production
NACE RP 0296	Guidelines for Detection, Repair and Mitigation of Cracking of Existing Petroleum Refinery Pressure Vessels in Wet H2S Environment
NACE TM 0284	Evaluation of Pipeline and Pressure Vessel Steel for Resistance to Hydrogen Induced Cracking
NACE TM 0177	Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in Hydrogen Sulphide Environment
WRC Bulletin # 107	Local Stresses in Spherical & Cylindrical Shells due to External Loadings.
WRC Bulletin # 297	Local Stresses in Cylindrical Shells due to External Loadings on Nozzles

1.41 DESIGN DOCUMENTATION

1.41.1 Detailed design calculations considering different loadings shall be made as per code/standards and the additional requirements as mentioned below:-

1.41.2 Design of equipment inside the plant complex shall be in accordance with the process licensor's data sheets and specifications.

1.41.3 LSTK Contractor shall consider the interfaces with other engineering disciplines w.r.t.

- Piping Layout/Location Drawings
- Civil / Structural Drawings
- P & ID's
- Materials
- 3D PDS Model for Piping and Equipment Layout
- Hazardous Area Classification

1.41.4 Design philosophy of other disciplines shall be observed and shall be relevant to the extent applicable.

- Civil/Structural Design Criteria
- Piping Design Criteria
- Process Design Criteria
- Electrical and Instrumentation Design Criteria

1.42 SITE CONDITIONS

1.42.1 Climatic and other site conditions as per DESIGN BASIS PROCESS (PC185/E-1/P-II/1.0) & DESIGN PHILOSOPHY- CIVIL & STRUCTURAL WORKS (PC185/E-1/P-II/12) listed in the bid.

1.43.2 OPERATING DUTY

1.43.1 Service shall be twenty-four (24) hours per day, seven (7) days per week, and fifty-two (52) weeks per year. The equipment design life shall be 20 years.

1.44 CONSTRUCTION & ERECTION

1.44.1 LSTK Contractor shall follow standard established procedures for handling storage, construction & erection. LSTK Contractor shall strictly follow Manufacturer's/Principal's instructions, approved drawings and procedures for construction & erection and satisfy Principal in all respects of storage, handling, construction & erection of Package. All erection work shall conform to the working/erection drawings (to be prepared by LSTK Contractor) and shall be in conformity with codes & standards as applicable. The LSTK Contractor shall supply & arrange all necessary construction & erection tools and tackles, machinery, scaffolding etc.

1.44.2 LSTK Contractor shall perform the following:

i) Before installing the equipment, the foundations shall be checked and wherever Necessary, chipping shall be done by the LSTK Contractor. All grouting materials, packing

plates/wedges required for the levelling and alignment of equipment, structures & pipelines etc shall be provided.

ii) Top of the foundations shall be thoroughly cleaned to the satisfaction of Principal / LSTK Contractor before placing base plates.

iii) All equipment & structure etc. shall be checked and inspected for its proper levelling and granting (grouting) shall be done with suitable grouting material as required.

iv) After tightening the foundation bolts, the final level / alignment shall be rechecked and redone, if required.

v) Installation of all supports and hangers, including concreting or welding as necessary.

vi) To check correctness of the piping, instruments and other connecting points in the equipment and piping installed.

vii) The welding joints shall be stress relieved wherever necessary as per applicable codes, Standards & specification.

1.44.3 The following shall be arranged and supplied by LSTK Contractor for completion of job. Any other item whatsoever required shall also be included by LSTK Contractor in their scope.

i) All construction & erection materials, equipment & machinery, scaffolding, consumable, and test equipment etc.
ii) Cranes/Hydra, temporary lifting beams and spreaders etc.
iii) Procedures for site assembly, construction & erection including lifting methodology for Owner/Third party approval

1.44.4 As a minimum contractor shall comply the requirements indicated below:

i) Fabricate, erect and align the equipment & internals as per applicable codes, standards & specifications. All internals shall be inspected before and after installation.

ii) Carry out all NDT's required. The Personnel performing NDT's should have a minimum qualification as "NDT LEVEL-II" in the relevant Technique, certified by American Society for Non-destructive Testing.

iii) Perform non-operating field pressure tests and leak tests on field fabricated equipment in accordance with the applicable codes, standards and specifications, ensuring disposal of test media in accordance with instruction/recommendations

.

iv) Notify Owner / Third party of the test schedules for witness the tests by concerned inspector.

1.45 QUALITY ASSURANCE & CONTROL

1.45 1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests , measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.

1.45.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that Equipment leaving LSTK Contractor's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

1.45.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

1.45.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems. QA/QC System shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.

1.45.5 QA/QC system shall cover all products and services required for the equipment as per scope of work including job sub contracted by the LSTK Contractor.

2.0 Material of Construction

2.1 The minimum requirement of the materials shall be as per the plant equipment metallurgy covered under specific process design guidelines. However superior materials as per the recommendation of Process Licensor's may be selected which shall be indicated in the bid by the LSTK Contractor.

Material of construction for various equipment shall be as selected as follows for general Condition/service unless specified otherwise in respective process data sheet.

a) **Pressure Vessel (KCS/CS)**

Shell /Head plates	: SA 516 Gr. 60/70
Nozzle Flange	: SA 105
Nozzle Neck (Pipe/Plate)	: SA 106 Gr. B (Nozzle size < 10"); SA 516 Gr. 60/70 (Nozzle size > 10")
Non standard forging	SA 266 Gr 2

b) Pressure Vessel (SS)

Shell /Head plates	: SA240 Gr*
Nozzle Flange	: SA 182 Gr*
Nozzle Neck (Pipe/Plate)	: SA 312 Gr* (Nozzle size < 10"); SA 240 Gr * (Nozzle size > 10")
SS grade as specified in datasheet	
c) Heat exchangers (KCS/CS)	
Shell /Channel plates	: SA 516 Gr. 60/70 & SA 516 Gr 60 for caustic, amine , hydrogen, sour (Wet H2S) or lethal service tanks, vessel and heat exchangers :Tube sheet : SA266 Cl2 (Forged) :Tubes : SA179 (Seamless)
Nozzle Flange	: SA 105 (Epoxy /rubber Lined as applicable)
Nozzle Neck (Pipe/Plate)	: SA 106 Gr. B (Nozzle size < 10"); SA 516 Gr. 60/70 (Nozzle size > 10")
d) Heat exchangers (SS)	

Shell /Channel plates	: SA240 Gr *
Tube sheet	: SA336 Gr*(Forged)
Tubes	: SA213 Gr* (Seamless)
Nozzle Flange	: SA 182 Gr*
Nozzle Neck (Pipe/Plate)	: SA 312 Gr* (Nozzle size < 10"); SA 240 Gr * (Nozzle size > 10")
Non standard forging	: SA336 Gr * / SA 965 Gr *
*SS grade as specified in datasheet	

e) **CS Tanks**

Shell/ Roof /Bottom Plates	: IS2062 GR B/SA36
Nozzle Flange	: SA 105
Nozzle Neck (Pipe/Plate)	: SA 106 Gr. B (Nozzle size < 10"); IS 2062 GR B/SA36 (Nozzle size > 10")
Stud/ bolts and nuts for nozzles fitted with blind flange	SA193 Gr B7/ SA 194 Gr. 2H
f) **SS Tanks/ Non- Coded Vessel**	
Shell/ Roof /Bottom Plates	: SA240 Gr *
Nozzle Flange	: SA 182 Gr*
Nozzle Neck (Pipe/Plate)	: SA 312 Gr* (Nozzle size < 10"); SA 240 Gr * (Nozzle size > 10")
Non standard forging	: SA336 Gr *
*SS grade as specified in datasheet	

2.2 The Additional material requirements as indicated below shall be considered by Bidder.

2.2.1 All raw materials including bought -out items, whatsoever required, to complete the supplies shall be procured and supplied by LSTK Contractor with due identifiable mill material test certificates & inspection reports duly certified by third party inspection agency.

2.2.2 For coarse grained and high tensile materials in carbon steel (UTS > 45 Kg/mm2) and low alloy steel, guaranteed impact strength shall be ensured at a temperature 15 degree C below envisaged hydraulic test temperature as a precaution against brittle fracture during hydraulic test.

2.2.3 Carbon steel plates shall be procured in fully killed condition. CS plates shall be fully killed & normalized. All plates above 50mm thickness shall be vacuum-degassed and examined by Ultrasonic Testing (UT) as per applicable material specification code/standard.

2.2.4 All Stainless Steel (SS) plates shall be hot rolled & solution annealed and pickled as per SA-480.

2.2.5 All forgings except for flanges as per ANSI shall be UT tested as per ASTM A 388 for the thickness greater than 50 mm and shall be procured in normalized / annealed condition acceptance standards shall be as per AM 203.2 of ASME Section VIII Div. 2. In case any defect is found, no repair by welding shall be allowed.

2.2.6 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after machining as per applicable material specification code & standard.

2.2.7 All external / internal attachments, pads/cleats for support directly welded to the equipment shall be of same materials (grade) as that of equipment, unless specified otherwise.

2.2.8 All nozzles up to DN 10" size shall be made of seamless pipe. For sizes above DN 10" nozzle connection shall be rolled from plates with full radiography of plates.

2.2.9 Unless otherwise specified girth flanges shall be of forged quality and ultrasonically tested.

2.2.10 Unless more restrictive prescription given by material specification the max. Content for carbon steel used for fabrication as shown by ladle analysis shall be 0.23% for plates, pipes & tubes 0.25% for forging.

2.2.11 Top portion of skirt (min. 500 mm height) welded to the bottom dished head shall be of same material (Grade) as that of shell /head for LAS & SS materials.

2.2.12 Heat treatment of formed parts shall be carried out as per following:

For Carbon Steel:

a. Cold formed dished ends or knuckles up to 16 mm nominal thickness shall be stress relieved.

b. Cold formed dished ends or knuckles above 16 mm nominal thickness shall be normalised.

c. For Low alloy Steel: - Cold Formed Dish ends and Knuckles shall be stress relieved.

d. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.

e. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.

f. Vessels in caustic service, Amine or Sour gas service shall be stress relieved.

g. All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment

2.2.13 Pressure part plates having thickness 16 mm to 50 mm (both inclusive) shall be ultrasonically Tested (UST) as per ASTM A-435. Pressure part plates having thickness above 50 mm and all Plates to be used shall be UST as per ASTM A-578 Level B. No laminations or inclusions shall be permitted.

2.2.14 The minimum thickness of weld overlay material (undiluted) shall be 1/8 inch (3 mm) except clad or weld Overlay tube sheets and gasket surfaces.

2.2.15 Unless otherwise specified Copper & Copper alloys shall not be used. Copper content up to 0.4% are acceptable in carbon steel & 0.6% in stainless steel.

2.2.16 PWHT of complete vessel shall be carried out in one go in a furnace. Local stress relieving of Weld joint in piece meal shall be avoided as far as possible.

2.2.17 For SS 316 & 316L, SS316L Mod materials the requirements of ferrite content and Inter granular corrosion test shall have to be complied with in conformity with Process Licensors standard. The inter granular corrosion test shall be carried on SS316L material ASTM A 262 practice E shall be applicable. The corrosion rate shall be as per the recommendations of Process Licensor.

2.2.18 For SS 316 & 316L material Ferrite content for plate, pipe and forging shall be max. 2%.

2.2.19 Inter granular corrosion test shall be carried out on all SS 316 L materials, weld & HAZ as Per ASTM A 262 practice E (Strauss test) unless otherwise specified in specification.

2.2.20 When post weld heat treatment is required for pressure vessels, all material for pressure holding Components shall be simulation tested with minimum additional two (2) heat treatment cycles. Additional two heat treatments are; one for PWHT after shop repairing and the other for future PWHT at site.

2.2.21 All Carbon Steel (CS) and Low-Alloy Steel (LAS) pressure parts shall have 3 mm corrosion allowance unless specified otherwise. All internal CS & LAS parts shall have at least 1.5 mm Corrosion Allowance on either side. No corrosion allowance shall be considered for SS. In general, the recommendation of Process Licensor shall be adopted for construction if found more stringent.

2.2.22 Cladded plates shall be supplied as per ASTM A264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A578 level S8.

2.2.23 Tube sheets shall have a nominal clad or weld overlay thickness of 3/8 inch (10 mm) but not less than5/16 inches (8 mm (undiluted)) regardless of shell side or tube side face. The minimum thickness of clad or weld overlay at a pass partition groove shall be 1/8 inch (3 mm) minimum

2.2.24 Weld overplayed nozzle and girth flange gasket faces shall have a minimum thickness of 3/16 inch (4.8 mm undiluted) after machining.

2.2.25 In order to minimise the effect of temper embrittlement for material to 2¼ Cr 1 Mo specifications in the temperature range of 375-575^{o}C, the embrittlement factors 'X' & 'J' shall be limited to:

$X = (10P + 5Sb + 4Sn + AS) / 100 \leq 15$
The elements above are expressed as ppm

$J = (Si + Mn)(P + Sn) \times 10^{4} < 160$
The elements above are expressed as percentages

A stimulated PWHT followed by step cooling shall be performed on a sample of material. Acceptable toughness shall be demonstrated by means of a Charpy V Impact Test.

2.2.26 Unless otherwise specified, all internal parts shall be removal type. Internal shall be designed in units as large as can be installed through the nearest upper manhole or opening. The weight of unit shall not generally exceed 40 Kg. except for support beams.

Trays, distributors, baffles and support beams shall be designed in such a way that deformation of shell due to operating pressure and thermal expansion does not occur.

. Bolts and nuts for fixing internals shall be 18/8 S.S and minimum size of bolts shall be M10. All internal bolts shall be provided with locking nuts.

2.2.27 Steel for Hydrogen service at elevated Temperature & pressure shall be selected as per API 941 & API 934 .The following special requirements shall be met with for Hydrogen/Sour gas as per NACE standard.

a) All pressure parts shall be post weld heat treated.

b) All pressure retaining welds shall be 100% radiographed. (Root run & Final Weld radiography is must)

c) Hardness of base metals, weld and HAZ shall not exceed 22 HRC.

2.2.28 Gaskets for all medium with flange rating ≤ 600 # shall be SS spiral wound type with external & internal guide rings shall be used unless otherwise specified. CAF gaskets are not acceptable.

2.2.29 For equipment designed as per IBR, materials shall strictly comply with the requirement of the IBR code.

2.2.30 When design pressure is more than 600# class and/or shell thickness is 50 mm and above, self reinforced forged nozzle shall be provided. Shell to SR nozzle welding shall be set-in type welding.

2.2.31 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

2.2.32 In case of equipment involving site assembly/fabrication the entire site job including loading & unloading at site, fabrication, radiography, heat treatment, Inspection & testing etc. shall be included in the scope of supply.

2.2.33 Production Control coupons, when required as per code and specifications, shall be subjected to all tests like impact, inter granular corrosion test etc., in addition to mechanical test as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.

2.2.34 No welding, hammering or deforming is permitted on the pressure retaining parts after post weld heat treatment except as permitted by the codes or standards and when approved by the purchaser.

2.2.35 Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.

3.0 Technical Requirements

3.1 PLATE TYPE HEAT EXCHANGER

3.1.1 The plate type exchanger shall be designed in accordance with “API 662"

3.1.2 All plates shall be pressed from a homogeneous single metal sheet in one placing and normal thickness of plate being pressed shall not be less than 0.5 mm

3.1.3 Nozzle neck attachments shall be with full penetration weld. Set on nozzles are not permitted.

3.1.4 Lock washers shall be provided for all rotated nuts.

3.1.5 SS plate shall be of SA 240 specification.

3.1.6 For gasket type PHE, vendor shall be responsible for the compatibility of gasket material & Glue, selected for specified fluids and design conditions.

3.1.7 All components in contact with process fluids shall be as per Process data sheets (PDS).

3.1.8 Equipment shall be hydro tested at test pressure limits (as differential pressure) for 30 Minutes minimum. Also mechanical strength of the frame shall be tested by raising the Pressure on both side equivalents to test pressure (i.e. 1.3 times design pressure) for 90 Minutes minimum.

3.1.9 All nozzles of Heat exchanger shall be of extended type. Studs connections are not acceptable.

3.1.10 The plate shall be fully supported by carrying bar and only guided by the guide bar.

3.1.11 The carrying bar shall be designed to support at least 1.5 times the total weight of movable cover and plate pack filled with water or process fluid whichever is having greater density.

3.1.12 Bidder shall furnish the complete details of the offered system like features, properties of the Descalant, system description, operating details etc.

3.1.13 Vendor to develop methodology or device to get the entrapped gases escaped during welding and also to ensure that no processed fluid should get entrapped during operation in such area otherwise it may lead to crevice Corrosion.

3.2 Vessel

3.2.1 Design, materials, fabrication and inspection of welded pressure vessels shall comply with ASME Code Section VIII, Division 1 (latest edition) and Technical Specifications.

Process licensors guidelines/standards may be adopted complying minimum requirements of this design philosophy of static equipment. Details of such selected guidelines/standards along with the list shall be furnished in the bid.

Unless specifically required, ASME Code stamp is not required.

Vessels will be sized according to inside diameter and 2:1 elliptical heads or hemispherical heads. Minimum inside diameter shall be 500 mm. Top cover shall be flanged if the ID is equal or less than 900 mm.

3.2.2 For vessels the minimum thickness of shell & heads, including corrosion allowance shall be as indicated below:

Sr. No	Shell Diameter (mm)	Thickness (Min.) mm	
		CS / LAS	HAS
1.	ID < 500	5	3
2.	501 < ID < 1200	5	4
3.	1201 < ID <2000	6	5
4.	2001 < ID < 2600	8	6
5.	ID > 2600	10	8
CS = Carbon Steel, LAS = Low-Alloy Steel, HAS = High-Alloy Steel			

3.2.3. All nozzles above 24" NB shall comply with ASME B16.47 Series B (API 605).

3.2.4. Minimum branch nozzle thicknesses shall be Schedule Extra Strong above 2" NPS, and Schedule 160 for 2" NPS and below.

3.2.5 Stress calculations due to Local loads on vessel for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.

3.2.6 Design of vessel skirt shall be based on seismic/wind/thermal considerations and fire proofing/insulation requirements.

3.2.7 Vessel skirts for carbon steel vessels shall be designed from the same material (Grade) as the shell or the head. Vessel skirts for other than carbon steel vessels shall be the same material (Grade) as the shell or the head for the top 500 mm.

3.2.8 Vessels with skirt support having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be an annulus 10 mm (minimum) thickness and 150 mm (minimum) wide, with bolt holes equal to bolt diameter plus 3 mm, stacked drilled with skirt base plate.

3.2.9 Maximum permissible deflection for vessel when subjected to design wind loadings shall not exceed 0.005 x Vessel height. For guidelines of Dynamic Wind Analysis refer Annexure-I.

3.2.10 Minimum man way size shall be equal to 24" nominal pipe size.

3.2.11 Manhole/hand hole/blind holes covers shall be equipped with davits or hinges to facilitate handling.

3.2.12 Horizontal vessels of large size and thin wall shell on saddle supports shall be investigated for buckling, local circumferential bending and shear stress. The method of L. P. Zick (Supplement to Welding Research, 1971) may be used for this investigation.

3.2.13 Use of structural steel shall be limited to non-pressure parts only.

3.2.14 Local vessel stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.

3.2.15 Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.

3.2.16 For vessel with diameter less than 900 mm and having removal internals, shell flange shall be provided.

3.2.17 The extent of radiographic examination of the shell and head seams shall be spot examination, as minimum.

3.2.18 Vessel stresses during hydrostatic tests shall not exceed 90% of the minimum ambient yield strength (tensile) of the material. However compressive shall be as per applicable code.

3.2.19 Vessels to be hydrostatically shop tested in the horizontal position shall be supported adequately to keep local stresses in the shell not exceeding 90% of the yield strength of the material.

3.2.20 The lifting lug, lifting trunion, tailing lug etc. shall be designed with shock factor 2.

3.2.21 Design of supports and anchor bolts considering soil & importance factors shall be performed for compressive & tensile loading. In no case, diameter of anchor bolts shall be less than M24 for skirt support & M16 for other type of support.

3.2.22 CORROSION ALLOWANCE

a) For an intermediate head, corrosion allowances shall be added to both sides.

b) For the inside of shells, heads, nozzles and manholes, the specified corrosion allowances Shall be added.

c) For non removable internal parts, the specified corrosion allowances shall be added to both sides.

d) For removable internal parts, the specified corrosion allowances shall be added to one side Only.

3.2.23 HEAD / DISHED ENDS

a) Dished ends shall be of seamless construction. However, dished ends with one chordal weld seam are acceptable. In such cases, the chordal seam shall preferably be in the middle one third of the blank. Intermediate heat treatment, if considered necessary, shall be carried out by the LSTK Contractor.

b) Whenever a dished end is made of more than two plates, it must have a crown plate. Whenever a nozzle or a manhole is positioned at the centre of the dished end, the crown plate should be larger than the nozzle /manhole reinforcing pad.

c) Torispherical heads shall be used for Pressures up to 6.86 bar (g). For torispherical heads, ratio of Knuckle to Inside Crown Radius shall not be less than 6 %.

d) Beyond 6.86 bar g, heads shall be of ellipsoidal type having a ratio of major axis to minor axis 2:1 or hemispherical type. Alternatively, Hemispherical Heads with minimum weld joints may also be used.

3.3 INTERNALS

3.3.1 For Tray design worst of the following conditions shall be considered:

a) For tray design minimum loads of 100 kg/m2 in active areas and 320 kg/m2 in down comer area shall be considered.

b) For atmospheric, pre flash & vacuum distillation columns for trays under flash area uniform load of 500 kg/m2 shall be considered. This loading shall be applicable to first three trays above flash section.

c) A concentrated live load of 150 kg at any point on the installed assembly independent of other design live loads.

d) Maximum horizontal deflection at effective tray loading shall not exceed 1/900 of the span or 7 mm. whichever is less.

e) Corrosion allowance shall be added to both sides of trays, support rings and other fixed internal non pressure parts.

3.3.2 All internal bolting shall be of corrosion resistant material.

3.3.3 Support for packing and internal shall be designed for the worst condition. In the condition of packing liquid hold up of minimum 20% of packing volume shall be considered. Tray support beams shall have height not exceeding 20% of distance between trays for diameter up to 2400 mm and 15% of the distance between trays for higher diameters.

3.3.4 Each tray shall be so designed as to ensure liquid tight construction. Each tray shall be provided with a man-way suitable for opening both from top and bottom unless otherwise specified.

3.3.5. **MINIMUM THICKNESS OF INTERNALS SHALL BE AS FOLLOWS:**

S. No.	Parts	CS & LAS (MM)	HAS (MM)
1.	Chimney tray	10	6
2.	Tray decks partition, down comers, weirs pans etc.	3.5	2.0
3.	Tray support rings & bolting bars	6.0	6.0
4.	Bubble caps	3.5	1.5
5.	Valves for trays	1.5	1.5
6.	Non-integral main & secondary supporting beams	5.0	2.0

Note: -1) All bolting size shall be minimum of M10. All nuts shall be hexagonal.

2) The min. thickness of Trays shall be as per the recommendation of Process Licensor

3) Allowable stress criterion for design of internals shall be as per ASME Section VIII Div.1.

3.3.6 All necessary approval on Hydraulic design and internal drawings shall also to be obtained from Process Licenser as applicable.

3.3.7 All removable internals shall be designed so that they can pass through the vessel man-way Internal diameter / shell flange if any.

3.3.8 The LSTK Contractor shall meet the process and hydrodynamic guarantee of towers along with their internals. All instruments including of special instruments required to verify the above requirements shall be arranged by the LSTK Contractor.

3.3.9 For an intermediate head, corrosion allowances shall be added to both sides.

3.3.10 Internal distribution pipes shall have flanged connections with gaskets unless otherwise specified. Internal pipes shall be divided into suitable lengths to pass freely through the vessel manholes and internal man ways, and shall be suitably supported from shells or tray decks.

3.3.11 Demisters shall be securely fastened to support ring by bolting or clamping.

3.3.12 Internals (trays, distributors, support beams) shall be so designed that any expansion of it Wouldn't affect shell deformation.

3.3.13 Hiccups load in vapour flow up the column shall be taken into account in the tray design.

3.4 Shell and Tube Heat Exchangers

3.4.1 Process Shell and Tube Exchangers will comply with the requirements TEMA (Latest) Class 'R'. The tube sheet shall be analysis by Appendix "UHX" of ASME Section VIII, Div. 1 & TEMA whichever is more stringent.
(TEMA Class 'C' may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.)

3.4.2 ASME Section VIII, Div. 1, Appendix "S" shall be considered mandatory for bolted flange connections. All mandatory requirements are covered under Appendix 2 for different loading condition.

3.4.3 Mean metal temperature of tube & shell be considered in the design of fixed tube sheet exchangers.

3.4.4 Parts such as tubes, tube sheets, floating heads etc. which simultaneously come in contact with both shell side and tube side fluids, shall be designed considering pressure acting on one side only or the combination of pressures, whichever results in higher thickness of parts.

3.4.5 Exchanger saddle and foundation design shall include additional loadings generated from bundle pulling. The saddle and foundation design for all exchanger for which tube bundle pulling is foreseen during maintenance, shall be designed for longitudinal force acting at the exchanger axis. Pulling force shall be 1.5 times the bundle weights:
Further wind load and piping load shall also considered on the exchanger supports and foundation.

3.4.6 Tube sheets in vertical exchangers shall be provided with drain and vent arrangement with threaded plug seal welded.

3.4.7 Shell side "hot" nozzles shall be located at the top of the shell at the channel end whenever possible.

3.4.8 Lifting lug for heads or bonnets shall be provided wherever frequent dismantling is required.

3.4.9 Bundle weights shall be limited to 10 tonnes. In case the bundle weight increases by 10 Tones, Bidder shall take care necessary precaution in the design and fabrication of exchanger e.g. by Providing rollers arrangement, support plates etc. to avoid excessive loading on shell while Pulling of tube bundle, proper reinforcement in equipment support etc.

3.4.10 Saddle wear plate material shall be the same as the shell material.

3.4.11 Tube sheets and Girth Flanges shall be shall be of Forged Quality & Ultrasonically tested. It shall not have any segmental joint.

3.4.12 All heat exchanger tubes shall be seamless, cold drawn and formed from single length. CS tubes shall be normalized. LAS tubes shall be normalized and tempered.

3.4.13 The minimum radius of U tubes shall be not less than 2xOD of tube. Thickness of 2 inner most rows will be higher than other rows with minimum difference of 2 gauges.

3.4.14 For U tube bundle, the following requirements shall also be met:

i) Each U tube shall be formed from a single straight length
ii) All U tubes shall be cold bent
iii) All C.S, C-Mo, Cr-Mo tubes shall be heat treated after bending
iv) Bent portion of all U tubes shall be examined by PT and hardness check on four opposite points of bent portion shall be carried out
v) Unless otherwise specified, after bending each tube shall be tested hydraulically

3.4.15 Where fixed tube sheet heat exchangers are specified, thermal stress shall be checked in accordance with the TEMA standard to determine if an expansion joint is necessary.

3.4.16 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm2 g wherever specified leak testing with halogen shall be carried out.

3.4.17 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

3.4.18 Minimum SS 304 as MOC for tubes shall be used for Heat Exchangers having Cooling Water. All tubes shall be seamless only.

3.4.19 After testing, all exchangers shall be completely dried.

3.4.20 Gaskets used during testing shall be same as specified for operating conditions. However all Joint gaskets shall be replaced by new gasket after Hydro testing.

3.4.21 Flow induced vibration analysis shall be carried out for all process heat exchangers..

3.4.22 While deciding the location of heat exchanger in the equipment layout it should be ensured that there is no restriction in complete opening of the channel, shell and floating head cover, bundle removal e.t.c. sufficient unobstructed space shall be provided in between two exchangers so as to allow a man to pass through for maintenance.

3.4.23 Unless otherwise stated inlet nozzles on shell side shall be provided with impingement plate in Compliance with TEMA requirement. The flow area around solid impingement plate shall be at least equal to the inlet nozzle cross-section. In case of two phase flow impingement baffle shall be perforated. Impingement baffle plate shall extent at least 25 mm beyond the projection of the nozzle bore. The clear distance from the nozzle (at the inner surface) to the impingement plate shall be at least 0.25 x nozzle diameters. The nominal thickness of the impingement baffle shall be at least 6 mm.

3.4.24 Where heat treatment of U-bends is required, the heat treated portion shall extend at least 150 mm beyond the point of tangency.

3.4.25 All heat exchanger tubes shall be 100% eddy current tested in supplement to hydro test.

3.24.26 Attachment of tube to tube sheet will be rolled and expanded (with seal welding), strength welded or seal welded as specified on data sheets. However, as a minimum following shall be adopted:

For tube sheet joint, tubes shall be expanded in grooved holes into the tube sheets. The expanding operation shall extend from the outer face of the tube sheets to a depth not < 90% of the tube sheet thickness. Welding shall be done in minimum two passes and each pass shall be DP checked. For tube-to-tube sheet joint GTAW (Gas-Tungsten Arc Welding) welding is required.

(A) Tubes shall be expanded and light seal welded if all the following conditions occur simultaneously:

a) Design pressure of shell/tube < 20 kg/cm2

b) Shell / Channel design temperature < 350 ºC

c) Fluid not containing lethal substances.

c) Hydrogen partial pressure <7 bars

(B) Tubes shall be strength welded & light expanded for any condition other than listed under (A).

3.24.27 Procedure shall be qualified for tube-to-tube sheet joints. The sample for tube sheet and tube for mock up test shall be drawn from the same heat Material from which the equipment shall be fabricated.

3.24.28 Removable tube bundle shall be provided with pulling York and suitable sliding arrangement.

3.24.29 Process Heat exchangers tubes shall be Eddy current tested at mill and the specified thickness Of tube shall be minimum (and not average).

3.24.30 Tube sheets shall have the corrosion allowance on each side. Tube Sheets from Plates shall not be used.

3.24.31 Floating head exchangers with test ring shall be procured as per TEMA for locating tube leaks. Drawing and calculations for test rings and test gland shall be provided by vendor for all Exchangers of applicable type.

3.24.32 In horizontal exchanger cross baffles and support plates shall be provided with notches for draining and venting.

3.24.33 Dowels or match marks shall be provided to prevent misassemble of floating head covers and channels with pass partitions, channel covers with grooves, and stationary tube sheets to shell flange.

3.24.34 Impingement plates shall be provided if required by TEMA or indicated as a part of Licensor's requirement.

3.24.35 Expansion joints shall be designed for the most severe conditions of differential expansion that can occur during normal operations, start up, shutdown, or upset conditions.

3.24.36 Expansion joints shall be of the single layer standard one-piece construction unless otherwise approved by purchaser. Length of the bellow and preset shall be specified on the manufacturer's drawings.

3.24.37 Expansion bellows shall be designed for min. 5000 cycle, as per TEMA

3.4.38 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards. Service bolts shall be used in all shop hydrostatic tests. After testing, all exchangers shall be completely dried.

3.24.39 The shell side test shall be performed in such a manner that the Tube–to- tube sheet joints can be adequately inspected during testing.

3.24.40 Stacked units shall be hydraulically tested in the fully assembled condition.

3.2.41 Floating head type heat exchangers as well as U-tube type without full diameter stationary tube sheets shall be provided with test rings and test gland so that the exchanger shells may be pressure tested with the channels removed. Drawing and calculations for test rings and test gland shall be provided by vendor for all exchangers of applicable type.

3.2.42 For stack type Heat Exchangers, complete assembly shall be hydraulically tested as a single unit except when the test pressures for individual heat exchangers are different.

3.2.43 Stacked exchangers shall have the lower shell(s) designed to withstand the superimposed load of the upper exchanger(s) full of water without distorting the shell and causing binding of tube bundle(s).

3.2.44 The lower fixed support of stacked exchangers shall be designed for bundle pulling loads for removal of the upper bundle.

3.2.45 When two or more exchangers are stacked, the entire stack shall be shop-assembled and checked for accuracy of saddle and nozzle fit-up.

3.2.46 Bolts for connecting nozzles of stacked exchangers shall be removable without moving exchangers.

3.5 **FRP/GRP TANKS**

Codes

Construction

- ASME X Rule for Construction
- BS EN 13121

Materials and material testing

- ASTM C-581 Chemical resistance of Resins
- ASTM D-2150 Woven roving Laminated FRP
- ASTM D-2583 FRP hardness test
- ASTM D-2584 Ignition loss of cured FRP
- ASTM D-2990 Flexural creep and Creep-rupture

- ASTM D-2997 Machine made FRP pipe
- ASTM D-3299 Filament-wound reinforcing
- ASTM D-3892 Resin and FRP packaging
- ASTM D-4024 Machine made FRP flanges
- ASTM D-4097 Contact-molded FRP tanks
- ASTM D-5421 Contact-molded FRP flanges
- ASTM D-618 Plastics testing conditions
- ASTM D-638 Plastics tensile properties testing.
- ASTM D-695 Plastics compressive testing
- ASTM D-883 Plastics terminology
- ASTM F-412 Plastics piping terminology

Equipment testing

- ASME V Non-destructive examination

Flange Drilling and bolting

- ASME/ ANSI B 16.5 Flanges and flange fittings
- ASME/ANSI B 16.47 Large diameter steel flanges

3.5.1 Graphite powder/ Resin paste shall be applied behind all welds to provide a permanent earth Path for spark testing. Permanent metal foil strips shall not be permitted.

3.5.2 Flange face (Front & back) shall be smooth & flat. If the flange faces are machined, the full Chemical liner shall be reinstated.

3.5.3 The Barcol Hardness of FRP/GRP wall shall be tested according to ASTM D2583.

3.5.4 The difference in the glass content of FRP/GRP between the samples shall not be more than 5% wt.

3.5.5 All items shall be cured in accordance with the resin supplier's instruction s. wherever possible curing shall be done at Manufacturers works.

3.5.6 High frequency spark testing

All production thermoplastic welds shall be examined visually & by high frequency spark test Equipment at the following stages:

- Completion of first weld run
- Completion of external run
- After pressure or static head test
- After any boil out test

3.5.7 Reinforcing materials used on the inner surface shall be in compliance with the latest edition of ASTM D3299.

3.5.8 For FRP/GRP tanks, thickness of Corrosion barrier of the thermoplastic lining shall not be included in the thickness calculation, to withstand design condition.

3.6 **Safety**

3.6.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable. All precautions as per latest regulations and AN Rule-2012, PESO requirement shall be complied.

3.6.2 Safety features to be incorporated into the design include, but are not limited to, the following features for equipment:

i) Ladder cages
ii) Safety chain across platform access
iii) Step-off platforms where necessary
iv) Platform grating
v) Toe plates

3.7 OPERABILITY AND MAINTENANCE

3.7.1 Equipment design and layout shall provide for ease of access, operability and maintenance.

3.8 DISPATCH

3.8.1 Equipment intended for ship transportation shall be transported in the hatch of the ship. Suitable seaworthy packing/painting shall be applied to avoid any damage during transportation.

3.8.2 The complete transport, packing & forwarding of equipment shall be the responsibility of bidder. In case of inland transportation, equipment shall be properly lashed/fixed on the wagon/trailer to avoid any damage due to shocks during transport. In case of ODC (Over Dimensional Consignment) movement, ODC sanction for movement either by rail/road shall be arranged by bidder from appropriate authorities.

3.8.3 All spares shall be properly packed, marked & sent separately along with equipment.

3.8.4 Equipment shall be despatched with nitrogen filling. Dry nitrogen shall be filled at a pressure of 0.5 kg/cm2g and equipment shall be filled with a pressure gauge and a valve along with nitrogen cylinder.

4.0 Fabrication

4.1 The Bidder shall comply in all respects with the provision of the applicable codes, standards and specification during fabrication with respect to tolerances, welding, fabrication, forming of heads, radiography, heat treatment, inspection, testing and quality control etc. unless & otherwise specified.

4.2 Plates of different thicknesses shall be made flush with the inner surfaces of equipment unless otherwise stated.

4.3 Larger heads which cannot be formed in one piece shall be fabricated as follows with prior approval from Principle.

a) In two pieces, with the welding seam included in the middle third and preferably on the centre line

b) In petal construction, with meridianal seams and a central cap of diameter not larger than 0.75 times the vessel outside diameter

4.4 Due provisions must be kept for venting out entrapped gases during welding of pads, flanges and liner plates etc.

4.5 All welding shall be carried out by qualified welders using approved procedures in compliance with the requirements of codes, standards & specifications and shall be duly certified by the concerned inspecting authority. All welding procedures must be got approved from authorised inspecting authority before starting any fabrication job. Welding of all parts must be completed before heat treatment.

4.6 All welds shall be full penetration welds with back chipping and re-welding from the second side. For those joints which are inaccessible for back chipping the root run shall be carried out with TIG process. Single side welding with backing strips shall are not permitted.

4.7 All parts shall be fabricated in accordance with good shop practice and in uniformity so that all corresponding parts will be inter-changeable.

4.8 All sharp corners shall be rounded off with smooth radius. Inside edge of manhole and hand hole at the internal surface shall be rounded to minimum radius 5 mm.

4.9 All flange bolts & skirt-bolts shall straddle centre line unless otherwise stated.

4.10 In case of nozzle with butt-end construction, extra length shall be provided to facilitate hydraulic testing and subsequently cutting and edge preparation to suit piping welding at site.

4.11 All nozzles less than or equal to NB 65 mm shall be stiffened with three equispaced plate ribs of the same material as that of shell.

4.12 Flange facing and thread connection shall be protected against oxidation during HT.

4.13 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible.

4.14 Welding wherever specified, is to be done by qualified and approved welders using the suitable fillers and fluxes recommended for the materials in the fabrication drawings.

5.0 Inspection & Testing

5.1 Equipment shall be inspected and tested in accordance with the relevant codes, standards and specifications by TPIA (owner approved) . The Inspection and testing shall be in accordance with the relevant codes, standards, specifications, including mandatory NDT requirements indicated under Inspection and Testing clause 5.3 & Inspection guidelines (Annexure-2). All equipment & bought -out items shall be inspected during various stages of manufacturing starting from identification of materials to final completion as per agreed QAP which shall be prepared by LSTK Contractor and shall duly approved by Owner/ It's authorised representative. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. The guidelines for minimum inspection requirements are listed in Annexure-2 & also defined under Inspection & Testing clause of the design philosophy.

5.2. The equipment shall be inspected by Third party inspection agency (TPIA) (owner approved) as defined elsewhere as inspection agency. It shall be the responsibility of the Bidder to make available to the inspector all the drawings, calculations and other documents. However the Principal shall have free access for inspection at vendor's/sub-vendor's shop and at site during project execution.

5.2.1 The equipment shall be considered acceptable for despatch only after final certification for acceptance is issued by concerned inspector.

5.2.2 All parent material (Primary & Secondary Components), welds and HAZ shall be impact tested at Minimum Design Metal Temperature (i.e. minimum service temperature or the temperature to be computed as per applicable codes, standards & specifications) by Bidder and shall have impact energy values as per the applicable codes, standards & specifications.

5.2.3 Production control coupons, when required as per codes & standards shall be subjected to impact test, corrosion test etc. in addition to mechanical tests as required. In case of heat treated equipment test coupons shall be given similar heat treatment as for the equipment.

5.2.4 Formed heads when fabricated in pieces shall be normalised and weld seams fully radio graphed after forming.

5.2.5 Vessel containing lethal, toxic and highly inflammable substance shall be fully radio graphed and stress relieved.

5.2.6 All nozzle reinforcing pads shall be tested pneumatically at 0.5 Kg/cm2g pressure with soap solution on attachment welds. Vent holes shall be plugged with non hardening mastic to prevent ingress of water.

5.2.7 All completed equipment shall be tested hydraulically as per the requirements of codes, standards & specifications in presence of the inspecting authority. Pneumatic test of completed equipment shall be carried out only when specially mentioned in the specification sheets. Chloride content in water used for testing shall not exceed 30 ppm for SS equipment and 40 ppm for CS and low alloy steel equipment. Duration of test shall be as minimum 1 hour. Hydrostatic test shall be done prior to painting at weld and/or coating on weld.

5.2.8 The temperature of test water shall comply with requirement of Fabrication code.

5.2.9 Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions. However all joint gaskets shall be replaced by new gasket after Hydro testing.

5.3 The following NDT requirements are mandatory in addition to codes, standards & specification requirements:

A) UT examination

i) All butt - welds in thickness greater than 50mm as supplement to radiographed.

ii) FPW of nozzle attachments of thickness above 50mm as supplement to radiography

iii) Clad Plates and formed heads from clad plates in all thicknesses

iv) All forgings

B) MP / PT examination

i) All edges of plates and opening in shell of CS having thickness equal to & above 40mm and LAS / SS having thickness more than 25mm

ii) Root and final layer of all butt welds

iii) Fillet welds of SS

iv) All weld surfaces after PWHT

v) Each layer of weld deposit in SS overlay

vi) Knuckle surfaces of dished ends, expansion bellows and pipe bends

vii) All forgings after machining

viii) Skirt to head joint

XI) All welds of SS and non ferrous materials and welds for vessels with design temp. (-)45 degree C and below after hydro testing.

x) All welds of SS over ¾ inch thk. after hydro testing.

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C) Radiography:

i) All weld seams of formed head, if made in more than one segment shall be full radio graphed after forming.

ii) When spot radiography is specified, all T – Joints & minimum10% of total weld length excluding T joints shall be radiographed

ii) All nozzles fabricated from plates shall be 100% radio graphed.

iv) Radiography of welds in C - 1/2 Mo & Cr - Mo - Steel preferably be carried out after heat treatment.

v) Vessel containing lethal, toxic and highly inflammable substance shall be full radio graphed

d) Hardness test on welds of Cr-Mo, Materials after final heat treatment. The value shall not exceed to:

i) 215 HB for steel having Cr content less than 2%

ii) 235 HB for steel having Cr content more than 2%

Note: If a vessel is not 100% radio graphed and/or UT tested, then a minimum examination of butt, corner & T-joints shall be made.

5.4 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor.

6.0 Pickling and Passivation

6.1 All SS material shall be Pickled & Passivated as per following procedures:

6.1.1 Pickling

Aqueous pickling solution shall be as follows:

Nitric acid (Tech. grade) 10 to 25% plus Hydrofluoric acid 1 to 8% (to be used only for stabilised SS grades). Temperature 50 to 60° C for 10% Nitric acid and 20° C for 25% Nitric acid. When size and shape of product permit, total immersion in the pickling solution is preferred. Where immersion is impractical, pickling may be accomplished by wetting the surface by

i) Swabbing or spraying
ii) Partial filling the item with pickling solution and rotating or rocking so that all the surface receives the required chemical treatment.

The maximum period for which the pickling solution shall be allowed to remain on the surface is 30 minute. During pickling removal of oxides may be hastened by brushing with a hard fibre or SS wire brush. Over pickling shall be avoided.
The pickling agent shall be washed off with plenty of water so as to leave no trace behind.

6.1.2 **Passivation**

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10 weight % and KMnO4 4 weight % shall be used for neutralising pickling solution. This shall be followed by thorough water rinsing.

Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

7.0 Painting

7.1 All CS external surfaces of shop fabricated equipment shall be primer and final painted as per PC185/E-1/P-II/16CONSTRUCTION/ERECTION, PRECOMMISSIONING, COMMISSIONING AND START-UP (Annexure-7-2H Painting work) Listed in bid document.

8.0 Insulation & Fire Proofing

8.1 The equipment shall be insulated as per design Philosophy- PC185/PNPR/E-601/SEC.9.0 (Thermal insulation section 7.0) & PC185/E-1/P-II/16 CONSTRUCTION/ERECTION, PRECOMMISSIONING, COMMISSIONING AND START-UP (Annexure-7-2G insulation work) Listed in bid document.

8.2 Fire proofing, if required shall be considered as per Process Licensor's recommendations.

9.0 Spares Parts (Erection & commissioning, 2 years operation & Special Spares etc.)

9.1 **COMMISSIONING SPARES**

9.1.1 All commissioning spares shall be included by LSTK Contractor in their scope of supply and shall be part of the main equipment.

9.2 **SPARES FOR 2 YEARS OPERATION**

9.2.1 2 years operation spares shall be supplied by the contractor as per Section-6 of Bid

10.0 Documentation Schedule

Documents shall be submitted as per “Documentation schedule” in Section-5 of Bid.

11.0 Vendor List

All equipment shall be procured/fabricated as per approved vendor list (Section-11). Any equipment for which vendor list is not enclosed, the LSTK Contractor may furnish a list of their proposed vendors along with their references for supply of similar type of equipment along with bid. However all the additional proposed vendors shall have well proven track record and shall be subjected to consultant/owner’s approval.

12 Guarantees

12.1 Mechanical Guarantee

LSTK Contractor shall guarantee the equipment & their components against faulty design with regard to their mechanical adequacy, improper material of construction & poor workmanship for the period specified in contract.

12.2 Performance Guarantee

LSTK Contractor shall stand Guarantee of equipment as per respective technical specifications/Process Data sheets

ANNEXURE-1

CALCULATION METHOD
DYNAMIC WIND ANALYSIS (GUIDELINES)
FOR VERTICAL EQUIPMENT

Check of the towers for dynamic wind moments due to vortex shedding shall be performed based on following assumptions:

Vcr = f * D/St

Vcr = Critical wind velocity
D = Outside diameter of tower
F = First natural frequency of tower considering foundation complete rigid (s-1)
St = Strouhol number, may be taken as 0.15 for Re > 106 and 0.2 for Re < 106
Re = Reynolds number at critical wind velocity

For Vcr < 30 m/s following shall be considered :

The tower shall be checked for additional moments due to vortex shedding in 2 cases.

1. Operating condition
2. Shut down condition

Dynamic wind moment shall be calculated as follows:

Md = Pd * Ck * S * Pi/d * H

Pd = Wind pressure at critical velocity = 0.5 * den* **$(Vcr)^2$**
Ck = Crosswind oscillatory force coefficient may be taken as **0.5 + (4 - Log10 Re)/5.7 for Re < 10^6 and 0.17 for Re > 10^6**
d = The logarithmic decrement of damping. For towers with trays or packing it is estimated 0.035
S = Surface on which dynamic wind forces are acting (height * diameter)
H = Height from base ring of point of application for dynamic wind force
Pi = 3.14

Den = Density

For tapered construction only the tip diameter shall be considered in calculation.

Moments to be considered for dynamic wind:

$$Mres = \sqrt{(Md^2 + Mst^2}$$

Mst = Static wind moment at critical wind velocity

Only if Mres exceeds moments due to static wind or earthquake moments, it shall be considered for equipment design.

ANNEXURE-2

INSPECTION GUIDELINES

1.0 GENERAL

The min. Inspection to be carried out by Authorized approved Inspection agency:

1.1 VESSELS

a) All carbon steel plates shall be identified against mill-test certificates at the VENDOR'S works before commencement of fabrication.

b) Establish that welding procedure and welders are qualified and welding electrodes are approved before commencement of fabrication.

c) Check fit-up and witness chipping-back of welded seams.

d) Wherever applicable, select spots for radiography, D.P and M.P Tests.

e) Witness any crack detection, hardness checks, ultrasonic tests etc. which may be specified. (1)

f) Review radiographs and in case it is unsatisfactory re-radiograph. (1)

g) Witness hydrostatic test.

h) Dimensionally check and carry out final internal and external inspection for quality of workmanship.

i) Check that all material test certificates and, where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and ensure that the documentation is submitted without any delay.

j) Check internal lining of reactors and vessels (if applicable) to specifications.

k) Witness any further test recommended by Process Licenser/Inspection agency and/or OWNER.

Note (1): X or Gamma rays

1.2 VESSEL INTERNALS

a) Leak testing & final inspection only is required.

b) Check one tray of each diameter and type, mock assembled in the shop.

c) Spot check for interchangeability of parts, where applicable.

d) Ensure that any uncommon down comers are fully assembled and offered along with their respective trays.

e) Where new designs and/or new VENDOR's are concerned, check that any applicable leakage tests have been carried out on prototype.

f) Check that materials including welding electrodes are in accordance with the requirements of the order and all applicable specifications and standards.

1.3 HEAT TRANSFER EQUIPMENT

1.3.1 SHELL AND TUBE EXCHANGERS

a) All carbon steel plates shall be identified against mill test certificates at the VENDOR'S works before commencement of fabrication.

b) Establish that welding procedure and welders are qualified before commencement of fabrication.

c) Check fit-up and witness chipping-back of welded seams.

d) Wherever applicable, select spots for radiography.

e) Witness any crack detection, hardness checks, ultrasonic tests etc. which are specified in drawing, specification, data sheet etc.

f) Review radiographs. (1)

g) Witness all hydrostatic tests on shell and tube sides.

h) Complete dimensional check for stacked units. This is to be carried out in the full assembly stage.

i) Check that all material test certificates and where applicable, heat treatment charts are in order. Ensure that VENDOR is familiar with the requirements regarding data books and see that the documentation is submitted without any delay.

j) Witness any further test recommended by Process Licensor/ Inspection agency and/or OWNER.

Note (1): x or Gamma rays

1.3.2 DOUBLE PIPE EXCHANGERS

a) Welding procedure and welders to be qualified.

b) Check fit-up of pipes.

c) Witness hydrostatic, D.P. & M.P. tests.

d) Check material certificates and identify the same.

e) Carry out final inspection and dimensional checks, review radiographs (note (1)) and

check material test certificates.

Note (1): X or Gamma rays

1.3.3 VACUUM EQUIPMENT, INCLUDING CONDENSERS

a) Tests on ejectors to be witnessed.

b) Inspection and tests of condensers shall be done as for shell and tube exchangers as far as applicable in addition applicable codes and standards shall be taken into account.

c) Check all material test certificates for tubes, plates etc.

d) Check and witness other tests as applicable as per the Tender documents as well as applicable codes and standards, for rotary equipment.

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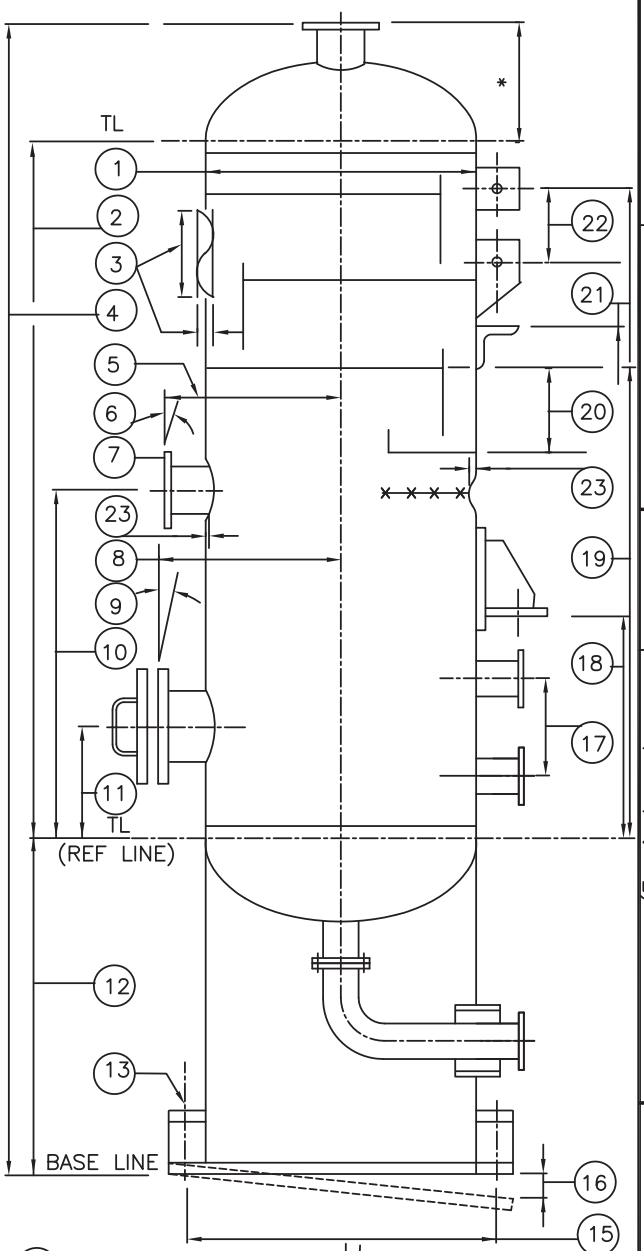
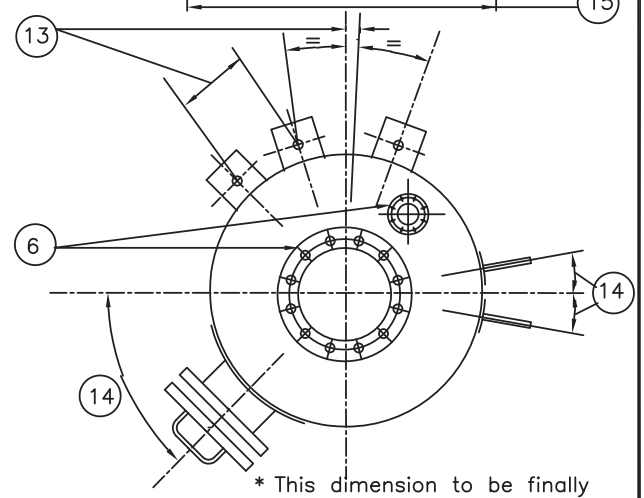
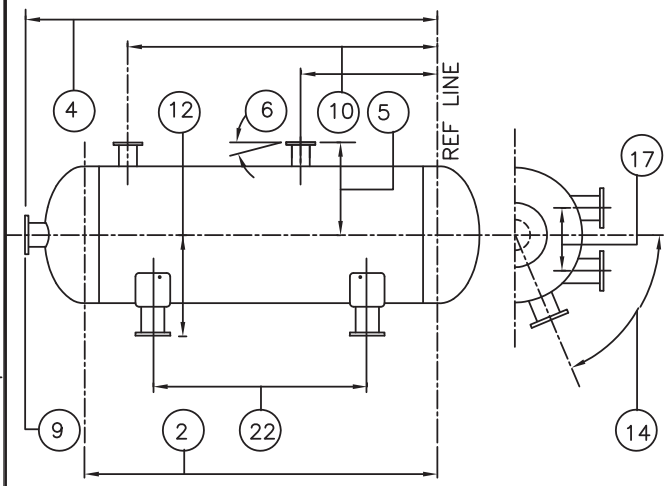
VESSEL TOLERANCES

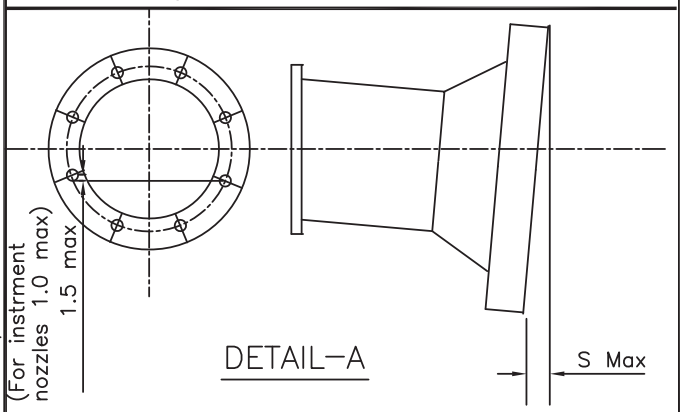




* This dimension to be finally adjusted to suit total height



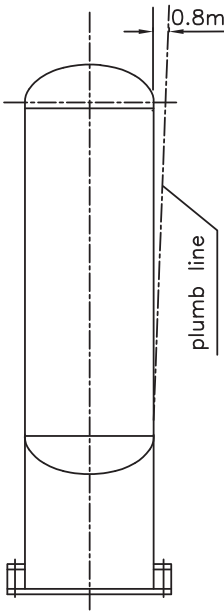
TOLERANCES FOR HORIZONTAL VESSEL



DETAIL–A

Nozzle size	S Max.
NPS ⩽ 4 INCH	1.5
6 INCH ⩽ NPS ⩽ 12 INCH	2.5
NPS > 12 INCH.	5.0

S max shall be ± 0.5mm for instrument nozzle



NOTE

For equipment constructed in flanged sections. The vertical tolerances shall be verified for each section.

Max. allowable deviation between adjacent courses ± 3.0

VERTICAL TOLERANCES AS ERECTED

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
22–09–99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

FILE NAME :STD/NCR/PV001

1) Shell Tolerances

Nom. vessel Diameter	Tolerance
600 & under	± 2.5
Over 600 to 1200	± 4.0
Over 1200 to 2100	± 6.0
Over 2100 to 2700	± 7.0
Over 2700	± 8.0

2) Distance between top & bottom tangent lines, ±1.5 mm/M height, max. ±12

3) Linearity of cylindrical surface, ± 3mm/6M, max. of 20

4) Height from base line to face of top nozzle, ± 5 max.

5) Face of nozzle from centre line of vessel, ± 3

6) Alignment of flange face of nozzle shall be as given in Table (Under Detail 'A')

7) Rotation of flange holes with reference to nozzle axis; 1.5 max.
(Refer Detail 'A')
In case of instrument connections this shall be 1.0 mm max.

8) Face of manhole from centre line of vessel, ± 6

9) Alignment of flange face of manhole shall be ± 6 in both vertical and transverse planes.

10) Location of shell nozzle from reference line, ± 3

11) Location of manhole from reference line , ± 12

12) Bottom of skirt base ring to the bottom tangent line of vessel, $^{+0}_{-6}$

13) Orientation of anchor bolts with respect to principal axes, ± 6

14) Tolerance in orientation of nozzles and external clips, ± 3

15) Distances of bolt holes from axis up to 2000 dia ±3 & over 2000 dia ± 6

16) Maximum deviation of skirt base

Nom. Vessel Diameter	Tolerance
1200 & under	±3
Over 1200 to 2000	±5
Over 2000	±7

17) Distance between level control nozzles, ± 1.0 mm

18) Distance between support bracket and reference line, $^{+6}_{-0}$

19) Location of tray support ring from reference line, ± 6

20) Tolerance between adjacent tray plates, ± 3

21) Location of external clips and attachments from reference line, ± 6

22) Distance between adjacent clips for platform brackets, ± 3

23) Irregularities in profile (checked by a 20° gauge) shall not exceed
$\delta \leq 0.05*e+0.002*D$ (Maximum 25 mm)

Where δ =Maximum local irregularities
e=Plate thickness
D=Shell outside diameter

Notes :

1) In case of difference between the values tabulated here and those shown in the drawings, the latter shall govern.

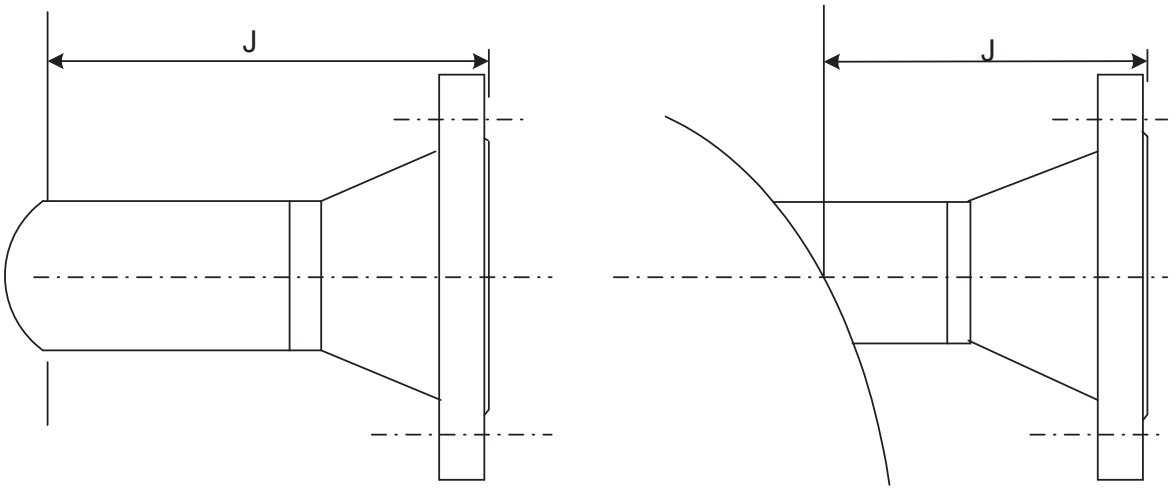
2) For fabrication & assembly tolerances on vessel internals, see ES : 3105

3) For vessels fabricated from pipe– diameter and out of roundness tolerance to be in accordance with relevant pipe specification.

4) All dimensions are in mm unless otherwise specified.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
22–09–99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

FILE NAME :STD/NCR/PV001SH2



VALUES OF 'J'

Nozzle Diameter NPS	Rating 150#	Rating 300#	Rating 600#	Rating 900#	Rating 1500#	Rating 2500#	Remarks
≤ 3″	200		200		200	350	
4″	200		250		250	350	
6″	200	250	250		250	350	
8″	250		300		350	550	
10″	250		300		350	550	
12″	250		300	350	350	550	
14″	250		300	350	450	--	
16″	300	350	350		450	--	
18″	300	350	350		450	--	Refer Note-4
20″	300	350	350		500	--	Refer Note-4
24″	300	350	350		500	--	Refer Note-4
26″ ≤ NPS ≤ 38″	300	350	350	--	--	--	Refer Note-6

NOTES :-

1. All dimensions are in millimeter unless otherwise shown.
2. The above projections are valid for all types of flanges.
3. However in case of forged nozzle, the projection shall be suitably increased to meet reinforcement requirement.
4. In case of manhole,projection shall be increased by the sum of 50 mm and difference of insulation thickness exceeding 50 mm.
5. Projection from vessel axis to nozzle facing shall be rounded off to 10 mm.
6. Flanges ≥ NPS 26″ will be as per ASME B 16.47 series 'B'.

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NAME PLATE FOR VESSEL & TOWER

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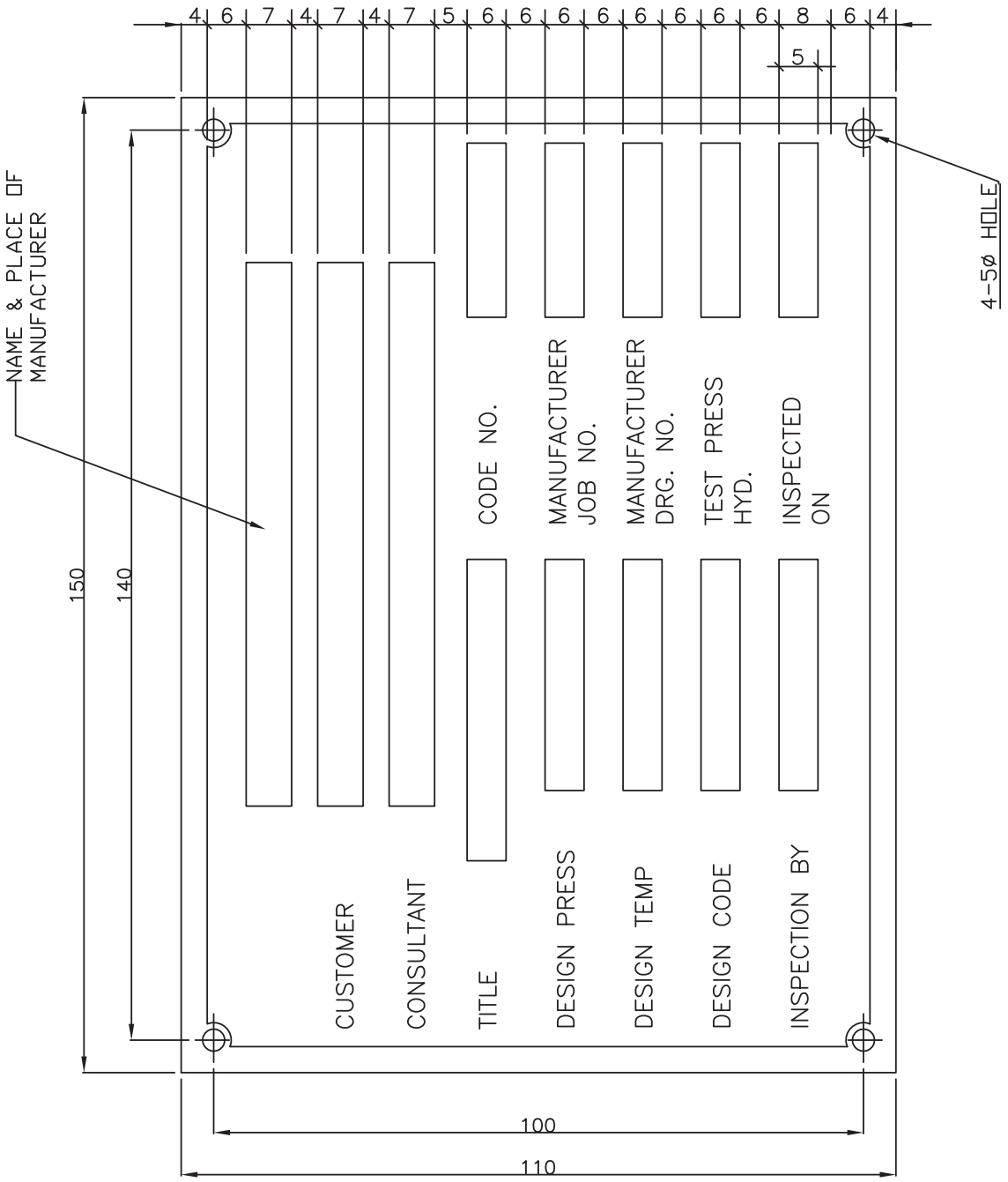

DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
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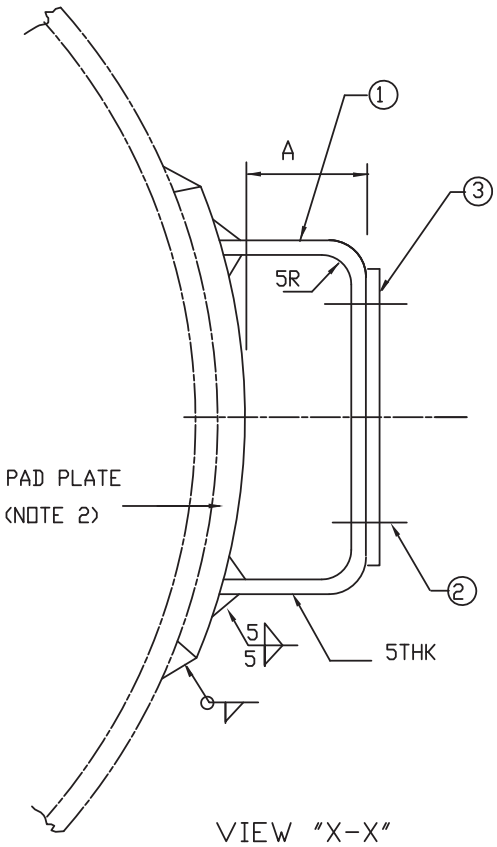
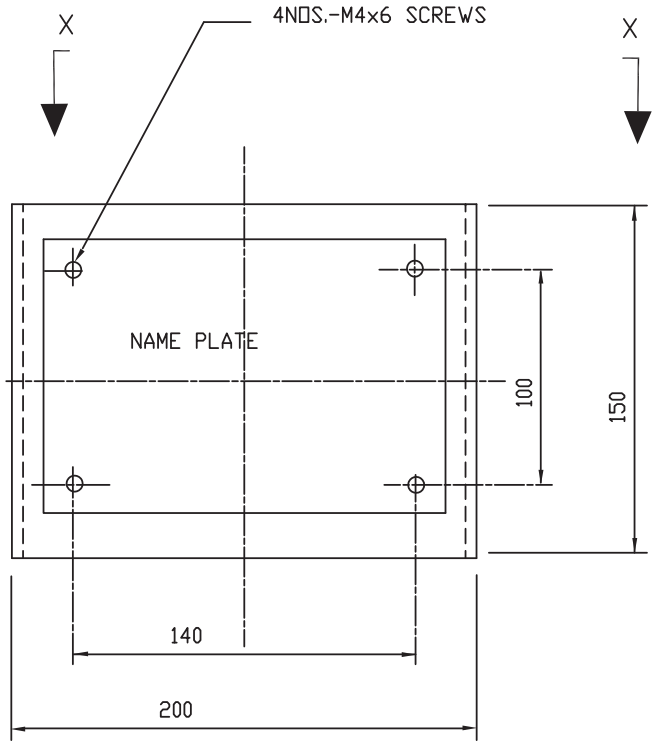
FILE NAME :STD/RCP/PV003SH1

NAME PLATE BRACKET



VIEW "X-X"



ELEVATION

DIMENSION "A"

a) VESSELS WITHOUT INSULATION = 25 mm

b) VESSELS WITH INSULATION = INSULATION THK + 25 mm

NOTES:

1 MATERIALS:

BRACKET (1) IS 2062 Gr.A
SCREWS (2) S.S.304
NAME PLATE(3) S.S.304

2 PAD PLATE OF SIMILAR COMPOSITION AS THAT OF SHELL SHALL BE WELDED ON VESSELS OF MATERIALS OTHER THAN CARBON STEEL AND THOSE UNDER LOW TEMPERATURE SERVICE

3 ALL DATA BLOCKS AND LETTERS MUST BE CHEMICALLY ENGRAVED (0.5 m.m.)

DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
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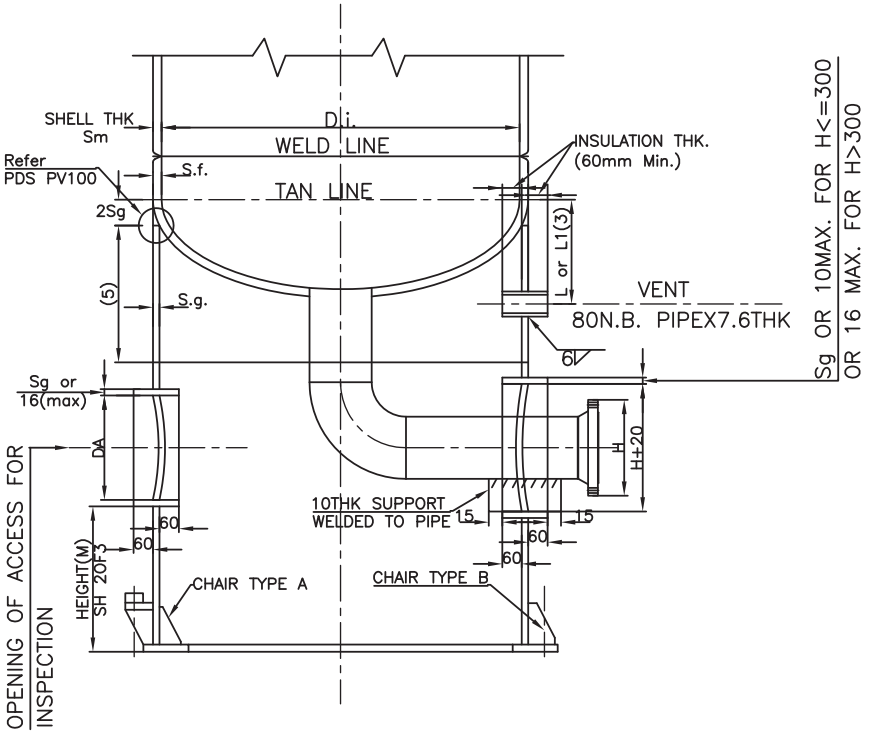

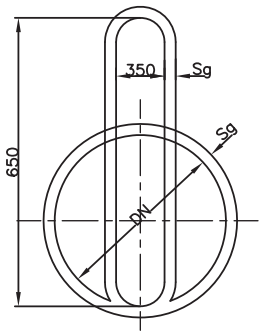

OPENING OF ACCESS

SKIRT DIAMETER DG	OPENING OF ACCESS			VENT		
	NO.	TYPE	DA	NO.	L	L1
<=700	1	CIRCULAR	250	2	260	230
701–1000	1	OVAL	350x650	2	290	250
1001–2500	1	CIRCULAR	500	4	400	360
2501–4000	2	CIRCULAR	500	8	550	450
4001–6000	2	CIRCULAR	500	12	670	560
>6000	2	CIRCULAR	500	16	700	600

NOTES :–

1. The No. dia and the type of bolt sahll be decided as per design. The bolt circle dia. 'DF' shall be fixed according to design , sheet 2 & 3 illustrate chair details (TYPE A, B & C)

2. For the skirt of conical(lapered) construction, the type and the no. of access opening and vent to be decided according to the dia. of skirt at corresponding elevation of centre line of opening.

3. The values of 'L' & 'L1' are adopted for insulation thickness<= 90mm. L for semielliptical head and 'L1' for torispherical head with r/D = 0.1. For other types of head and insulation thickness > 90mm. 'L' & 'L1' shall be decided case by case.

4. 'M' the minimum height of each opening, shall be such that it allows for mounting of nut for type 'A' and welding of gussets for type 'B' foundation bolt chairs.

5. In case the head is made of S.S. or of special material and skirt in C.S., unless otherwise specified provide the skirt length ot the same material as that of head with minimum length of 250mm. For high temperature service, the length and the material of the skirt shall be decided according to design condition.

6. Where the skirt is attached to a stress relieved vessel the skirt to shell or head weld and at least 600mm of the skirt shall be stress relieved.

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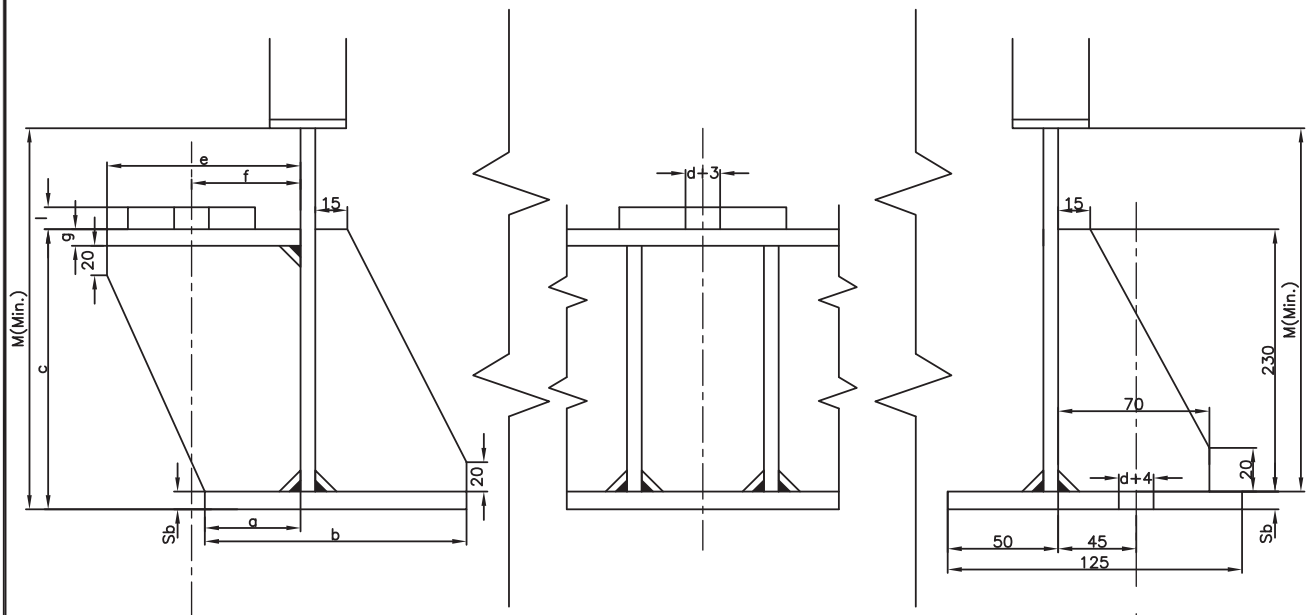
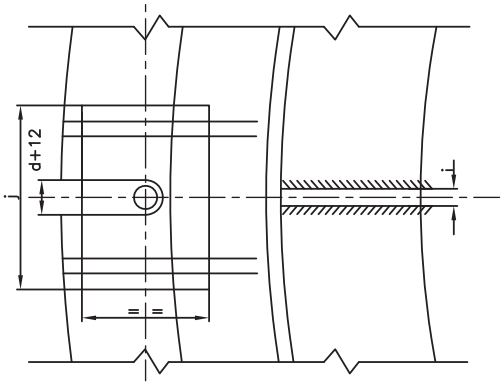
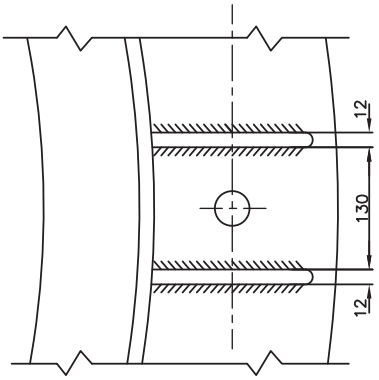




CHAIR TYPE"A"(HEAVY)



CHAIR TYPE"B"(LIGHT)

CHAIR TYPE	FOUNDATION BOLT DIA. (d)	a	b	BASE RING Different bearing capacities 25kg/cm2	35kg/cm2	45kg/cm2	CHAIR DIMENSIONS c	e	f	g	h	i	j	k	l	M (Min.)
B	M16–M27	SEE DETAIL		20	25	28	SEE DETAIL									300
A	M30	50	130	20	25	28	250	125	75	14	70	12	105	80	32	420
	M33	50	130	20	25	28	250	130	76	14	75	12	110	90	32	436
	M36	55	140	22	28	32	280	145	84	14	80	12	115	100	36	480
	M39	55	140	22	28	32	280	150	84	16	85	14	125	110	36	490
	M42	60	150	25	28	32	300	160	92	16	90	14	130	110	40	525
	M45	60	150	25	28	32	300	165	92	18	95	16	140	120	40	535
	M48	65	170	25	32	36	330	180	100	18	100	16	150	130	45	580
	M52	70	180	28	32	36	360	190	110	20	105	18	160	140	50	625
	M56	70	180	28	32	36	360	200	110	20	110	18	170	150	56	645
	M60	80	200	32	36	40	400	220	122	22	115	20	180	160	56	700
	M64	90	200	32	40	45	440	235	134	25	120	20	190	170	63	760

NOTES :–

1. The fillet size of the welding shall be equal to minimum of the thicknesses to be welded.

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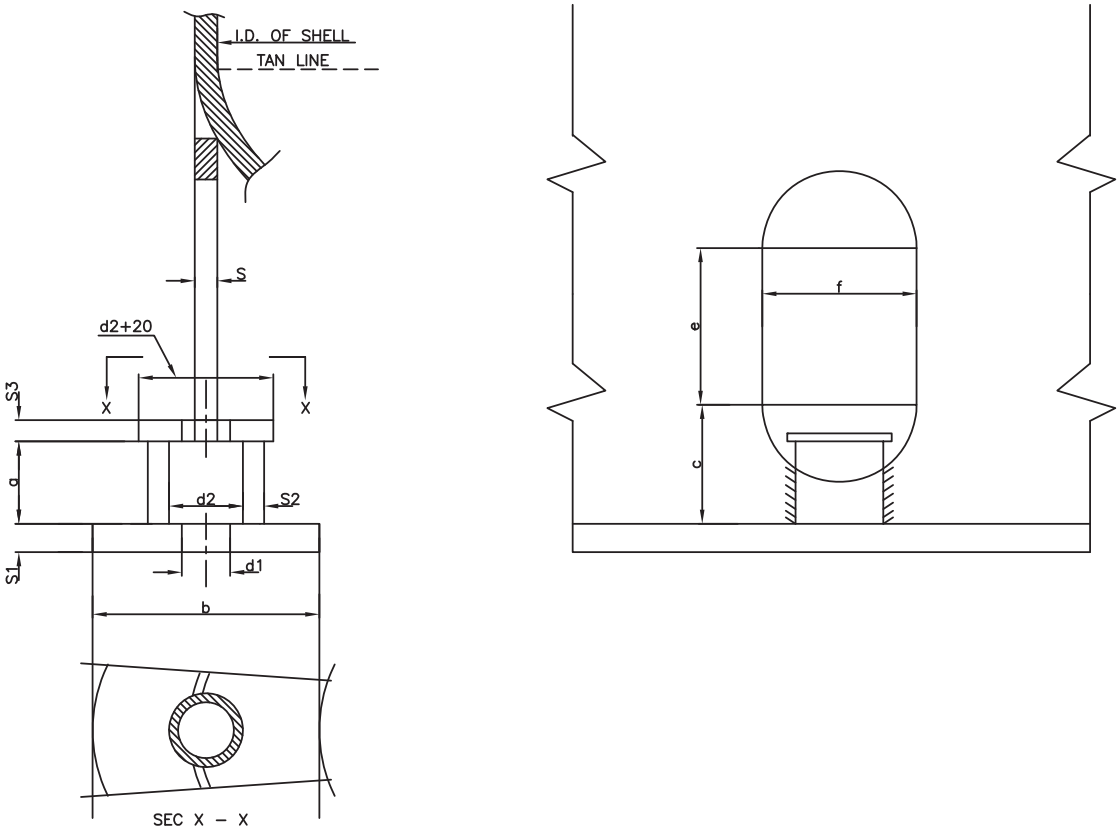
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:

FILE NAME :STD/NCR/PV301



DIA. OF BOLTS	NO. OF HOLES	a	b	c	d1	d2	e	f	S1	S2	S3
20	SEE NOTE – 2	55	80	70	24	48	70	80	20	7	12
24		55	80	70	28	48	70	80	20	7	12
27		55	80	70	32	60	70	85	20	9	12
30		60	110	75	35	60	80	90	22	9	16
33		70	110	85	39	60	85	95	22	9	16
36		75	110	90	42	73	95	105	22	10	16
39		90	130	105	45	73	105	110	22	10	16
42		100	130	115	48	73	115	115	22	10	16
45		115	130	130	51	90	125	120	22	12	16
48		125	150	140	54	90	135	130	25	12	20
52		140	200	155	58	90	140	135	30	12	20

NOTES :–

1. The base ring can also be manufactured in four equal parts and the relating welding must be ground on both sides. The ring dimensions must be checked case by case on the basis of the specific loads.
2. The number of the anchor bolts shall be determined case by case and at any rate in a number multiple of four the type to be selected is a designers choice..
3. The fillet size of welding shall be minimum of the thicknesses to be welded.

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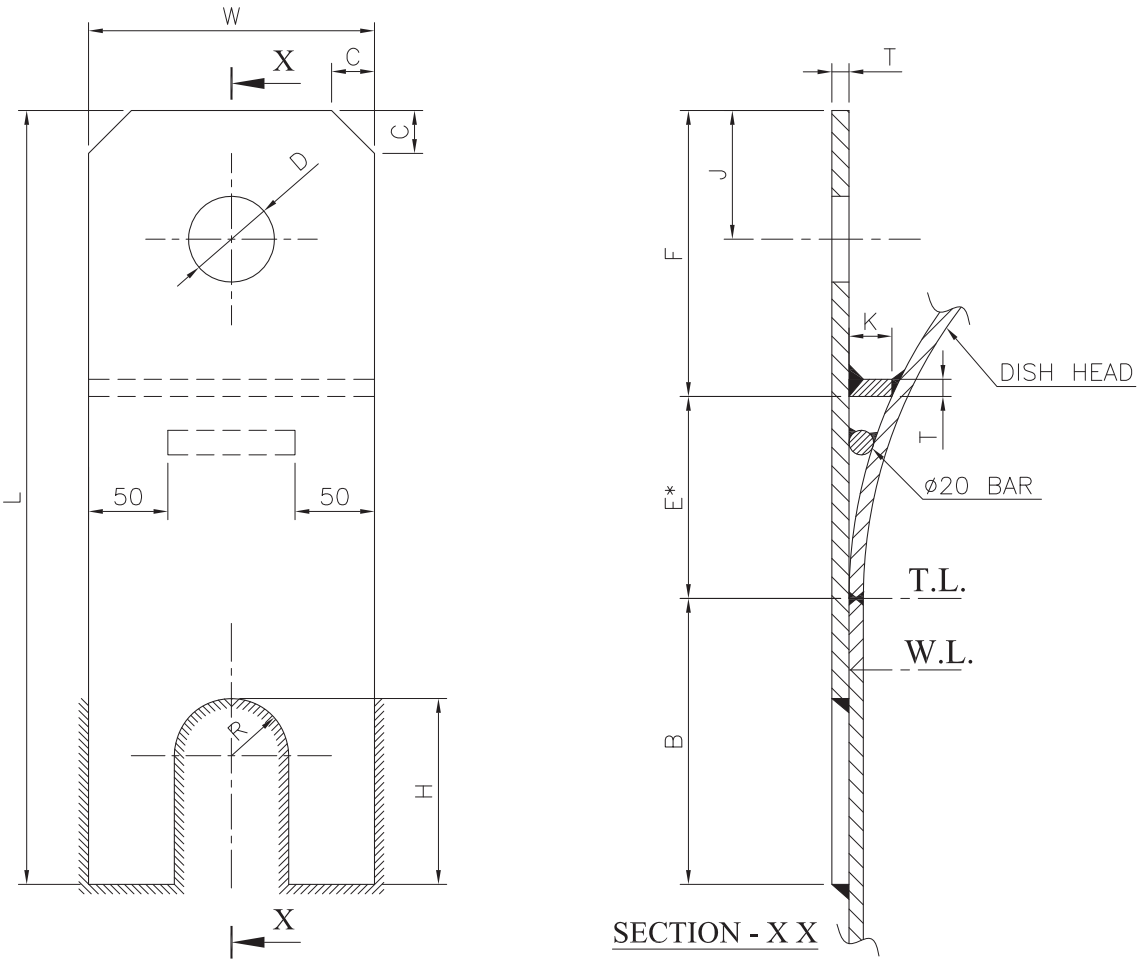
LIFTING LUG

PDS : PV 302
ISSUE: SEP. 2014
SHEET 1 OF 2



MAX. ERECTION WT OF VESSEL (M TON)	10	25	45	90	140	180
THICKNESS OF PLATE (T)	12	28	40	50	70	80
WIDTH (W)	200	230	300	400	500	615
LENGTH (L)	400+E	460+E	580+E	750+E	900+E	1080+E
DIAMETER OF HOLE (D)	60	75	75	100	130	150
HEIGHT OF NOTCH & SIDE WELD (H)	130	130	150	200	250	300
RADIUS OF NOTCH (R)	40	40	50	75	90	100
WELD SIZE	10	14	20	30	38	46
BOTTOM OF BRACE TO TOP OF LUG (F)	200	230	300	400	500	600
BOTTOM OF BRACE TO T.L. OF HEAD (E)	see note 2*					
T.L. OF VESSEL TO END OF LUG (B)	200	230	280	350	400	480
CHAMFER (C)	30	40	50	70	90	100
TOP OF LUG TO CENTER LINE OF LUG (J)	90	90	115	150	180	230
(K)	30	40	50	70	80	100
NO. OF LUGS (T)	2	2	2	2	2	2

NOTES :

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE INDICATED.
2. DIMENSION 'E' TO BE DETERMINED BY SHAPE OF HEAD IN CONJUNCTION WITH DIMENSION 'K'.
3. DETAIL DIMENSIONS AND NOTES GIVEN IN DESIGN DRAWING TAKE PRECEDENCE OVER THOSE SHOWN HERE.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
20–09–14	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

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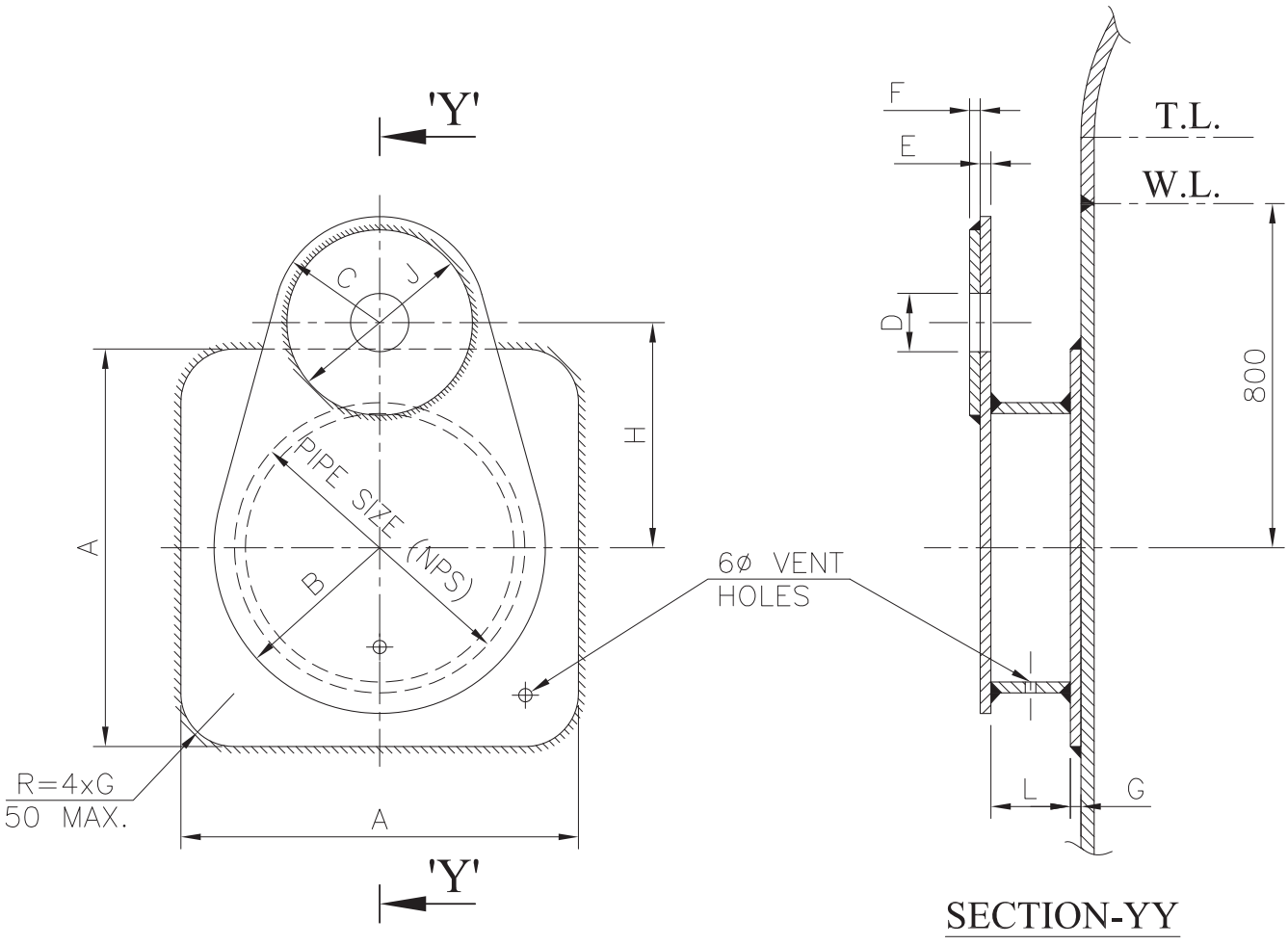
LIFTING LUG



SECTION-YY

LIFTING CAPACITY PER LUG (M. TON)	PIPE			PLATE								
	NPS	MIN. THK.	L	A	B	C	D	E	F	G	H	J
<5	6"	7.11	60	25	100	50	27	8	–	8	130	–
>5 ⩽10	8"	8.18	85	300	125	80	38	8	–	8	170	–
>10 ⩽20	8"	8.18	85	300	125	80	44	10	8	10	170	140
>20 ⩽25	10"	9.27	100	350	150	120	54	12	10	12	210	220
>25 ⩽30	12"	8.38	110	400	175	160	60	12	10	10	250	300

NOTES :

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE INDICATED.
2. LIFTING CAPACITY RELATES TO PER LUG. THIS TYPE OF LUGS MAY BE USED TO LIFT UPTO 60 TONS.
3. WELDING SIZE SHALL BE 0.7 OF THICKNESS BUT NOT LESS THAN 7 MM.
4. MATERIAL PLATES–SA 516 Gr. 70 OR EQUIVALENT (SEE NOTE 5). PIPE–SA 106 Gr. B OR EQUIVALENT.
5. THE PLATE WELDED TO SHELL FOR ALLOY STEEL EQUPMENT SHALL BE OF SAME MATERIAL OF THE SHELL.

20–09–14	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:

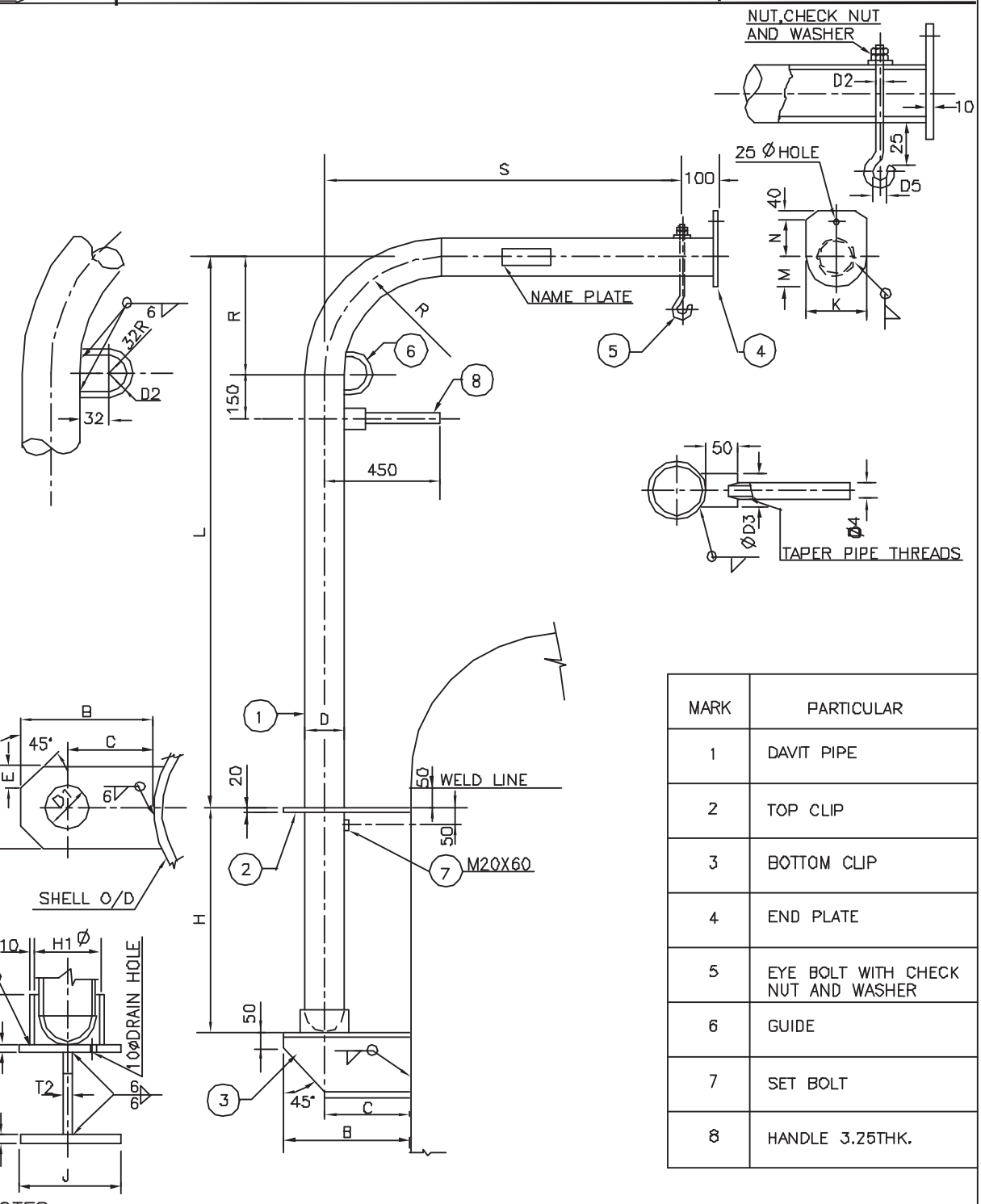
PDIL

PIPE DAVIT

PDS:PV 303

ISSUE: AUG. 1999

SHEET 1 OF 2



MARK	PARTICULAR
1	DAVIT PIPE
2	TOP CLIP
3	BOTTOM CLIP
4	END PLATE
5	EYE BOLT WITH CHECK NUT AND WASHER
6	GUIDE
7	SET BOLT
8	HANDLE 3.25THK.

NOTES:

1. FABRICATOR TO INDICATE IN PARMANENT LETTERING ON THE NAME PLATE THE RATED LOAD.
2. FABRICATOR TO MAKE SURE THAT DAVIT TURNS EASILY.
3. VESSEL CLIP PLATES TO BE OF THE SAME MATERIAL AS SHELL PROPER AND TO BE WELDED TO EACH OTHER AND TO SHELL WITH 6mm FILLET WELD.
4. FOR STERSS RELIEVED VESSELS,CLIP MUST BE SHOP WELDED TO VESSELS.
5. OTHER STRUCTURAL PARTS TO IS:2062 Gr A/B.
6. PIPE THREADS TO IS:554.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
AUG. 99	ISSUED FOR IMPLEMENTATION			

Davit pipe size	A	B	C	D_1	D_3	D_4	E	F	G	H_1	J	K	M	N	T_1	T_2
DN 100	250	355	225	118	55	26.9	65	180	100	120	150	140	70	140	16	10
DN 150	300	400	250	172	70	42.4	75	200	100	175	200	190	95	160	16	10
DN 200	400	475	275	222	70	42.4	100	250	100	225	250	240	120	185	20	12

Rated load 500 kg.					Rated load 1000 kg.							
Davit type	D DN x Thk.	R	D_2	D_5	Davit type	D DN x Thk.	R	D_2	D_5	S	L	H
1	100 x 7.9	500	16φ	40φ						600	2300	750
2	100 x 7.9	500	16φ	40φ						700	2300	750
3	150 x 7.11	750	16φ	40φ	103	150 x 9.52	750	20φ	50φ	800	2500	750
4	150 x 7.11	750	16φ	40φ	104	150 x 9.52	750	20φ	50φ	900	2500	750
5	150 x 7.11	750	16φ	40φ	105	150 x 9.52	750	20φ	50φ	1000	2500	900
6	150 x 7.11	750	16φ	40φ	106	200 x 8.18	1000	20φ	50φ	1100	2500	900
7	150 x 7.11	750	16φ	40φ	107	200 x 8.18	1000	20φ	50φ	1200	2500	900
8	150 x 7.11	750	16φ	40φ	108	200 x 8.18	1000	20φ	50φ	1300	2800	1100
9	150 x 7.11	750	16φ	40φ	109	200 x 8.18	1000	20φ	50φ	1400	2800	1100
10	150 x 9.52	750	16φ	40φ	110	200 x 8.18	1000	20φ	50φ	1500	2800	1100
11	150 x 9.52	750	16φ	40φ	111	200 x 11.13	1000	20φ	50φ	1600	3000	1250
12	150 x 9.52	750	16φ	40φ	112	200 x 11.13	1000	20φ	50φ	1700	3000	1250
13	150 x 9.52	750	16φ	40φ	113	200 x 11.13	1000	20φ	50φ	1800	3000	1250
14	150 x 9.52	750	16φ	40φ	114	200 x 11.13	1000	20φ	50φ	1900	3000	1250
15	150 x 9.52	750	16φ	40φ	115	200 x 11.13	1000	20φ	50φ	2000	3000	1250
16	150 x 9.52	750	16φ	40φ	116	200 x 11.13	1000	20φ	50φ	2100	3300	1400
17	200 x 8.18	1000	16φ	40φ						2200	3300	1400
18	200 x 8.18	1000	16φ	40φ						2300	3300	1550
19	200 x 8.18	1000	16φ	40φ						2400	3300	1550
20	200 x 8.18	1000	16φ	40φ						2500	3300	1550
21	200 x 8.18	1000	16φ	40φ						2600	3300	1550

Controlled Copy
Copy Serial No. 01
Issued by: S. K. Upadhyay
Dated: 09.09.99
(Signature & Name)

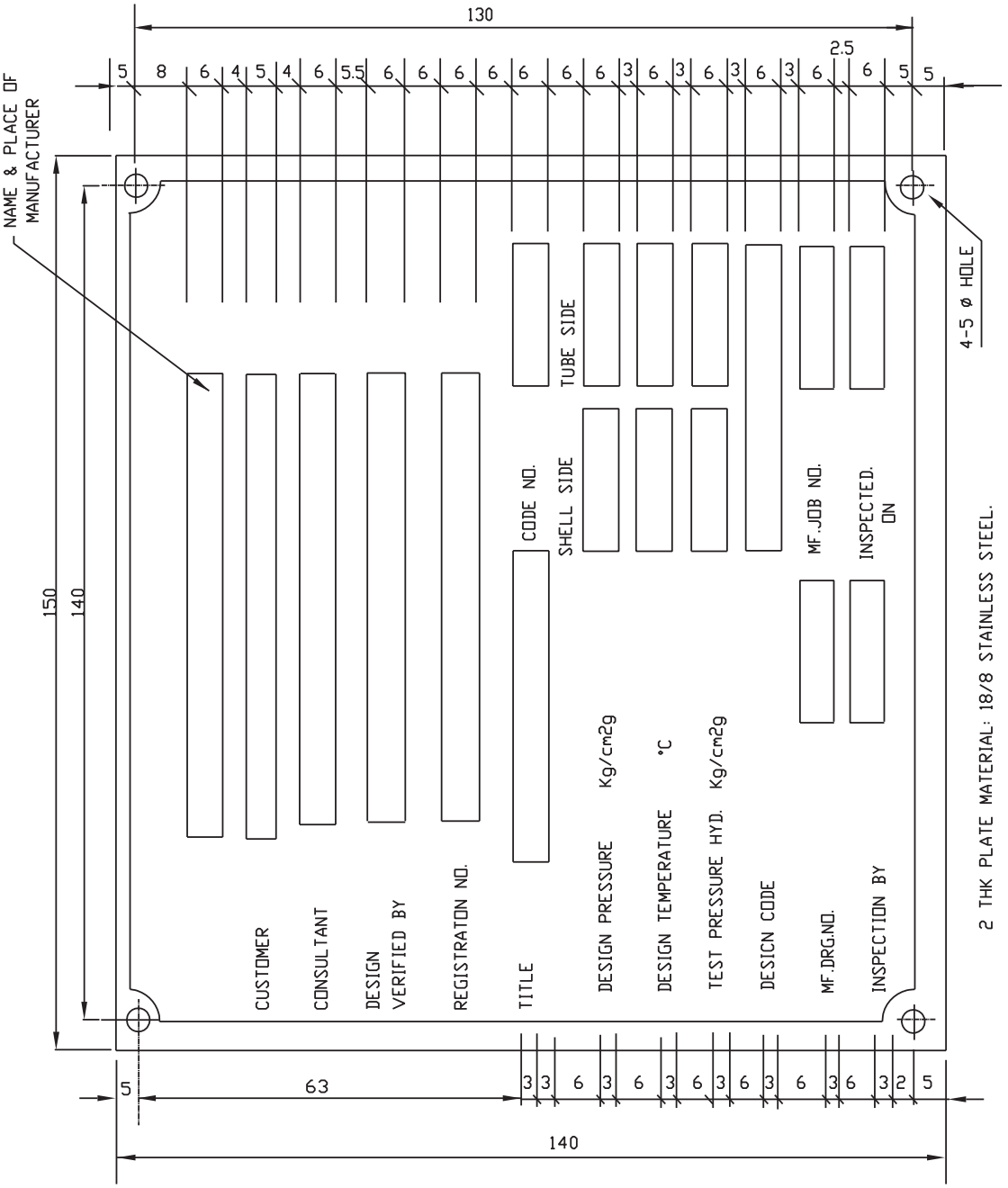
31/08/99	ISSUED FOR IMPLEMENTATION			
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED

PDIL

NAME PLATE FOR HEAT EXCHANGERS

-HE321

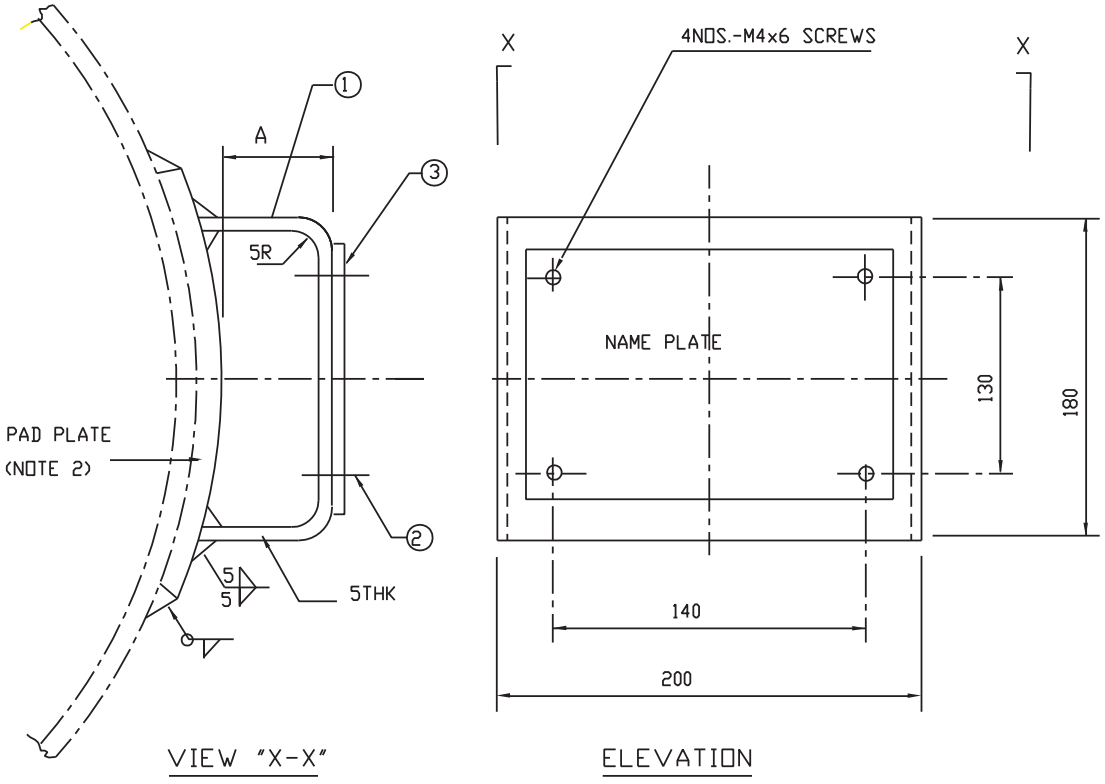
ISSUE:OCT.2003



DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
21.10.03	ISSUED FOR IMPLEMENTATION	TKC	SUJEET	AKG

FILE NAME :1065HE321SH1

NAME PLATE BRACKET



VIEW "X-X"

ELEVATION

DIMENSION "A"

a) VESSELS WITHOUT INSULATION = 25 mm

b) VESSELS WITH INSULATION = INSULATION THK + 25 mm

NOTES:

1 MATERIALS:

BRACKET (1) SA283 Gr.C OR EQUIVALENT

SCREWS (2) S.S.304

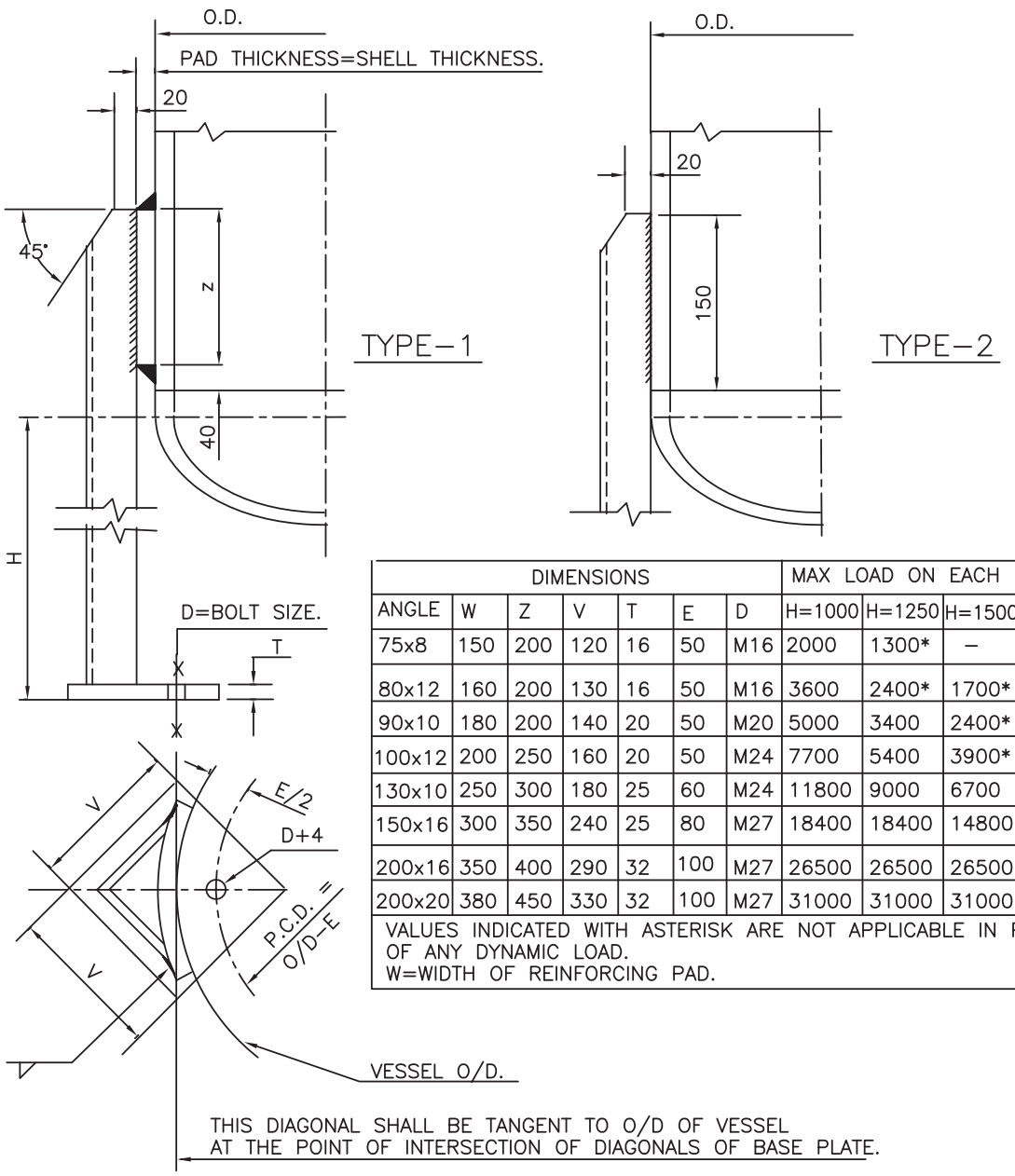
NAME PLATE(3) S.S.304

2 PAD PLATE OF SIMILAR COMPOSITION AS THAT OF SHELL SHALL BE WELDED ON VESSELS OF MATERIALS OTHER THAN CARBON STEEL AND THOSE UNDER LOW TEMPERATURE SERVICE

3 ALL DATA BLOCKS AND LETTERS MUST BE CHEMICALLY ENGRAVED (0.5 m.m.)

DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
21.10.03	ISSUED FOR IMPLEMENTATION	TKC	SUJEET	AKG

FILE NAME :1065HE321SH2



DIMENSIONS							MAX LOAD ON EACH LEG 'P' IN KG.				
ANGLE	W	Z	V	T	E	D	H=1000	H=1250	H=1500	H=1750	H=2000
75x8	150	200	120	16	50	M16	2000	1300*	–	–	–
80x12	160	200	130	16	50	M16	3600	2400*	1700*	–	–
90x10	180	200	140	20	50	M20	5000	3400	2400*	1800*	–
100x12	200	250	160	20	50	M24	7700	5400	3900*	2900*	–
130x10	250	300	180	25	60	M24	11800	9000	6700	5100	3900*
150x16	300	350	240	25	80	M27	18400	18400	14800	11600	9300
200x16	350	400	290	32	100	M27	26500	26500	26500	22000	15500
200x20	380	450	330	32	100	M27	31000	31000	31000	31000	26000

VALUES INDICATED WITH ASTERISK ARE NOT APPLICABLE IN PRESENCE OF ANY DYNAMIC LOAD.
W=WIDTH OF REINFORCING PAD.

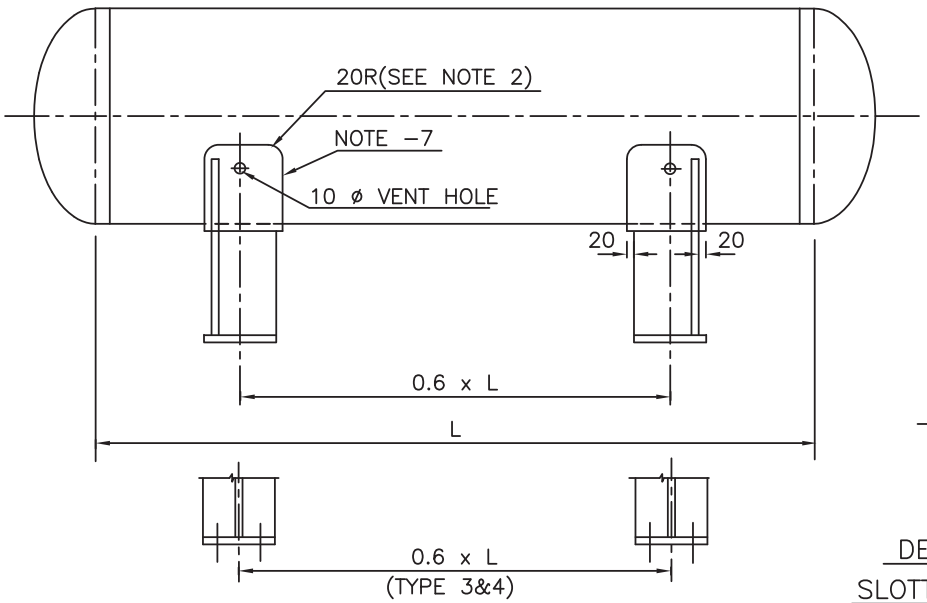
NOTES

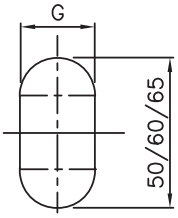
1. WEIGHT ON EACH LEG 'P'>=Q/N+M/C IN KG, WHERE
   Q= WT OF VESSEL FULL OF LIQUID KG.
   N=NO OF LEG SUPPORTS
   M=WIND MOMENT IN Kg cm.
   C=0.75XP.C.D OF FOUNDATION BOLTS FOR 3 LEGS IN CM.
   C=P.C.D OF FOUNDATION BOLTS FOR 4 LEGS IN CM.
2. FOR VESSELS = < 1000 O/D ADOPT 3 NO OF SUPPORTS.
   AND VESSELS >1000 O/D ADOPT MIN. 4 NO. OF SUPPORTS.
3. SUPPORT TYPE 2 SHALL BE USED ONLY FOR TANK = < 600 O/D.
4. DIMENSION 'H' AND TYPE OF SUPPORT ARE TO BE DECIDED AS PER DESIGN CONDITION.
5. REINFORCING PAD SHALL BE OF SAME MATERIAL AS THAT OF SHELL.
6. ALL CORNERS OF REINFORCING PAD SHALL BE ROUNDED TO RADIUS OF 20 MM.
   FOR CARBON AND NICKEL STEEL VESSELS OPERATING AT LOW TEMPERATURES,
   MINIMUM CORNER RADIUS SHALL BE OF 50 MM.
7. ALL WELDS SHALL BE CONTINUOUS, SIZE OF FILLET WELD SHALL BE EQUAL
   TO THE MINIMUM THICKNESS TO BE WELDED.
8. ADOPT SKIRT SUPPORT (PDS:PV 301)PREFERABLY FOR VESSEL HAVING
   HEIGHT TO DIAMETER RATIO >5.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

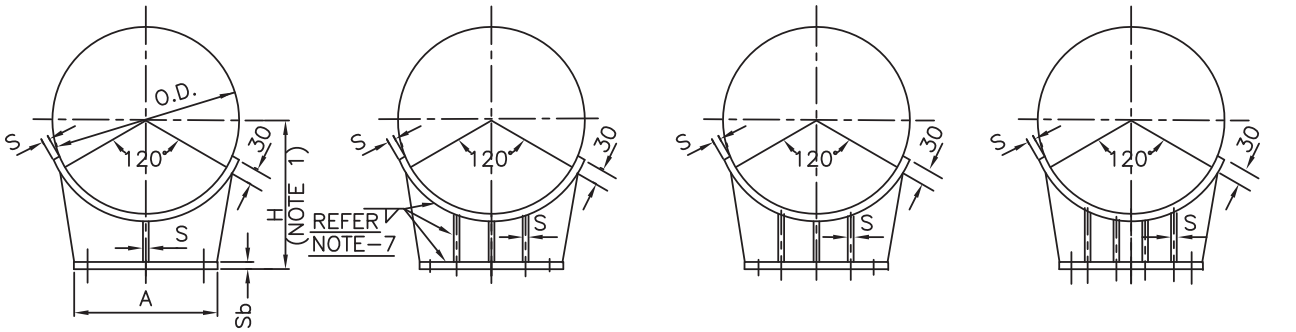
FILE NAME :STD/NCR/SR300

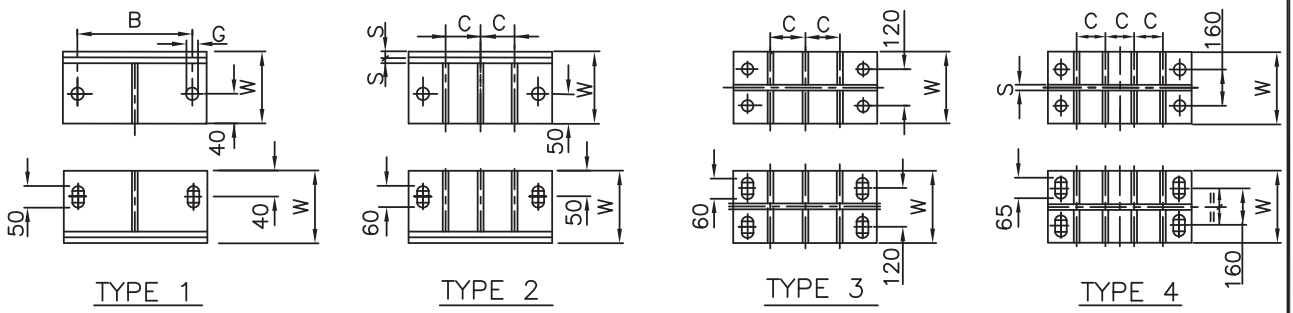
SUPPORT SADDLE FOR HORIZONTAL VESSELS





DETAIL OF SLOTTED HOLES





NOTES:

1. DIMENSION 'H' TABULATED ASSUMES A MAXIMUM PROJECTION OF ANY PART BELOW THE SHELL 250mm. WHERE ANY PART PROJECTS BEYOND 250 mm, 'H' SHALL BE EQUAL TO MAXIUM PROJECTION PLUS 50 mm.
2. FOR CARBON STEEL AND NICKEL STEEL VESSELS OPERATING AT LOW TEMP., CORNERS OF WRAPPER PLATE SHALL BE ROUNDED TO A RADIUS NOT LESS THAN 50mm.
3. IN CASE OF VESSELS OF STAINLESS STEEL OR OTHER ALLOY MATERIALS,THE WRAPPER PLATE SHALL BE OF SAME MATERIAL AS THE SHELL.
4. IN CASE OF CONFLICT BETWEEN THE DIMENSIONS GIVEN HERE AND THOSE SHOWN ON THE DRAWINGS, THE LATTER SHALL GOVERN.
5. NUTS FOR BOLTS PASSING THROUGH SLOTTED HOLES SHALL BE LEFT LOOSE.
6. SLIDE PLATE SHALL BE PROVIDED BELOW THE BASE PLATE IN CASE OF VESSELS WHERE UNUSUAL EXPANSION IS EXPECTED. OR EQUIPMENT SUPPORTED ON STEEL STRUCTURE. SIZE OF SAME SHALL BE 100 mm HIGHER IN LENGTH AND WIDTH OF BASE PLATE.
7. FILLET WELDS SHALL BE CONTINUOUS & SIZE 0.7xTHK. OF THINNER PLATE MIN. 6mm.
8. FOR INTERMEDIATE DIAMETER THE SADDLE OF SMALLER SIZE SHALL BE USED.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION			

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PDIL

SUPPORT SADDLE FOR HORIZONTAL VESSELS

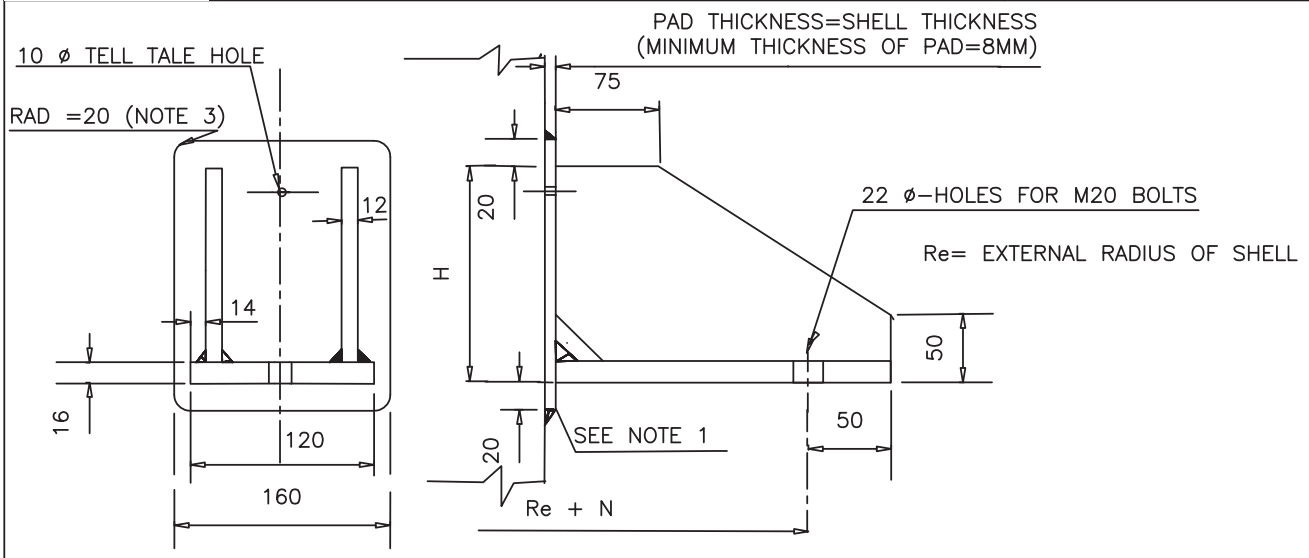
	SHELL O.D.	A	B	C	S	Sb	BOLT SIZE	G	H	W	WT. IN KG.
TYPE 1	324	290	210	–	6	10	M16	22	460	110	15
	355	320	240	–	6	10	M16	22	480	110	20
	406	360	280	–	6	10	M16	22	500	110	25
	508	450	370	–	6	10	M16	22	550	110	25
TYPE 2	600 TO 700	530	450	180	8	12	M20	26	650	130	40
	701 TO 800	620	540	210	8	12	M20	26	700	130	40
	801 TO 900	710	610	240	8	12	M20	26	750	130	50
	901 TO 1000	790	690	270	8	12	M20	26	800	130	55
	1001 TO 1100	880	780	320	10	12	M20	26	850	130	60
	1101 TO 1200	960	860	360	10	12	M20	26	900	130	70
	1201 TO 1300	1050	950	400	10	12	M20	26	950	130	70
TYPE 3	1301 TO 1400	1140	1040	440	12	16	M20	26	1000	200	125
	1401 TO 1500	1230	1130	480	12	16	M20	26	1050	200	130
	1501 TO 1600	1320	1200	520	12	16	M20	26	1100	200	135
	1601 TO 1700	1400	1280	560	12	16	M20	26	1150	200	145
	1701 TO 1800	1490	1370	600	12	16	M20	26	1200	200	155
	1801 TO 1900	1570	1450	630	12	16	M20	26	1250	200	160
	1901 TO 2000	1660	1520	660	12	16	M20	26	1300	200	170
TYPE 4	2001 TO 2100	1750	1610	480	12	16	M24	30	1350	250	275
	2101 TO 2200	1840	1700	510	12	16	M24	30	1400	250	285
	2201 TO 2300	1930	1790	540	12	16	M24	30	1450	250	300
	2301 TO 2400	2020	1880	570	14	20	M24	30	1500	250	310
	2401 TO 2500	2100	1960	600	14	20	M24	30	1550	250	320
	2501 TO 2600	2190	2050	620	14	20	M24	30	1600	250	390
	2601 TO 2700	2270	2130	650	14	20	M24	30	1650	250	400
	2701 TO 2800	2360	2200	670	14	20	M24	30	1700	250	415
	2801 TO 2900	2450	2290	700	14	20	M24	30	1750	250	430
	2901 TO 3000	2540	2330	720	14	20	M24	30	1800	250	440
	3001 TO 3100	2620	2460	740	16	20	M24	30	1850	250	450
	3101 TO 3200	2710	2550	770	16	20	M24	30	1900	250	470
	3201 TO 3300	2800	2640	800	16	20	M24	30	1950	250	485
	3301 TO 3400	2880	2700	820	16	20	M24	30	2000	250	500
	3401 TO 3500	2970	2780	840	16	20	M24	30	2050	250	510
	3501 TO 3600	3060	2870	870	16	20	M24	30	2100	250	520
	3601 TO 3700	3140	2950	900	16	20	M24	30	2150	250	540

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION			

FILE NAME :STD/PPS/SR302

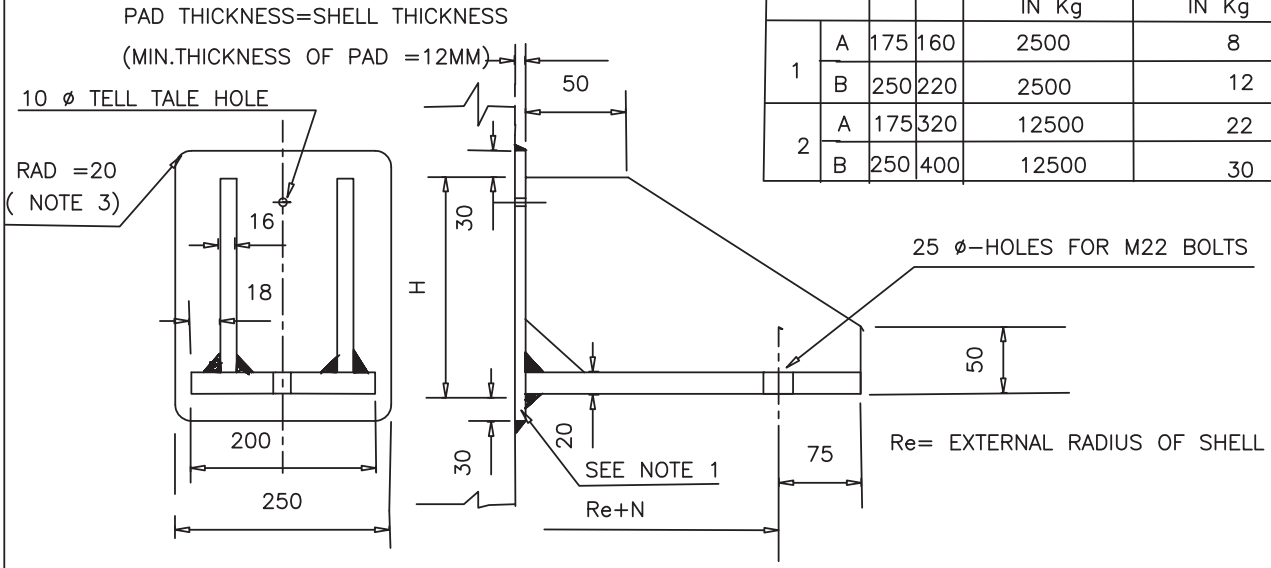
BRACKET SUPPORT FOR VERTICAL VESSEL

PDS:SR 304	0
DOCUMENT NO.	REV
SHEET 1 OF 1	



TYPE–1

TYPE OF BRACKET		N	H	MAX.LOAD FOR EACH BRACKET IN Kg	WEIGHT OF EACH BRACKET IN Kg
1	A	175	160	2500	8
	B	250	220	2500	12
2	A	175	320	12500	22
	B	250	400	12500	30



TYPE–2

NOTES

1) IF THE SHELL IS MADE OF S.S. OR OF SPECIAL MATERIAL, PROVIDE A REINFORCING PAD OF THE SAME MATERIAL AS THAT OF SHELL.
2) ALL THE WELDS SHALL BE CONTINUOUS.THE FILLET SIZE SHALL BE EQUAL TO THE MINIMUM OF THE THICKNESSES TO BE WELDED.
3) FOR CARBON AND NICKEL STEEL VESSELS OPERATING AT LOW TEMPERATURES,MINIUM CORNER RADIUS SHALL BE 50MM.

RECOMENDATION FOR USE

–IN GENERAL,THE BRACKET TYPE 1 SHOULD BE USED FOR VESSEL OF DIA < = 1000MM.
–FOR LARGER DIA, USE BRACKET TYPE 2.
–A OR B IS TO BE SELECTED DEPENDING UPON OBSTRUCTIONS
(SUCH AS INSULATION,EXPANSION JOINT, STUB PIPE, ETC)
–HOWEVER,THE TYPE AND NO.OF BRACKET SHALL BE DECIDED AS PER DESIGN.
–VESSELS>600 O.D. SHALL HAVE MINIMUM 4 NO. OF BRACKETS.

REV	DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
0		ISSUED FOR IMPLEMENTATION			

FILE NAME :STD/RPAL/SR304

SECTION –20

TENTATIVE QAP/ITP-VESSEL (ITP-02)

PLANT: RCF TROMBAY

PROJECT: AMMONIUM NITRATE MELT PLANT RCF, TROMBAY)

TENTATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc (ITP-02)

PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc								
Sl. No.		DESCRIPTION OF ACTIVITY	INSPECTION BY					
			VENDOR	TPIA	LSTK CONTRACTOR	LICENSOR	OWNER/PMC	RECORD
01		Detailed Inspection & Test Plan after issue of PO/PR/PS (including for bought out items)	P	A	A		R	X
1.1		DESIGN & DRAWING Approval	P	I	A		R	X
02		Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, Painting, etc.	P	A	A		I	X
03		Pre inspection meeting	P	H	H		I	X
04		Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A			X
05		Welders Qualification Record	P	R	R			X
06		Welding Consumable Batch Certificate in accordance with EN 10204 3.1 / ISO10474 3.1b	P	R	R			X
07		Sub order verification						
08		Inspection of Bought out items at Sub vendor's works for Flanges / Forgings, Fitting, Pipes, Fasteners, Plates, dished ends, Expansion Bellows, Clad plates, etc.						
	a	Material Identification	P	W/R	R			X
	b	Sampling for test	P	W/R	R			X
	c	Mechanical/Corrosion Testing	P	W/R	R			X
	d	Relevant NDT	P	W/R	R			X
	e	Hydro test as applicable	P	W/R	R			X
	f	Final Visual/Dimension	P	W/R	R			X
09		Material for Pressure Parts after receipt – Visual/Dimension Inspection, Verification of Marking and Correlation w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC	P	H	W/R			X
10		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
11		Formed Components such as Dished ends, Cones etc.						
	a	Visual, Dimensional, (Profile, Thickness, ovelity, diameter etc.)	P	W	R			X
	b	NDE of weld joint	P	W/R	R			X
	c	PT on inside & outside surface	P	W/R	R			X

TENTATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc (ITP-02)

	d	Heat treatment chart (if applicable)	P	R	R			X
	e	Testing of Test coupon as applicable including IGC test as applicable	P	W/R	R			X
	f	UT for lack of bond in formed shall, cone etc. for Cladded equipment	P	W/R	R			X
12		Inspection for Weld Overlay						
	a	PT after first layer of weld overlay	P	W/R	R			X
	b	PT after final layer of weld overlay	P	W	R			X
	c	Check of effective thickness of weld overlay	P	W	R			X
	d	Check of Chemical composition at required depth as applicable	P	W	R			X
	e	Ferrite check of weld overlay	P	RW	R			X
	f	Visual & Dimensional						
13		Weld edge preparation & set up of pressure parts						
	a	Visual & Dimensional	P	W/R	R			X
	b	MT / PT of weld edges	P	W/R	R			X
14		ISR, DHT for LAS as applicable during welding	P	W/R	R			X
15		PT of root run for single side weld / back chipped surface of weld for pressure retaining weld joints	P	R	R			X
16		Inspection of completed pressure retaining weld joints						X
	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W	R			X
	b	NDE before PWHT as applicable	P	W/R	R			X
	c	Ferrite check of weld	P	W	R			X
	d	Dimensional check before PWHT	P	W	R			X
	e	Clearance for PWHT	P	H	R			X
	f	PWHT	P	R	R			X
	g	NDE after PWHT as applicable	P	W/R	R			X
	h	Hardness check after PWHT as applicable	P	RW	R			X
	i	Testing of Production Test coupon as applicable including IGC test as applicable	P	W	W/R			X
17		NDE of Non pressure weld joints	P	R	R			X
18		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
19		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc. (before PWHT as applicable)	P	H	H			X
20		Trial assembly of internals / trays and column/vessel section etc. as applicable.	P	W	W/R			X
21		Pneumatic test of pads	P	W/R	R			X
22		Hydrostatic test	P	H	H			X
23		Check Chloride content of Hydro test water	P	R	R			X

TENTATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc (ITP-02)

24		NDE after Hydro test as applicable	P	RW	R			X
25		Drying of equipment	P	W/R	R			X
26		Pickling and Passivation (Inside & Outside surface) for SS Equipment						
	a	Visual check	P	W	R			X
27		Surface Preparation and Painting						
	a	WFT check of intermediate coat	P	R	R			X
	b	DFT check of final coat	P	W	R			X
	c	Adhesion test as applicable	P	W/R	R			X
	d	Visual check of final coat	P	W	R			X
28		Visual/Dimension of Foundation Template, Gage plat for base ring & foundation bolt as applicable	P	W/R	R			X
29		Review of final documents including MDR of AI (as applicable)	H	R	R			X
30		Final stamping & issue of Inspection release certificate	P	H	H			X
31		Rust Prevention (N2 purge, VCI)	P	W/R	R			X
32		Packing & Marking inspection	P	W/R	R			X

LEGEND	1)	LSTK CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P - PERFORM
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD
	2)	This is only an indicative ITP and covers major inspection stages only. Vendor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and specific technical requirements of applicable PR/PS/design code
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with vendor/LSTK contractor only irrespective of the place of inspection i.e. Vendor shop / sub vendor shop / sub-sub vendor shop/contractor facility/site etc
	4)	Inspection Stages Of OWNER/PMC/Licensor Would Be Informed During Order Execution/Pre-Inspection Meeting
	5)	Owner/PMC reserves the right to involve in all inspection activities irrespective of whether it is witness point or not
	6)	For Sub-Vendor Items, Main Vendor Shall Be Involved In The Inspection Prior To Offering To LSTK/TPIA
	7)	Vendor shall ensure that all test and measuring instruments are duly calibrated and calibration shall be valid at the time of inspection. Calibration records shall be reviewed by LSTK & TPIA
	8)	For 'R' No Issue Of Inspection Call Is Required
	9)	For "W" & "H" Points – Inspection Call To Be Issued By Vendor
	10)	Sub Vendor For All Bought Out Items Shall Be From Approved Vendor List
	11)	ITP shall be prepared as per format provided by LSTK contractor if any
	12)	Approved Third Party Inspection Agencies as per NIT.
	15)	Wherever "W/R" Is Mentioned, It Is At The Sole Discretion Of Owner To Decide "W" Or "R" While Approval Of ITP During Order Execution.
	16)	A new welding procedure shall be qualified for the project. A proposed welding procedure specification (WPS) shall be submitted to approved inspection agency for approval. On approval, a procedure qualification test shall be conducted which shall be witnessed by approved inspection agency. Approved inspection agency may accept previously qualified WPS/PQR at his sole discretion
	17)	ZERO DEFECT CONTROL SHEET(ZDCS) is applicable for this project and vendor shall endorse the same during order execution as a part of compliance.
	18)	Explosion Clad Material Shall Not Be Used Without Advance Written Consent Of The Owner.

TENTATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc (ITP-02)

	19)	For Austenitic Stainless Steel Material IGC Test As Per ASTM A262 PRACTICE “E” to be carried out
	20.)	Heat exchanger Tubes shall be hydro tested and eddy current tested at manufacturer’s works.
	20)	This ITP is applicable for Pressure Vessels, Reactors, Columns ,Filter, Etc. And All Vessels Designed As Per ASME SECTION VIII.

SECTION –20

TENTATIVE QAP/ITP –SHELL AND TUBE HEAT EXCHNAGER (ITP-01)

PLANT: RCF TROMBAY

PROJECT: AMMONIUM NITRATE MELT PLANT RCF, TROMBAY)

TENTATIVE QAP/ INSPECTION AND TEST PLAN- Shell and Tube Heat Exchanger (ITP-01)

Shell and Tube Heat Exchanger								
Sl. No.		DESCRIPTION OF ACTIVITY	INSPECTION BY					
			VENDOR	TPIA	LSTK CONTRACTOR	LICENSOR	OWNER/ PMC	RECORD
01		Detailed Inspection & Test Plan after issue of PO/PR/PS (including for bought out items)	P	A	A		R	X
1.1		DESIGN & DRAWING Approval	P	I	A		R	
02		Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, PMI, Painting, etc.	P	_	A		I	X
03		Pre inspection meeting	P	H	H		I	X
04		Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	H	A			X
05		Welders Qualification Record	P	R	R		I	X
06		Welding Consumable Batch Certificate in accordance with EN 10204 3.1 / ISO10474 3.1b	P	R	R			X
06		Sub order verification						
	a	Material Identification	P	W/R	R			X
	b	Sampling for test	P	W/R	R			X
	c	Mechanical/Corrosion Testing	P	W/R	R			X
	d	Relevant NDT	P	W/R	R			X
	e	Hydro test as applicable	P	W/R	R			X
	f	Final Visual/Dimension	P	W/R	R			X
08		Material for Pressure Parts after receipt – Inspection, Identification w.r.t. Mill / Manufacturer's Test Certificate, Review of MTC	P	H	W/R			X
09		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
10		Formed Components such as Dished ends, Cones etc.						
	a	Visual, Dimensional, Profile, Thickness checks	P	W	R			X
	b	NDE of weld joint	P	W/R	R			X
	c	PT on inside & outside surface	P	W/R	R			X
	d	Heat treatment chart (if applicable)	P	R	R			X
	e	Testing of Test coupon as applicable including IGC test as applicable	P	W/R	R			X
	f	UT for lack of bond in formed shall, cone etc. for Cladded equipment	P	W/R	R			X
11		Inspection for Weld Overlay						

TENTATIVE QAP/ INSPECTION AND TEST PLAN- Shell and Tube Heat Exchanger (ITP-01)

	a	PT after first layer of weld overlay	P	W/R	R			X
	b	PT after final layer of weld overlay	P	W	R			X
	c	Check of effective thickness of weld overlay	P	W	R			X
	d	Check of Chemical composition at required depth as applicable	P	W	R			X
	e	Ferrite check of weld overlay	P	RW	R			X
12		Weld edge preparation & set up of pressure retaining weld joints						
	a	Visual & Dimensional	P	W/R	R			X
	b	MT / PT of weld edges	P	W/R	R			X
13		ISR, DHT for LAS as applicable during welding	P	W/R	R			X
14		PT of root run for single side weld / back chipped surface of weld for pressure retaining weld joints	P	R	R			X
15		Inspection of completed pressure retaining weld joints						X
	a	Visual check for reinforcement, undercuts, surface defects etc.	P	W	R			X
	b	NDE before PWHT as applicable	P	W/R	R			X
	c	Ferrite check of weld	P	W	R			X
	d	Dimensional check before PWHT	P	W	R			X
	e	Clearance for PWHT	P	H	R			X
	f	PWHT	P	R	R			X
	g	NDE after PWHT as applicable	P	W/R	R			X
	h	Hardness check after PWHT (as applicable)	P	RW	R			X
	i	Testing of Production Test coupon as applicable including IGC test as applicable	P	W	W/R			X
16		NDE of Non pressure weld joints	P	R	R			X
17		Tube Bundle Assembly						
	a	Tube to Tube sheet join mock up procedure & qualification	P	H	W/R			X
	b	Inspection of Tube sheet after machining	P	W	W/R			X
	c	Skeleton assembly of Tube bundle before tube insertion	P	H	W/R			X
	d	Hydro testing of U tubes	P	W	W/R			X
	e	Final inspection after tube insertion	P	W	W/R			X
	g	Tube to Tube sheet expansion check (Thinning, Length of expansion, Go / No – Go gauge check etc.	P	H	W/R			X
18		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
19		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc.	P	H	H			X
20		Trial assembly of internals if any	P	W	W/R			X
21		Pneumatic test of pads and	P	W	R			X

TENTATIVE QAP/ INSPECTION AND TEST PLAN- Shell and Tube Heat Exchanger (ITP-01)

		Tube to Tube sheet joint and Helium leak test (as applicable)						
22		Hydrostatic test – Shell side, Tube side outside shall, Shell & Tube side after assembly, in condition (if applicable)	P	H	H		W	X
23		Check Chloride content of Hydro test water	P	R	R			X
24		NDE after Hydro test as applicable	P	RW	R			X
25		Drying of equipment	P	W	R			X
26		Pickling and Passivation (Inside & Outside surface) for SS Equipment	P	W	R			X
27		Surface Preparation and Painting						
	a	Adhesion check for individual coat & final coat	P	R	R			X
	b	WFT check of intermediate coat	P	R	R			X
	c	DFT check of final coat	P	W	R			X
	d	Visual check of final coat	P	W	R			X
29		Foundation Template, Gage plate for base ring & foundation bolt – Visual/Dimension	P	W	R			X
30		Review of final documents including MDR of AI (as applicable)	P	W	R			X
31		Final stamping & issue of Inspection release certificate	P	W	R			X
32		Rust Prevention (N2 purge,)	P	W/R	W/R			X
33		Packing & Marking inspection	P	W/R	W/R			X

LEGEND	1)	LSTK CONTRACTOR , 2) PMC – PROJECT MANAGEMENT CONSULTANT, 3) TPIA – THIRD PARTY INSPECTION AGENCY 4) H - HOLD, 5) A - APPROVE, 6) W - WITNESS, 7) RW – RANDOM WITNESS 8) R - REVIEW, 9) P - PERFORM
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD
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	10)	Sub Vendor For All Bought Out Items Shall Be From Approved Vendor List
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	15)	Wherever "W/R" Is Mentioned, It Is At The Sole Discretion Of Owner To Decide "W" Or "R" While

TENTATIVE QAP/ INSPECTION AND TEST PLAN- Shell and Tube Heat Exchanger (ITP-01)

		Approval Of ITP During Order Execution.
	16)	A new welding procedure shall be qualified for the project. A proposed welding procedure specification (WPS) shall be submitted to approved inspection agency for approval. On approval, a procedure qualification test shall be conducted which shall be witnessed by approved inspection agency. Approved inspection agency may accept previously qualified WPS/PQR at his sole discretion
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	18)	Explosion Clad Material Shall Not Be Used Without Advance Written Consent Of The Owner.
	19)	For Austenitic Stainless Steel Material IGC Test As Per ASTM A262 PRACTICE “E” to be carried out
	20.)	Heat exchanger Tubes shall be hydro tested and eddy current tested at manufacturer’s works.

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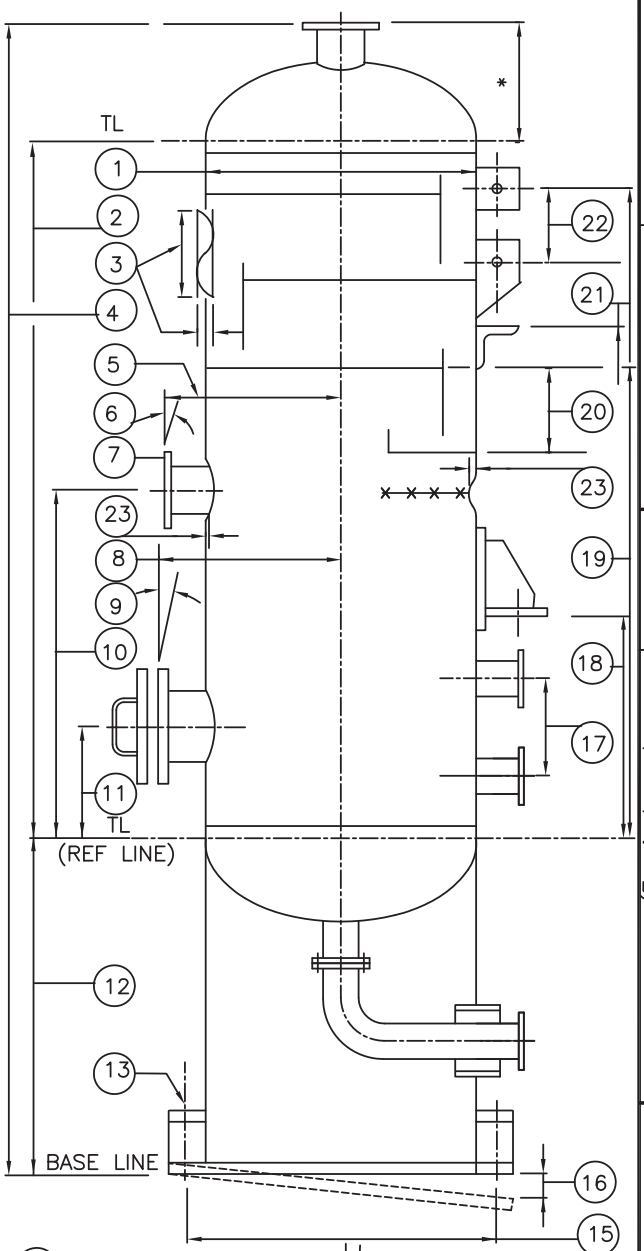
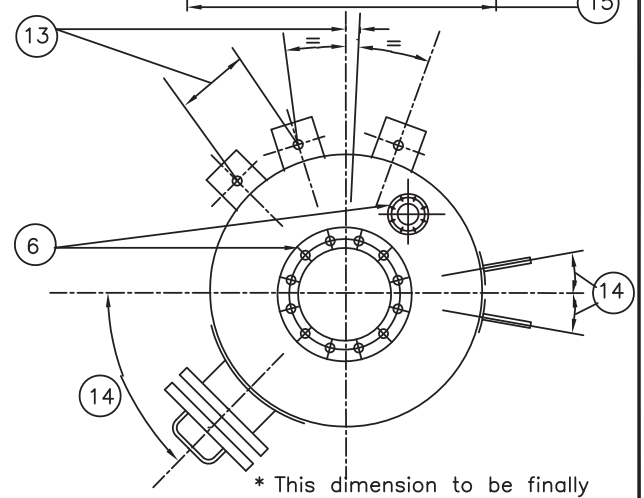
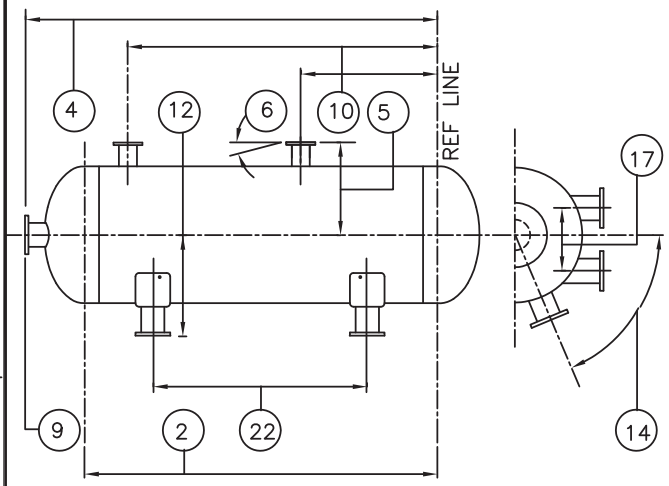
VESSEL TOLERANCES

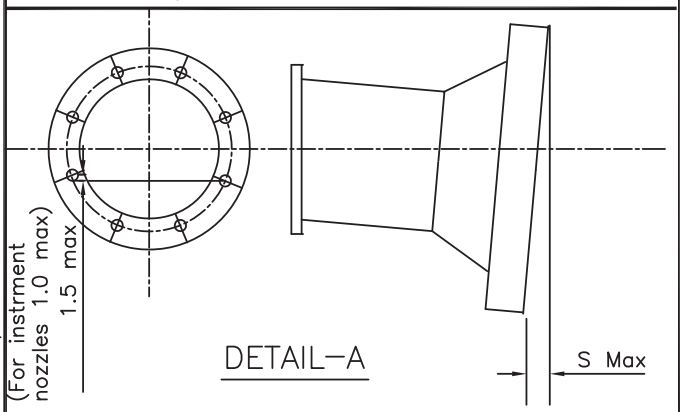




* This dimension to be finally adjusted to suit total height



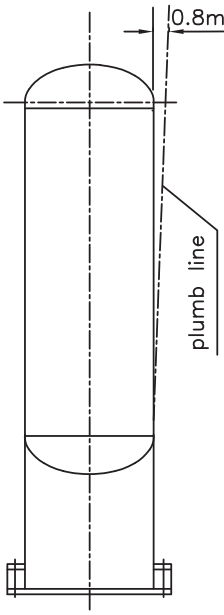
TOLERANCES FOR HORIZONTAL VESSEL



DETAIL–A

Nozzle size	S Max.
NPS ⩽ 4 INCH	1.5
6 INCH ⩽ NPS ⩽ 12 INCH	2.5
NPS > 12 INCH.	5.0

S max shall be ± 0.5mm for instrument nozzle



NOTE

For equipment constructed in flanged sections. The vertical tolerances shall be verified for each section.

Max. allowable deviation between adjacent courses ± 3.0

VERTICAL TOLERANCES AS ERECTED

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
22–09–99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

FILE NAME :STD/NCR/PV001

1) Shell Tolerances

Nom. vessel Diameter	Tolerance
600 & under	± 2.5
Over 600 to 1200	± 4.0
Over 1200 to 2100	± 6.0
Over 2100 to 2700	± 7.0
Over 2700	± 8.0

2) Distance between top & bottom tangent lines, ±1.5 mm/M height, max. ±12

3) Linearity of cylindrical surface, ± 3mm/6M, max. of 20

4) Height from base line to face of top nozzle, ± 5 max.

5) Face of nozzle from centre line of vessel, ± 3

6) Alignment of flange face of nozzle shall be as given in Table (Under Detail 'A')

7) Rotation of flange holes with reference to nozzle axis; 1.5 max.
(Refer Detail 'A')
In case of instrument connections this shall be 1.0 mm max.

8) Face of manhole from centre line of vessel, ± 6

9) Alignment of flange face of manhole shall be ± 6 in both vertical and transverse planes.

10) Location of shell nozzle from reference line, ± 3

11) Location of manhole from reference line , ± 12

12) Bottom of skirt base ring to the bottom tangent line of vessel, $^{+0}_{-6}$

13) Orientation of anchor bolts with respect to principal axes, ± 6

14) Tolerance in orientation of nozzles and external clips, ± 3

15) Distances of bolt holes from axis up to 2000 dia ±3 & over 2000 dia ± 6

16) Maximum deviation of skirt base

Nom. Vessel Diameter	Tolerance
1200 & under	±3
Over 1200 to 2000	±5
Over 2000	±7

17) Distance between level control nozzles, ± 1.0 mm

18) Distance between support bracket and reference line, $^{+6}_{-0}$

19) Location of tray support ring from reference line, ± 6

20) Tolerance between adjacent tray plates, ± 3

21) Location of external clips and attachments from reference line, ± 6

22) Distance between adjacent clips for platform brackets, ± 3

23) Irregularities in profile (checked by a 20° gauge) shall not exceed
$\delta \leq 0.05*e+0.002*D$ (Maximum 25 mm)

Where δ =Maximum local irregularities
e=Plate thickness
D=Shell outside diameter

Notes :

1) In case of difference between the values tabulated here and those shown in the drawings, the latter shall govern.

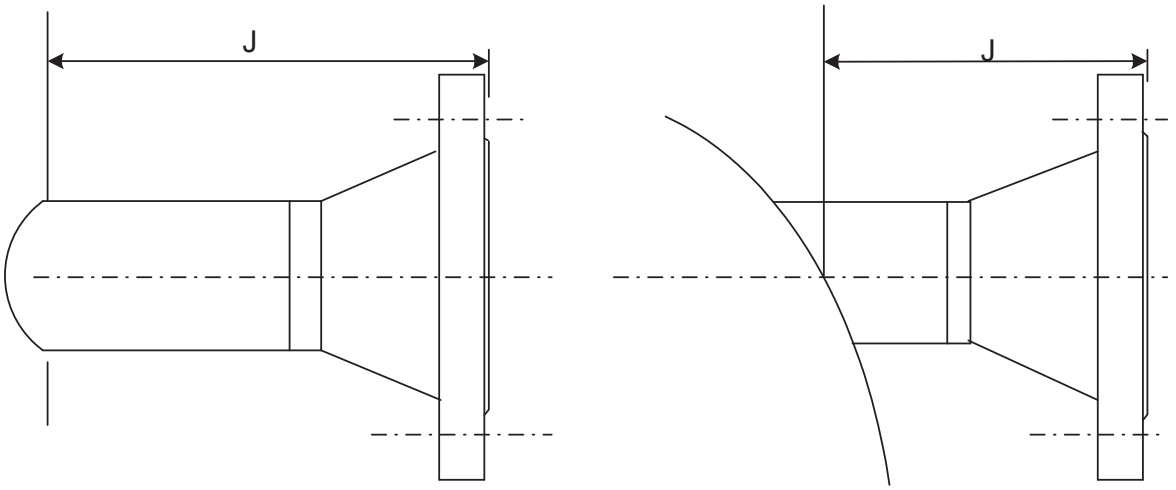
2) For fabrication & assembly tolerances on vessel internals, see ES : 3105

3) For vessels fabricated from pipe– diameter and out of roundness tolerance to be in accordance with relevant pipe specification.

4) All dimensions are in mm unless otherwise specified.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
22–09–99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

FILE NAME :STD/NCR/PV001SH2



VALUES OF 'J'

Nozzle Diameter NPS	Rating 150#	Rating 300#	Rating 600#	Rating 900#	Rating 1500#	Rating 2500#	Remarks
≤ 3″	200		200		200	350	
4″	200		250		250	350	
6″	200	250	250		250	350	
8″	250		300		350	550	
10″	250		300		350	550	
12″	250		300	350	350	550	
14″	250		300	350	450	--	
16″	300	350	350		450	--	
18″	300	350	350		450	--	Refer Note-4
20″	300	350	350		500	--	Refer Note-4
24″	300	350	350		500	--	Refer Note-4
26″ ≤ NPS ≤ 38″	300	350	350	--	--	--	Refer Note-6

NOTES :-

1. All dimensions are in millimeter unless otherwise shown.
2. The above projections are valid for all types of flanges.
3. However in case of forged nozzle, the projection shall be suitably increased to meet reinforcement requirement.
4. In case of manhole,projection shall be increased by the sum of 50 mm and difference of insulation thickness exceeding 50 mm.
5. Projection from vessel axis to nozzle facing shall be rounded off to 10 mm.
6. Flanges ≥ NPS 26″ will be as per ASME B 16.47 series 'B'.

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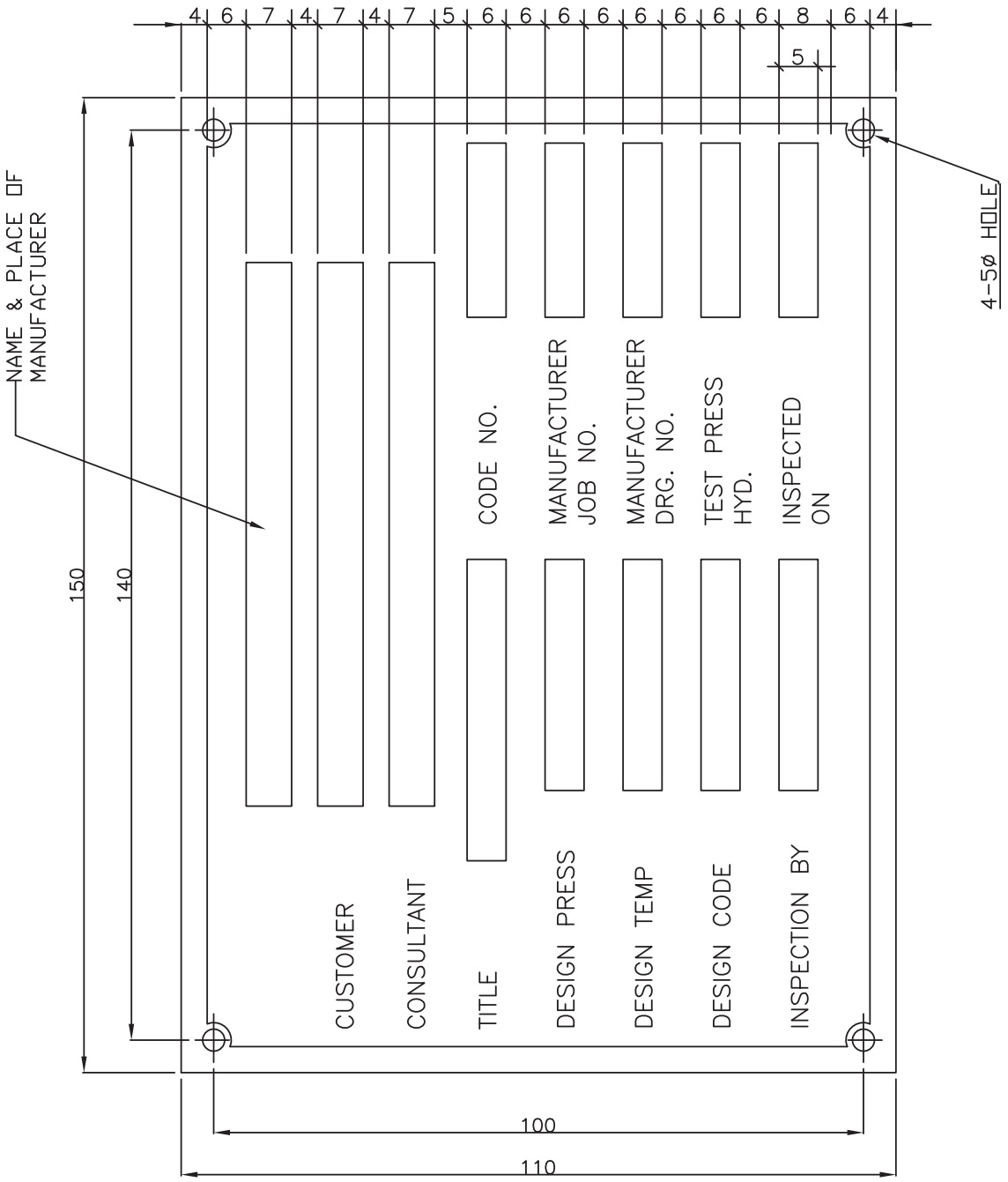
NAME PLATE FOR VESSEL & TOWER

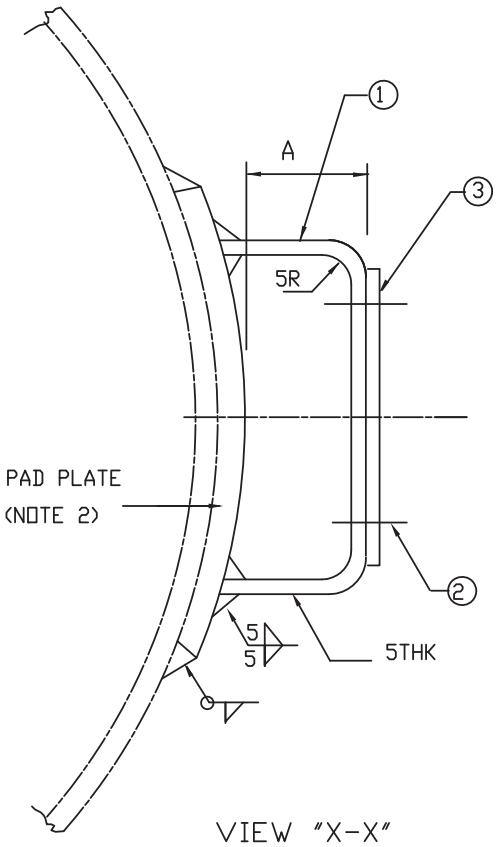
PDS:PV 003
ISSUE: AUG. 1999
SHEET 1 OF 2



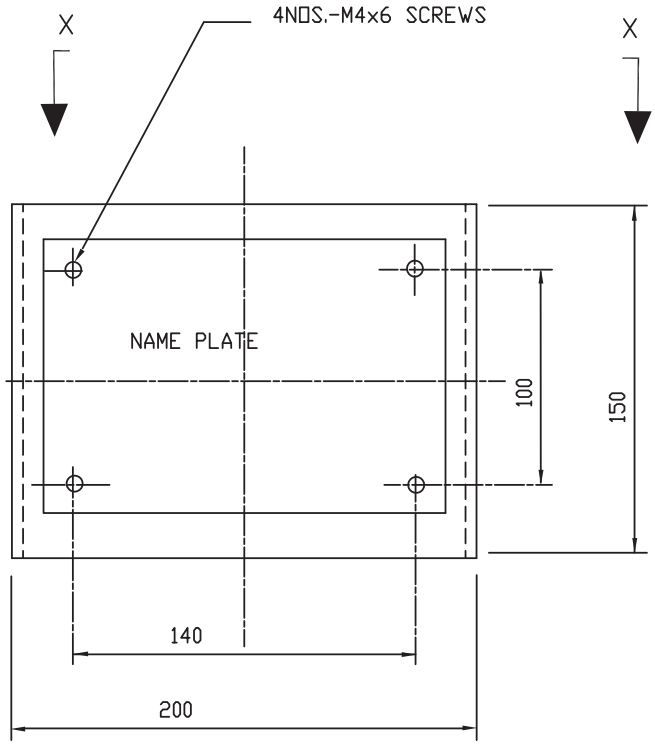
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
AUG. 99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

FILE NAME :STD/RCP/PV003SH1

NAME PLATE BRACKET



VIEW "X-X"



ELEVATION

DIMENSION "A"

a) VESSELS WITHOUT INSULATION = 25 mm

b) VESSELS WITH INSULATION = INSULATION THK + 25 mm

NOTES:

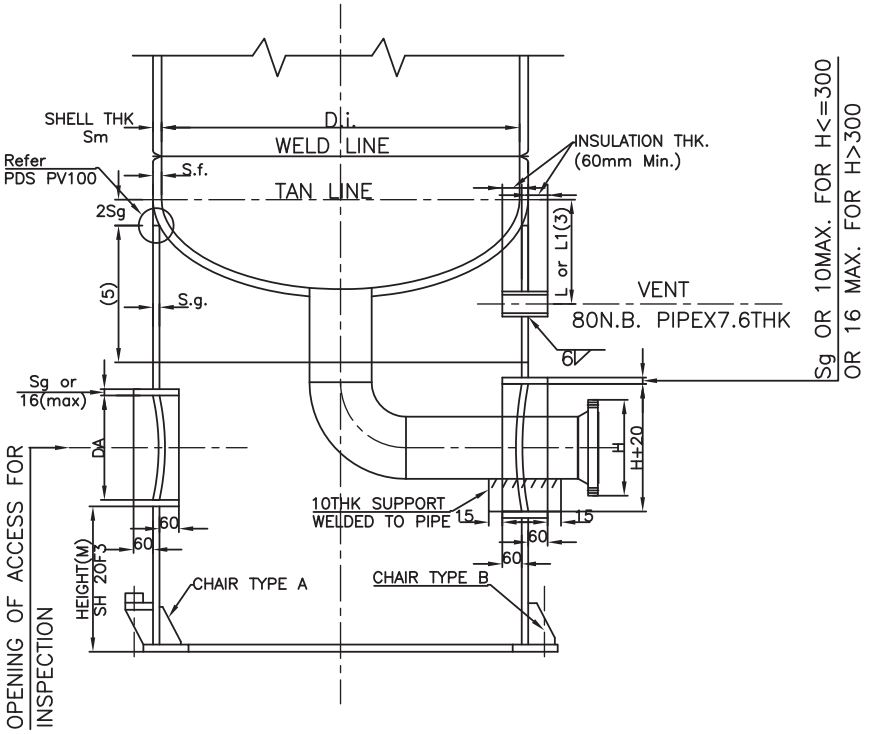
1 MATERIALS:

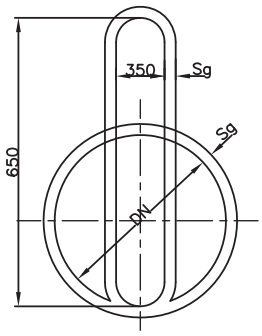
BRACKET (1) IS 2062 Gr.A
SCREWS (2) S.S.304
NAME PLATE(3) S.S.304

2 PAD PLATE OF SIMILAR COMPOSITION AS THAT OF SHELL SHALL BE WELDED ON VESSELS OF MATERIALS OTHER THAN CARBON STEEL AND THOSE UNDER LOW TEMPERATURE SERVICE

3 ALL DATA BLOCKS AND LETTERS MUST BE CHEMICALLY ENGRAVED (0.5 m.m.)

DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
AUG. 99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		





OPENING OF ACCESS

SKIRT DIAMETER DG	OPENING OF ACCESS			VENT		
	NO.	TYPE	DA	NO.	L	L1
<=700	1	CIRCULAR	250	2	260	230
701–1000	1	OVAL	350x650	2	290	250
1001–2500	1	CIRCULAR	500	4	400	360
2501–4000	2	CIRCULAR	500	8	550	450
4001–6000	2	CIRCULAR	500	12	670	560
>6000	2	CIRCULAR	500	16	700	600

NOTES :–

1. The No. dia and the type of bolt sahll be decided as per design. The bolt circle dia. 'DF' shall be fixed according to design , sheet 2 & 3 illustrate chair details (TYPE A, B & C)

2. For the skirt of conical(lapered) construction, the type and the no. of access opening and vent to be decided according to the dia. of skirt at corresponding elevation of centre line of opening.

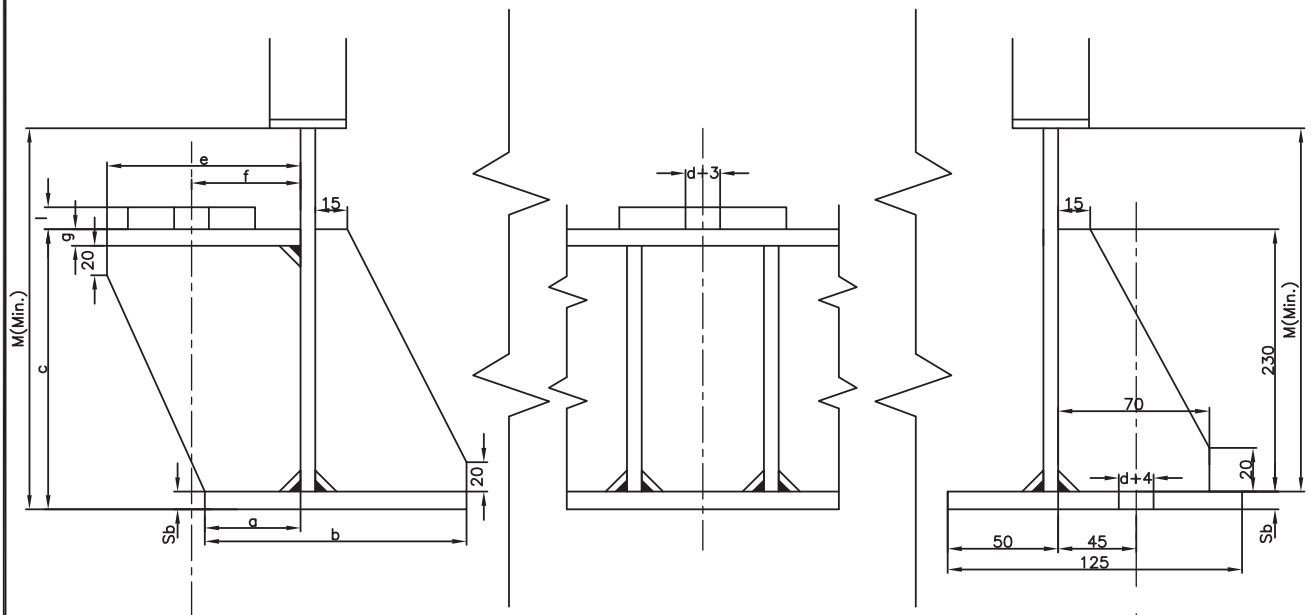
3. The values of 'L' & 'L1' are adopted for insulation thickness<= 90mm. L for semielliptical head and 'L1' for torispherical head with r/D = 0.1. For other types of head and insulation thickness > 90mm. 'L' & 'L1' shall be decided case by case.

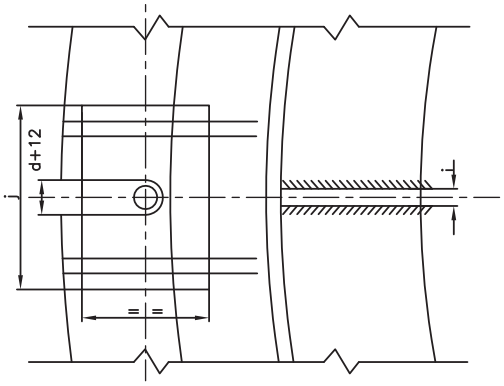
4. 'M' the minimum height of each opening, shall be such that it allows for mounting of nut for type 'A' and welding of gussets for type 'B' foundation bolt chairs.

5. In case the head is made of S.S. or of special material and skirt in C.S., unless otherwise specified provide the skirt length ot the same material as that of head with minimum length of 250mm. For high temperature service, the length and the material of the skirt shall be decided according to design condition.

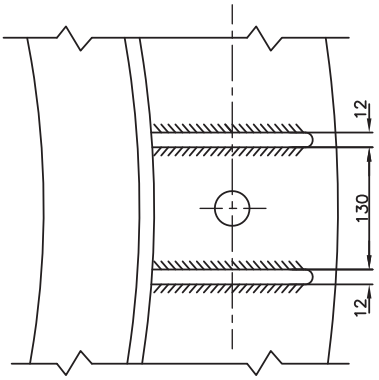
6. Where the skirt is attached to a stress relieved vessel the skirt to shell or head weld and at least 600mm of the skirt shall be stress relieved.

SEP. 2014	ISSUED FOR IMPLEMENTATION	ENGG COMM		
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:





CHAIR TYPE"A"(HEAVY)



CHAIR TYPE"B"(LIGHT)

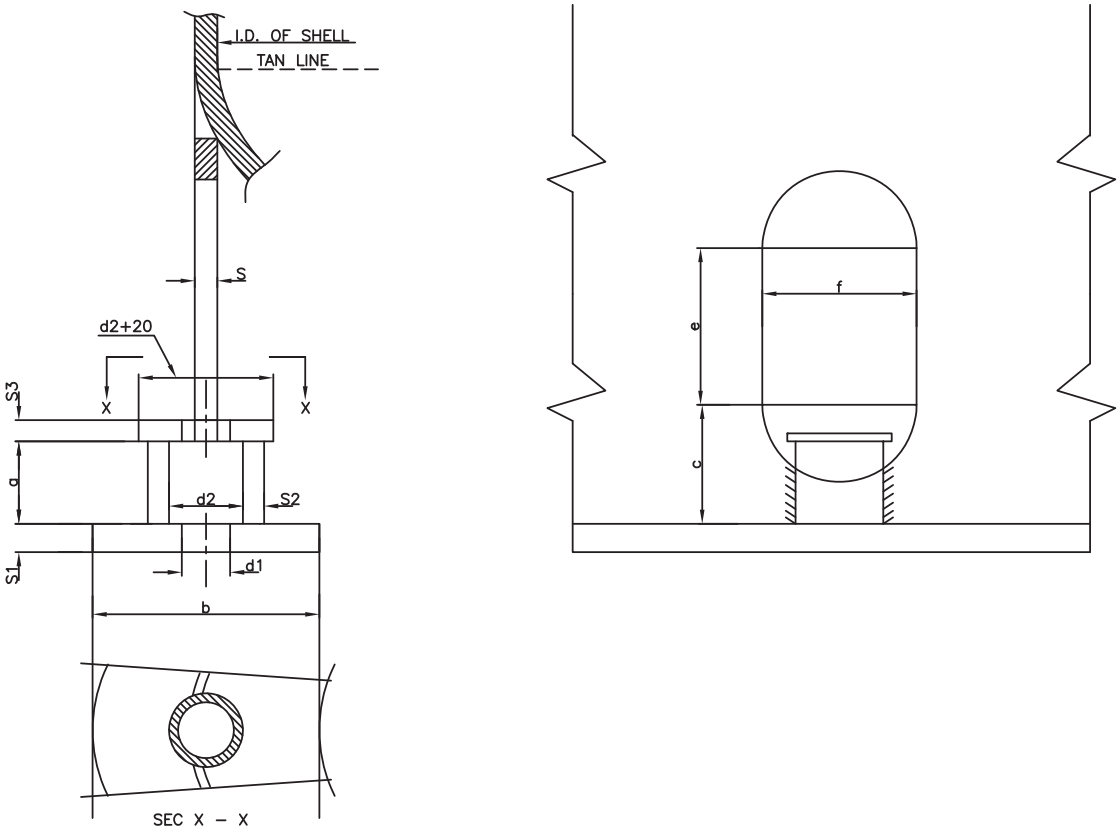
CHAIR TYPE	FOUNDATION BOLT DIA. (d)	a	b	BASE RING Different bearing capacities 25kg/cm2	35kg/cm2	45kg/cm2	CHAIR DIMENSIONS c	e	f	g	h	i	j	k	l	M (Min.)
B	M16–M27	SEE DETAIL		20	25	28	SEE DETAIL									300
A	M30	50	130	20	25	28	250	125	75	14	70	12	105	80	32	420
	M33	50	130	20	25	28	250	130	76	14	75	12	110	90	32	436
	M36	55	140	22	28	32	280	145	84	14	80	12	115	100	36	480
	M39	55	140	22	28	32	280	150	84	16	85	14	125	110	36	490
	M42	60	150	25	28	32	300	160	92	16	90	14	130	110	40	525
	M45	60	150	25	28	32	300	165	92	18	95	16	140	120	40	535
	M48	65	170	25	32	36	330	180	100	18	100	16	150	130	45	580
	M52	70	180	28	32	36	360	190	110	20	105	18	160	140	50	625
	M56	70	180	28	32	36	360	200	110	20	110	18	170	150	56	645
	M60	80	200	32	36	40	400	220	122	22	115	20	180	160	56	700
	M64	90	200	32	40	45	440	235	134	25	120	20	190	170	63	760

NOTES :–

1. The fillet size of the welding shall be equal to minimum of the thicknesses to be welded.

SEP. 2014	ISSUED FOR IMPLEMENTATION	ENGG COMM		
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:

FILE NAME :STD/NCR/PV301



DIA. OF BOLTS	NO. OF HOLES	a	b	c	d1	d2	e	f	S1	S2	S3
20	SEE NOTE – 2	55	80	70	24	48	70	80	20	7	12
24		55	80	70	28	48	70	80	20	7	12
27		55	80	70	32	60	70	85	20	9	12
30		60	110	75	35	60	80	90	22	9	16
33		70	110	85	39	60	85	95	22	9	16
36		75	110	90	42	73	95	105	22	10	16
39		90	130	105	45	73	105	110	22	10	16
42		100	130	115	48	73	115	115	22	10	16
45		115	130	130	51	90	125	120	22	12	16
48		125	150	140	54	90	135	130	25	12	20
52		140	200	155	58	90	140	135	30	12	20

NOTES :–

1. The base ring can also be manufactured in four equal parts and the relating welding must be ground on both sides. The ring dimensions must be checked case by case on the basis of the specific loads.
2. The number of the anchor bolts shall be determined case by case and at any rate in a number multiple of four the type to be selected is a designers choice..
3. The fillet size of welding shall be minimum of the thicknesses to be welded.

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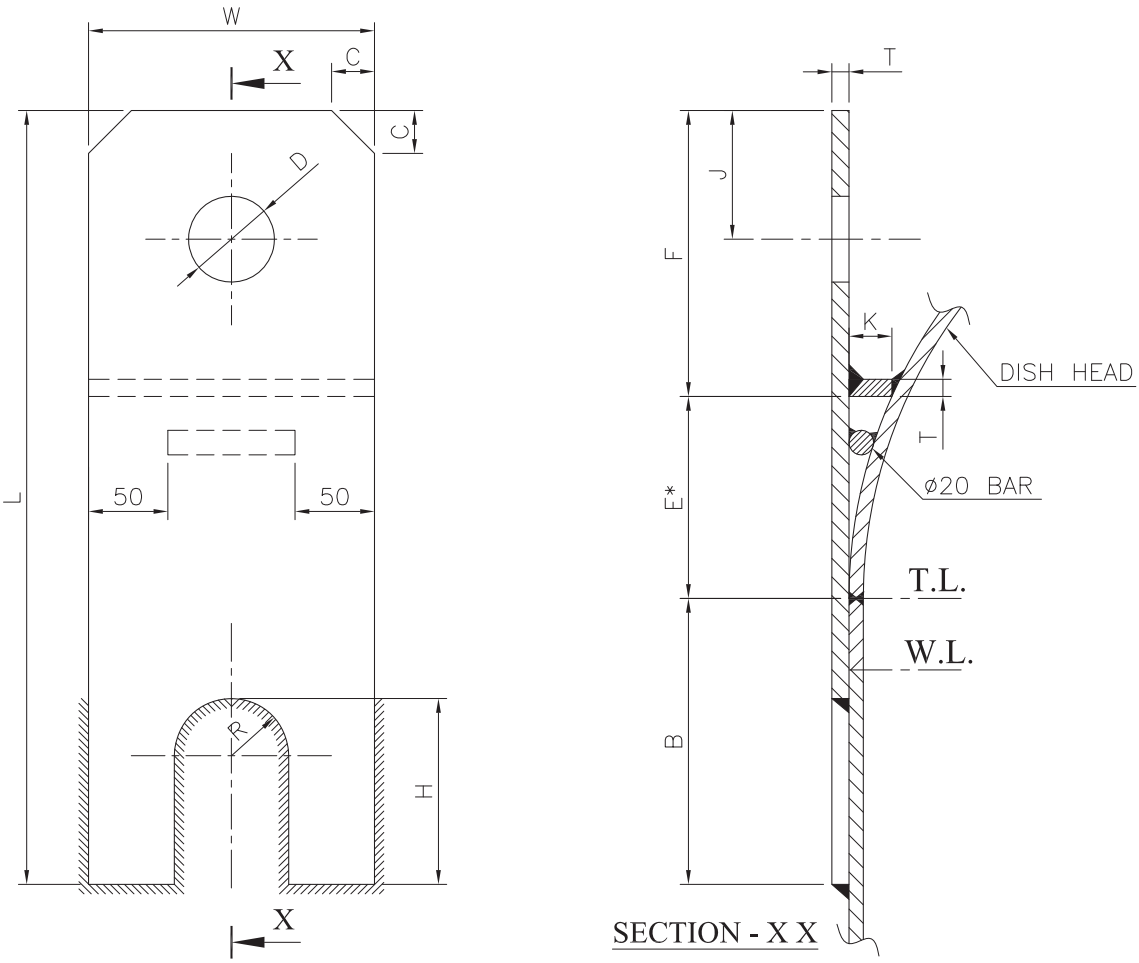
LIFTING LUG

PDS : PV 302
ISSUE: SEP. 2014
SHEET 1 OF 2



MAX. ERECTION WT OF VESSEL (M TON)	10	25	45	90	140	180
THICKNESS OF PLATE (T)	12	28	40	50	70	80
WIDTH (W)	200	230	300	400	500	615
LENGTH (L)	400+E	460+E	580+E	750+E	900+E	1080+E
DIAMETER OF HOLE (D)	60	75	75	100	130	150
HEIGHT OF NOTCH & SIDE WELD (H)	130	130	150	200	250	300
RADIUS OF NOTCH (R)	40	40	50	75	90	100
WELD SIZE	10	14	20	30	38	46
BOTTOM OF BRACE TO TOP OF LUG (F)	200	230	300	400	500	600
BOTTOM OF BRACE TO T.L. OF HEAD (E)	see note 2*					
T.L. OF VESSEL TO END OF LUG (B)	200	230	280	350	400	480
CHAMFER (C)	30	40	50	70	90	100
TOP OF LUG TO CENTER LINE OF LUG (J)	90	90	115	150	180	230
(K)	30	40	50	70	80	100
NO. OF LUGS (T)	2	2	2	2	2	2

NOTES :

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE INDICATED.
2. DIMENSION 'E' TO BE DETERMINED BY SHAPE OF HEAD IN CONJUNCTION WITH DIMENSION 'K'.
3. DETAIL DIMENSIONS AND NOTES GIVEN IN DESIGN DRAWING TAKE PRECEDENCE OVER THOSE SHOWN HERE.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
20–09–14	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

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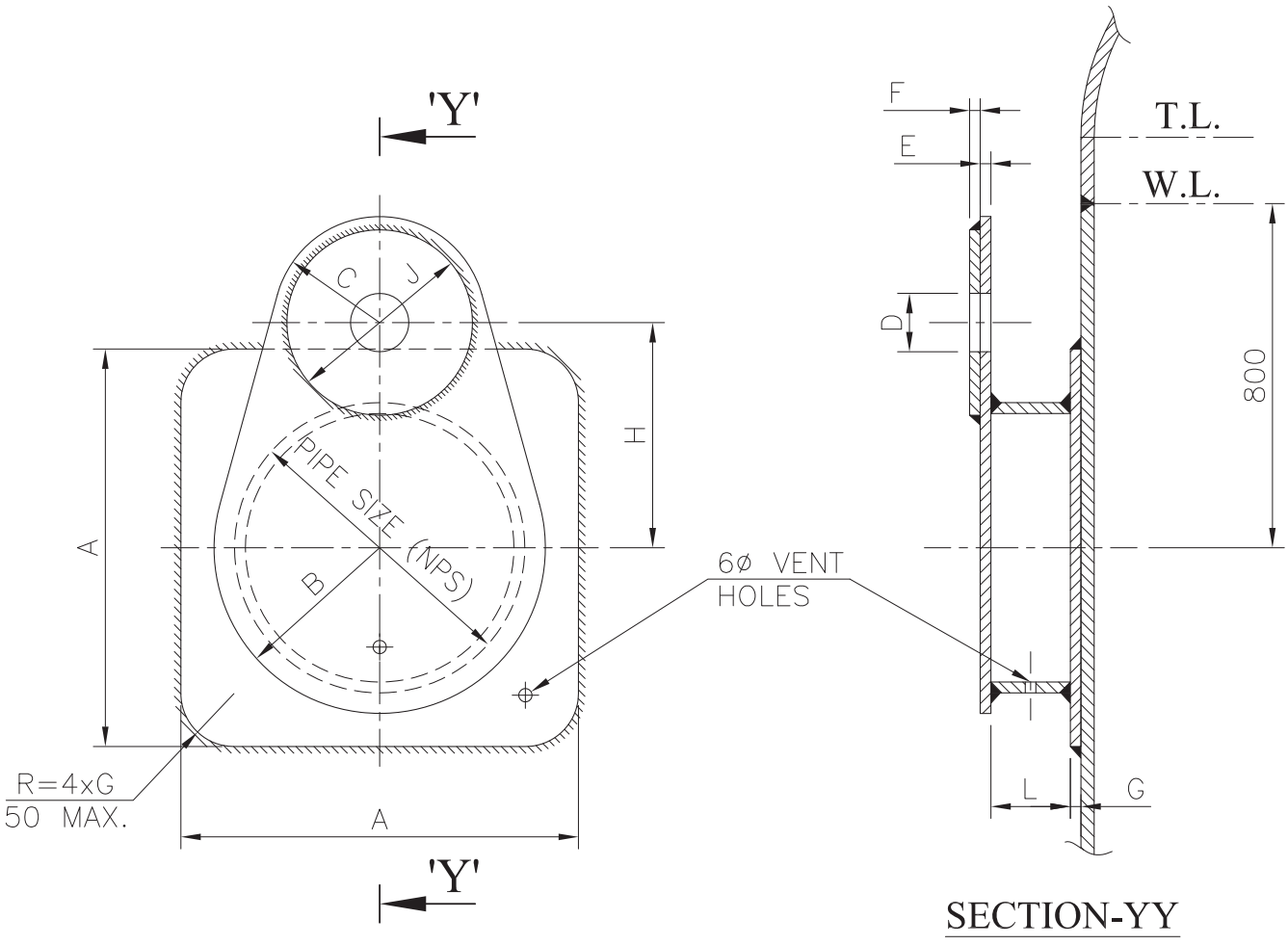
LIFTING LUG



SECTION-YY

LIFTING CAPACITY PER LUG (M. TON)	PIPE			PLATE								
	NPS	MIN. THK.	L	A	B	C	D	E	F	G	H	J
<5	6"	7.11	60	25	100	50	27	8	–	8	130	–
>5 ⩽10	8"	8.18	85	300	125	80	38	8	–	8	170	–
>10 ⩽20	8"	8.18	85	300	125	80	44	10	8	10	170	140
>20 ⩽25	10"	9.27	100	350	150	120	54	12	10	12	210	220
>25 ⩽30	12"	8.38	110	400	175	160	60	12	10	10	250	300

NOTES :

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE INDICATED.
2. LIFTING CAPACITY RELATES TO PER LUG. THIS TYPE OF LUGS MAY BE USED TO LIFT UPTO 60 TONS.
3. WELDING SIZE SHALL BE 0.7 OF THICKNESS BUT NOT LESS THAN 7 MM.
4. MATERIAL PLATES–SA 516 Gr. 70 OR EQUIVALENT (SEE NOTE 5). PIPE–SA 106 Gr. B OR EQUIVALENT.
5. THE PLATE WELDED TO SHELL FOR ALLOY STEEL EQUPMENT SHALL BE OF SAME MATERIAL OF THE SHELL.

20–09–14	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:

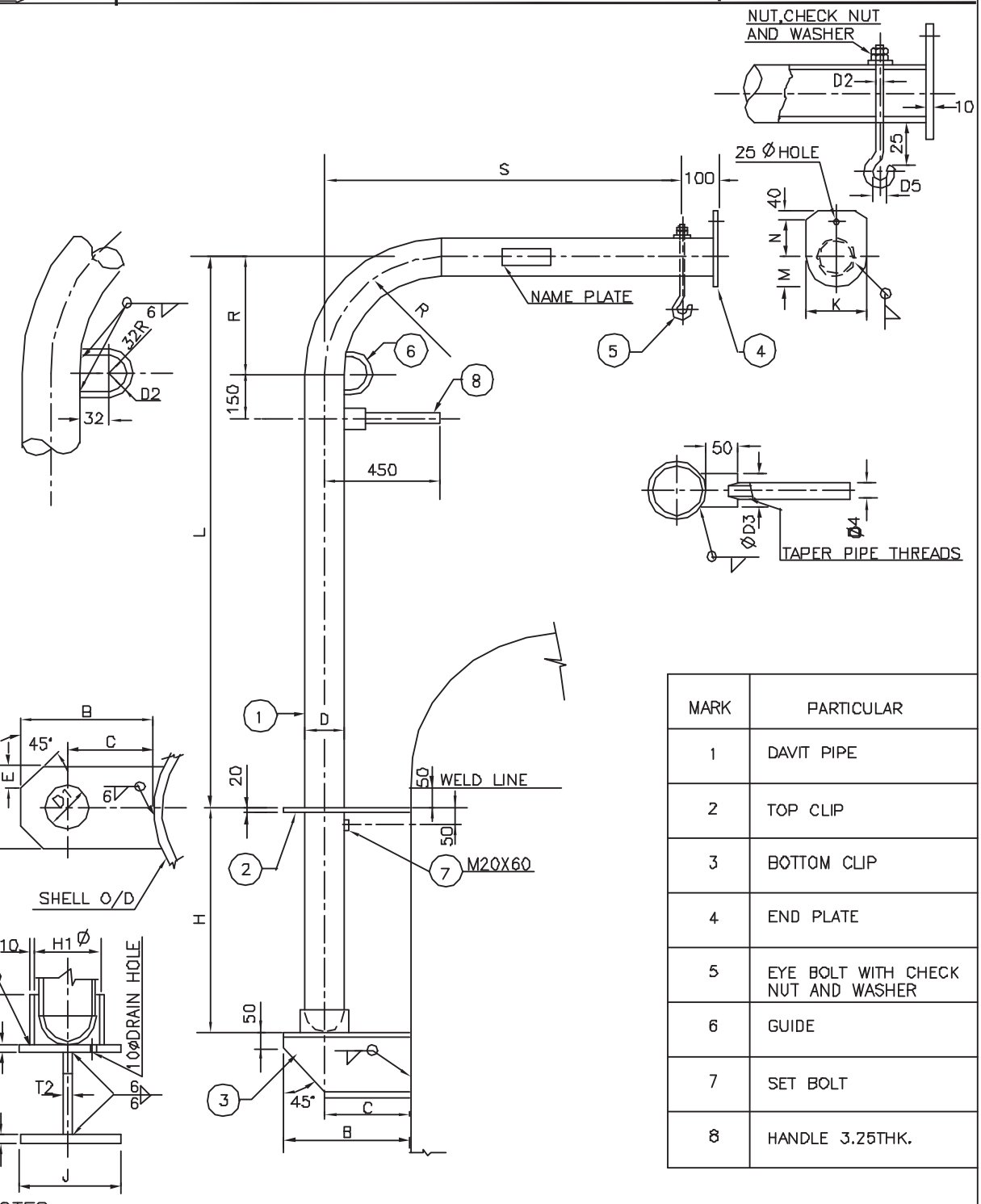
PDIL

PIPE DAVIT

PDS:PV 303

ISSUE: AUG. 1999

SHEET 1 OF 2



MARK	PARTICULAR
1	DAVIT PIPE
2	TOP CLIP
3	BOTTOM CLIP
4	END PLATE
5	EYE BOLT WITH CHECK NUT AND WASHER
6	GUIDE
7	SET BOLT
8	HANDLE 3.25THK.

NOTES:

1. FABRICATOR TO INDICATE IN PARMANENT LETTERING ON THE NAME PLATE THE RATED LOAD.
2. FABRICATOR TO MAKE SURE THAT DAVIT TURNS EASILY.
3. VESSEL CLIP PLATES TO BE OF THE SAME MATERIAL AS SHELL PROPER AND TO BE WELDED TO EACH OTHER AND TO SHELL WITH 6mm FILLET WELD.
4. FOR STERSS RELIEVED VESSELS,CLIP MUST BE SHOP WELDED TO VESSELS.
5. OTHER STRUCTURAL PARTS TO IS:2062 Gr A/B.
6. PIPE THREADS TO IS:554.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
AUG. 99	ISSUED FOR IMPLEMENTATION			

Davit pipe size	A	B	C	D_1	D_3	D_4	E	F	G	H_1	J	K	M	N	T_1	T_2
DN 100	250	355	225	118	55	26.9	65	180	100	120	150	140	70	140	16	10
DN 150	300	400	250	172	70	42.4	75	200	100	175	200	190	95	160	16	10
DN 200	400	475	275	222	70	42.4	100	250	100	225	250	240	120	185	20	12

Rated load 500 kg.					Rated load 1000 kg.					S	L	H
Davit type	D DN x Thk.	R	D_2	D_5	Davit type	D DN x Thk.	R	D_2	D_5			
1	100 x 7.9	500	16 ϕ	40 ϕ						600	2300	750
2	100 x 7.9	500	16 ϕ	40 ϕ						700	2300	750
3	150 x 7.11	750	16 ϕ	40 ϕ	103	150 x 9.52	750	20 ϕ	50 ϕ	800	2500	750
4	150 x 7.11	750	16 ϕ	40 ϕ	104	150 x 9.52	750	20 ϕ	50 ϕ	900	2500	750
5	150 x 7.11	750	16 ϕ	40 ϕ	105	150 x 9.52	750	20 ϕ	50 ϕ	1000	2500	900
6	150 x 7.11	750	16 ϕ	40 ϕ	106	200 x 8.18	1000	20 ϕ	50 ϕ	1100	2500	900
7	150 x 7.11	750	16 ϕ	40 ϕ	107	200 x 8.18	1000	20 ϕ	50 ϕ	1200	2500	900
8	150 x 7.11	750	16 ϕ	40 ϕ	108	200 x 8.18	1000	20 ϕ	50 ϕ	1300	2800	1100
9	150 x 7.11	750	16 ϕ	40 ϕ	109	200 x 8.18	1000	20 ϕ	50 ϕ	1400	2800	1100
10	150 x 9.52	750	16 ϕ	40 ϕ	110	200 x 8.18	1000	20 ϕ	50 ϕ	1500	2800	1100
11	150 x 9.52	750	16 ϕ	40 ϕ	111	200 x 11.13	1000	20 ϕ	50 ϕ	1600	3000	1250
12	150 x 9.52	750	16 ϕ	40 ϕ	112	200 x 11.13	1000	20 ϕ	50 ϕ	1700	3000	1250
13	150 x 9.52	750	16 ϕ	40 ϕ	113	200 x 11.13	1000	20 ϕ	50 ϕ	1800	3000	1250
14	150 x 9.52	750	16 ϕ	40 ϕ	114	200 x 11.13	1000	20 ϕ	50 ϕ	1900	3000	1250
15	150 x 9.52	750	16 ϕ	40 ϕ	115	200 x 11.13	1000	20 ϕ	50 ϕ	2000	3000	1250
16	150 x 9.52	750	16 ϕ	40 ϕ	116	200 x 11.13	1000	20 ϕ	50 ϕ	2100	3300	1400
17	200 x 8.18	1000	16 ϕ	40 ϕ						2200	3300	1400
18	200 x 8.18	1000	16 ϕ	40 ϕ						2300	3300	1550
19	200 x 8.18	1000	16 ϕ	40 ϕ						2400	3300	1550
20	200 x 8.18	1000	16 ϕ	40 ϕ						2500	3300	1550
21	200 x 8.18	1000	16 ϕ	40 ϕ						2600	3300	1550

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Copy Serial No. 01

Issued by: S. K. Upadhyay

Dated: 09.09.99

(Signature & Name)

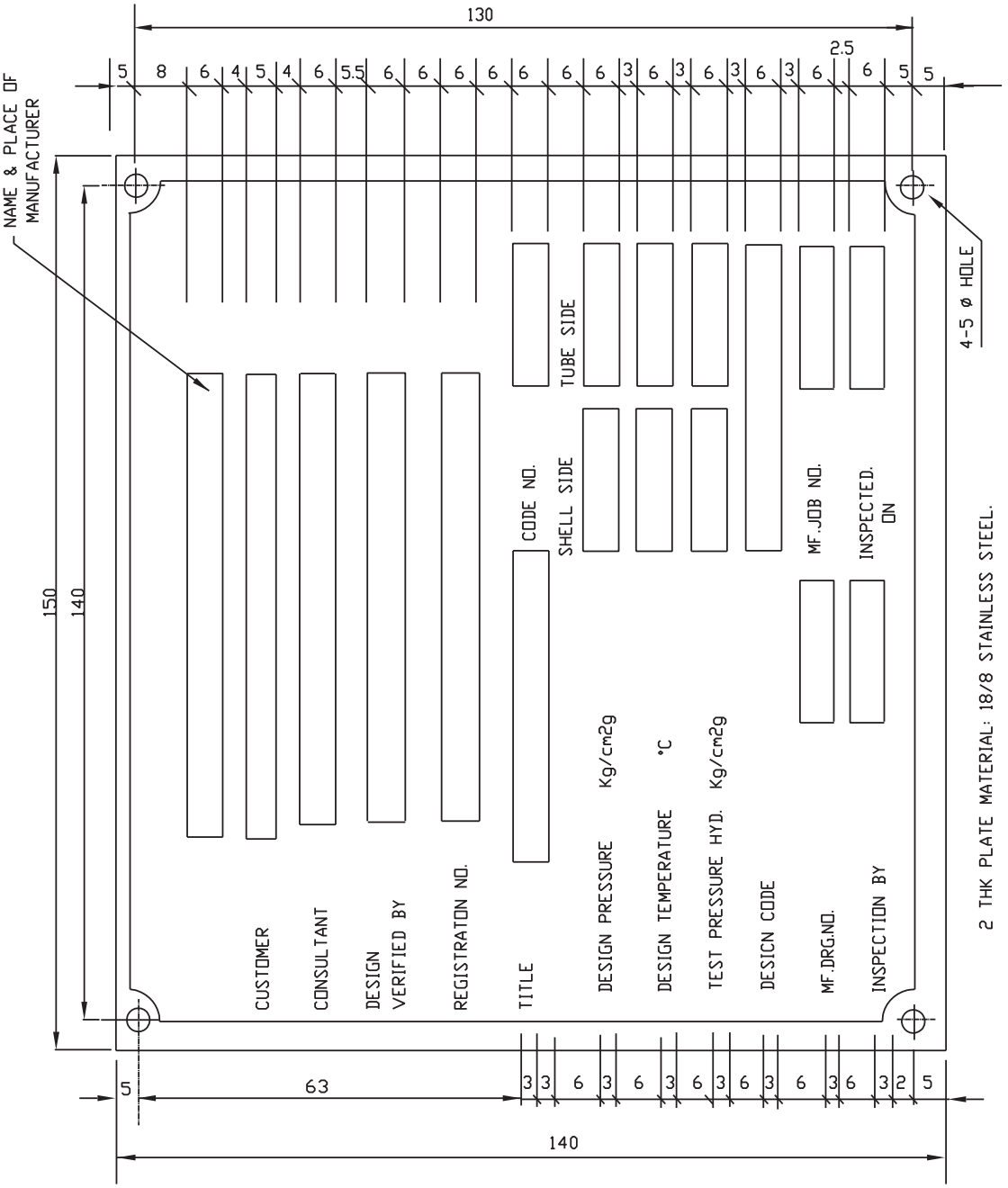
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
31/08/99	ISSUED FOR IMPLEMENTATION			

PDIL

NAME PLATE FOR HEAT EXCHANGERS

-HE321

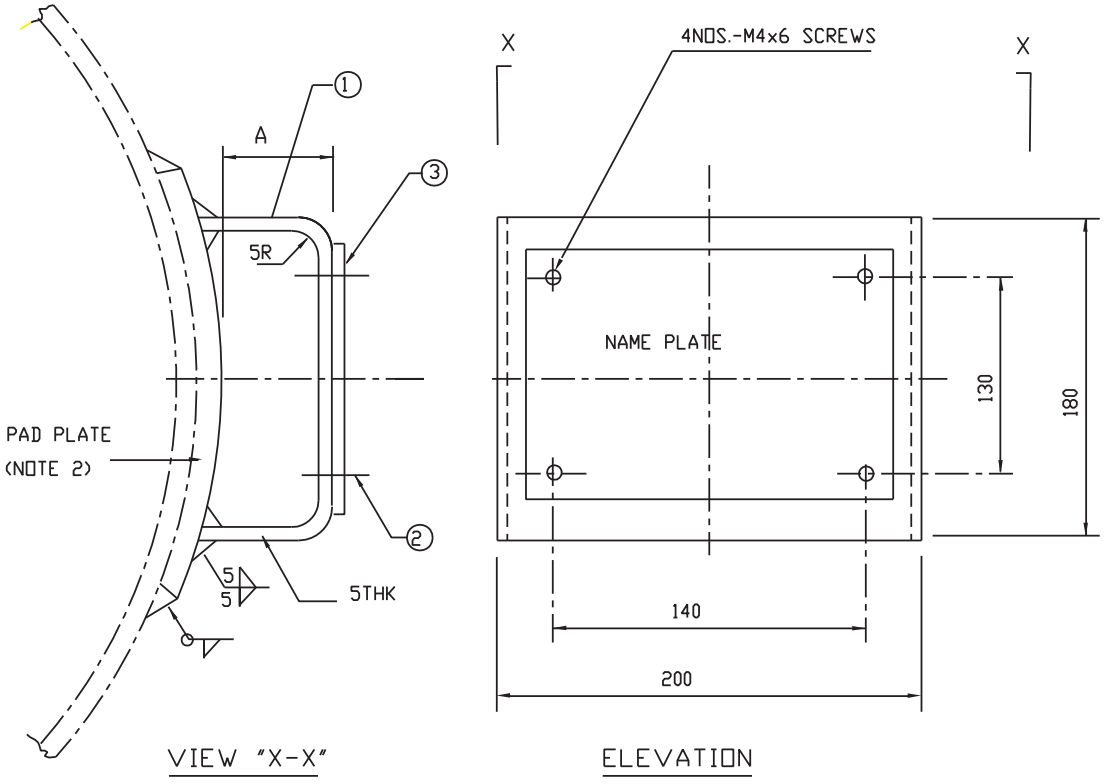
ISSUE:OCT.2003



DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
21.10.03	ISSUED FOR IMPLEMENTATION	TKC	SUJEET	AKG

FILE NAME :1065HE321SH1

NAME PLATE BRACKET



VIEW "X-X"

ELEVATION

DIMENSION "A"

a) VESSELS WITHOUT INSULATION = 25 mm

b) VESSELS WITH INSULATION = INSULATION THK + 25 mm

NOTES:

1 MATERIALS:

BRACKET (1) SA283 Gr.C OR EQUIVALENT

SCREWS (2) S.S.304

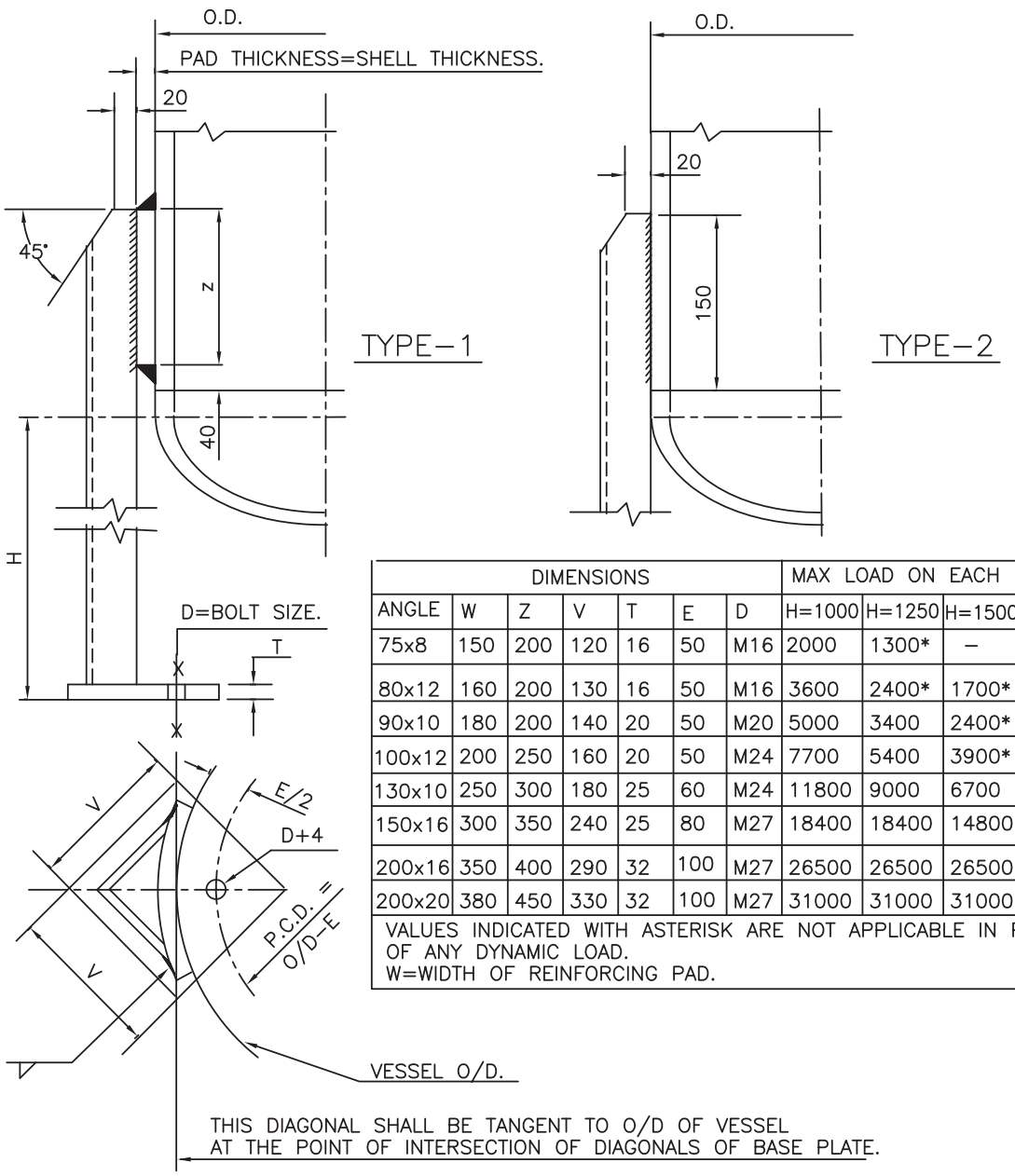
NAME PLATE(3) S.S.304

2 PAD PLATE OF SIMILAR COMPOSITION AS THAT OF SHELL SHALL BE WELDED ON VESSELS OF MATERIALS OTHER THAN CARBON STEEL AND THOSE UNDER LOW TEMPERATURE SERVICE

3 ALL DATA BLOCKS AND LETTERS MUST BE CHEMICALLY ENGRAVED (0.5 m.m.)

DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
21.10.03	ISSUED FOR IMPLEMENTATION	TKC	SUJEET	AKG

FILE NAME :1065HE321SH2



DIMENSIONS							MAX LOAD ON EACH LEG 'P' IN KG.				
ANGLE	W	Z	V	T	E	D	H=1000	H=1250	H=1500	H=1750	H=2000
75x8	150	200	120	16	50	M16	2000	1300*	–	–	–
80x12	160	200	130	16	50	M16	3600	2400*	1700*	–	–
90x10	180	200	140	20	50	M20	5000	3400	2400*	1800*	–
100x12	200	250	160	20	50	M24	7700	5400	3900*	2900*	–
130x10	250	300	180	25	60	M24	11800	9000	6700	5100	3900*
150x16	300	350	240	25	80	M27	18400	18400	14800	11600	9300
200x16	350	400	290	32	100	M27	26500	26500	26500	22000	15500
200x20	380	450	330	32	100	M27	31000	31000	31000	31000	26000

VALUES INDICATED WITH ASTERISK ARE NOT APPLICABLE IN PRESENCE OF ANY DYNAMIC LOAD.
W=WIDTH OF REINFORCING PAD.

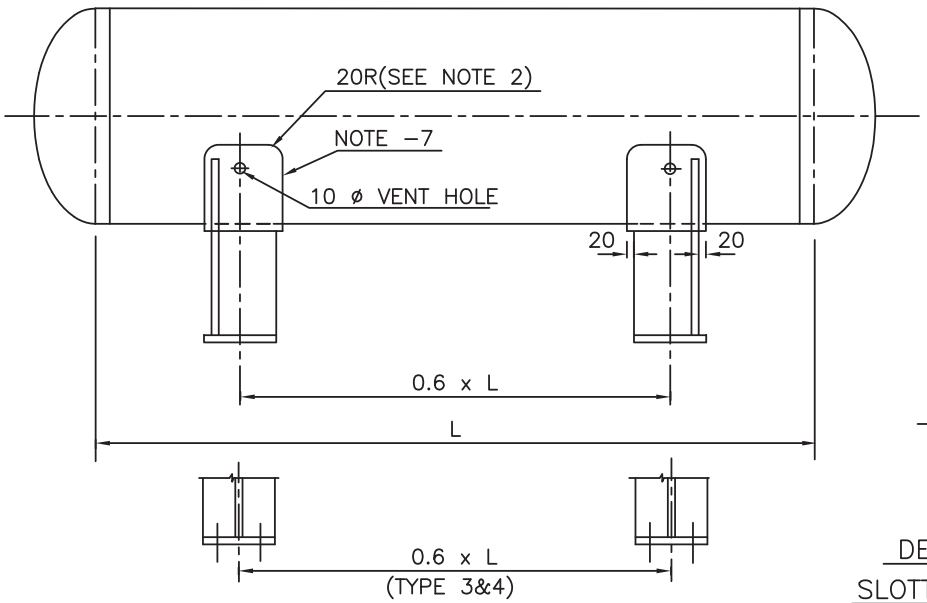
NOTES

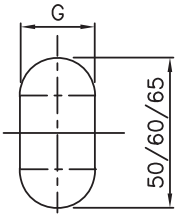
1. WEIGHT ON EACH LEG 'P'>=Q/N+M/C IN KG, WHERE
   Q= WT OF VESSEL FULL OF LIQUID KG.
   N=NO OF LEG SUPPORTS
   M=WIND MOMENT IN Kg cm.
   C=0.75XP.C.D OF FOUNDATION BOLTS FOR 3 LEGS IN CM.
   C=P.C.D OF FOUNDATION BOLTS FOR 4 LEGS IN CM.
2. FOR VESSELS = < 1000 O/D ADOPT 3 NO OF SUPPORTS.
   AND VESSELS >1000 O/D ADOPT MIN. 4 NO. OF SUPPORTS.
3. SUPPORT TYPE 2 SHALL BE USED ONLY FOR TANK = < 600 O/D.
4. DIMENSION 'H' AND TYPE OF SUPPORT ARE TO BE DECIDED AS PER DESIGN CONDITION.
5. REINFORCING PAD SHALL BE OF SAME MATERIAL AS THAT OF SHELL.
6. ALL CORNERS OF REINFORCING PAD SHALL BE ROUNDED TO RADIUS OF 20 MM.
   FOR CARBON AND NICKEL STEEL VESSELS OPERATING AT LOW TEMPERATURES,
   MINIMUM CORNER RADIUS SHALL BE OF 50 MM.
7. ALL WELDS SHALL BE CONTINUOUS, SIZE OF FILLET WELD SHALL BE EQUAL
   TO THE MINIMUM THICKNESS TO BE WELDED.
8. ADOPT SKIRT SUPPORT (PDS:PV 301)PREFERABLY FOR VESSEL HAVING
   HEIGHT TO DIAMETER RATIO >5.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

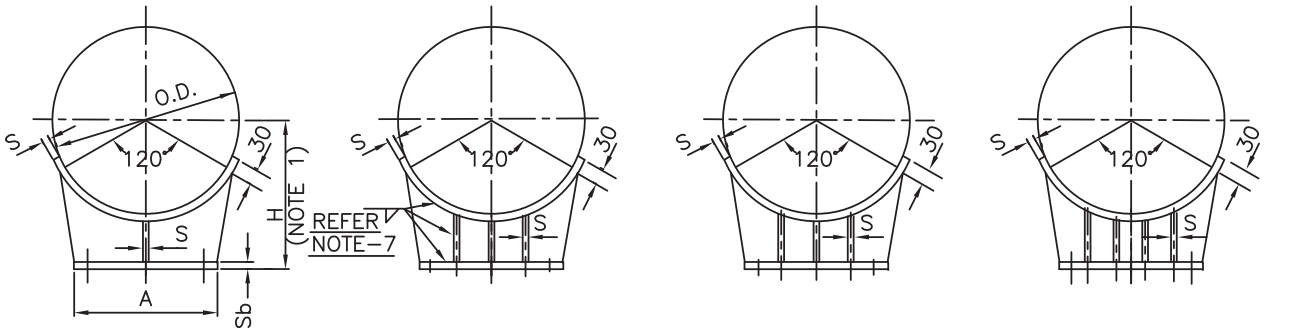
FILE NAME :STD/NCR/SR300

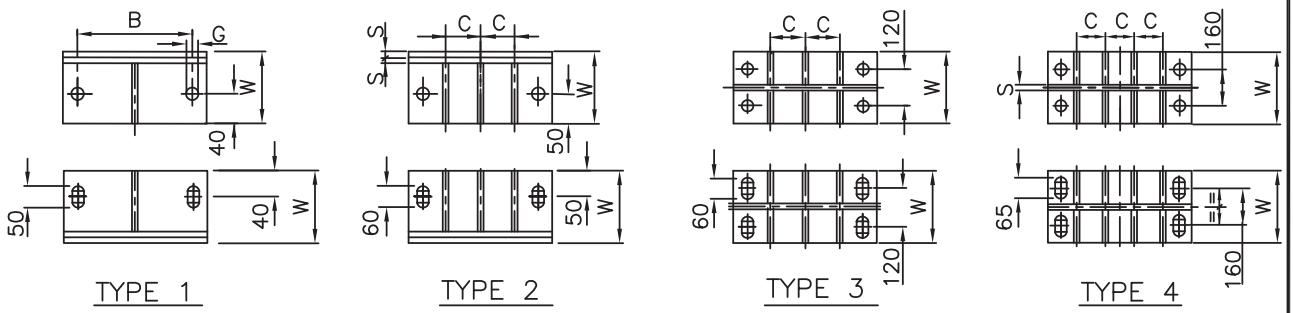
SUPPORT SADDLE FOR HORIZONTAL VESSELS





DETAIL OF SLOTTED HOLES





NOTES:

1. DIMENSION 'H' TABULATED ASSUMES A MAXIMUM PROJECTION OF ANY PART BELOW THE SHELL 250mm. WHERE ANY PART PROJECTS BEYOND 250 mm, 'H' SHALL BE EQUAL TO MAXIUM PROJECTION PLUS 50 mm.
2. FOR CARBON STEEL AND NICKEL STEEL VESSELS OPERATING AT LOW TEMP., CORNERS OF WRAPPER PLATE SHALL BE ROUNDED TO A RADIUS NOT LESS THAN 50mm.
3. IN CASE OF VESSELS OF STAINLESS STEEL OR OTHER ALLOY MATERIALS,THE WRAPPER PLATE SHALL BE OF SAME MATERIAL AS THE SHELL.
4. IN CASE OF CONFLICT BETWEEN THE DIMENSIONS GIVEN HERE AND THOSE SHOWN ON THE DRAWINGS, THE LATTER SHALL GOVERN.
5. NUTS FOR BOLTS PASSING THROUGH SLOTTED HOLES SHALL BE LEFT LOOSE.
6. SLIDE PLATE SHALL BE PROVIDED BELOW THE BASE PLATE IN CASE OF VESSELS WHERE UNUSUAL EXPANSION IS EXPECTED. OR EQUIPMENT SUPPORTED ON STEEL STRUCTURE. SIZE OF SAME SHALL BE 100 mm HIGHER IN LENGTH AND WIDTH OF BASE PLATE.
7. FILLET WELDS SHALL BE CONTINUOUS & SIZE 0.7xTHK. OF THINNER PLATE MIN. 6mm.
8. FOR INTERMEDIATE DIAMETER THE SADDLE OF SMALLER SIZE SHALL BE USED.

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION			

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SUPPORT SADDLE FOR HORIZONTAL VESSELS

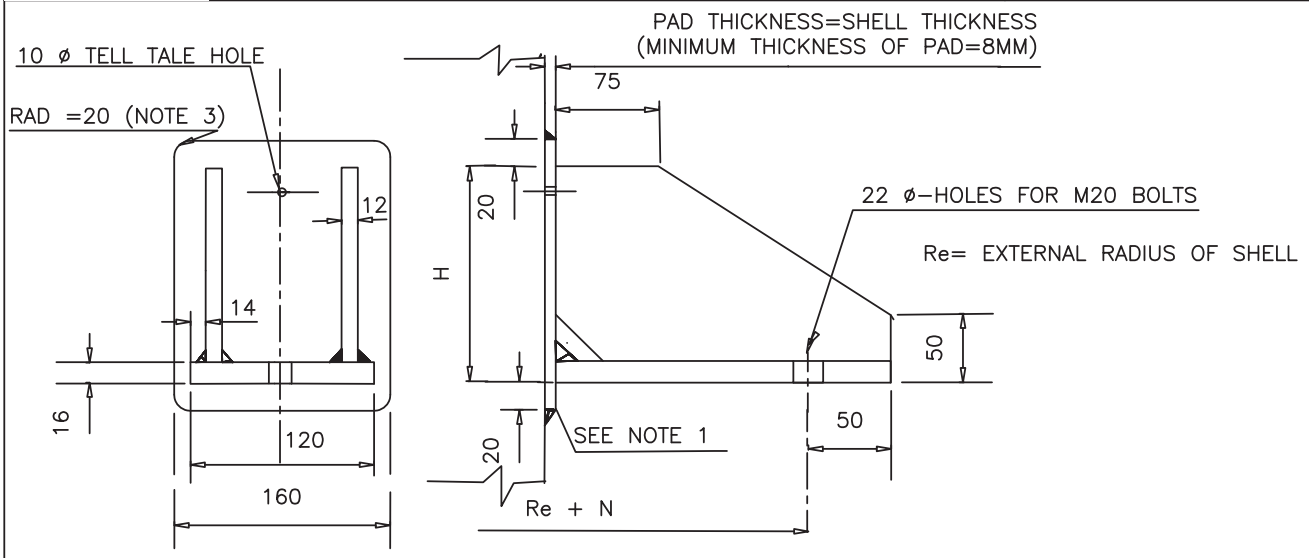
	SHELL O.D.	A	B	C	S	Sb	BOLT SIZE	G	H	W	WT. IN KG.
TYPE 1	324	290	210	–	6	10	M16	22	460	110	15
	355	320	240	–	6	10	M16	22	480	110	20
	406	360	280	–	6	10	M16	22	500	110	25
	508	450	370	–	6	10	M16	22	550	110	25
TYPE 2	600 TO 700	530	450	180	8	12	M20	26	650	130	40
	701 TO 800	620	540	210	8	12	M20	26	700	130	40
	801 TO 900	710	610	240	8	12	M20	26	750	130	50
	901 TO 1000	790	690	270	8	12	M20	26	800	130	55
	1001 TO 1100	880	780	320	10	12	M20	26	850	130	60
	1101 TO 1200	960	860	360	10	12	M20	26	900	130	70
	1201 TO 1300	1050	950	400	10	12	M20	26	950	130	70
TYPE 3	1301 TO 1400	1140	1040	440	12	16	M20	26	1000	200	125
	1401 TO 1500	1230	1130	480	12	16	M20	26	1050	200	130
	1501 TO 1600	1320	1200	520	12	16	M20	26	1100	200	135
	1601 TO 1700	1400	1280	560	12	16	M20	26	1150	200	145
	1701 TO 1800	1490	1370	600	12	16	M20	26	1200	200	155
	1801 TO 1900	1570	1450	630	12	16	M20	26	1250	200	160
	1901 TO 2000	1660	1520	660	12	16	M20	26	1300	200	170
TYPE 4	2001 TO 2100	1750	1610	480	12	16	M24	30	1350	250	275
	2101 TO 2200	1840	1700	510	12	16	M24	30	1400	250	285
	2201 TO 2300	1930	1790	540	12	16	M24	30	1450	250	300
	2301 TO 2400	2020	1880	570	14	20	M24	30	1500	250	310
	2401 TO 2500	2100	1960	600	14	20	M24	30	1550	250	320
	2501 TO 2600	2190	2050	620	14	20	M24	30	1600	250	390
	2601 TO 2700	2270	2130	650	14	20	M24	30	1650	250	400
	2701 TO 2800	2360	2200	670	14	20	M24	30	1700	250	415
	2801 TO 2900	2450	2290	700	14	20	M24	30	1750	250	430
	2901 TO 3000	2540	2330	720	14	20	M24	30	1800	250	440
	3001 TO 3100	2620	2460	740	16	20	M24	30	1850	250	450
	3101 TO 3200	2710	2550	770	16	20	M24	30	1900	250	470
	3201 TO 3300	2800	2640	800	16	20	M24	30	1950	250	485
	3301 TO 3400	2880	2700	820	16	20	M24	30	2000	250	500
	3401 TO 3500	2970	2780	840	16	20	M24	30	2050	250	510
	3501 TO 3600	3060	2870	870	16	20	M24	30	2100	250	520
	3601 TO 3700	3140	2950	900	16	20	M24	30	2150	250	540

DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION			

FILE NAME :STD/PPS/SR302

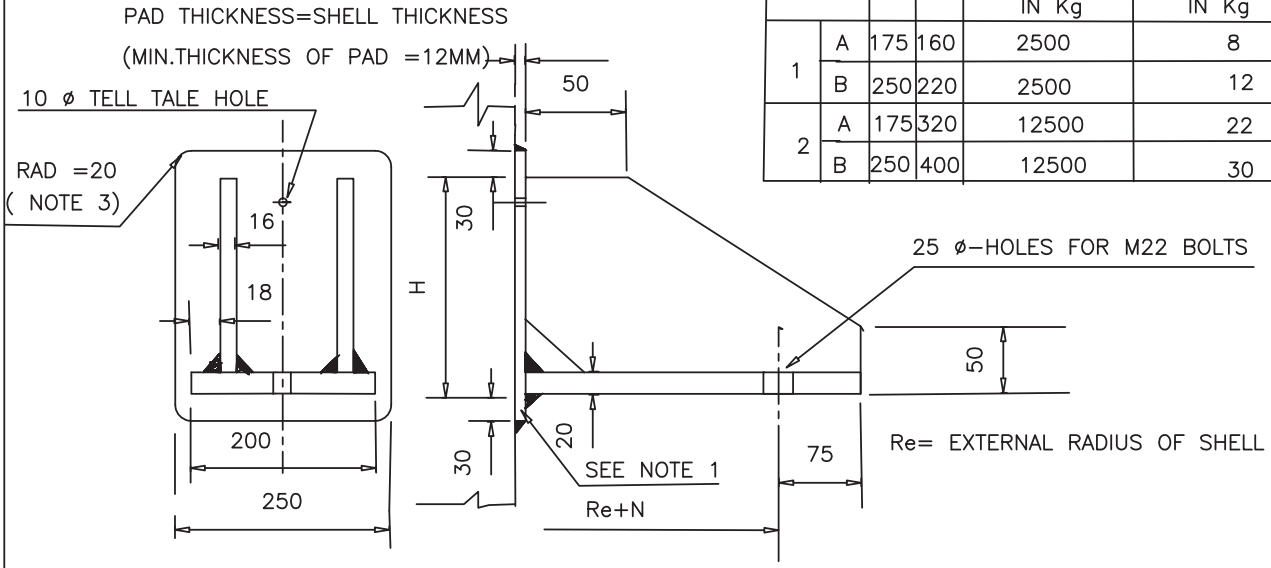
BRACKET SUPPORT FOR VERTICAL VESSEL

PDS:SR 304	0
DOCUMENT NO.	REV
SHEET 1 OF 1	



TYPE–1

TYPE OF BRACKET		N	H	MAX.LOAD FOR EACH BRACKET IN Kg	WEIGHT OF EACH BRACKET IN Kg
1	A	175	160	2500	8
	B	250	220	2500	12
2	A	175	320	12500	22
	B	250	400	12500	30



TYPE–2

NOTES

1) IF THE SHELL IS MADE OF S.S. OR OF SPECIAL MATERIAL, PROVIDE A REINFORCING PAD OF THE SAME MATERIAL AS THAT OF SHELL.
2) ALL THE WELDS SHALL BE CONTINUOUS.THE FILLET SIZE SHALL BE EQUAL TO THE MINIMUM OF THE THICKNESSES TO BE WELDED.
3) FOR CARBON AND NICKEL STEEL VESSELS OPERATING AT LOW TEMPERATURES,MINIUM CORNER RADIUS SHALL BE 50MM.

RECOMENDATION FOR USE

–IN GENERAL,THE BRACKET TYPE 1 SHOULD BE USED FOR VESSEL OF DIA < = 1000MM.
–FOR LARGER DIA, USE BRACKET TYPE 2.
–A OR B IS TO BE SELECTED DEPENDING UPON OBSTRUCTIONS
(SUCH AS INSULATION,EXPANSION JOINT, STUB PIPE, ETC)
–HOWEVER,THE TYPE AND NO.OF BRACKET SHALL BE DECIDED AS PER DESIGN.
–VESSELS>600 O.D. SHALL HAVE MINIMUM 4 NO. OF BRACKETS.

REV	DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
0		ISSUED FOR IMPLEMENTATION			

FILE NAME :STD/RPAL/SR304

DESIGN PHILOSOPHY – ROTATING EQUIPMENTS

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY
PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

REV	REV DATE	EFF DATE	PURPOSE	PRPD	REVD	APPD
0	15.1.21	15.1.21	Issued for Tender	NY	ASR	RRK
P	26.10.20	26.10.20	Issued for Tender	NY	ASR	RRK

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1.0	SCOPE
2.0	DESIGN PHILOSOPHY FOR MACHINERY
3.0	DESIGN REQUIREMENTS
4.0	INSPECTION AND TESTING
5.0	SPARES
6.0	PAINTING
7.0	VENDOR LIST
8.0	LSTK CONTRACTOR/ VENDOR DOCUMENTATION

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
ANNEXURE - 1	INSPECTION & TESTING GUIDE LINES – ROTATING EQUIPMENT	2

1.0 SCOPE

1.1 General

1.1.1 This Philosophy states that contractor's scope of work shall include basic & detailed engineering, procurement, supply, manufacturing, fabrication, transportation, loading, unloading, insurance during transit, storage, construction, erection/ installation of all **Mechanical Rotating Equipment** with allied electrical, instrumentation and civil works, obtaining all necessary statutory approvals from concerned government authorities as applicable, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs including total project management and handing over of **425 MTPD Ammonium Nitrate (AN) melt plant along with associated facilities at RCF, TROMBAY on a lump-sum turnkey basis on single point responsibility**

1.1.2 In addition, all statutory rules & regulations shall also be complied with.

2.0 DESIGN PHILOSOPHY FOR MACHINERY

2.1 Codes and Standards

The ***Latest Edition*** of codes and standards as listed below shall be followed for design and manufacturing of different machinery items. Generally the manufacturer will comply with these codes and standards as indicated therein with minor deviations that are normally adopted by manufacturer and are reasonably accepted as per good engineering practice.

A list of such deviations, if any, may be furnished by the LSTK Contractor along with offer. Deviations / exceptions against API requirement/ guidelines, if any, furnished by successful bidder are subject to owner's review and approval during detail engg.

Code	Description
API 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industry
ANSI/ ASME B 73.1 M	Horizontal, End Suction centrifugal Pumps for Chemical Process
International Standard	Horizontal Centrifugal Pumps for Clear Cold Water
API 611	General-Purpose Steam Turbines for Refinery Service.
API 612	Petroleum, Petrochemical and Natural Gas Industries Steam Turbine - Special Purpose application
API 613	Special Purpose Gear Units for Petroleum, Chemical and

	Gas Industry Services
API 614	Lubrication, Shaft-Sealing, and Control Oil System for Petroleum, Chemical and Gas Industry Services
API 617	Axial, Centrifugal Compressors and Expander Compressor for Petroleum, Chemical and Gas Industry Services
API 618	Reciprocating Compressors for Petroleum, Chemical and Gas Industry Services
API 619	Rotary Type Positive Displacement Compressors for General Refinery Services.
API 670	Vibration, Axial-Position, and Bearing- Temperature Monitoring Systems.
API 671	Special Purpose Coupling for Refinery Services, Petrochemical and Gas Industry .
API 673	Special Purpose Centrifugal Fans for General Refinery Services.
API 674	Positive Displacement Pumps-Reciprocating
API 675	Positive Displacement Pumps-Controlled Volume
API 676	Positive Displacement Pumps-Rotary.
API 678	Accelerometer based Vibration Monitoring Systems.
API 682	Shaft sealing Systems for Centrifugal and Rotary Pumps.
API 685	Sealless Pump (Magnetic & Canned)
ISO / DIN	Centrifugal Pumps for smaller size & Non Critical Services.
International Standard, ASHRAE / ISHRAE	HVAC
Performance Testing (ASME Codes)	
PTC 8.2	Centrifugal Pump
PTC 6	Steam Turbines
PTC 9	Displacement Compressors
PTC 10	Centrifugal Compressors
PTC 11	Centrifugal Fans
AGMA Standard	

420	Practise for Enclosed Reducers or Increasers using Spur, Helical, Herringbone and Spiral Bevel Gears.
421	Practise for High Speed Helical Gear Units.
NEMA Standards	
SM 23	Steam Turbine for Mechanical Drive Service.

2.2 Design Life

All equipment shall be designed for a minimum service life of 20 years and at least 2 years of uninterrupted operation under normal operating conditions. This requirement excludes specialised components requiring periodic maintenance and replacement.

2.3 Essential Project Reference Documents

The following documents shall be observed, and relevant aspects incorporated into specifications and datasheets:

- Process Description, Specifications and Data Sheets from Licensor
- Hazardous Area Classification
- Electrical and Instrumentation Design Criteria

2.4 Regulations

Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations together with Local by Laws for the state including statutory requirements as applicable.

2.5 Site Conditions

Site conditions shall be as defined elsewhere.

2.6 Material of Construction

Generally Materials of construction shall be as per the process licensor's recommendation. However, API guideline may be adopted to the extent applicable.

Use of equivalent & superior material may be selected & shall be furnished with the offer along with chemical composition.

2.7 Quality Assurance & Control

2.7.1 The quality assurance shall be as per the approved procedures, test methods & facilities to be developed by the LSTK Contractor to ensure that the supplied equipment shall be of highest quality. The quality control shall mean that all the tests , measurements, checks & calibration which are to be carried out may be compared with the actual specified characteristics of the equipments/unit /system.

2.7.2 Quality Assurance (QA) shall mean the organizational set up, procedures as well as test methods and facilities developed by LSTK Contractor in order to assure that the machines & associated auxiliaries leaving LSTK Contractor's shop are of the highest possible quality i.e. either equal to or better than the requirement specified.

2.7.3 Quality Control (QC), shall mean all the tests, measurement, checks and calibration which are to be carried out in LSTK Contractor's shop in order to compare the actual characteristics of the equipment/unit/system with the specified ones, along with furnishing of the relevant documentation (certificates/records) containing the data or result of these activities.

2.7.4 LSTK Contractor shall submit a comprehensive description (manual) of QA/QC measures contemplated by him for implementation with regard to this specification. It is contractual obligation of the LSTK Contractor to develop and implement adequate QA/QC systems.

2.7.5 QA/QC system shall cover all products and services required for the complete machine unit as per scope of work including job sub contracted by the LSTK Contractor.

3.0 DESIGN REQUIREMENTS

3.1 General

3.1.1 All machines shall be directly coupled to their prime movers. Belt drive for transmission shall be avoided. If not, specifically mentioned, the drivers shall have rated output at least 10% greater than the power requirement at design operating condition of the driven equipment.

3.1.2 Copper (Cu) or Cu-alloy shall not be used for any components in .

3.1.3 All process pumps shall have Mechanical Seals. Single seals will be used in most cases, however, for ignitable or hazardous fluids, double, or Inside Wet and Outside Dry running seals will be used. Non-process/ non-critical pumps shall also have mechanical seal.

3.1.4 Special tools and wrenches required for installation and maintenance shall be provided.

3.1.5 LSTK Contractors have to submit the reference list for similar equipment's models (minimum 2 nos.) supplied in past for similar duty conditions. Reference list must contain at least the following: Fluid handled Capacity, Suction Pressure, Discharge Pressure, Model No., Power consumption, Client Name, Address, and Year of supply.

3.1.6 Coast down tank shall be provided in the Lube Oil System. Lube oil system shall have Main oil pump, auxiliary oil pump and emergency oil pump with power back-up arrangement. Lube oil system to also comply API-614.

3.1.7 Dedicated portable oil clarifiers with all hose & piping connection for each compressor trains to be provided.

3.1.8 Besides major process compressors , low capacity and intermittently used process compressors shall also be provided with permanent mounted vibration sensors and allied system for safe operation.

3.1.9 Noise level for all rotating equipment shall be limited to 85 dBA measured at 1meter distance from the equipment.

3.2 Centrifugal compressors

The centrifugal compressors shall conform to API 617, latest edition. In addition, following points shall be applicable:

3.2.1 All machines shall have stable operating characteristics. The head generated shall rise continuously from choke point to surge point.

3.2.2 The manufacturer's criteria for suction and discharge piping shall be incorporated into the piping design and layout.

3.2.3 Torsional and lateral critical speed analysis shall be carried out and it shall be ensured that no critical speed (Torsional or lateral) shall be within 15% of any operating speed.

3.2.4 Casings shall be preferably centre line supported.

3.2.5 Vertical split (Barrel type) compressors shall have the inner casing designed for easy withdrawal from the outer shell and easy reassembly for inspection or replacement of parts.

3.2.6 Impellers shall be welded or electrochemically eroded. Tip speed of the impeller shall not exceed 310 m/s.

3.2.7 Labyrinths seals preferably made of stainless steel shall be used for Air service.

3.2.8 Diaphragm type coupling of proven make, Shim pack dry flexible coupling from reputed coupling manufactures like M/s Turboflex, Euroflex & KOP Flex shall be used. The couplings shall be designed as per API-671.

3.2.9 Dry Gas seals shall be provided for major Process Gas compressors.

3.2.10 Combined lubrication and seal oil system (as applicable) shall be provided as per API 614 (latest edition) for each compressor and drive turbine. All the lube oil piping shall be made of SS.

3.2.11 Twin oil cooler and twin oil filter shall be provided.

3.2.12 For machines with oil seals, two seal oil traps shall be provided with each casing - one for each seal. These traps shall be sized and interconnected so that each trap is capable of accepting the flow from both the seals while one trap is removed for maintenance.

3.2.13 Complete Anti-Surge control system with computerised calculations with compressor characteristics shall be provided for each machine.

3.2.14 Shaft vibration monitoring instruments (both radial and axial) shall be provided to trip the machine in case of high radial vibration or axial movement.

3.2.15 All the trip interlock shall be two out of three voting logic. Instrumentation design philosophy of NIT to also to be referred.

3.2.16 All the transmitters shall be smart type and suitable for communication with DCS.

3.3 Reciprocating Compressors

The reciprocating compressors shall conform to API-618, latest edition. In addition to the above, the following shall be applicable:

3.3.1 Lateral and torsional critical speed analysis shall be carried out to ensure the elimination of any lateral and torsional vibration that may hinder the operating speed range.

3.3.2 Machine shall be balanced to minimise lateral loads.

3.3.3 The piston speed for lubricated cylinder shall not exceed 4 m/s and for non-lubricated cylinders it shall be limited to 3 m/s.

3.3.4 Distance piece of non-lubricated compressor shall of sufficient length to ensure that no oil is in contact with gland packing.

3.3.5 The design of compressor valve shall be such that the valve assembly cannot be inadvertently reversed e.g. Suction valve cannot be fitted into the discharge port.

3.3.6 Valve plates and springs shall be made of stainless steel. PEEK may be used for valve plates in case the vendor has experience of using it for similar service and duty conditions.

3.3.7 Cylinders shall be water cooled.

3.3.8 The maximum piston rod loading shall be calculated considering safety valve set pressure.

3.3.9 Non-lubricated compressors shall be provided with piston rings, packing made of carbon filled PTFE or equivalent.

3.3.10 The packing boxes shall be provided with atmospheric vents to minimize gas leakage.

3.3.11 Pulsation dampeners shall be provided for meeting the residual pulsation requirements as per API.

3.3.12 For API compressors the requirements for acoustic study shall be in accordance with the API recommendation.

3.3.13 To minimise the need for heavy overhead pipe structures, suction and discharge piping to and from the knockout drums should run close to grade, supported on sleepers.

3.3.14 Frame lubrication system shall be provided with auxiliary pump driven by electric motor for initial lubrication.

3.3.15 Cylinder lubrication, if required, shall be provided by a separate forced feed mechanical lubricator complete with necessary tubing/piping, check valve and sight flow indicator.

3.3.16 Manufacturer's standard based on national / international standards can also be accepted for special duty like passivation Air Compressor and other Non-Critical smaller machines. However Bidder to follow the Vendor list attached with the NIT for the selection of Vendors.

3.3.17 Full flow twin oil filter shall be provided.

3.4 Screw Compressor (If applicable)

The Ammonia Compressor shall be designed as per API 619 latest edition. However as per Licensor's recommendation, Bidder may also opt for Centrifugal Compressor designed as per API 617 (latest edition)

3.5 Centrifugal Pumps

The process pumps shall be designed as per API 610, latest edition. The pumps shall be of robust design to ensure long service life and minimum maintenance requirement. The pumps shall be designed for easy access for inspection and maintenance. All continuously running pumps shall have a spare pump.

In addition to codes & standards, following points shall also be applicable:

3.5.1 All pumps shall have continuously rising head curve from any specified operating point to shut off point. Pumps running in parallel shall have equal head rise to shut off point.

3.5.2 The pumps should have stable operating characteristics. The pump head at shut off shall be approximately 110% of head at rated capacity and not exceeding 120%.

3.5.3 Best efficiency point shall be as close as possible to normal operating point.

3.5.4 Impellers of multistage pumps shall be secured positively against axial movement.

3.5.5 For multistage pumps, a lateral critical speed analysis shall be carried out.

3.5.6 Pumps with centre line support shall be provided for pumps handling fluids of operating temperature more than 177^0C.

3.5.7 The maximum calculated axial load shall not in any operating condition exceed 50% of bearing manufacturer's load rating.

3.5.8 Shim pack dry flexible coupling from reputed coupling manufactures like M/s Turboflex, Euroflex & KOP Flex shall be used. Coupling guard shall be non-sparking for pumps located in hazardous area.

3.5.9 Mechanical seal of John crane / Flowserve / Eagle-Burgmann/ Equivalent reputed make only shall be provided. Only balanced mechanical seal shall be used.

3.5.10 For pumps with forced lubrication system, the lubrication system shall be designed as per API 614 latest edition.

3.5.11 All running pumps shall have a stand-by pump.

3.5.12 Cooling water pumps shall be horizontal split casing type with mechanical seals.

3.6 Reciprocating Pump / Metering pumps

Reciprocating pump shall be designed as per API 674 latest edition and metering pump shall be designed as per API 675 latest edition.

3.6.1 The metering pumps shall be suitable for continuous capacity variation from 0 to 100%. The capacity variation should be possible while the pumps are working.

3.6.2 All running pumps shall have a stand-by pump.

3.7 Steam Turbine

Steam turbine shall be designed as per API 611 or API 612, latest edition, as specified in Specification sheet.

3.7.1 Turbine driver and driven equipment shall be mounted on a common base plate unless otherwise specified on turbine specifications sheet. Turbine manufacturer shall provide dimensional and load data to driven equipment supplier for design and supply of common base plate by driven equipment supplier.

3.7.2 Piping connected to turbine shall be designed to limit forces, stresses, vibration and noise to acceptable limits as per relevant codes (API 611 and API 612) on account of flow, pressure and temperature conditions of fluid flowing through them. Adequate anti-vibration supports, springs, etc. shall be provided to limit vibrations and accommodate thermal movements.

3.7.3 Noise level shall be limited to 85 dBA at one metre distance by provision of silencers/acoustic insulation and/or noise hood as may be necessary.

3.7.4 Special provisions for emergency lube oil supply to bearings and gears shall be made in case of power failure. This shall require overhead reserve oil tank to supply lube oil at adequate pressure when there is breakdown of power. Necessary control circuit shall also be provided for this system.

3.7.5 All main and auxiliary piping shall be laid out in neat fashion to allow adequate clearances for operation and maintenance (Min 900 mm), and head rooms (Min 2200 mm) for working personnel. Design shall allow maintenance of parts without dismantling piping or supports.

3.7.6 The turbine and auxiliary equipment shall be designed for outdoor operation totally unprotected from weather, but due to grouping of equipment they may be installed in a common building for convenience in operation. Several compressors, turbines shall be placed at common operating platform and maintained by an overhead travelling crane. The crane capacity shall be decided based on maximum weight of maintenance part to be lifted. A loading bay shall be kept open for erection and maintenance purposes.

3.7.7 Local control panel shall be adjacent to turbine for easy operation.

3.7.8 All valves and controlling devices shall be within easy reach for convenient and quick attention by operators.

3.7.9 Turbine auxiliaries such as lubrication circuit with tanks and exchangers, stage heaters, safety valves, etc. shall be arranged with economising space and provided with suitable devices for removal and maintenance.

3.8 Centrifugal Fans

Centrifugal fans shall be designed as per API 673, latest edition for critical services and for non-critical services manufacturer's standard based on national / international standards may be applicable.

3.8.1 Forced and induced draught fans shall be coupled to drivers through shim pack dry flexible coupling, and the complete assembly shall be mounted on a substantial bedplate.

3.8.2 First critical speed of the rotor shall be higher than 120% of rated speed.

3.8.3 Capacity control shall be achieved by means of dampers (Preferably on suction side) specially for constant speed fans.

3.8.4 The fan casing shall be suitably split such that impeller assembly can be removed for maintenance without disturbing inlet and outlet ducting.

3.8.5 SS bolts and nuts shall be provided for the split casing joints of fans for corrosive service.

3.8.6 The drive motors of the fans should be designed with additional capacity to take care of surge loading. However Motor rating shall be minimum 125 % of shaft power for shaft power up to 22 KW, 115 % of shaft power for shaft power between 22 – 55 KW and 110 % of shaft power for shaft power above 55 KW.

3.8.7 Bearing shall be preferably oil lubricated.

3.9 Agitator

3.9.1 Assembly shall be such as to enable replacement of bearings, shaft sealing devices, gear unit and driver without dismantling other major parts of unit and without emptying or depressurising the vessel.

3.9.2 First critical speed of the rotor shall not be less than 140% of rated speed.

3.9.3 Adequate space shall be provided for packing replacement without removing or dismantling of any part other than the gland and the seal cage.

3.9.4 Motor rating shall be minimum 125% of shaft power.

3.9.5 Shim pack dry flexible coupling shall be provided between the power drives and agitator shaft or gear, and shall have minimum service factor of 2.

3.9.6 Spacer type coupling shall be provided for units provided with Mechanical Seals. The spacer shall be of sufficient length to permit replacement of the seal assembly without removing the driver / gear.

3.9.7 Gear unit shall be provided in accordance with AGMA standard. Gear box rating shall be selected based on minimum service factor of 1.5.

3.10 HVAC System

Air conditioning system & air flow ventilation rate should be sufficient to satisfy not only air removal specification, but also to maintain over pressure and temperature specification. It should be also capable to avoid wind penetration in order to meet the requirements of a conditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution should be considered in design & selection of HVAC equipment. Eco-friendly refrigerant to be used in HVAC equipment. All civil buildings, Control room, Sub-stations, labs etc to be equipped

with suitable HVAC system with 100 % redundancy. Chemical filters are to be used for critical area like Control room building .

3.11 EOT Cranes

LSTK Contractor to provide EOT Cranes of adequate capacity in various Pump Houses, Compressor & turbine House and other location wherever required for ease in operation and maintenance activities . Cranes to be provided in nearest multiple of 5 Metric Tonnes considering maximum weight to be lifted. Relevant Indian/ ISO Standards to be applicable for EOT Crane . All statutory guidelines to be complied by the contractor/ sub-contractor.

4.0 INSPECTION & TESTING

Machines shall be inspected by Third Party Inspection Agency. The Inspection and testing shall be in accordance with the all relevant codes, standards, specifications, including the minimum guide line given in Annexure – 1 (attached).

4.1 All testing accessories, measuring instruments including NDT testing equipment, etc. shall be arranged by LSTK Contractor. DM water shall be used for hydro testing of the equipment.

4.2 In general, following tests shall be conducted for all rotating equipments including stand-by equipment as well:

- Material test
- Non-destructive test

Below testing shall be subject to Witness by TPI & owner :-

- Hydrostatic test for all the pressure containing parts Dynamic balancing of rotor
- Over speed test of impeller (only for compressors)
- Helium leak test of compressor casing (if required as per API Code)
- Mechanical running test of compressor and turbine
- Barring over check for reciprocating compressor
- NPSHR test for pumps
- Performance Test
- Disassembly Test

The tests required to be conducted and witnessed shall be specified in the equipment data sheet & QAP to be furnished by the Vendor . Disassembly test for Fans, Blowers & small Pumps can be waived –off in case no problem occurs during mechanical / performance Test.

5.0 SPARES

5.1 All erection & commissioning spares shall be supplied by LSTK Contractor & cost shall be included in the cost of main equipment.

5.2 2 years operation spares / recommended spares, Mandatory spares etc shall be supplied by the contractor as per NIT.

6.0 PAINTING

6.1 All exterior non-stainless steel surfaces subject to atmospheric corrosion with the exception of machined surfaces shall be epoxy painted.

6.2 All exterior machined surfaces shall be coated with suitable rust preventives.

7.0 VENDORS LIST

All equipment shall be procured / fabricated as per approved vendor list. However, LSTK contractor may have to furnish Proven track record / reference record of any vendor opted for specified services / equipment, if, owner desires.

Any equipment for which vendor list is not enclosed, LSTK Contractor may furnish a list of proposed vendors along with their references for supply of similar type of equipment along with bid. However all proposed additional sub-vendors shall have well proven track record and shall be subjected to owner's / consultant approval during detail engg.

8.0 LSTK CONTRACTOR/VENDOR DOCUMENTATION:

Drawings & Documents of machinery items/ rotating equipment shall be as mentioned elsewhere in the ITB.

ANNEXURE-1

INSPECTION & TESTING GUIDE LINES – ROTATING EQUIPMENT

1.0 SCOPE

This document covers the minimum guide lines for the Inspection & Testing for the rotating Equipments.

All rotating Equipments shall be inspected by Third Party Inspection Agency. The Inspection and testing shall be in accordance with the all relevant codes, standards, and specifications as specified in Specification sheet.

2.0 PUMPS, TURBINES AND DRIVERS

2.1 Pump and turbine casings to be identified against foundry test certificates and thickness checked to conform to approved drawings.

2.2 Witness hydrostatic test on casings.

2.3 Dynamic balancing of rotor

2.4 Witness running tests on pumps including N.P.S.H. where applicable.

2.5 Non- destructive test

2.6 Strip inspection of pumps on completion of running tests. Wearing surfaces to be checked and recorded. As a general principle, mechanical seals will not be dismantled after running tests. This necessity will be discussed on a case to case basis if abnormal noise or temperature has need records during testing. All materials to be checked against test certificates or VENDOR'S bill of materials.

2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).

2.8 Heat run or standard abbreviated tests, as specified, to be witnessed on electric motor drives.

2.9 Final inspection and dimensional check to be carried out on motor drivers.

2.10 For steam turbine drivers, hydrostatic test on pressure parts to be witnessed.

2.11 Running tests on steam turbines to be witnessed.

2.12 Final inspection and dimensional check on steam turbines to be done.

2.13 Check all test certificates.

3.0 COMPRESSORS / BLOWERS AND DRIVERS

3.1 Material of casings or cylinders to be checked against test certificates.

3.2 For fabricated casings, inspection shall be as per API 617/API 618.

3.3 Hydrostatic test on casings or cylinders to be witnessed.

3.4 Dynamic balancing of rotor

3.5 Non- destructive test

3.6 For fabricated impellers, welding procedure and welder's qualifications to be established and impellers to be inspected before assembly. Impellers overspeed, NDT after overspeed and dimensional inspection.

3.7 Ensure that overspeed tests on impellers have been carried out and related certificate for dynamic balancing of impellers and subsequently the complete rotating assembly shall be provided. The over speed test shall be carried out to prove the impeller proper balancing and relevant certificate shall be provided.

3.8 Witness leakage test on lube oil tank and carry out internal and external inspection. Tank to be finally inspected after internal coating and /or painting.

3.9 Inspect prefabricated lube oil piping.

3.10 Witness performance tests shall be done and check all safety and alarm devices when contact instrumentation is fitted.

3.11 If spare rotating assembly is ordered, any running tests with spare fitted or the dropping of the spare into the casing, as may be specified, to be witnessed.

3.12 Strip inspection on completion of running tests. To include examination of all running surfaces, checking of critical clearances, and examination of lube oil filters in the tests.

3.13 Final inspection and dimensional check of compressors mounted on base plates.

3.14 Gearing, pinion forgings and main wheel forgings or castings to be inspected at forge shop or foundry.

3.15 Any dynamic balancing of gearing rotors to be witnessed.

3.16 Fabricated gear cases to be inspected at sub-supplier's works.

3.17 Light or full load running tests, as specified to be witnessed on gearing.

3.18 Final inspection and dimensional check of gearing to be done at manufacturer's works.

DESIGN PHILOSOPHY – HVAC SYSTEM

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY
PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

REV	REV DATE	EFF DATE	PURPOSE	PRPD	REVD	APPD
0	15.1.21	15.1.21	Issued for Tender	NY	ASR	RRK
P	26.10.20	26.10.20	Issued for Tender	NY	ASR	RRK

CONTENT

SN	DESCRIPTION
1.	General
2.	Codes & Standards
3.	Technical Requirement
4.	Inspection & Testing
5.	Performance testing and Guarantees
6.	Protection and Painting
7.	Packaging & Identification
8.	Spare part requirement
9.	Special tools & tackles
10.	Technical document requirements
11.	Engineering responsibility of the system
	Appendix-1: Insulation material and thickness

1.0 GENERAL

1.1 Intent:

1.1.1 This Philosophy states that LSTK Contractor's/ Bidder's scope of work shall include basic & detailed engineering, procurement, supply, manufacturing, fabrication, inspection & testing, transportation, loading, unloading, insurance, storage, construction, erection/ installation of all HVAC (Heating, Ventilation, Air Conditioning) System / package with auxiliaries viz. chillier units, chilled water pumps, condenser water pumps, cooling towers , air handling units, package /portable AC units, Ventilation system, piping, electrical, instrumentation and civil works, obtaining all necessary statutory approvals from concerned government authorities as applicable, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test runs including total project management and handing over of complete HVAC System / package for **425 MTPD Ammonium Nitrate (AN) melt plant along with associated facilities at RCF, TROMBAY on a lump-sum turnkey basis on single point responsibility**

1.2 Scope of work:

1.2.1 LSTK Contractor shall provide suitable HVAC system for all process / non-process buildings/ facilities mentioned in the NIT as well as for other buildings /structures also, which are not specifically mentioned in the NIT, however, required in view of plant's operational needs, shall be in the bidder's scope .

Indicative list wherein HVAC system are required :

1. Control room(s)
2. Sub -station(s)
3. Lab Tech Building(s)
4. Field Maintenance office(s)
5. Operator cabins
6. Lift machine rooms
7. Chemical storage shed
8. Feeder panel rooms
9. Other miscellaneous building , if any.

1.2.2 Type of Air conditioning system and Ventilation system are preferably required as under for various above mentioned buildings / facilities :

1. Control room (s): Central AC system with complete auxiliaries with 100% stand-by chillers & AHUs are required with chemical filters.

2. Substation Buildings : Central AC system with complete auxiliaries with 100% stand-by chillers & AHUs are required with chemical filters.
3. Lab Tech Building(s):
   a) Gas analyzer room, Chemical testing room, inst analysis room, chemical storage room in lab building shall have central AC system/ package ACs with 100% stand-by.
   The treated air shall be distributed by ducts from air handling unit to each room and the return air from laboratory rooms shall not be mixed.
   b) Laboratory fume cupboards exhaust by ventilation fans along with standby units. Individual ventilation system with draught chamber shall be provided for laboratory room as necessary.
   c) Office in lab tech buildings shall have portable ACs with stand-by units.

4. Field maintenance offices : shall be air-conditioned through portable ACs with stand-by units.
5. Lift machine room: shall be air-conditioned through portable ACs with stand-by units.

1.2.3 Ventilation system with adequate stand-by equipment to be provided not limited to the following buildings:

- Battery rooms (explosion proof fans with100% stand-by)
- Maintenance rooms
- Pantry room
- All Toilets
- Plant room
- Clean agent room
- AHU (Air Handling Units) Rooms
- Locker rooms
- Electrical room
- Cable cellar (explosion proof fans with100% stand-by)
- Store rooms
- Change rooms
- Chemical, Lube oil and Bulk storage shed

Bidder to please refer ISHRAE/ ASHRAE guidelines for Industrial Ventilation as prescribed in NIT.
However, minimum assumption shall be :
i) 20 ACPH for toilet
ii) 20 ACPH for Battery Room
iii) 10 ACPH for Cable cellar area
iv) Actual ventilation required by Fume cupboards
v) 20 ACPH for plant room

1.2.4 Philosophy for Split AC /Cassette AC/ portable AC/ package units shall be opted as :
Bidder to note that for centralized AC system 100% redundancy shall be there as per NIT requirement. Moreover, for package AC/ Split ACs dedicated for 'plant equipment' shall have 1W + 1Standby (100% standby) concept.
Split ACs / Portable ACs dedicated for human habitation / officer's cabins shall have no redundancy.

1.2.5 Noise level shall be limited to 70 DBA at 1 meter distance from the equipment complying national & state regulation.

1.2.6 Bidder to assure that HVAC system and auxiliaries shall be complete in all aspect complying to national / international / statutory requirement and bidder shall furnish their selection and design calculation of HVAC system w.r.t various buildings/ facilities during detail engg for owner's review and approval.
Bidder to also note that atleast 20% extra Design margin for HVAC to be considered above peak load requirement.

2.0 CODES AND STANDARDS:

2.1 The *Latest Edition* of codes and standards as listed below shall be followed for design and manufacturing of different machinery / package items.

IS: 659	:	Safety code for Air-conditioning
IS: 660	:	Safety code for Mechanical Refrigeration
IS: 655	:	Metal Air ducts
IS: 2494	:	V-Belts for Industrial Purposes.
IS: 3142	:	V-Grooved Pulley
IS: 2379	:	Colour Code for Identification of Pipe Lines.
IS: 1239 (Part1)	:	Mild Steel Tubes
IS: 3589	:	Seamless or electrically welded steel pipes for water, gas and sewage.
IS:277	:	Galvanised Steel Sheets (Plain and Corrugated)
IS: 2062	:	Steel for General Structural Purposes.
IS: 3103	:	Code of Practice for Industrial Ventilation
IS: 4894	:	Test Code for Centrifugal Fans.
IS: 8148	:	Packaged Air Conditioners.
ISO/HIS	:	Centrifugal Water Pumps
ARI-450	:	Water cooled refrigerant condensers, Remote Type
ARI-460	:	Remote mechanical draft air cooled refrigerant Condensers.
ARI-480	:	Refrigerant cooled liquid coolers, Remote Type
ARI-520	:	Positive displacement refrigerant compressor and Condensing units
ARI-550/590	:	Water Chilling Packages using Vapour Compression Cycle.
ASME Section VIII Div.	:	Code for unfired pressure vessels
TEMA	:	Tubular Exchanger Manufacturers Association.
SMACNA	:	Sheet Metal and Air Conditioning Contractors' National Association.
AMCA-210	:	Laboratory Method of Testing Fans for rating purpose
ASHRAE/ISHRAE	:	Handbooks of : - Fundamentals - HVAC Systems and Equipments - HVAC Applications. - Refrigeration
BS-6540 Part-1:		Method of Test for atmospheric dust spot efficiency and synthetic dust weight arrestance.
BS EN 779	:	Particulate air filters for general ventilation – Requirements, testing marking.

2.2 Other international standards may also be acceptable subject to their being equivalent

or superior to those listed above, with prior approval of owner.

2.3 For provisions not covered by the above codes and standards, applicable good engineering practices and norms shall govern.

3.0 TECHNICAL REQUIREMENT:

3.1 <u>Duty</u>

3.1.1 HVAC system/ package to be designed considering continuous 24 hours operation for all concerned areas. The plant shall be suitable for maintaining inside design conditions all the year round. Notwithstanding the duty specified, all equipment shall be suitable for continuous operation for 8000 hrs. per year.

3.1.2 Heat load calculation of entire area of plant Building/Facilities shall be done by bidder and AC plant shall be selected on the basis of heat load calculation. Bidder has to submit heat load calculation of the various building including different area and bidder to furnish type of HVAC plant with technical details in his offer.

3.1.3 Outside atmospheric condition shall be referred as given elsewhere in process design philosophy of NIT.

Inside condition of various major areas under all weather condition i.e. summer, monsoon and winter shall prevail as under :

Area	**Required Inside temperature**	**Required Relative Humidity**
Control rooms	22 ±2 ºC	55 ± 5%
Sub Stations (Switchgear rooms)	22 ±2 ºC	55 ± 5%
Rack rooms	22 ±2 ºC	Rack room equipment OEM requirement to be followed.
PLC room	22 ±2 ºC	PLC OEM requirement to be followed.
UPS room	22 ±2 ºC	UPS OEM requirement to be followed.
Computer room	22 ±2 ºC	OEM requirement to be followed.
Any other 'plant equipment' building / room	22 ±2 ºC	OEM requirement to be followed.
Meeting rooms, conference rooms , executive separate Cabins/room , staff rooms, dining halls, Kitchens where human occupancy is predominant.	22 ±2 ºC	55 ± 5%

Other plant building/ facilities shall also be equipped with adequate HVAC system by LSTK contractor.

3.2 Refrigerant :

R-134a / equivalent and Eco-friendly refrigerant to be supplied & filled in the chiller units by LSTK Contractor.

3.3 Chilled units (with Centrifugal Refrigerant Compressor):

The compressor shall be of proven design based on national / international standards unless otherwise mentioned in specification.

Chiller units shall have proven track record of satisfactory operation for a minimum period of 8000 hours for process / power plant industry.

Casing hydraulic/pneumatic test pressure shall be at least 125% respectively of design pressures.

Refrigerant gas/water cooled oil cooler, thermostatically operated electric oil heater, oil pressure regulator, oil filter, shall form part of lubrication system.

Automatic capacity regulation feature is desired on compressor along with manually operated device.

Purge recovery unit, if required, shall be provided to efficiently separate out non-condensable gases and moisture from refrigerant as per Manufacturer's Standard.

3.4 Chiller units (with Screw Refrigerant Compressor- hermetic or semi hermit sealed units):

The compressor shall be of proven design based on national / international standards unless otherwise mentioned in specification and the offered model shall have proven track record of satisfactory operation for a minimum period of 8000 hours for process / power plant industry. The compressor shall be equipped with automatic unloaded starting arrangement. It shall have automatic sliding valve capacity control arrangement actuated through suction pressure sensor.

Compressor unit shall be complete with base frame, control desk with gauges, suction strainer, suction and discharge valves with check valves, drive motor, drive arrangement, motor driven oil pump / rotor shaft driven built-in oil pump.

Reciprocating Chiller Units shall not be acceptable.

3.5 Water cooled Condenser:

The tubes shall not be less than 12.5 mm diameter and shall be adequately supported to prevent tube vibration.

Condensers for rated AC plants shall have water boxes and covers to that each tube sheet can be exposed without disturbing the piping connections.

3.6 Evaporator / liquid cooler :

Tubes shall not be less than 12.5 mm diameter and Tubes shall be adequately supported to prevent tube vibration.

Condensers for rated AC plants shall have water boxes and covers to that each tube sheet can be exposed without disturbing the piping connections.

3.7 Refrigeration Packaging Assembly:

Skid shall be designed so as to provide maintenance accessibility and operation ease of valves and controls. Instruments shall be easily readable.

Lifting hook/eye shall be provided for handling of equipment during maintenance.

Steel structural members of the skid shall conform to IS-2062 / ASTM A 36.

3.8 Air Handling Unit:

Air-handling unit shall be of double skin with insulation in sectionalized construction for convenient transportation and installation. The air handling unit shall comprise of filter section, damper section, heating section (if required), humidifier section (if required), cooling coil section, fan section and drain pan.
Cooling coil shall be minimum 4 rows deep .
Damper section shall have face and bypass damper. Bypass area shall not be less than 1/4th of the face area.
Filter section shall be provided with Chemical filters, as applicable.
Filters shall be selected for a pressure drop of maximum 4mm WG in clean condition.
Filters (prefilter + fine filter assembly) shall be capable of filtering up to 5-micron dust particles with an efficiency of more than 95%.
Inclined tube manometer with tubing shall be provided on AHU for indication of pressure drop across the filters.
Fan selection will have centrifugal type with electric motor. Fan rotating assembly shall be dynamically balanced. Flame resistant flexible bellow connection with metallic flanges shall be provided between fan outlet and duct.
Taper lock pulleys shall be provided with wedge type belts for drive. However, Direct coupled Fan with motor with flexible coupling shall be more preferred.
Grease cups shall be provided for fan bearings.
Drain pans for condensate shall be of stainless steel (18/8 grade) construction and thermally insulated. Water seal shall be provided in the drain outlet.
Ribbed neoprene rubber pads shall be provided as vibration isolators for the Air handling unit.

3.9 Chemical Filters :

Chemical filters shall be designed & selected by bidder for the indoor condition for Control room(s) and Sub-station(s) considering the worst surrounding atmosphere of plant.
Chemical filter shall be selected for the chemical media life of minimum 2 years. Outside gas concentration shall be considered while evaluating the life. Chemical filter's nomographs etc to be submitted by LSTK Contractor in support of the chemical media life.
Chemical air filter unit shall be skid mounted cubicle for horizontal installation.
Three stage chemical filter shall be provided.
Chemical filter shall have adequate provision for easy removal & servicing of filter packs. Bidder to provide differential pressure indication across filters and velocity across the filter shall be in range of 100-110 FPM.

3.10 Heating Unit :

Heating shall be preheating and / or Reheating as per psychometric Process requirement.
Heating shall be with electrical heaters.
Electric strip heaters, if provided, shall be complete with heating thermostats/humidistat, safety thermostats and contractors.

3.11 Humidifier Unit:

Humidifier shall be stream pan type or water spray type.

Pan humidifier shall be complete with immersion type electric heaters actuated by humidistat, water float valve, stop valve in water make up line, level switch interlocked with heaters. Pan/ storage shall be fabricated with 18/8 grade stainless steel. The outer surface shall be thermally insulated.

Water spray type humidifier shall comprise of spray header, nozzles, arms , pump sets, humidistat, solenoid valve etc. Make up tank, water collecting trough complete with drain, quick fill, overflow, strainer make up connection with ball and float valve and isolating valves shall be provided.

Drain pan/water collecting trough of water spray humidifier shall be of stainless steel construction and thermally insulated.

The humidifier shall be sized to deliver 110% of capacity required.

3.12 Cooling Tower:

Cooling tower shall be natural or induced draft type in FRP construction. Cooling tower fan shall be of FRP blades directly mounted on the shaft of totally enclosed weather-proof (IP-55) motor with suitable weather proof canopy hood. The fan shall be protected by guard. The fan assembly shall be dynamically balanced.

Service ladder shall be provided for the cooling tower.

Water basin shall be made of F.R.P. and provided with suction strainer.

The cooling towers shall be provided with drift eliminator.

Supporting framework for the cooling tower shall be made of galvanized steel and further lined with FRP.

Cooling tower structure shall be designed to withstand wind load as specific, per IS-875.

Local lockable push button station in weather-proof enclosure with a canopy cover shall be provided.

3.13 Water Pumps:

Pumps shall preferably be back pullout type with mechanical seals.

Pumps shall be designed and selected by considering overall requirement of the AC plant , condenser water circuit and chilled water circuit, NPSH, pressure & temperature of the liquid etc and shall be provided with mechanical seal.

The pumps shall be complete with drive motor, coupling with non-sparking guard, common base plate, fixing and hold down bolts.

Bidder to note that nos. of chilled water pump & condenser water pump sets shall be selected as the numbers of chiller units plus one set of chilled water & condenser water pumps shall be operated as in standby mode. However, chilled water pumps and condenser water pumps shall have their respective common headers at inlet / outlet to ensure availability and inter-changeability of pumps in all condition.

3.14 If not specifically mentioned, all continuous operating machine shall have 100% stand-by.

3.15 Refrigerant Piping:

All piping network shall be leak tested with nitrogen at 1.25 times of design pressure using soap water solution followed by electronic / halide torch leak detection. The piping network shall be further pressure tested with nitrogen at 1.25 times of design pressure for minimum 24 hours. After establishing the capability to withstand test pressure, the piping network shall be dried and vacuumized to 2.5mm Hg absolute. Vacuum shall be broken with dry nitrogen and the system shall be revacuumised to 2.5 mm Hg absolute. This vacuum shall be held for 12 hours before charging the refrigerant.

3.16 Water Piping:

All water piping shall be of Carbon steel and all chilled water and condenser water piping shall be complete with, flanges, fittings, valves , strainers, gasket & fasteners , hanger/ supports etc.

3.17 Fire Dampers:

Fire dampers shall be installed in supply air and return air path. These shall conform to UL555 for 1.5 hour fire rating.
The fire dampers shall be spring return, motorized & fail safe type with indication for open and Close position.
Fire damper operation shall be interlocked (through HVAC Panel) with the Signal from purchaser's fire and gas panel.

3.18 HVAC system interlocks with plant Fire and Gas system:

Unless otherwise specified, all the HVAC system of project will be interlocked with plant Fire and GAS system as follows complying to statutory requirement:
Fire alarm signal from fire and gas system to HVAC control Panel : Whole HVAC system shall shutdown.

3.19 Equipment Automatic Change over requirement :

Change –over from duty to stand-by equipment , in case of failure of the duty unit, shall be fully automatic.
Automatic Change over shall be provided to switch, on weekly basis, the duty and stand-by equipment , in order to ensure an even number of running hours for each units.

3.20 Expansion Tank (for Chilled Water System only):

Expansion tank shall be provided by vendor and installed at-least 1 m above the highest point of the system.
Tank shall be of minimum 500 liter capacity (unless otherwise required because of System design requirement) fabricated from 18/8 grade stainless steel min 3 mm thick with all requisite stiffeners.
The tank shall be complete with float valve assembly backed up with Gate valve for make up, quick fill gate valve, drain with valve and overflow.
Tank shall have rigid supporting arrangement. All piping and instrumentation shall be in scope of contractor only.

3.21 Portable AC/ Split AC/ Package AC shall be used wherever required with optimization of energy consumption. Minimum 3 star BEE-Star rating to be used for the same. Window AC shall be avoided. Adequate stand-by units are to be provided as per this specification.

3.22 Plant Room Ventilation:

A.C. Plant room shall be forced ventilated by wall mounted exhaust fan(s) complete with electric motor, louver shutter and 18/8 grade stainless steel wire protection guard on intake side of exhaust fans.
The capacity shall be decided based on 20 air changes per hour.
Air intake weather protection louvers along-with bird protection screen shall be provided with suitable structural steel frame in wall.

3.23 Air Distribution, Ducting, Diffusers /Grilles:

Ducts shall be designed, fabricated and flanged as per IS-655 for static pressure up to 65 mmWG. In case, static pressure is more than 65 mmWG, SMACNA code shall be followed for design and fabrication of duct.
Duct hangers shall be supported with anchor fasteners in the roof. Anchor fasteners shall be provided by vendor.
All flange joints shall have minimum 6 mm thick Neoprene packing as gasket stuck to the flanges with adhesive (viz., resins like araldite or equivalent).
All the duct shall be made air tight with the help of sealant.

Ductwork shall be provided with following accessories.

- Turning Guide Vanes.
- Extractor with operating lever.
- Splitter Damper with control rod & locking device.
- Volume control Damper (opposed bladed type with 16 gauge with ~ 250 mm wide blades and 14 gauge casing of Galvanized Sheet Steel).
- Fire resistant flexible connection between duct chute and diffuser (if required).
- Access doors for heaters, fire dampers and filters.

Supply air diffusers or grilles, as required, shall be provided and shall be fitted with sponge foam tape. Volume control damper shall be provided with each supply air diffuser/grille. Volume control damper shall be key operated from the front of diffuser/grille. Supply air grilles shall be provided with vertical & horizontal adjustable louver
All return air diffusers/grilles, if required, shall be without volume control damper.
Diffusers/grilles shall be of powder coated steel construction with angle frame.
Diffusers/grilles shall not be supported from False Ceiling.
All ducting shall be designed and laid out as per requirement of various area of CCR Building so that an efficient layout may be done.
LSTK Contractor to submit a complete P&ID,GA of entire AC plant and duct layout proposed/ envisaged by LSTK Contractor for Owner's review and approval.

3.24 **Insulation:**

Surfaces to be insulated shall be thoroughly cleaned and allowed to dry.
Pneumatic/hydraulic test, if any, shall be carried out before insulation. Insulation material shall be high class fire resistant material and 'Non Combustible'.

a) **Hot Insulation:-**
Bare surfaces of pipe/equipment shall be provided with one coat of 20 micron min. (dry film thickness) heat resistant primer up to 125°C operating temperature.
Resin bonded mineral wool conforming to IS-8183 shall be used for hot insulation.

Preformed pipe sections/mattresses of min. density 120 kg/m3 shall be used.
Hot insulation shall be cladded with 24 SWG aluminium sheeting.

b) **Cold Insulation:-**
The pipes and duct shall be insulated and finished as per this specification.
Sound Attenuators shall be installed in ducts, as required.

For all inspection covers and hatches on equipment, pump casing, valve bodies & flanges more than 100 mm dia, the insulation shall be applied so as to facilitate removal without its damage. This shall be achieved by encasing the insulation in 24 gauge aluminium sheet metal sections, which are screwed together around the equipments to permit easy removal and replacement maintaining continuity of vapour seal.

The insulation materials shall be :

i) Resin bonded fiber-glass of 24 kg/m3 density to IS: 8183.
ii) Poly isocynurette of 32 kg/m3 density to IS: 12436.
iii) Phenolic Foam of 32 kg/m3 density to IS: 13204.
iv) Polyurethane Foam of 32 kg/m3 density to IS-I2436.

The application, insulation material and recommended thickness are given in Appendix of this tech specification.

c) **Underdeck insulation:-**
Phenolic foam underdeck insulation shall be of rigid slab of 25 mm thickness and approx. 1000 mm x 500 mm size and shall conform to IS:13204. It shall have density of 32 kg/m3 and K value of 0.0034 w/mk at 53 deg. Mean temperature. The insulation shall be classified as 'Non Combustible' as per BS 476.It shall be pre-laminated on both sides with kraft paper.
Entire surface of slab and beams shall be thoroughly cleaned. Bituminous primer or zinc chromate primer shall be applied evenly @ 0.5 kg/m2 over the entire surface. Hot bitumen or CPRX adhesive shall then be applied on the insulation panel @1.5 Kg/ m2. The panels shall be pressed in position and further secured by dash fasteners.
Underdeck insulation shall be fixed only after all fixtures like hooks, clamps, cleats etc for light fixtures, ducts etc. have been fixed in the ceiling.

3.25 **Controls And Instrumentation:**

Vendor shall include all controls & instruments as required for safety & operational requirements of the plant.

Automatic operation of all controls wherever feasible is required, with manual overdrive for maintenance etc.

All control shall be suitably interlocked for safe & sequential operation of plant generally in the following order:

a) Start AHU blower.
b) Start Cooling tower fan.
c) Start Condenser water flow/condenser fan.
d) Start Chilled water pump.
e) Start Refrigeration unit/compressor.
While shutting down the plant, equipment will stop in the reverse order as listed above.

Humidifier heaters shall be actuated by humidistat.

Potential free contact shall be provided by vendor for closing motorised fire dampers and simultaneously tripping the AHU blower motor on receiving the fire signal from purchaser's Fire & Gas Panel. On expiry of fire signal, fire dampers shall open manually through reset button.

A) Requirements for Centrifugal compressor / chiller package:

The control panel shall be machine mounted In cubicle construction per manufacturer's standard design and shall have protection against following situation as a minimum.

i) High condenser pressure.
ii) Low oil pressure.
iii) High bearing temperature switch for compressor.
iv) Low evaporator pressure.
v) Low chilled water flow.
vi) Low condenser cooling water flow
vii) Overload protection for all motors.
viii) Low chilled water temperature.
ix) Excessive vibration switch.
x) Purge pump high discharge pressure.
xi) High lube oil temperature to cut off heater supply.
xii) Anti freeze.
xiii) High Compressor discharge temperature.
xiv) Oil Filter differential pressure.
xv) To ensure opening of inlet guide vanes after compressor motor has stabilized.
xvi) Motor current limiter.
xvii) To ensure close guide vanes at start-up.
xviii) Low water level in humidifier tank.
xix) Air heater change over switch.
xx) Air flow switch.

B) Requirements for Screw compressor/ chiller package:

Local Control desk with gauges shall be machine .mounted in cubicle construction provided with:
i) Suction & discharge pressure gauges.
ii) Suction & discharge pressure switches.

The control panel shall be either machine mounted or floor mounted in cubicle construction as per manufacturer's standard design and shall have protection against following situations as a minimum:-

i) Low oil pressure.
ii) High bearing temperature switch for compressor motor.
iii) Low oil temperature.
iv) Low chilled water flow.
v) Low condenser cooling water flow.
vi) Overload protection for all motors.
vii) Low chilled water temperature.
viii) High lube oil temperature to cut off heater supply.
ix) Anti freeze.
x) High Compressor discharge temperature.
xi) Oil Filter differential pressure.
xii) Motor current limiter.
xiii) To ensure minimum position of slide valve at start-up.
xii) Low water level in humidifier tank.
xiv) Air heater change over switch

The control panel shall be fully wired and factory tested before dispatch. The Control panel shall contain at-least the following control for the automatic operation of chilling unit.

i) Compressor capacity control device.
ii) Start/stop push button station for the machine.
iii) Automatic temperature controller for oil temperature and Chilled water temperature controller shall be of PID type.
iv) Start/stop push button station for chilled water pump set.
v) Operation indicating pilot lamps.
vi) Vane opening indicator calibrated in percent (for centrifugal package).
vii) Pressure Gauges for purge unit (for centrifugal package).

The entire control panel shall be factory wired and factory tested before despatch.

All controls such as fire damper motors, face and bypass damper motors, modulating type thermostat; high/low pressure switches, oil pressure switches, controls for actuating capacity control solenoid. valves, thermostatic expansion valves, pilot solenoid valves" flow/pressure switches, heater, heating thermostats, humidistat, and all necessary instruments for automatic, ,regulated and safe operation of the plant shall be included in the scope of supply and installation. All controls shall be suitably interlocked to operate the equipment' in their proper sequence.

Flow meters in chilled water and, condenser' water lines signal to control panel, temperature and Pressure Gauges in inlet and outlet of cooling water and chilled water shall be provided locally.

All electric motor driven equipments shall be provided with local Start/Stop Pushbutton stations for operational and statutory requirements. Stop push button shall be lockable type.

Vendor shall provide thermowells in- refrigerant circuit so as to enable to take readings for temperature of refrigerant at' various places of the circuit during performance testing.. Exact locations shall however, be finalised by Owner and vendor mutually during drawing approval stage.

Calibration of all instruments shall be done by Vendor.
Pressure gauges shall be provided with bleed and block valves.

3.26 Audio-visual Annunciation Section:

It shall consist of facia type Annunciators having translucent plastic window of 35 mm x 50 mm (min.) size engraved with appropriate function in block letters for each 'alarm trip point. Annunciators shall be suitable for operation on 24V D.C. and shall have a single alarm buzzer common to all points. Three push buttons 'for audible alarm acknowledge, reset and test with appropriate name plates shall be provided common to all alarm points. Annunciators shall be solid state type of, reputed make. Annunciators shall operate satisfactorily between 80 .and 110% of rated supply voltage.

Annunciators shall be provided for all faults covering at least the followings:-

a) Low oil pressure.
b) Low chilled water flow.
c) Low condenser cooling water flow.
d) Low chilled water temperature
e) Low evaporator pressure.
f) High condenser pressure.
g) Compressor motor overload.
h) Low water level in humidifier tank.
i) Chilled water pump motor over load.
j) Condenser cooling water pump, motor over load,
k) Air handling unit motors overload.
l) Cooling tower fan motors overload.
m) Treated water plump motors overload (in case ~water softening plant is furnished).
n) Crankcase heater / heaters.
0) Open/close position of fire/smoke dampers.
p) Fresh Air fan status.
q) Any other as necessary.

In the event of a fault, the particular window shall glow and the window will remain lighted till the fault is rectified. Minimum 20% spare windows shall be provided on annunciator.

3.27 Motor / Driver rating :

Electrical drivers (Motors) shall have power ratings at least equal to following percentage of rated absorbed power for all equipments :

Absorbed power (in kW)	Motor rating percentage of
< 22	125
22 - 55	115
> 55	110

4.0 INSPECTION AND TESTING

Equipment shall be subjected to expediting, inspection and testing at vendor's/sub-vendor's Works by Third Party Inspection agency (TPI) as per NIT COMMERCIAL PART. Vendor shall submit Quality Assurance (QA) plan before commencement of fabrication. Approved QA plan by owner shall form the basis for equipment inspection. **TPI Cost shall be in vendor' scope.**

For Inspection and Testing at Site, vendor shall comply with the following procedures:

I. All electrical items will be subjected to inspection at any stage. Routine electrical test as per relevant codes. Inspection of Manufacturer's test certificates.

II. Inspection of raw materials to be used for fabrication and. assembly and inspection of manufacturer's test certificates.

III. Inspection of welding including welder's qualification as desired by inspection engineer. Inspection of fabricated items.

IV. Pressure testing of pipe fit ups for refrigerant and water services.

V. Pressure testing, leak testing of complete piping network for chilled water/brine, condenser water & refrigerant services.

VI. Vacuumising & gas/oil charging for refrigeration system.

VII. Checking of electrical circuits (Power and control) and checking functioning of controls of refrigerant system and other circuits of air conditioning plant.

VIII. Checking of assemblies for MCC, control panel, local panel (dimensional & functional), annunciation panel etc.

IX. Checking of calibration of controls and instrumentation.

X. Inspection of complete electrical installation at site and clearance from local authorities.

XI. Installation of main equipments like compressor, condenser, chiller, evaporator, AHU etc.

XII. Mechanical run test of AHU .

NOTE:
Inspection & testing procedure mentioned above is for general guidance & information of vendor and inspection by purchaser/consultant is not limited to these. Inspection engineer of Purchaser/consultant will have full right to have detailed inspection of vendor shop/ works. Co-ordination of inspection agency / purchaser/consultant with his factory/erection site will be sole responsibility of successful LSTK Contractor after placement of order for complete air conditioning plant covered under these specifications.
However, such inspection by Ownerside, shall in no way absolve the vendor of his responsibility.

5.0 PERFORMANCE TESTING AND GUARANTEES:

Performance Testing

Vendor shall give two seasonal tests for (i) summer or monsoon (More stringent of the two) & (ii) winter to determine the equipment capacity and performance of the system in accordance with applicable Standards and as agreed with owner. For chilling package, performance test at site shall be as per ARI Standard based on the available load and cooling water temperature/ambient conditions. Period of each test shall be at least 48 hours or as agreed by Owner and time for each test will be fixed up mutually with the purchaser and/or his authorised representative.
The vendor shall operate, test and adjust all equipment and balance the system.

Following test readings shall be recorded during the performance testing:

Test Readings

1.Compressor

Refrigerant gas suction pressure	(kg/cm2 g)
Refrigerant gas suction Temperature	(^{0}C)
Refrigerant gas discharge Pressure	(kg/cm2 g)
Refrigerant gas discharge Temperature	(^{0}C)
Operating speed	(rpm)

Power consumption at 100% load and at each step of capacity regulation.

2.Chiller (for chilled water system only)

Refrigerant liquid temperature at inlet	(^{0}C)
Refrigerant Gas suction pressure	(kg/Cm 2g)
Refrigerant Gas suction temperature	(^{0}C)
Water flow rate	(m3/ hr.)
Water temperature – entering	(^{0}C)
Water temperature – leaving	(^{0}C)
Water pressure – entering	(kg / cm2 g)
Water pressure –leaving	(kg / cm2 g)

3.Condenser

Refrigerant gas temperature at inlet	(^{0}C)
Refrigerant condensing pressure	(kg/cm^{2}g)
Refrigerant liquid temperature at outlet	(^{0}C)
Air / Water flow rate	(m3/ hr.)
Air / Water temperature – entering	(^{0}C)
Air/ Water temperature –leaving	(^{0}C)
Water pressure – entering	(kg / cm2 g)
Water pressure – leaving	(kg / cm2 g)

4.Water Pump

Flow rate	(m3/ hr.)

Discharge pressure	(kg / cm2 g)
Suction pressure	(kg / cm2 g)
Operating speed	(rpm)

5.Air handling unit

Refrigerant liquid temperature at inlet to coil	
Air temperature - entering (D.B)	(^{0}C)
Air temperature - entering. (W.B)	(^{0}C)
Air temperature -leaving (D.B)	(^{0}C)
Air temperature -leaving (W.B)	(^{0}C)
In case of chilled water coils:	
Water pressure - entering coil	(kg / cm2 g)
Water pressure - leaving coil	(kg / cm2 g)
Water Temperature - entering coil	(^{0}C)
Water Temperature -leaving coil	(^{0}C)

Velocity of air in various sections of air handling unit.

6.Electric motor

Starting current/ No load current	(A)
Motor terminal current	(A)
Power factor	
Supply voltage	(volts)
Kwh for Compressor motors	

7. Supply Air Grilles / Diffusers

Air flow rate	(m3 / hr.)
Air temperature (D.B)	(^{0}C)
Air temperature (W .B)	(^{0}C)

8. Room conditions

D.B. & W.B., temperature, RH at different points

9.Air handling unit blower

Speed, static/total pressure, outlet velocity and air flow.

Vendor shall bring all required testing instruments at site duly calibrated. Plant shall be formally taken over by owner after witnessing the seasonal performance tests successfully as per terms & condition prescribed in NIT.

Guarantee for Supply and WorkManship (Defect Liability) :

LSTK Contractor shall provide guarantee against workman-ship, standard performance parameters and materials of their supply as per provision available in NIT. Guarantee shall be provided by LSTK Contractor for their supplied materials/ equipments and workman-ship. In this period, if contractor's supplied item(s) fails during operation or not meeting standard performance parameters, then LSTK Contractor shall have to replace with new parts/ equipments without any additional cost to owner.

6.0 PROTECTION AND PAINTING:

All exposed carbon steel parts to be painted. Non-ferrous materials, austenitic stainless steels, plastic or plastic coated materials, insulated surfaces of equipment and pre-painted items need no painting.
Stainless steel surfaces, both inside and outside, shall be pickled and passivated.
Machined and bearing surfaces shall be protected with varnish.
Painting Specification shall be as per manufacturer standards..
The color of finish coat may be intimated to vendor, after placement of order.

7.0 PACKAGING AND IDENTIFICATION:

All packaging shall be done in such a manner as to reduce the volume. The equipment shall be dismantled into major components, suitable for shipment and shall be properly packed. To provide adequate protection during shipment. All assemblies shall be properly match marked for site erection.
Attachments, spare parts of the equipment and small items shall be packed separately in wooden-cases. Each item shall be appropriately tagged with identification of main equipment, item denomination and reference number of the respective assembly drawing.
Detailed packing list in water-proof envelope shall be inserted in the package together with equipment.
Each equipment shall have an identification plate (made of SS material) giving salient equipment data, make, year of manufacture, equipment number, name of manufacturer etc

8.0 SPARE PARTS REQUIREMENT:

All erection, pre-commissioning & commissioning spares including spares consumed during testing / PGTR till handing over the plant to owner shall be supplied by LSTK Contractor free of cost. Any unused commissioning spares shall be owner's property.

Mandatory spares shall be supplied by the LSTK contractor as per NIT.

LSTK Contractor to also furnish separate recommended list of 2 years operation & maintenance spare part list along with budgetary offers, valid for 2 years from the date of submission of offer for owner's consideration .

Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.

Detail List of special tools & tackles shall be furnished by the LSTK bidder along with

the bid and shall be in scope of supply of the LSTK contractor.

9.0 SPECIAL TOOLS & TACKLES:

Vendor shall provide one set of special tools & tackles as a minimum for operation & maintenance along-with HVAC plant.

10.0 TECHNICAL DOCUMENT REQUIREMENTS

Bidder shall furnish design calculations, Heat Load Calculations for all three seasons (Summer, Monsoon & Winter) with Psychrometric plots specifying the design TR capacity, dehumidified air quantity and Monsoon & Winter heating capacity.
Any other data over & above that furnished by Owner shall be referred from Handbook of ASHRAE and Climatological Data Book.
Bidder has to submit all Equipment list with power consumption , GA, Plant layout, Cross sectional drg, technical Drawings of all equipment , Data Sheets, specifications, catalogues, O&M Manual, QAP/ITP, pamphlets and other documents of all equipments in AC plant with their installation and operation & trouble shooting manuals. Bidder has to provide training to purchaser's engineers / operation team for the operation and maintenance of the entire plant as mutually agreed with Owner.

11.0 ENGINEERING RESPONSIBILITY OF THE SYSTEM:

The responsibility of complete system design, manufacturing, erection, working and safety will solely be responsibility of the LSTK Contractor for the parameters as mentioned in the tender document and this philosophy.
The system after commissioning shall be offered to owner for PGTR with mutually agreed period/ duration. Thereafter, Owner will monitor the performance for standard designed parameters for the period agreed with owner. In case, during this period, performance is not found satisfactory and rectification / replacement, design improvement or any other change as felt necessary, will be made by the LSTK Contractor at no extra cost. Though, these improvements can only be done after getting the approval from the owner.
Contractor shall provide supervision services from OEM (original equipment manufacturer) during erection, commissioning and PGTR of the system.

APPENDIX-1

INSULATION MATERIAL AND THICKNESS

S. No.	Application	Insulation Material	From	Thickness (mm)
1	Supply / Return air duct	Resin bonded Fiber glass / equivalent	Slab / Roll	50
2	Outdoor Exposed supply / return duct	Resin bonded Fiber glass / equivalent	Slab / Roll	50
3	Refrigeration Piping	Polyurethane or Phenolic Foam or, Polysicocynurette	Pipe Section	50
4	Chiller	-Do-	Slab	60
5	Chilled water pumps	-Do-	Slab	40
6	Expansion tank & associated piping	-Do-	Slab	30
7	Chilled eater piping, valve, specialties	-Do-	Pipe Section	40
8	AHU Drain pipe	-Do-	Pipe Section	15
9	AHU Drain pan, coil & blower section	-Do-	Slab	15
10	Acoustic treatment	Resin bonded Fiber glass / equivalent	Slab/ Roll	40
11	Pan Humidifier	Resin bonded Fiberglass	Slab	75
12	Hot Water / Steam piping	Resin bonded Fiberglass	Pipe Section / Roll	75

DESIGN PHILOSOPHY – EOT CRANE & HOIST

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY
PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

REV	REV DATE	EFF DATE	PURPOSE	PRPD	REVD	APPD
0	15.1.21	15.1.21	Issued for Tender	NY	ASR	RRK
P	26.10.20	26.10.20	Issued for Tender	NY	ASR	RRK

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2.0	Scope of Supply & Erection
3.0	General Design Requirements
4.0	Specific Design Requirements
5.0	Battery Limits
6.0	Extent of Supply & Erection
7.0	Inspection, Testing & Repairs
8.0	Preparation of Shipment
9.0	Painting
10.0	Spares
11.0	Drawings and Documents
12.0	Guarantee
13.0	Priority
14.0	Sub-Vendors

1.0 INTENT

1.1 Design, detailed engineering, manufacturing, shop testing & inspection, painting, supply, transportation to site, unloading and storage at site, load testing at site, final painting and Erection & commissioning, requisite statutory approval of Electric Over head Travelling Crane along with runway rails and supply of spare parts for crane as per the technical specifications, terms and conditions mentioned in this Technical Specification.

LSTK Contractor to provide EOT Cranes of adequate capacity in various Steam Generator Unit, Maintenance Bay, Pump Houses, Compressor & turbine House and other location wherever required for ease in operation and maintenance activities . Cranes to be provided in nearest multiple of 5 Metric Tonnes considering maximum weight to be lifted. Relevant Indian/ ISO Standards to be applicable for EOT Crane . The main hook capacity of each crane shall be minimum 25% over and above the heaviest component/ equipment to be handled. 15 T and above EOT cranes shall have 5T auxiliary hoist. All statutory guidelines to be complied by the contractor/ sub-contractor.

2.0 SCOPE OF SUPPLY & ERECTION

2.1 The scope of supply & erection shall be, but not limited to, the following:

Sl. No.	Description	Qty & Scope (Location wise)
1.1	Design, Engineering, Manufacturing, Testing, Inspection, Supply, Erection & Commissioning of suitable capacity EOT Cranes including its drives and all other relevant electricals	Bidder to furnish
1.2	Runway Rails for crane along-with necessary fixtures for fixing the rails on structural steel girder, along-with electrical interconnection for the earthing of rails.	Bidder to furnish
1.3	Mechanical stoppers on both the ends of runway rails for LT motion and for CT motion.	Bidder to furnish
1.4	Festoon flexible cable type down-shop leads system along with necessary insulators, brackets, lighting etc.	Bidder to furnish
1.5	Access ladder, Platform and safety handrail for EOT cranes	Bidder to furnish

2.2 CODES AND STANDARDS

The Design, manufacture, performance and testing of the EOT crane as specified herein after shall comply with the requirements of the applicable latest standards and codes of practice. The latest standards with all amendments shall be followed in particulars.

IS:3177 code of practice for overhead traveling Crane and Gantry crane other than steel work crane.

IS:2365 steel wire suspension ropes for lifts elevators and hoists.

IS:807 code of practice for design, manufacture, erection & testing of crane and hoists.

IS:3443 crane rail section.

IS:3815 point hook with shanks for general Engineering purpose.

IS:800 code of practice for use of structural steel in general building structure.

IS:2062 weldable structural steel.

IS:3681 spur and helical gears.

IS:3734 dimensions for worm gearing.

IS:1364 precision and semi-precision, hexagonal bolts, screws, nuts and locknuts.

IS:816 code of practice for use of metal arc welding for general construction in mild steels.

IS:1181 qualifying test for metal arc welders.

IS:1323 code of practice for oxy-acetylene welding for structural work.

IS:3961 recommended current rating of cables.

IS:282 hard drawn copper conductors for overhead power transmission.

IS:2147 degree of protection provided by enclosures for L.V. switchgear and control gear.

IS:2959 contactors for voltage not exceeding 1000V AC or 1200V DC.

IS:2208 HRC cartridge fuse links for voltage above 650V.

IS:4047 heavy duty air break switches not exceeding 1000V.

IS: 5749 forged rams horn hooks.

The material of various components shall be in accordance with relevant IS or equivalent international standard.

3.0 GENERAL DESIGN REQUIREMENTS:

Whole supply & erection shall conform to the following standards and specifications except as modified herein:

The Vendor shall be responsible for complying with any other statutory requirements governing the work.

DESIGN OF MECHANISM

For the hoist mechanism of cranes electric motor shall be connected to the reducer through floating shaft and half geared couplings. Coupling of the output shaft of the reducer to single or double drum shall be by means of geared coupling.

BEARINGS

All running shafts and wheels running on fixed axle shall be fitted with sealed antifriction ball or roller bearings.

COUPLINGS

1. All couplings shall be gear couplings, except that rigid coupling may be used on long transmission shafts.

2. All couplings shall be of steel. Cast Iron shall not be used.

GEARINGS

All gear boxes shall be in totally enclosed construction and gears shall be spur or helical type with machine cut teeth suitably hardened and tempered and shall conform to AGMA standard. The surface hardness of pinion shall be between 255 to 300 BHN and for gear 217 to 255 BHN. Difference in hardness of pinion and gear must not be less than 20 BHN.

For Accurate fixing of unit mechanism (reducer, brakes, motor etc.) and as well as to exclude the possibility of misalignment while working, support surfaces shall be machined level.

TRACK WHEELS

In case where crane and trolley have more than four wheels, balancers shall be used.
The body of the balancer may be fabricated from steel plates or from cast steel.

BRAKES

Hoisting Motion: - The brake shall be automatic electro-mechanical or thrusters release brake applied directly to the hoist motor shaft.

Traversing Motion: - The traversing motion (CT) of every electric overhead travelling crane shall be fitted with an automatic electro-mechanical brake irrespective of traversing speed.

Capacity of hoist brakes shall be determined as follows:

Mt= K. Mct Kg-m where,

Mct = Static Moment on the braking shaft, due to action of the load, considering the maximum efficiency of the mechanism.

K= Co-efficient of reserve of braking, taking from following figures, corresponding to the class of duty of the mechanism.

For light duty (Class I) K = 1.5
Medium duty (Class II) K = 1.75
Heavy duty (Class III) K = 2.0

Manufacturer to consider Heavy duty co-efficient (K=2.0) of reserve of braking and shall be compliant to IS: 3177.
In case of hoist mechanism with two drives, each drive must have at least one brake. Co-efficient of reserve of braking of each brake is taken not less than 1.25, considering that the full load can be held by one brake.

In case where two brakes are used for each of the two drives co-efficient of reserve of braking must not be less than 1.1 for each brake.

Required capacity of braking in case of traverse and travel motions shall be 0.8 – 1.0 times the static moment on the respective braking shafts due to action of inertial forces, considering maximum efficiency of the mechanism.

Brake drums shall preferably be made of steel castings or steel forging.

HOOKS

Hooks shall conform to the relevant Standards.
The crane hooks shall be provided with spring loaded safety locking arrangement.

No repair work on hook made to shall be allowed without prior approval from purchaser.

MEANS OF ACCESS

Platforms: - An adequately guarded platform minimum 750 mm wide shall be provided on both sides for the full length of the bridge. All platforms and ladders shall have non-skid chequered plate treads and shall be provided with handrails

and toe guards. Opening on guard railings for access from outside shall be provided with safety chains.
The access ladder to EOT assembly from G.L. shall be suitably located avoiding any hindrance to EOT travel

LUBRICATION

All the grease points shall be brought to a safe and easily accessible place which shall be prominently displayed.
All gear boxes shall be fully enclosed type prohibiting ingestion of outside dust, oil and moisture. Gear shall be compliant to AGMA/ IS:4460. There will be no centralised lubrication system.

BUFFERS

Bridge of crane and trolley shall be provided with buffers for soft dashing with end Stop. Buffers ends should be made of rubber or iron & wood.

Welding: Welding shall be in accordance with relevant Standards.

ELECTRICAL DESIGN

All electrical including electro-magnetic brakes, limit switches, cables, wirings, lightings etc. shall be in accordance with the Electrical Specifications enclosed.

4.0 SPECIFIC DESIGN REQUIREMENTS:

The Cranes shall be suitable for the duty conditions as given in the specifications sheets.

4.01 Material of construction must be well proven for the required services.

4.02 Cranes shall be suitable for outdoor installation but placed under the roof.

4.03 All gear boxes shall be fully enclosed type.

4.04 The rail and roller support for the flexible cable shall be designed for maximum reliability and minimum maintenance requirements. The roller supports shall be interconnected by flexible steel wire in order to protect the flexible cables against mechanical stress. DSL trolleys shall be provided with four wheels. Rollers should not require greasing.

4.05 Mechanical safety lowering brake shall be supplied by the Vendor which shall be capable of holding the test load in addition to electro hydraulic thrusters brake for all the hoisting motions.

4.06 The Vendor shall provide non-sparking type aluminium guards for couplings.

4.07 The Vendor shall, if required, provide a clearance certificate from a Competent Authority regarding following the safety rules and regulations.

4.08 All the Bearings shall be antifriction type. Bush Bearings are not acceptable.

4.09 1 No. rotary type and 1 No. gravity type limit switches will be provided for each crane/ hoist.

4.10 2 Nos. one way lever type limit switch will be provided for trolley and 1 No. anti-collision device and 1 No. one way type limit switch will be provided for LT.

Anti collision device will consist of 1 No. one way lever type limit switch and striker arm.

4.11 Micro speed arrangement on main hoist, CT *and LT* will be achieved through separate sq. cage motors, 1 No. thruster brake and planetary gear box arrangement.

4.12 Installation

The cranes shall be placed on rails at an suitable elevation of equipment/ train building and shall be operated from pendant push-button boxes.

The flexible supply cables shall allow operation of the cranes in the full length of the equipment/ train building.

5.0 BATTERY LIMITS

The following items are excluded from the supply from EOT Crane Manufacturer :

Building structure including beams supporting crane rails.
Gangways and ladders along building walls.
Earth connection to gantry rails.

5.1 It is the obligation of the vendor / OEM to ensure supply of complete package of EOT Crane.

5.2 However, all requisite regarding supply, erection, commissioning covering wide spectrum of project shall be LSTK Contractor's responsibility.

6.0 EXTENT OF SUPPLY & ERECTION

6.1 General

Supply includes Design, calculations and all materials and services needed for satisfactory and safe operation of the cranes including :

erection on site
pre-commissioning and start-up
load testing which will be performed after erection.

6.2 The supply shall include but not be limited to:-

6.2.1 Design, engineering and fabrication.

6.2.2 The electrical equipment including isolator, flexible feeder cables/internal connection
and the control system as per electrical specifications.

6.2.3 The roller supports, fixing material and rails for flexible supply cables.

6.2.4 Crane rails including support plates, cleats, etc. and electrical inter-connections for earthing of rails.

6.2.5 Mechanical stops and buffers for LT & CT motions.

6.2.6 Gangways and steps on the cranes but not on the building.

6.2.7 Workshop tests according to Clause No. 7.0

6.2.8 Painting according to brief specification as described in Article 9.0

6.2.9 The documentation in accordance with NIT/ITB.

6.2.10 The spare parts for 2 years operation as per NIT/ITB.

6.2.11 Inspection programme as per Clause No. 7.0

6.2.12 The name plate in the English Language with indication of max. Permissible load.

6.2.13 Alignment of sole plates, erection and alignment of rails, and down shop leads including supporting arrangement for DSL, wherever required.

7.0 INSPECTION, TESTING & REPAIRS

7.1 Inspection & Testing programme shall be furnished by the Vendor after placement of order for OWNER'S approval.

7.2 Inspection and testing shall conform to relevant standards.

Parts found defective or not conforming to the Standards as to workmanship or materials shall be rejected and replaced by the Vendor free of cost.

Waiving of inspection or acceptance of material or equivalent by the purchaser shall not relieve the manufacturer from the responsibility of furnishing material or workmanship in accordance with the relevant Standards.

All welding shall be carried out by qualified welders. Manufacturer shall furnish evidence acceptable to Third party Inspector of qualification tests of welders as required by relevant Indian Standards. All welding shall be

subject to inspection by TPI, who will have the option to call for radiography or other non-destructive examination of welds to check soundness.

The main bridge girder shall be completely radiographed and radiographs produced. However, butt welds of bridge girder will be 100% radiographically tested on tension zone and 25% at random on compression zone.

7.3 TESTS AT MANUFACTURER'S WORKS

All electrical and mechanical equipment shall be tested in accordance with the appropriate Standards at either the crane maker's or the equipment manufacturer's works and test certifications shall be furnished.

The cranes shall be tested at manufacturer's works under no-load. Travelling gear may be run light to check shaft and gear alignments.

TESTS AT SITE

For testing of electrical installation, refer Electrical Specification.

Test for Operation:

After the supply has been connected, and before the complete crane installation is put into commercial service, tests shall be carried out to prove the following :
Satisfactory operation of all motors under no-load conditions.
The satisfactory operation of each controller, switches contractor, relay and other control devices and in particular the correct operation of all limit switches under the most unfavourable conditions:
The correctness of all circuits and interlocks and sequence of operation.
The satisfactory operation of all protective devices:
The satisfactory operation of each motion of the cranes.
The compliance of the crane with the specified performance requirements: and
Tolerance on specified speeds at full load shall be with = ± 10%.

7.4 DEFLECTION TESTS:

The deflection test shall be carried out *at site* with the safe working load at rest and with the crab in a central position. The measurement shall not be taken on the first application of the load. The datum line for measuring the deflection shall be obtained by placing the crab on the extreme end of the crane span with smaller hook approach.

7.5 OVERLOAD TESTS:

After tests but before the crane is put into service, it shall, with overload relays approximately set, be tested to lift and sustain a minimum test load of as per codes & standards requirement.

During the overload test each motion in turn shall be manoeuvred in both directions and the crane shall sustain the load under full control. The specified speeds need not be attained but the crane shall show itself capable of dealing with the overload without difficulty.

8.0 PREPARATION FOR SHIPMENT

8.1 Each transport unit shall be suitably prepared for shipment, properly braced and loose parts secured to prevent damage during shipment. All material shipped shall be properly marked with the item number for which it is intended by means of a metal tag.

8.2 The vendor shall give all information concerning the protection needed for preservation of the equipment.

9.0 PAINTING

Painting shall be as per manufacturer standard and appropriately chosen for owner's site condition.

10.0 SPARES

10.1 All erection, pre-commissioning & commissioning spares including spares consumed during testing / PGTR till handing over the plant to owner shall be supplied by LSTK Contractor free of cost. Any unused commissioning spares shall be owner's property.

10.2 Mandatory spares shall be supplied by the LSTK contractor as per NIT.

10.3 LSTK Contractor to also furnish separate recommended list of 2 years operation & maintenance spare part list along with budgetary offers, valid for 2 years from the date of submission of offer for owner's consideration .

Recommended spares and their quantities should take into account related factors of equipment reliability, effect of equipment downtime upon production or safety, cost of parts and availability of vendor's service facilities around the proposed location of equipment.

10.4 Detail List of special tools & tackles shall be furnished by the LSTK bidder along with the bid and shall be in scope of supply of the LSTK contractor.

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11.0 DRAWINGS AND DOCUMENTS:

The drawings, documents and data to be supplied after placement of the order shall be as per NIT.

12.0 GUARANTEE:

The crane shall be guaranteed by the supplier to be of accepted design, free from inherent defects in either workmanship or materials and to safely handle its rated capacity load without any undue deflections on its structure or mechanism. Any part proving defective within the warranty period shall be replaced free of charge by the Vendor.

12.1 Performance Guarantee:

The cranes with its drives and other equipment shall be tested at site to verify the electric consumption, various speeds, deflection and other performance figures guaranteed by the Vendor.

Noise levels at 1.0 M distance from package machine's surface shall not exceed 85 d B(A).

13.0 PRIORITY:

In case of any conflict between the data sheets & the technical documents referred / enclosed, the information given in data sheets shall govern.

14.0 SUB-VENDOR(S):

The Sub vendor / manufacturer/ Supplier must have supplied similar model, size for two similar installations & service which are working satisfactorily. Feed Back report for the same shall be furnished to Owner / PMC prior to placement of order.

PART: TECHNICAL

SECTION – 9.0

DESIGN PHILOSOPHY & GENERAL SPECIFICATION – PIPING

PLANT: AMMONIUM NITRATE (AN) MELT PLANT AT RCF, TROMBAY

CONTENTS

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LIST OF ATTACHMENTS

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2	Accessibility For Valves & Instruments
3	Vertical And Horizontal Guides Spacing
4	Clearances
5	Design Philosophy for Stress Analysis
6	Design Philosophy for 3D Modeling

1.0 SCOPE

The scope of this document is pertaining to the design philosophy, supply of basic design , detailed engineering, procurement, supply, fabrication, inspection by third party inspection agency (TPI) as applicable, expediting, insurance, transportation of all equipment / materials to work site, storage, construction and erection of all civil structure , mechanical, electrical and instrumentation works, assembly and installation, obtaining all necessary statutory approvals, testing, mechanical completion, pre-commissioning, commissioning, performance guarantee test run and specific requirements which shall be adhered to by LSTK contractor or his associates and representatives during the course of the project in designing, procurement & construction of piping material.

1.1 Applicable Standard & Codes

Standard No.	Title
ASME/ANSI B16.5	Steel Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	Steel Butt-Welding Fittings
ASME/ANSI B16.10	Face to Face and End to End Dimensions of Valves
ASME/ANSI B16.11	Forged Fittings Socket Welded and Threaded -
ASME/ANSI B16.20	Metallic Gaskets for Pipe Flanges – Ring Joint, Spiral Wound, and Jacketed.
ASME/ANSI B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
ASME/ANSI B16.25	Butt-Welding Ends
ASME/ANSI B16.34	Valves – Flanged, Threaded Welding End.
ASME/ANSI B16.47	Large Diameter Steel Flanges
ASME/ANSI B31.1	Power Piping
ASME/ANSI B31.3	Process Piping.
ASME/ANSI B31.5	Refrigeration Piping
ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe.
ASME/ANSI B36.19M	Stainless Steel Pipe
API 6D	Specification for Pipe Line Valves (Gate, Plug, Ball and Check Valves).
API 6FA	Fire Test for Valves.
API 501	Specifications for Metallic Gaskets for Refinery Piping.
API 594	Check Valves:, Wafer-Lug and double flanged type
API 598	Valve Inspections and Testing.
API 599	Steel Plug Valves Flanged and Butt-weld ends
API 600	Steel Gate Valves Flanged and Butt-welding ends, Bolted Bonnets

API 602	Gate, Globe, and Check Valves for Sizes DN 100 (NPS 4) and Smaller for the Petroleum and Natural Gas Industries
API 602	Corrosion resistant, bolted bonnet Gate Valves – Flanged & butt welding ends
API 603	Corrosion resistant, bolted bonnet gate valves-flanged & butt welding ends
API 604	Ductile Iron gate valves – flanged ends.
API 606	Compact C.S. Gate Valve extended body.
API 607	Fire Test for soft seated Ball Valve.
API-608	Metal Ball Valves, Flanged, Threaded & BW Ends.
API 609	Butterfly Valves, Lug type & Wafer type.
API 623	Steel Globe Valves—Flanged and Butt-welding Ends, Bolted Bonnets
IBR	Indian Boiler Regulations
AWWA C207-D	Large Dia. Steel Flanges (Ring Type).
EJMA	Expansion Joints Manufacture Association.
MSS SP 6	Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves and Fittings.
MSS SP 25	Standard Marking System for Valves, Fittings, Flanges & Unions
MSS SP 43	Wrought Stainless Steel Butt-weld Fitting
MSS SP 45	By-pass and Drain Connection.
NACE MR0175-94	Sulphide Stress Cracking resistant Metallic Material
NFPA	National Fire Protection Association.
EN 10204	Metallic Products - Types of Inspection documents

2.0 DESIGN PHILOSOPHY

2.1 General

2.1.1 Piping systems shall be in accordance with Clause 1.1, which permits the use of the following specifications:

ASME B31.1 Power Piping

ASME B31.3 Process Piping

ASME B31.5 Refrigeration Piping

Materials, design, construction, testing and inspection shall be fully in accordance with the selected specification.

2.1.2 The dimensions, manufacturing tolerances and marking of ferrous and non ferrous piping components shall conform to the applicable standards .The design shall comply with all

applicable codes, laws and statutory regulations. The Contractor shall optimize the layout with the approval of the owner and include any changes resulting from HAZOP studies and taking into consideration the following :

i) General site layout taking into account the topographical geo-technical aspect of the site.

ii) Access for maintenance and fire appliances.

iii) The interdependency of units and buildings with each other within the complex.

iv) Safety escape routes for personnel based on emergency or disaster management plans in the event of environmental upset or fire.

v) Suitable drainage system of Project site.

2.1.3 Material of construction shall be suitable for specified process duty (both normal and abnormal operations) and have a projected life and corrosion/ erosion allowance in excess of minimum life of the project. Piping materials specified in piping materials specification shall be used for selection of material of construction of major services.

All materials under steam service shall be supplied with proper certificates in prescribed forms.

2.1.4 **Design Pressure**

The design pressure of each component in a piping system shall be the most severe condition of the followings:

i) Design pressure of equipment to which it is connected.

ii) Set pressure of a pressure relieving device which protects the system.

iii) Shutoff discharge pressure of centrifugal pumps, not protected by a pressure relieving device.

If the shutoff discharge pressure is unknown, it may be determined by the largest of the followings:

a) 1.2 times the differential pressure at normal flow plus the maximum pump suction pressure.

b) 1.1 times pump discharge pressure at normal flow.

iv) Full vacuum for a system operating below atmospheric pressure.

2.1.5 **Design Temperature**

The design temperature of a piping system shall be the design temperature of connected equipment, unless the equipment is obviously overrated.

For un-insulated piping, the design temperature may be determined in accordance with the ASME B31.3.

The reducing coefficient for piping components not specified in the ASME B31.3 shall be 95% for the fluid temperatures over 37°C.

The design temperature for a steam traced or steam-jacketed piping shall be the higher of the followings:

I) Fluid temperature

II) Normal operating temperature of steam

3.0 CODES, STANDARDS AND SUPPLEMENTARY SPECIFICATIONS:

3.1 General

3.1.1 The latest edition of codes listed in clause 1.1 shall be applicable for piping system design, materials, fabrication, manufacture, erection, construction and inspection etc. For any item not covered in the list of codes and standards / International Standards / proven design may be finalized based on discussion with OWNER/Consultant.

3.1.2 Where conflict occurs, the order of precedence shall be:

a) Statutory Regulations

b) National, International and Industry Standards and Codes of Practice.

c) Technical Specifications

3.1.3 Standards, Codes and Supplementary Specifications for piping design shall be applied as follows:

i) Process and utility piping to ASME B31.3 Process Piping

ii) Power Plant piping to ASME B 31.1

iii) Requirements of Anhydrous Ammonia Code

iv) Sour service piping to NACE (National Association of Corrosion Engineers) specification MR0175.

v) Plant layout and fire protection piping to Dangerous Goods Regulations and “Storage and Handling of Flammable and Combustible Liquids”, supplemented where required by NFPA (National Fire Protection Association) Code 30.
Fire protection system shall be designed and installed in accordance with applicable NFPA (National Fire Protections Associations) Codes.

vi) Piping fabrication tolerances to ASME B31.3 and PFI (Pipe Fabrication Institute) practice ES-3.

vii) Color coding for identification of piping material to PFI Practice ES-22/ as per owner's approval.

viii) Pipe wall thicknesses shall be in accordance with ANSI B36.10 or B36.19. “Identification of Pipe Contents”.

4.0 GENERAL DESIGN

4.1 Design

4.1.1 Flanges for process and utility piping shall be in accordance with ANSI B16.5 and ANSI B16.47.

4.1.2 Wherever possible all purchased equipment shall be supplied with flanges that comply with ANSI B16.5.

4.1.3 The minimum size of piping to be used in pipe-racks shall be 2" NB.

4.1.4 With the exception of equipment connections the minimum size of piping shall be ½" NPS.

4.1.5 Pipe sizes 1 ¼", 2 ½", 3 ½" and 5" NPS shall not be used except as connections to purchased equipment.

4.1.6 Threaded pipe nipples between headers and vent, drain and instrument isolation valves shall be Schedule 160 for CS and Schedule 80S for SS in the size range ½" to 2" NPS.

4.1.7 Piping 2" NPS and above shall be butt-welded. All weld joints in piping 1½" NPS and below shall be socket welded using socket weld fittings.

4.1.8 In Class 600 and higher pressure rating double block valves shall be used for systems open to atmosphere, such as vents and drains. Piping in hazardous service shall have vents, drains routed to a safe location. Category 'M' substances shall be vented to the flare system.

4.1.9 When a line of one material specification is connected to a line of higher material specification, the connecting line shall be constructed of the higher material specification or pressure rating up to & including the first block valve.

4.1.10 As a minimum, piping systems shall have isolation facilities as follows:
ASME B31.3 Category 'M' service and Normal service (Class 900 and above) shall have double block isolation valves with a downstream drop-out spool.
ASME B31.3 Normal service (Class 150 and 600) shall have a valve and downstream spectacle blind.
ASME B31.3 Category 'D' service shall have a valve and downstream spectacle blind.
Generally, equipment shall have provision for isolation of piping to each equipment connection by means of valve and /or blinds as determined by service conditions.

4.1.11 Piping flexibility shall be achieved by the use of piping offsets and expansion loops whenever possible. Expansion joints shall not be used without written permission of the Owner.

5.0 DESIGN PHILOSOPHY / GENERAL CRITERIA

5.1 Equipment Layout

5.1.1 Basis of Equipment Layout

Equipment Layout shall be finalised based on the following data:

a) Site Location Plan (Drg No.4002-0000-0001)

b) P&I Ds

c) Equipment Data Sheets

d) Wind Direction

e) Overall Plot Plan

f) Safety Distance and Specific Distance mentioned in Piping Design Basis and as per statutory requirements.

5.1.2 **Development of Equipment Layout**

The following aspects shall be considered during development of equipment layout.

a) Process Requirement -Proper interconnection between equipment as per P&I Ds to achieve the intended process parameters.

b) Economy of piping material- Minimize the quantity of costly piping.

c) Erection & Construction requirements:

Erection scheme and schedule of all equipment must be considered during equipment layout to have smooth erection mainly in case of tall columns, heavy equipments like thick walled reactors, space for laying tall columns, approach roads for cranes / derricks for lifting the column or reactors and requirement of special foundation / pile etc.

d) Operation and Maintenance Requirement

- Overhead and side clearances for exchangers and pumps
- Provision of exchangers tube bundle pulling area
- Horizontal & overhead clearances for easy movement of working personnel.
- Crane approaches for air coolers.
- Provision of catalyst loading/unloading facilities.
- Provision of monorail for pumps and exchangers
- Provision 'of EOT crane for compressors.
- Provision of operator's cabin.
- All coke chambers shall be having the lift provision.

e) Similar equipment grouping - All columns, exchangers, pumps etc. should be grouped together for convenience of maintenance and safety wherever feasible.

f) The technological structures should be interconnected for easy movement of operational personnel.

g) U/G piping corridors for main headers should be marked in equipment layout for all underground piping.

5.1.3 **Plant Layout & Design guidelines**

5.1.3.1 **General**

The plant layout shall be based on ensuring adequate access, to allow construction, inspection, maintenance and operation to be performed in a safe and efficient manner. The alignment of equipment and pipe shall offer an organised appearance. The layout shall be in accordance with, but not limited to the design practices described in this criteria.

Where dynamic loading, limited pressure drop or other severe service condition applies, particular care shall be taken in routing pipe lines.

Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify– when the line is dead. Sufficient Nitrogen purging points shall also be provided. Supply piping of fuel gas shall be arranged for equal flow distribution.

Trolley beams, pipe davits, shall be provided with appropriate removable hoists mechanism for charging and discharging catalysts, chemicals, packing rings etc.

Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.

All utility and process piping shall be located above ground, and major lines shall be located in overhead pipe ways.

The following lines may be buried providing they are adequately protected.

i) Cooling Water Lines 18" dia. and larger.

ii) Fire water mains.

iii) Drain and Sewer (oily and chemical) lines from catch basin to mains and manholes.

Lines that must be run below grade, and must be periodically inspected or replaced, shall be identified on the P & ID's; these lines must be placed in covered concrete trenches. Sleeper-ways shall not be used in process areas where they may block access for personnel and equipment.

Fire protection system shall be designed as per NFPA, / TAC and as per statutory requirements. Refer Fire Fighting Design Basis

Drip legs and dead ends shall be avoided, especially for piping where solids or fluids may congeal from corrosive condensate.

Where sleeper ways are used the elevations shall be staggered to permit ease of crossing or change of direction at intersections. Flat turns may be used when entire sleeper ways change direction. Flat turns must not be used within pipe racks.

All cooling towers should have sunshades at top distribution decks to avoid algae growth. Cooling towers should be located away from process unit area, preferably downstream direction of wind. Orient the short side of the tower along the prevailing summer wind for maximum efficiency. Locate cooling towers a minimum of 30m away from process units, utility units, fired equipment, and process equipment.

Locate flare stacks upwind of process units, with a minimum distance of 90 m from process equipment, tanks and cooling towers.

Spacing and routing of piping shall be such that expanding/contracting lines (including insulation) will not clash with adjacent lines, structures, instruments and electrical equipment during warm up and cool down.

Piping to be sloped shall be indicated on the P&I D's.

5.1.3.2 Pipe-Rack/T-Post/Small Portals

In general, equipment layout shall be prepared considering straight pipe rack, however other shapes like L / T / U / H / Z etc can also be considered based on area available.

The width of the rack shall be 4M, 6M, 8M, 10M or 12M for single bay having four (4) tiers maximum. In general, the spacing between pipe rack portals (span) shall be taken as 8 M for main rack. However it can be decreased to 6 M depending on the size/number of the pumps to be housed below pipe rack. Intermediate Beams between two portals shall be provided to support smaller pipes <= 2". 20% extra space shall be provided on the pipe rack and portals on each tier for future expansion/modifications. Water lines more than 16" shall not be routed over rack.

-Clearance beneath pipe rack shall be 3.8 M minimum.

-Road clearance shall be 9 M minimum wherever heavy duty crane movement is required during construction and future maintenance.

-Road clearance shall be 7.5 M minimum for main roads.

-Road clearance shall be 5 M minimum for secondary roads.

-T-Portal's width shall not be more than 2.5 M and height shall not be less than.3.0 M

5.1.3.3 Towers and Vertical Vessels

Towers and vertical vessels shall be arranged in a row with common centre line, decided by the largest vessels, placing O.D. Of the equipment minimum 4 M away from the pipe rack. A minimum clearance of 3 M shall be allowed between tower shells, but in any case adjacent towers shall be checked so that platforms do not overlap considering the deflection of towers (deflection of towers shall be considered minimum L/200 MM, WHERE, (L=height of tower). A minimum 100 mm horizontal gap shall also be provided

between platforms of adjacent towers after deflection and that a minimum 900 mm is left between tower plinths. Also the gap between vertical vessels shall allow full opening of manhole covers without restriction.

Efforts shall be made to provide interconnecting platforms at suitable levels for adjacent towers and/or adjacent technological structure etc., Interconnections where ever feasible shall be done, after taking thermal expansions of towers into consideration.

The maximum vertical distance between platforms shall be 6 m. All level switches, LGs etc including their isolation valves shall be accessible from ladders or platforms. To handle heavy items (like relief valves, blinds etc.), davit of suitable capacity to lift higher weight of safety valves/ Blind/ Internals etc. is needed. The davit shall be on the side of the vessel away from the rack. The area at grade shall be kept clear for a dropout. Davit capacity shall be minimum 1 MT.

Chemical vessels to be located close to the dosing point to the extent possible, specially ammonia & corrosion inhibitors.

5.1.3.4 Re-boiler

Re-boiler shall be located next to the tower they serve. The elevation of re-boiler shall be as given in the P & ID's. Horizontal thermo siphon types are usually supported by the tower and are located on the back side to be accessible for maintenance. Large vertical types may require a supporting structure which cannot be supported from the tower/column. Re-boiler piping shall be checked for pressure drop before finalization.

5.1.3.5 Horizontal Vessels

The horizontal vessels shall be laid perpendicular to pipe rack and shall be placed minimum 4M away from the pipe rack. The clearance between horizontal vessel shells shall be minimum 2M or 900 'mm clear aisle whichever is higher.

5.1.3.6 Pumps

Wherever practicable pumps shall be arranged in rows with the centre line of the discharge on a common line. In general, pumps shall be kept inside the pipe rack. However in case of smaller racks, pumps shall be kept on one side or outside the pipe rack to provide clear access under the rack as per clause 5.1.3.11.2**.**

Pump foundation height shall be 300 mm above H.P.P.

Pumps which are handling hydrocarbon at temperature above 315°C and pumps for which specific notes are given in P&ID shall be necessarily housed outside the rack.

Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.

All pumps not open to sky with motor rating >= 45 KW shall be provided with monorail. No monorail should normally be provided for pumps outside rack and sufficient space below rack shall be available for pump maintenance.

5.1.3.7 **Exchangers**

In most of the cases floating head of exchangers are placed on a line minimum 4M away from pipe rack. Shell and tube type exchangers may have a removable shell cover with flanged head. Tube pulling or rod cleaning area must be allowed at the channel end. This shall be minimum the tube bundle length + 1.5M from the channel head. In case of vertical exchanger suitable platform shall be provided below the top flange of channel or bonnet.

Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher.

Likewise Heat Exchanger train should be suitably spaced such that shell/ tube inlet/outlet piping do not foul floating Head Covers creating maintenance problem.

Hydro extractor is considered for exchanger bundle/ shell removal. Monorails to be provided for tube bundle removal only for exchangers not accessible to Hydro extractor. No special bundle removal arrangement will be provided for exchangers which are open to sky. Davit shall be provided for floating head cover for all exchangers.

5.1.3.8 **Fin Fan Exchangers**

Fin fan exchangers shall be located over the main pipe rack or on technological structure.

15.0 M horizontal distance shall be maintained from furnace/heater. Concrete floor shall be provided below the fin-fan coolers located above the pipe rack. The width of the structure from where Air Fin exchanger assembly is supported shall be minimum 2.0 M more than the Air Fin exchanger tube bundle length so that proper supporting of inlet/outlet piping manifolds can be done from the main members of pipe rack/technological structure to transfer piping load to main structural members. Monorail shall be provided at one end of air cooler platform area for lowering the gear boxes. Adequate headroom /clearance shall be provided between concrete floor and fan location

5.1.3.10 Compressors and their Prime Movers

Two major types of compressors used in process plants:

1. Centrifugal compressors
2. Reciprocating compressors.

Compressors shall be located to keep suction lines as short as possible. Drivers for compressor may be electric motor, gas engine, gas-fired turbine or steam turbines as per P& ID. The gas compressors shall be located downwind side of furnace so that leaks are not blown towards furnace. In general compressors are kept under shed. When compressors are kept under shed, sides are fully open for the low shed or partially closed from top for high shed to avoid accumulation .of heavier gases in the shed.

In case of a turbine driven compressor, if exhaust steam is condensed, turbine and compressor to be located at an elevated level and condenser to be located below turbine.

A major consideration in centrifugal compressor location is the lube and seal oil console. It must be accessible from road and must be lower than the compressor to allow gravity drain of oil to the consoles oil tank.

Intercoolers are placed near compressor and are kept within/outside shed, keeping the safe distance. Knockout pots and after coolers may be kept outside the shed but near compressor house.

For compressors one electrically operated Crane to handle heaviest removable piece shall be provided for each compressor house. Maintenance bay for compressors shall be provided. Maintenance bay shall be accessible from road to facilitate unloading of load on to truck etc. For removal of bundles of exchangers located within building monorail arrangement shall be provided.

Compressor manufacturer may be consulted for better layout and additional requirement for maintenance. However licensor's requirement, if any, shall also be taken into consideration.

In case the compressors are located at grade level; the finished floor level for compressor house shall be 300 mm above HPP. However if the compressors are located at elevated structure the finished floor can be same as HPP.

Layout of compressor house for AN Melt plant shall be such as to have minim. Distance of:

a) When installed in a line
   - i) 5 meters on either side of compressor train.
   - ii) 5 meters between compressors.

b) When installed in parallel.
   - i) 5 meters at both ends of compressor/turbine train.
   - ii) 5 meters between compressors

All distances are to be measured from the edge of base plate.

The bidder shall submit plan layout of the compressor house and the design of plant layout shall be in agreement with owner. The compressor house shall be covered. The drop down area shall be provided with removal grating and structure. All other area shall be covered.

5.1.3.11 Clearance and Accessibility

5.1.3.11.1 Crane Access & Tube bundle pulling

Equipment, structures shall be arranged to permit crane access to service air coolers, compressors and exchangers. All exchanger tube bundles shall be "jacked out" against shell. A clear space for tube bundle removal shall be provided. Dropout bay may be considered for exchangers at elevated structures. For high pressure exchangers, shell pulling on rails should be considered.

5.1.3.11.2 Access to Pumps

Clear access of 3.8M vertically and 4.5M horizontally shall be provided centrally under main pipe rack for small mobile equipment to service pumps, wherever these are put under pipe ways with prior specific approval. Pumps outside rack shall be approachable by small cranes etc. from under the pipe rack.

5.1.3.11.3 Access to lower items to grade (Lowering Area)

Clear access shall be provided at grade on the access side for lowering external and internal fittings from tall elevated equipment by providing pipe davits.

5.1.3.11.4 Layout & Access Requirements for Platforms ladders and Stairs

For providing platform ladder & staircase following guidelines shall be followed.

- Two means of access (i.e. two ladders or one ladder and one stair case) shall be provided at any elevated platform which serves three or more vessels & for B/L valves operating platform.
- Platforms, ladders and stairways shall be the minimum, consistent with access and safety requirements.
- Stairway for tanks to be provided on upstream of predominant wind direction.

i) Platform at elevated structure

a) Dual access (i.e. one staircase and one ladder) shall be provided at large elevated structure if any part of platform has more than 22.65M (75 ft) of travel.

b) Air coolers shall have platforms with interconnected walk-ways provided to service valve, fan motors and instruments. Access requirements shall conform to paragraph (a) above.

ii) Platforms with stair access shall be provided for:

a) Location at which normal monitoring (once a day or more) is required or where samples are taken.

b) Locations where vessels or equipment items need operator attention "such as compressors, heaters, boilers etc.

iii) Platforms with ladder access shall be provided for:

a) Points which require occasional operating access including valves, spectacle blind and motor operated valves, heater stack sampling points.

b) Man ways above grade on equipment.

iv) Ladder location

a) Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.

b) Landings shall be staggered. No ladder shall be more than 6 M in one flight.

5.1.3.12 Valves

5.1.3.12.1 Piping shall be so arranged that valves can be operated easily.
Frequently operated valves shall be located in such a way that the valves are easily accessible from grade, platforms, stairs or ladders, and that the bottom of a hand wheel is located less than 1.8 m above the operating floor level.

5.1.3.12.2 Other valves should also be accessible where they are located at more than 1.8 m above the operating floor level. Chain-operated valves, shall not be used.

5.1.3.12.3 For valves in trenches, if hand wheels are located more than 300 mm below the cover plate, the valves shall be provided with extension stems extending to within 100 mm below the cover plate.

5.1.3.12.4 Manually operated valves, which are used in conjunction with locally mounted flow indicators, shall be placed at the same operating level and located where the instrument can be readily observed.

5.1.3.12.5 Double block valves shall be provided with interconnecting piping where intolerable contamination could result from valve leakage.

5.1.3.12.6 Where block valves are installed in branch lines from headers, the valves shall be located in horizontal runs at high points so that lines will drain both ways.

5.1.3.12.7 All valves shall be so installed that the stems are not below horizontal positions unless otherwise specified.

5.1.3.12.8 All valves shown on the piping and instrument flow diagrams as located at nozzles of equipment, such as towers and reservoirs, shall be connected directly to the nozzles.

5.1.3.12.9 Battery limit valves, if required, shall be grouped together and consideration shall be given to provide a common operation platform.

5.1.3.12.10 Vessel nozzles located below the normal or emergency liquid level shall be provided with the block valves as specified in paragraph 4.3.8, if practical. Other vessel nozzles Shall be provided with block valves only if required for operation.

5.1.3.13 **Control Valves**

5.1.3.13.1 All control valves shall be easily accessible from grade or permanent platforms and conveniently located for operations and maintenance.

5.1.3.13.2 Control valves shall be provided with block valves, a bypass valve and a drain valve. Fitting (flange or pipe fitting) shall be provided between the control valve and the block valves for easy maintenance. The drain valve shall be provided with the fittings (flange or pipe fittings) upstream of the control valve.

5.1.3.13.3 Block valves, bypass valve and drain valve may be omitted at the following conditions:

1) **Block valves**
   a) Where operating conditions are mild, and omission of the block valves will not jeopardize safety or operability of the unit.
   b) Where continuous operation using a bypass valve is impossible.
   c) For the downstream block valve of control valve, where discharged to atmosphere.

2) **Bypass valve**
   a) Where the block valve is omitted.
   b) Where continuous operation using a bypass valve is impossible.
   c) Where a globe valve is used instead of upstream block valve of a control valve, when discharged to atmosphere.

3) **Drain valve**
   Where operating conditions of piping for water, brine, nonflammable or nontoxic fluid are mild.

5.1.3.13.4 Unless otherwise specified on piping and instrument flow diagrams, sizes of block valves and bypass valves shall generally be as follows:
(Unit: Inch)

Flange Size of Control Valve	Line Size	Block Valve Size	By-pass Valve Size
3/4	3/4	3/4	3/4
	1	1	1

	1-1/2	1-1/2	1-1/2
	2,3,4	2	1
1	1	1	1
	1-1/2	1-1/2	1-1/2
	2,3,4	2	1-1/2
1-1/2	1-1/2	1-1/2	1-1/2
	2,3,4	2	2
2	2	2	2
	3,4,6	3	3
2-1/2	3,4,6	3	3
3	3	3	3
	4,6,8	4	4
4	4	4	4
	6,8,10	6	6
6	6	6	6
	8,10,12	8	8
8	8	8	8
	10,12	10	10
10	10	10	10
	12,14	12	12

5.1.3.13.5 Control valves, where practicable, shall be installed with the stems vertical.

5.1.3.14 **Orifice**

5.1.3.14.1 The length of straight run piping upstream and downstream of the orifice shall be in accordance with API RP550, Manual on Installation of Refinery Instruments and Control Systems, unless otherwise specified.

5.1.3.14.2 The straight run shall be designed for a beta ratio of 0.7. The smaller ratio may be used where practical considerations preclude the longer straight run installation.

Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation ver 4.5m above grade, including installed in pipe racks, shall be accessible from a platform with permanent ladder.

5.1.3.14.3 Orifice taps shall be located as follows: (Please also refer specs. For Instrumentation)

i) Air, Gas and steam

Top vertical centerline (preferred)

45 degrees above horizontal centerline (alternate)

ii) Liquid

Horizontal centerline (preferred)

45 degrees below horizontal centerline (alternate)

iii) Tap orientation shall be shown on piping isometrics.

iv) Finally all orifice impulse tapping / spare tapping will have to be seal run

5.1.3.15.1 Clearances

Minimum clearances shall be as indicated in Annexure - 4.

5.2 Unit Piping

5.2.1 Basis of Unit Piping

- Piping & Instrument Diagram
- Equipment layout
- Equipment Data sheet & Setting plan
- Line list
- Instrument Data sheet
- Structural & building drawings
- Topography of the plant
- Piping material specification
- Overall plot plan

The following objective shall be ascertained during piping layout.

- Proper access to all operating points including valves, and for all orifice tapping points and instruments in particular (refer Annexure-2).
- Proper access to interrelated operating points for specific purpose and for maintenance.

5.2.2 Pipe Ways/Rack piping

5.2.2.1 Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.

5.2.2.2 Predominantly process lines are to be kept at lower tier and, utility & hot process lines on upper tier.

5.2.2.3 Generally the top tier is to' be kept for Electrical (if not provided in underground trench as per electrical design basis) and Instrument cable trays. Cable tray laying to take care of necessary clearances for the fire proofing of structure.

5.2.2.4 Generally the hot lines and cold lines shall be kept apart in different groups on a tier. .

5.2.2.5 Generally the bigger size lines shall be kept nearer to the column.

5.2.2.5 Minimum spacing between adjacent lines shall be decided based on O.D of bigger size flange'(minimum rating 300# to be considered), O.D of the smaller pipe, individual insulation thickness and additional 25 mm clearance, preferably. Wherever even if flange is not appearing the minimum spacing shall be based on above basis only.

5.2.2.6 Actual line spacing, especially at 'L' bend and loop locations, shall take care of thermal expansion / thermal contraction / non expansion of adjacent line. Non expansion / thermal contraction may stop the free expansion of the adjacent line at "L' bend location.

5.2.2.7 Anchors on the racks are to be provided on the anchor bay, if the concept of anchor bay is adopted. Otherwise anchors shall be distributed over two to three consecutive bays.

5.2.2.8 Anchors shall be provided within unit on all hot lines leaving the unit.

5.2.2.9 Process lines crossing units (within units or from unit to main pipe way) are normally provided with a block valve, spectacle blind and drain valve. Block valves are to be grouped and locations of block valves in vertical run of pipe are preferred. If the block valves have to be located in an overhead pipe way, staircase access to platform above the lines shall have to be provided.

5.2.2.10 Provision of block valves, blinds etc. shall be as per Process Design Basis and P & IDs.

5.2.2.11 All small bore piping shall be designed in a way so as to ensure adequate space for maintenance and operation. For small bore piping intermediate support shall be provided in between portals.

5.2.2.12 Stubs on saline water (if applicable) service shall be from top of main header.
Minimum branch size for tapping including for instruments e.g. PG/ *PTI* TE etc. shall be of 3" NPD and 150 mm height on internal cement lined pipes.

5.2.2.13 Above ground lines shall be grouped to run on pipe racks or sleepers in so far as practicable.

5.2.2.14 Hot lines on pipe racks or sleepers shall be grouped and expansion loops shall be nested together. The number of expansion loops shall be kept to a minimum.

5.2.2.15 Piping handling corrosive fluids shall be run under piping handling non corrosive fluids, and shall not, where possible, be run overhead across walkways or normal passages for personnel.

5.2.2.16 All process and utility piping will be located aboveground within the plant battery limit, except water mains.

5.2.2.17 All piping shall be arranged in horizontal banks, where possible, to facilitate supporting.
Banks running north-south shall be at different elevations from banks running east-west. Exceptions are permitted to avoid unnecessary change in elevation at change of

direction or where essential to avoid pockets.

5.2.2.18 All piping shall be routed for the shortest possible run and have the minimum number of Fittings consistent with provision for expansion and flexibility. All piping shall be arranged in a neat manner, providing free access around all operating equipment.

5.2.2.19 Vertical lines at vessels shall run close to the vessel shell to facilitate supporting. The line shall be arranged and grouped to allow the use of single support.

5.2.2.20 Lines carrying molten solids, slurries or highly viscous liquids shall have a sufficient slope for each gravity flow.

5.2.2.21 The shortest and most direct layout possible shall be provided for gravity flow lines, especially when the fluid is subject to solidification and when the differential pressure is small.

5.2.2.22 Piping shall be arranged to facilitate handling of equipment for inspection or maintenance.

5.2.2.23 Vapour collecting system shall be routed so that the vapour rises continuously from the vessel being vented to a higher point without pocketing.

5.2.2.24 Pockets shall be avoided in lines, particularly those carrying corrosive chemicals, slurries, vents, blow down lines, etc.

5.2.3 Column / Vessel Piping Control Valves

5.2.3.1 Piping from column shall drop or rise immediately upon leaving the nozzle and run parallel and as close as practicable to vessel. Re-boiler outlet piping shall be as short as possible with minimum bends.

5.2.3.2 Piping shall be grouped as far as possible for the ease of supports and shall run on the rack side of the column.

5.2.3.3 Manholes shall be kept on the road side of the column and approachable from the platform. Platform width shall be such that minimum 1.0 M space is available beyond manhole for movement.

5.2.3.4 Piping shall be supported from cleats welded on the vessel as far as possible.

5.2.3.5 Proper guides at intervals shall be provided for long vertical lines.

5.2.3.6 Access platforms/ladders shall be provided along the column for valves and instruments. Minimum width of platform shall be 750 mm clear.

5.2.3.7 For ease of operation and maintenance, column and vessels which are grouped together, shall have their platforms at the same elevation interconnected by walkways wherever feasible. However each column \ vessel shall have an independent access also. Column vessel platforms should be designed in such a way so that all the nozzles should be approachable from platforms.

5.2.3.8 Unless specifically indicated in P&ID's control valves shall preferably be kept at grade instead of platform.

5.2.3.9 Piping intended for vacuum services shall be routed as short as possible, with minimum bends and flanged joints.

5.2.3.10 Piping support cleats shall be designed for safety valves considering impact loading during popping off.

5.2.4 Exchanger Piping

5.2.4.1 Exchanger piping shall not run in the way of built in or mobile handling facilities.

5.2.4.2 Wrench clearance shall have to be provided at exchanger flanges.

5.2.4.3 Piping shall be arranged so that they do not hinder removal of shell end and channel cover and withdrawal of tube bundle.

5.2.5 Heater / Furnace Piping

5.2.5.1 Arrange piping to permit burner removal by providing break up flanges in the piping.

5.2.5.2 Burner valves shall be located close to peep holes for operation. Piping to burners shall be arranged in such a way to give equal and sufficient quantity of oil/gas to all burners.

5.2.5.3 Only flexible metallic SS hoses shall be used for burner piping if required.

5.2.5.4 Block valves for emergency snuffing steam valves shall be located minimum 15M away from the heater, preferably on the upwind side of the heater.

5.2.5.5 Piping from various passes of heater outlet nozzles should preferably be symmetrical. Transfer line from heater to column shall be as short as possible, without pockets, free draining and with minimum bends.

5.2.5.6 No piping shall be routed in the tube withdrawal area. If unavoidable, break up flanges shall be provided in the piping for removal.

5.2.5.7 All furnaces, if they are located in the same area they should be interconnected with platforms at different locations.

5.2.6 Pump Piping

5.2.6.1 Pump drives shall have clear access.

5.2.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapour pockets.

5.2.6.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket. For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.

5.2.6.4 Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.

When a suction vessel operates under vacuum, the vent connection of the pump has to be permanently connected to vapour space of the suction vessel to allow possible filling of the pump with liquid before it is started.

5.2.6.5 Unless otherwise specified T -type strainers shall be used on pump suction piping for sizes 2" and above.

5.2.6.6 Y-type strainers to be used for all sizes in steam services and for pump suction lines 1½ and below.

5.2.6.7 All small bore piping connected to pump (drain to OWS & CBD, seat and gland leak drain) shall have provision for break up flanges for removal of pumps.

5.2.6.8 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610.

5.2.6.9 Pump discharge should preferably be routed away from the pump rather than towards the motor side.

5.2.6.10 Pump cooling water connection shall be taken from the top of circulating cooling water header.

5.2.7 Compressor Piping

5.2.7.1 Suction lines shall be as short as possible.

5.2.7.2 Suction piping shall have adequate flanged joints for ease of erection and maintenance.

5.2.7.3 Lube oil cooler space shall be provided such as to facilitate tube bundle removal.

5.2.7.4 All operating valves on main suction and discharge piping shall be lined on one side as far as possible.

5.2.7.5 A minimum straight length of suction pipe is to be provided as per manufacturer's recommendation.

5.2.7.6 Piping shall be designed so that forces and moments imposed on the compressor do not exceed the manufacturer's recommendation.

5.2.7.7 Compressor suction lines between the knockout drum and the compressor shall be as short as practicable. "

5.2.7.8 Where the line between knockout drum and the compressor cannot be routed without pocket, low point in compressor line shall be provided with drains to remove any possible accumulation of liquid. In no case accumulation at low point should be allowed to go towards the compressor.

5.2.7.9 Low points in the discharge line from an air compressor shall be avoided because it is possible for lube oil to be trapped and subsequently ignited. If low points are unavoidable,

they shall be provided with drains- In case of reciprocating compressor, piping shall be suitably supported to avoid vibrations due to pulsating flow. Unless specific requirements of no pockets are there from the licensor, all the piping shall run at 500 mm above grade level so that proper. Supports can be provided and also to minimize vibrations.

Analog study shall be carried out for complete compressor piping including suction / discharge piping as per P&ID' s and the analog study recommendations if any, shall be implemented.

5.2.7.10 Reciprocating compressor piping should not be supported from compressor shed / platform structure.

5.2.7.11 Pulsation dampers or surge bottles at the suction and discharge of reciprocating and displacement type compressors shall be provided according to manufacturer's recommendations.

5.2.7.12 A suction filter shall be provided in each compressor suction line to completely remove debris from the system.

5.2.7.13 Whenever possible, suction and discharge piping in the immediate vicinity of a compressor shall be located at or close to grade level to minimize vibration.

5.2.7.14 Spring loaded hangers or equivalent means shall be provided in compressor piping to minimize stress to nozzles. The allowable end reactions shall be based on manufacturer's recommendations.

5.2.8 Piping around Tanks Area

5.2.8.1 Nozzles for level controlling instruments shall be oriented within an angle not exceeding 60 degrees against the fluid inlet nozzles.

5.2.8.2 Nozzles shall be easily accessible from platforms or ladders, if provided with block valves, sampling valves, instruments, and all other devices to be manually operated.

5.2.8.3 Fluid inlet nozzles shall be located as far apart as possible from fluid outlet nozzles.

5.2.8.4 Vessel working platforms where man ways and hand holes are located shall preferably be provided with utility stations prescribed in paragraph 4.10.

5.2.8.5 The first pipe support from tanks shall be located sufficiently away from the tank to prevent damage caused by settling.

5.2.8.6 The number of pipelines in the tank dyke shall be kept' at minimum and shall be routed in the shortest practicable way to main pipe track outside the tank dyke, with adequate allowance for expansion. With nozzle tank Dyke the piping connected to that tank shall only be routed. Pad shall be provided at pipette sleeve interface at dyke wall entry point.

5.2.8.7 Manifolds shall be located outside the tank dyke & by the side of the roads, easily accessible by the walkway.

5.2.8.8 Plug valves whenever specified shall be of pressure balance type.

5.2.8.9 Analysis shall be carried out to prevent damage to lines and tank connection caused by tank settlement. If exceptionally high 'settlement is expected, Dressers coupling or flexible ball joint may be provided, after necessary analysis.

5.2.8.10 Special consideration shall be given as regards to spacing of nozzles while installing special item like hammer blind, MOV etc.

5.2.9 Relief System/blow down System Piping (CBD, OWS, FLARE)

5.2.9.1 Relief of liquids and easily condensable hydrocarbons are usually discharged to a closed system.

5.2.9.2 Wherever the inlet line size is higher than the safety valve inlet size, reducer shall be installed adjacent to inlet of safety valve.

5.2.9.3 Relief valve discharging steam, air or other non-flammable vapour or gas directly to atmosphere shall be equipped with drain and shall be suitably piped to prevent accumulation of liquid at valve outlet. Liquid phase blow down system piping connected to a closed system shall be self draining to the blow down drum. Closed blow down header shall be sloped towards the CBD drum to assure free drainage.

5.2.9.4 Liquid-vapour phase relief valves shall discharge into the flare header at an angle 45 degrees in the direction of header flow, to minimize the effect of kinetic energy and to avoid accumulation of liquid.

5.2.9.5 Pockets in the flare header and blow down system shall be prohibited.

5.2.9.6 Relief valve discharge piping shall be taken to safe location as per following.

3M above top platform of column or structure, within 6M radius for steam and 8M for Hydro carbon / toxic discharge.

25M horizontally away from furnace.

5.2.9.7 Inlet and outlet piping of pressure relief valve shall be adequately supported to take care of the thrust induced by the relief valve during popping.

Reaction forces due to safety valve popping shall be ascertained in the connected piping. The effect of these forces on the piping supports and the anchors of the piping system shall be calculated to ascertain that the allowable limits at these locations are not exceeded. The supporting structure also shall be adequately designed so that when subjected to these reaction forces the supporting elements connected to piping as well as the basic .supporting structure i.e. platform members etc. are capable of withstanding them. System stresses in the inlet and outlet piping portions at safety valves also shall be

kept within the allowable limits, inclusive of the distribution branching points in the inlet portion. These reactive forces shall not lead to any leakage at the flanged joints present in the system. To ascertain these necessary calculations for checking leakage at the flanged joints shall be performed.

5.2.9.8 Safety and relief valves shall be accessible from platform or grade. For the valves weighing more than 45 kg, davits or other lifting devices shall be provided. Alternatively crane access shall be provided for these valves.

5.2.9.9 Safety and relief valves shall be installed in a vertical position and shall have a minimum of pipe length between the protected line or equipment and the valve inlet.

5.2.9.10 Safety valves discharging to atmosphere shall have the outlet piping extending at least 2.2 m above operating platforms or levels within a radius of 7.5 m. A 9 mm minimum weep hole shall be provided at the lowest point of the outlet piping.

5.2.9.11 Safety and relief valves connected to flare lines shall be located higher than the flare header, where the fluid discharged from valve is liquid or condensable.

5.2.9.12 Outlet piping or safety and relief valves, including flare lines, shall be designed to prevent excessive stresses in the line due to rapid temperature change or uneven temperature distribution.

5.2.9.13 All flare headers shall be sloped 1 m per 400 m to 1 m per 1000 m downward to the blow down drum.

5.2.9.14 Flare System shall be designed such that:

a) There will be 1 Running + 1 standby Safety Valve. (For all process & utilities lines)

b) Each Valve shall have full relieving capacity.

c) Isolation Valve shall be provided on Up Stream side & Spectacle Blind with Valve on downstream side so that individual safety valve can be isolated for maintenance purpose.

5.2.10 Steam Piping - Indian Boiler Regulations (IBR)

Generally steam lines with conditions listed below fall in the scope of IBR.

- Lines having design pressure (maximum working pressure) Above 3.5 Kg/cm2 (g)
- Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm2 (g) & above.
- Lines with pressure less than 1.0 Kg/cm^2 (g) are excluded.
- Users of steam like steam tracing lines, jacket of the steam jacketed lines, steam heating coil within the equipment are excluded from IBR scope.
- Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum as marked in P&I D shall be under purview of IBR.

IBR requirements (in brief)

a) All materials used on lines falling under IBR must be accompanied with IBR Inspection Certificate in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local IBR inspector is acceptable. Whereas for Indigenous (Indian) supply, only IBR is the inspection authority.

However, for non - indigenous supply, IBR inspection shall be carried out by the inspection agencies approved by IBR.

b) Drawings like General Arrangement Drawings (GAD) and system isometrics / line wise isometrics of lines falling under IBR must also be approved by IBR authority of State in which the system is being installed.

c) All welders used on fabrication of IBR system must possess IBR welding qualification certificate.

d) IBR system must be designed to comply IBR regulations as well as ASME B31.3. All design calculations towards the same must be approved by IBR authority.

e) IBR approval is obtained with requisite fees payable to Indian Boiler Board of the State concerned.

f) Steam generators (boilers/heat exchangers) shall require exclusive IBR approval along with its integral piping up to the final isolation valve.

g) The discretion of IBR authority of state is final and binding for the above cases.

5.2.11 Steam Header & Supply Lines / Steam and Condensate Systems

5.2.11.1 Steam piping shall be designed to have complete condensate removal. Drip legs shall be provided with steam traps at low points in the system.

5.2.11.2 All steam branch connections shall be taken from the top of the header.

5.2.11.3 Return exhaust steam / condensate lines shall connect to the top of the exhaust steam Condensate header.

5.2.11.4 Where block valves have been installed in the main steam header such that condensate can collect either side of the valve when closed, a safe means of draining the condensate prior to opening the valve shall be provided.

- Steam header shall be located generally on the upper tier and at one end of the rack adjacent to columns.
- Branch lines from horizontal steam header, except condensate collection points, shall be connected to the top of the pipe header.
- Isolation valves (if provided) on the branch line shall preferably be provided on the horizontal run and outside the pipe rack.
- All branch lines shall be drainable.

- Drip legs & steam traps shall be provided at all low points and dead ends of steam header. Drip legs at low points shall be closer to downstream riser and shall be provided to suit bidirectional flows, if applicable.
- All turbines on automatic control for startup shall be provided with a steam trap in the steam inlet line.
- All traps shall be provided with strainers if integral strainers are not provided.
- Steam traps discharging to atmosphere shall be connected to storm water drain/storm sewer, in case of open system. In case of condensate recovery, traps shall discharge into condensate header.
- Expansion loops are to be provided to take care of the expansions within units.
- Wherever condensate is to be drained, proper condensate draining facility shall be provided.

5.2.12 Steam Tracing

5.2.12.1 Tracers for the individual lines shall be supplied from manifolds when there are two or more connections. Steam supply headers shall be located on continuous platform along the rack. No steam supply station shall be located at grade.

5.2.12.2 Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve and thermostatic steam trap shall be used. Number of tracers shall be 4/8/12 and tracer size 0.5" to .75" depending upon the detail engineering requirement. 20% or minimum 2 no. tracer connections shall be kept spare for future use for both steam supply and condensate collection manifolds.

5.2.12.3 All manifolds shall be installed in vertical position and manifold size shall be 3".

5.2.12.4 For steam tracing balanced pressure thermostatic steam trap with 40 mesh strainer to be used.

5.2.12.5 Manifolds shall be accessible from grade or from a platform.

5.2.12.6 Pockets in steam tracers shall be avoided as far as possible.

5.2.12.7 Tracers shall be limited to the following run length upstream of traps:

Size of Tracer	Length of tracer pipe (Meters) Steam operating pressure				
	20 psig	50 psig	100 psig	150 psig	200 psig & above
0.5" (Inch)	30	45	60	75	90

Tracers shall generally be of 0.5". Tracers shall be of CS steel seamless pipe and valves on the steam tracing circuit including steam station block valve shall be glandless piston

type construction. Heat transfer cement shall be applied in between main pipe and tracer pipe to improve heat transfer.

Size of the lead line to manifold shall be as follows:

Number of connections	Size of Lead Line
2	3/4"
3	1"
4-6	1 1/2”
7 -12	2"

The lead line to manifold, manifold up to the block valves of individual tracer shall be carbon steel of IBR quality.

Tracer lines shall be provided with break up flanges for main line flange joints and valves.

All tracers shall have individual steam traps before condensate manifolds.

Condensate manifold including the last valve on individual tracer shall be of carbon steel.

All steam traps discharging to a closed system shall have a block valve upstream and downstream of the trap. A bypass globe valve shall be installed around the trap. Check valve shall be installed on the downstream of the steam trap near the condensate header in case discharging to a closed system.

Number of tracers required on a line shall be as follows:	
Size of Line	Number of Tracers
up to 4"	1
6" to 16"	2
18" to 24"	3
26" & above	To Calculate

Steam Jacketing System

A steam jacketed pipe consists of a product line which passes through the centre of a larger diameter steam line.

The nominal size of the inner pipe (CORE) and outer pipe (JACKET) in inches shall be as per table below unless otherwise mentioned in project piping material specification (PMS) or P&ID.

Core pipe	Jacket pipe	Steam feeder to jacket
3/4"	1-1/2"	0.5"
1"	2"	0.5"
1-1/2"	3"	0.5"
2"	3"	0.5"
4"	6"	0.75"
6"	8"	0.75"
8"	10"	0.75"
10"	12"	0.75"

For jacketed lines using high pressure steam, actual calculations for core, jacket and feeder pipe shall be performed before finalization of sizing.

Distance between steam inlet and condensate outlet shall be similar to steam tracing system. Baffle plates, flanged joints or end caps shall be used to discontinue one feed length from the next.

Flanged jump over shall be used in case of a flanged joint. In case of discontinuous jacketing simple jump-overs shall be employed. The length of jacket shall be 4 to 5 meters or as mentioned in job specification.

Intermediate partial baffles shall be provided if a separate branch portion is to be heated from the main line stream.

Steam inlet to jacket shall generally be provided from top of the pipe in case of horizontal lines. The jump over and condensate outlets shall be from the bottom.

In case of vertical lines steam inlet shall be done at the topmost points and condensate outlet shall be done from the lowest possible points. Two consecutive Slipovers shall be 180 deg. apart.

Each feed length shall be provided with individual trap before connecting to condensate recovery headers.

Balanced pressure / bi-metallic type thermostatic steam traps with 40 mesh strainer shall be used in jacketing.

To keep proper concentricity between core and jacket pipe internal guides (rods or flat bars) shall be provided at intervals depending on the size of the pipe.

Wherever anchors are provided on jacket lines proper interconnection of jacket pipe and core pipe shall have to be provided with proper jump over for steam.

5.2.13. Water Piping

5.2.13.1 Water piping shall be designed to minimize the possibility of water hammer.

5.2.13.2 Water main headers may run underground to prevent freezing.

5.2.13.3 Unless local code or regulation prohibits, firewater lines shall be underground to prevent freezing. Firewater piping system shall conform to regulations of the competent governmental authorities.

5.2.14 **Instrument Air Piping**

5.2.14.1 Instrument air lines shall not be connected to process lines, service lines, and other equipment.

5.2.14.2 Instrument air shall not be used as plant air or service air.

5.2.14.3 Branch lines form the instrument air header shall be taken from the top of the header and shall be provided with a block valve close to the header. Also in the upstream of Instrument manifold, Gate valve has to be provided

5.2.15 Supports and Anchors

5.2.15 1 Supports and/or anchors shall be provided close to changes in direction of lines, branch lines and, particularly, close to valves to prevent excessive sagging, vibration and strain.

5.2.15 2 Allowable spans between pipe supports shall be determined to keep the maximum deflection within 16 mm.

5.2.15 3 In cases where periodic maintenance requires removal of equipment, such as pumps and relief valves, and where lines must be dismantled for cleaning, piping shall be supported to minimize the necessity of temporary supports.

5.2.15.4 Spring-loaded hangers may be used on piping subject to thermal expansion or contraction. In cases where the movement is very large, or the limitation of reaction and stress are very severe, constant support spring hangers shall be used.

5.2.15.5 Suction and discharge lines of rotating equipment shall be supported as close as possible to equipment nozzles, and shall be relieved of excessive strains by using proper pipe supports.

5.2.15.6 Supports shall not be directly welded to pipes. Where welding is unavoidable, supports having the same chemical composition as pipe shall be carefully welded.

5.2.15.7 All piping shall be properly supported to minimize vibration.

5.2.15.8 Outlet piping of safety and relief valves shall be supported so that the inlet piping is capable of withstanding the reaction caused by operation of safety and relief valves. Furthermore, the supports shall be designed to minimize the stresses due to thermal expansion and the stresses in the valve body due to the weight of piping.

5.2.15 .9 Expansion joints shall be guided and anchored to the extent necessary for their proper operation and alignment.

5.2.15 10 Anchors shall provide sufficient fixation to substantially transmit all load effects into the foundations.

5.2.15 11 Underground piping shall be given special anchoring consideration for differential settlement.

5.2.16 Utility Stations

Requisite number of utility stations shall be provided throughout the unit to cater for the utility requirement. Utility stations shall have four connections one for LP steam (SL), one for Plant Air (AP), one for Service Water (WS) and one for nitrogen each of 1.0" with isolation valves unless otherwise specified in P&ID.

Utility connection with nitrogen shall be provided with NRV along with isolation valve kept at a separate location other than this cluster @ 15 M

Air and water lines shall have quick type hose connection and steam line shall have flanged type hose connection. All connections shall be directed downward. All connections shall have globe valve for isolation purpose. An inter connection with valve shall be provided between steam and service water lines shall be provided. Inert gas hose, when required, shall have built in non return valve in quick connection coupling of piping end.

Number of utility stations shall be such that all equipments shall be approachable from at least one utility station. The approach of utility station shall be considered 15 M all around the station location.

The Utility stations shall generally be located adjacent to pipe-rack column.

The utility stations shall also be provided on elevated structures like - technological structure, operating platforms of vertical equipments etc.

Operating platforms having manholes must have a utility station. Utility station locations shall be limited to a height of 35 M from H.P.P.

5.2.17 Fire Fighting

All fire fighting facilities shall be as per statutory norms. Fire fighting points are to be provided for fighting fire at highest elevation in case of tall columns.

(Refer Fire Fighting System Design Philosophy)

5.3 Offsite & Yard Piping

In general, offsite piping (except tank ages area), electrical cable and instrumentation cable shall also be laid either on pipe rack or pipe sleepers.

Wherever piping is laid on pipe sleepers, it shall have hard surfacing below it keeping a gap of 300 mm from the bottom of the pipes. Hard surfacing should be completed before start of pipe laying. Width of hard surfacing shall be about 1.0 meter more than the piping corridor. This extra hard surfacing shall be for movement of operating personnel along the piping corridor.

Pipes at road crossing shall be under culverts in general. Overhead pipe bridges may be used for areas where pipe racks are provided. Where culverts are not provided, pipe sleeves shall be used for underground road crossing. Culverts / overhead pipe bridges shall be adequately designed to take care of future requirements. Minimum 20% extra width shall be provided in all such structures.

Clearances between lines shall be minimum "C" as given below:

$C= (Do+D_f)/2 + 25$ mm + Insulation thickness (es) where,

Do - outside diameter of smaller pipe (mm)

D_f - outside diameter of flange of bigger pipe (mm)

However this 'C' spacing between the offsite piping on the rack/sleeper can be suitably increased so that the lines should not touch each other after insulation / lateral thermal expansion.

Adequate clearance shall be provided for every long & high temperature lines to avoid clashing at the bends. See 5.2.2 also for line spacing at 'L' bends and loops.

Expansion loops for all lines shall generally be kept at the same location.

Vents shall be provided on all high points & drains shall be provided at all low points. Drain valves at sleeper piping shall be kept outside the sleeper way if the same is not accessible and valves shall be put in horizontal only.

Places where piping is extended to make drain valves accessible - 2 nos. of stiffeners, irrespective of pipe rating, shall be provided as per 5.13.1. Spacing of guides on each line on a pipe bay shall not exceed the value given in clause 5.13.1

5.4 Flare Piping

Flare header shall be sloped towards flare knock-out drum. Only horizontal loop shall be provided as per requirement to accommodate thermal expansion. The desired slope shall be ensured throughout including flat loop. Flare header shall be supported on shoe of height ranging from 100mm to 300mm.

Proper thermal analysis temperature shall be established including the possibility of temperature gradient along the line before providing expansion loops. Efforts shall be made to minimize the number of loops. Flare line between knock out drum and water seal

drum shall be designed for pressure fluctuations and adequately supported to avoid vibrations.

5.5 Underground Piping

5.5.1 Underground steel piping shall be protected from electric corrosion.

5.5.2 Underground piping passing under loaded areas, such as main roads in the plant, shall be protected from heavy traffic by casing pipes or covers extending at least 1 m on either side of the area or having the wall thickness sufficient to bear earth pressure.

5.5.3 Underground piping shall be sloped to all drain points with a downward slope of not less than 1 m in 150 m.

5.5.4 Expansion elbows or joints of underground piping for hot fluids, such as steam or heated heavy oil, shall be enclosed in a conduit from which they are separated to allow free longitudinal expansion.

5.5.5 Where it is impossible to run pipe aboveground or underground, trenches may be used.

5.5.6 Trenches for piping close to process equipment should be avoided, whenever possible.

5.5.7 All underground pipe work shall be provided with following protection:

a) At location where Underground Piping becomes above ground, INSULATING GASKET with material Glass Filled Teflon or Phenolic Laminated with rubber shall be provided.

b) IMPRESSED CURRENT CATHODIC PROTECTION (ICCP) shall be provided to all underground piping Specification shall be submitted by the CONTRACTOR & shall be approved by the OWNER.

c) Underground piping shall be wrapped & coated by “PYP KOTE” or equivalent material tapes / sheets, 4.00 mm thick & shall be “HOLIDAY TESTED” before Hydro Test.

d) All underground pipes shall have Sand Bed, at least 150 MM all around the pipe.

e) All road crossings by Underground piping shall be through Hume Pipe Sleeves.

5.5.8 Buried Pipes

The following points to be considered in designing of buried pipes.

i) All underground metallic piping shall be coated and wrapped and provided with cathodic protection system. If sacrificial metal is used, permanent testing arrangement shall be provided.

ii) All cooling water distribution headers 18" and higher shall be laid underground.

iii) All Sewage lines (oily and chemical) from catch basin to mains and manholes shall be laid underground.

iv) Underground pipe crossing roads, access ways, rails shall have casing pipe (R.C.C or C.S)

v) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/Maintenance.

vi) All U.G. headers shall clear equipment foundations as far as possible. Under special cases, the C.W. header may be laid over the footing of foundations.

vii) Provide break flange at + 500 MM from floor level connection with cathodic protection to isolate underground pipe from above ground piping. With insulating gasket KIT

ix) Pipes shall be laid below electrical cables if any.

5.5.9 **Piping in Trenches**

The following points to be considered in designing of trench pipes.

i) Piping located below grade, requiring inspection, servicing or provided with protective heating.

ii) Fire water lines/Process lines.

iii) Drain lines requiring gravity flow trenches.

iv) Sump for valves and trenches shall be provided.

v) Suitable draining scheme for trenches shall be provided.

5.6 Air Systems

5.6.1 Branch connections shall be taken from the top of the header.

5.6.2 Low points shall be fitted with drains.

5.7 In-Line Instruments

5.7.1 Liquid level controllers and level glasses shall be located so as to be accessible from grade, platform or permanent ladder. The level glass shall be readable from grade wherever possible.

5.7.2 Relief valves shall be accessible. Relief valves with a centre line elevation over 4.5 M above grade (expect in pipe racks) shall be accessible from a platform or permanent ladder.

5.7.3 Relief valves that discharge to a closed system shall be installed higher than the collection header, with no pockets in the discharge line.

5.7.4 Relief valves that discharge to atmosphere shall have tail-pipes extended to a minimum of 3.0 M above the nearest operating platform that is within a radius of 8 M.

5.7.5 Provide steam traps at pocketed low points and at dead ends of steam headers. Provide steam traps on excessively long runs of steam piping to ensure dry quality steam at destination. Steam traps located more than 4.5 M above grade, except in pipe racks, shall be accessible from a platform.

5.7.6 Control valves shall be accessible from grade or platforms. In general, the instruments or indicators showing the process variables shall be visible from the control valve.

5.7.7 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation over 4.5m above grade, except in pipe racks, shall be accessible from a platform or permanent ladder.

5.7.8 Orifice taps shall be located as follows:

i) Air, Gas and steam
Top vertical centreline (preferred)
45 degrees above horizontal centreline (alternate)

ii) Liquid
Horizontal centreline (preferred)
45 degrees below horizontal centreline (alternate)

iii) Tap orientation shall be shown on piping isometrics.

5.8 Sample Connections

5.8.1 Sample connections shall be accessible from grade or platforms. In general, where liquid samples are taken in a bottle, locate the sample outlet above a drain funnel to permit free running of the liquid before sampling.

5.9 Vents and Drains

5.9.1 The minimum size of vent and drain connections in shall be as follows:

For process & utilities lines:

4” & Below NPS ¾”

6” & 10” NPS 1”

12” & above NPS 11/2”

Vent & Drain shall be provided with the valve & blind flange. For all vents / drains of process lines / utilities lines, double valves shall be required for 600 # & more rating.

Process vents and drains shall be indicated on the P&ID’s

5.9.2 Vent, drain and sampling valves on process lines, not connected to a piping system, shall be provided with appropriate end closures.

5.9.3 Vents shall be located at high points of pipelines when necessary.

5.9.4 Drains shall be located at low points to empty pipelines or equipment after testing or during maintenance (i.e for every loop).

5.9.5 All drains and vents shall be provided with valve, except that vents for test purpose for flare liens (header), may be plugged. Exposed threads shall generally be seal welded.
Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the design review

5.9.6 Vent valves shall be the globe or gate type and drain valves the gate type.

5.9.7 Valved bleeds shall be provided at control valve stations, level switches, level controllers, and gauge glasses

5.10 Line Strainers

5.10.1 Provide temporary conical type strainers in 2” NB and above butt weld pump suction lines for use during start-up. Arrange piping to facilitate removal.

5.10.2 Provide permanent Y-type strainers for pump suction piping below 2” NB Thd Or SW.

5.10.3 Provide temporary basket type strainers located at the suction pulsation device inlet for start-up of reciprocating compressors. Arrange piping to facilitate removal of the filter.

5.10.4 Provide temporary basket type strainers and locate them as close as possible to the compressor inlet flange for start-up of centrifugal compressors. Arrange piping to facilitate removal of the filter.

5.10.5 Allowable pressure drop when specified shall be certified by vendor along with the offer. If asked specifically, vendor shall furnish pressure drop calculations

5.10.6 All 2" & higher sized Y type strainers shall be provided with 3/4" threaded ,tap and solid threaded plug as drain connection. For less than 2", this shall be ½ " size.

5.10.7 Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.

5.10.8 For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.

5.10.9 All the strainers shall be hydrostatically tested at twice the design pressure

5.11 Spectacle Blinds

5.11.1 Spectacle blinds shall be provided to isolate equipment. In hazardous service flanged drop-out spools shall be provided for safety purposes. Both shall be shown on the P&ID’s.

5.11.2 Spectacle blinds shall be accessible from grade or platforms. Blinds located in a pipe-rack are considered to be accessible. Blinds that weigh over 40kg shall be accessible by mobile equipment. Where this is not possible davits or hitching points shall be provided.

5.12 Personnel Protection

5.13.1 Eyewash and emergency safety showers shall be provided in areas where operating Personnel are subject to hazardous sprays, emissions or spills.

5.13.2 Personnel protection shall be provided on un-insulated lines and equipment operating above 70 deg C when they constitute a hazard to the operators during normal operation of the facility.

5.13.3 Leakage indicating tape and spray impingement shrouds shall be provided at flanged joints in hazardous service.

5.13 Mechanical Handling

5.14.1 Handling facilities such as davits and monorails shall be provided on vessels over 10m in height where the weight of removable internal and/or external equipment is greater than 35 Kg.

6.0 MATERIALS

Basic material selection of particular line depending on its service, temperature and corrosivity shall be spelt out in process package. Material specification shall follow the requirements as specified in PMS as per Licensor's requirement.PMS / VMS shall be supplied by bidder and will be approved by owner / PMC.PMS shall generally follow the requirements given in this section.

6.1 Piping Materials

6.1.1 All materials for piping components shall conform to the relevant code and/or specification.

6.1.2 All materials shall be new.

6.1.3 All plate, sections, pipe, fittings, flanges, valves and special items shall have Material Test Certificates.

6.1.4 All alloy materials shall have Material Certificates verifying the alloy content.

6.1.5 All bolting and gasket material shall have Letters of Compliance as a minimum.

6.1.6 All alloy bolting and gasketing shall have material Letters of Conformance verifying the alloy content.

6.1.7 ERW pipe and fittings shall only be used for category ‘D’ service as defined by ASME B31.3.

6.1.8 Category ‘M’ and Normal Service piping as defined by ASME B31.3 shall use seamless or 100% radio graphed EFW pipe and fittings.

6.1.9 Only piping materials listed in ASME B31.3 shall be used for Category ‘M’ and Normal Service piping. For Category ‘D’ utility piping, where scaling and impurities are to be

avoided (such as instrument air, potable water and deluge water) hot dipped galvanised and threaded fittings may be used in sizes up to and including 4" NB. Galvanised piping shall not be used in environments containing acids or other corrosive commodities. In corrosive environments stainless steel piping material shall be used for such utility systems.

6.1.10 For services defined within ASME B31.3 as Category 'M', no socket welded or threaded construction or connections shall be used for process equipment piping systems. Construction shall be by butt-welding with a minimum 20% radiography. Flanged connections shall be minimised.

6.1.11 All insulation and gaskets shall be asbestos free.

6.1.12 Insulating flange sets shall be provided between dissimilar materials as required.

6.1.13 Aluminium or copper alloys shall not be used for any component in the piping systems.

6.1.14 The use of 1.25Cr-0.5Mo alloy shall be a minimum requirement for piping systems having a design temperature above 425°C.

6.1.15 Nelson Curves in accordance with API 941 shall be applicable to piping system materials in hydrogen service.

6.1.16 The minimum corrosion allowance for any material, other than stainless steel, shall not be less than 1.6 mm. For stainless steel it is zero.

6.1.17 All instrument air pipe line shall be of SS304.

6.2 PIPE

6.2.1 Wall Thickness

6.2.1.1 Calculation of pipe thickness and branch reinforcement shall be based on requirements of ASME B31.3. Proper corrosion allowance and mill tolerance shall be considered to achieve the selected thickness.

6.2.1.2 For carbon steel and low alloy steel pipes (except for steam tracing piping) minimum pipe thickness shall be:

S80 up to 0.75",
XS for 1" to 2",
STD for above 2"
For stainless pipes minimum pipe thickness shall be
40S up to 2",
10S for above 2"

6.2.1.3 The philosophy of minimum thickness/schedule is applicable for both seamless and welded pipes.

6.2.1.4 The above mentioned minimum thickness/schedule criteria is not applicable to category -D classes, Firewater service and specification where API 5L pipes respectively, are being used.

6.2.1.5 All welded pipes shall have uniform negative wall thickness tolerance of 12.5% for wall thickness calculations purpose.

6.2.1.6 For thicknesses exceeding minimum thickness/schedule criteria, Schedule XS shall be selected for CS & AS classes (for 2" & above). Intermediate schedules between STD & XS shall be ignored. Similarly for SS classes (2" & above) S10, S20, S30 & 40S may be selected beyond minimum thickness/schedule criteria.

6.2.1.7 If, the thicknesses exceed XS in CS & AS classes and 40s in SS classes, only then, the thickness shall be calculated based on actual service conditions subject to a minimum of 80% class rating. Maximum 10% of corrosion allowance may be reduced in special cases, to optimize the pipe schedules.

In general, the pressure-temperature combination to calculate wall thickness shall be as follows:

Material	**Class**	**Size**	**Design Condition**
C.S. (A 106 GR.,B, API-5L GR.B, A672 GR.B60/C60 :CL 12) LTCS (A333 GR.6), Low Alloys (1.25% Cr- 0.5% Mo. 2.25% Cr-1.0% Mo. 5%Cr-0.5% Mo. 9%Cr- 1.0% Mo	150	Up to 24"	Class condition
		Above 24"	Line condition #
	300	Up to 14"	Class condition
		Above 14"	Line condition #
	600	Up to 8"	Class condition
		Above 8"	Line condition #
	900	Up to 8"	Class condition
		Above 8"	Line condition
	1500 & 2500	Up to 4"	Class condition
		Above 4"	Line condition
SS (A312 TP304, 304L.316L,321,347) OR (A358 TP304,304L,316, 316L, 321,347)	150	Up to 24"	Class condition
		Above 24"	Line condition ($)
	300	Up to 14"	Class condition
		Above 14"	Line condition ($)
	600	Up to 6"	Class condition
		Above 6"	Line condition ($)
	900,1500	Up to 4"	Class condition
		Above 4"	Line condition*

	2500	Up to 2"	Class condition
		Above 2"	Line condition*
Higher Alloys	150	Up to 6"	Class condition
		Above 6"	Line condition*
	300-2500	All sizes	Line condition*

Only If the thickness/schedule as per class condition exceeds XS

$ Only If the thickness/schedule as per class condition exceeds 40S

* Minimum thickness/schedule shall be 80% of Class rating (Full Flange Rating)

Up to sizes 48", D/t ratio shall be restricted to 100(max.) Where D is nominal dia. And t is nominal thickness. However for category-D classes D/t ratio may be taken as max.150 where t is minimum calculated thickness excluding Corrosion and Manufacturing allowance. The minimum corrosion allowance for all material shall be as specified by the Process Licensor.

6.2.2 Pipe Size

Pipe sizes shall normally be 0.5", 0.75", 1.0", 1.5", 2.0", 3", 4", 6", 8", 10", 12", 14", 16", 18", 20", 24", 26", 28", 30", 32", 36", 40", 44", 48", 52", 56", 60", 64", 72", 78", and 80".

6.2.3 Pipe Type

Material	Size	Type
CS, LTCS, AS Seamless (except for Cat 'D' fluids & LP hydrocarbon in offsite)	Up to 14"	Seamless
	16" and above	E.F.S.W
SS Process lines	Up to 6"	Seamless
	8" and above	E.F.S.W
SS Non process lines	Up to 1.50"	Seamless
	2" & Above	Welded
CS (Cat 'D' fluids)	ALL size	Welded

Note

Instrument impulse piping for steam services shall be S-160 – ½ "Seamless

6.3 Fittings

6.3.1 Type of fittings shall be equivalent to pipe type. All fittings shall be seamless similar to pipe specification in construction unless otherwise specified.

6.3.2 Thickness of fittings at ends to match pipe thickness for BW fittings. For reducing BW fittings having different wall thicknesses at each end, the greater one shall be employed and the ends shall be matched to suit respective thickness.

6.3.3 SW fittings shall be 3000#, 6000# and 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.

6.3.4 All branch connections shall be as follows, unless specifically mentioned otherwise in PMS:

Up to 1-1/2" NB	O-lets/ Tee
2" and above	Tees/O-lets / Pipe to Pipe with or without Reinforcement pad up to 600# rating. Only Tee/ Red Tee/ Sweepolets above 600# rating.

6.3.5 Branch connections shall be preferably made by fittings such as tees,half couplings, weldolets, H.P Nozzles. If the branch connections are made by welding the branch pipe directly to the run pipe, the required reinforcement shall be designed in accordance with the ASME B31.3. For underground piping, all branches shall be with reinforcement pad of 2 D diameter & thickness similar to header shall be used.

6.3.6 Fittings of NPS 2 and larger shall be butt weld type and fittings of NPS 1-1/2 and smaller socket weld or threaded type.-For the rating 900 # & above only butt welded fittings, valves etc. have to be used. SW fitting are allowed up to 600 # only.

Long radius butt welding elbows shall be used wherever possible.

Unless otherwise specified, flanged elbows shall not be used.

All welded fittings shall have maximum negative tolerance equivalent to pipe selected. .

All welded fittings shall be double welded for size 16” and above. Inside weld projection shall not exceed 1.6mm, and the welds shall be ground smooth at least 25mm from the ends.

For fittings made out of welded pipe, the pipe itself shall be of double welded type, manufactured with the addition of filler material and made employing automatic welding only.

All welded fittings shall be normalised for CS, normalised & tempered for AS; and 100% radiographed by X-ray for all welds made by fitting manufacturer as well as for welds on the parent material.

Bevel ends of all BW fittings shall undergo 100% MP/DP test.

When fluids have the possibility of causing corrosion in crevice, socket welded piping fitting will not be used.

6.3.7 Mitres shall be used in Category 'D' service above 6". For other than Category 'D' fluid in 150# and 300# Class mitres can be permitted for sizes 'above 48". Mitres to be designed as per ASME B31.3.However, use of mitres shall be minimum. All miters shall be with 100 % Radiography.

Miter bends may be used within the limitations in the ASME B31.3 only where they have been stress analyzed and subject to approval of OWNER.

Bushings shall not be used.

6.4 Flanges

6.4.1 The number of flanges in piping systems shall be kept to minimum and should be installed only to facilitate maintenance and inspection and where construction or process conditions dictate. They are for instance:

1) Where pipelines are connected to at connections with flanged equipment and valves.
2) Where frequent dismantling of piping is required.
3) Where clearance for dismantling equipment, such as compressors and reactor heads, is required.
4) Where steel piping is connected to nonmetallic or nonferrous piping.

6.4.2 Flange Type

1) Slip-on Flanges

a) Carbon steel piping
b) Piping handling nontoxic fluids.
c) Pressure-temperature conditions are within the ANSI 300Lb rating.
d) Design temperature exceeding minus 20°C.
e) Many large temperature cycles are not expected.

Slip-on flanges of austenitic stainless steel may be used within limitation of item b) through e) above, it justified from economical view point.

2) Welding Neck Flanges

Welding neck flanges shall be used in all instances where slip-on flanges, socket weld flanges and screwed flanges are not permitted.

3) Socket Weld Flanges

For NPS 1-1/2 or smaller, socket weld flanges may be used within the limitations specified as below:

a) Pressure-temperature conditions are within the ANSI 600Lb rating.

6.4 3) Flange Facings

1) Flat face flanges shall not be used.
2) Raised face flanges shall in general be used:
   a) For flanges of 300LB or lower rating in process services.

For 150 # Rating, Non Asbestos Flat Ring Gasket, inside reinforced with Stainless Steel OR Glass Filled Teflon Sheet Gaskets shall be used.

For 300 # Flanges, Spiral Wound Gaskets with Inner & Outer Rings shall be used.

b) For flanges of 150 Lb or lower rating in utility services.

c) Regardless of the above limitations a) and b), for design temperatures not exceeding 450°C.

3) Ring joint type flanges shall be used for flanges of 900 Lb rating or higher, or for design temperatures exceeding 450°C. This is applicable for all type of service. The flanges can also be used for lower ratings for service conditions which require higher degree of tightness.

4) Ring joint type flanges shall be used for services requiring higher degree of tightness , for sub zero temp , for ammonia service etc.

6.4 4) Hardness of the Flanges

- For Ring Joint Flanges Blinds and Spacers, the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)
Carbon Steel	120
1% Cr to 5% Cr, 1/2 Mo	150
Type 304, 316, 347,321	160
Type 304L. 316L	140

- For RTJ flanges, blinds & spacers, the hardness of the groove shall be specified on the test report
- Bore of weld neck flange shall correspond to the inside diameter of pipe for specified schedule/ thickness. Ends shall be bevelled to suit the specified schedule/thickness.
- For RTJ flanges, only octagonal section ring joint flanges shall be used.

6.4 5) **Face Finish**

The face finish of flanges/flanged items shall be to MSS-SP-6/ASME B 46.1 / ASME B16.5. The interpretation shall be:

Stock Finish		250-1000µ in AARH
Serrated Finish/125 AARH	:	125-250 µ in AARH
Smooth Finish/63 AARH	:	32-63 µ in AARH

6.4 6 **Flanges shall be as follows**.

Rating	Size	Type	Remarks
150	Up to 1.50"	SW RF	If non metallic gasket used.
	Up to 1.50"	WN RF	If metallic gasket is used.
	2" & above	WN RF/LJ FF	For SS LJ FF + Stub Ends
	2" & above	SO FF/WN RF	If used in CAT 'D' service
300,600	Up to1.50"	SW RF	
	2" & above	WN RF	except H2 SERVICE(*)
For 900,& Above	All	WN RTJ.	

(*) For H2 service, use of WN RTJ flanges shall be as specified in PMS.

All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Torque wrench / hydraulic bolt tensioner depending upon service criticality.

6.5 1 **Gaskets**

Rating	Material/ service	Temperature (^{O}C)	Type	GASKET OR STRIP MATERIAL + FILLER MATERIAL/RTJ GASKET MATERIAL
150	CS & SS (utilities)	Up to 371°C	PLAIN	Asbestos free
150	CS &LTCS (other than utilities)	up to 371°C	Spiral wound	SS316
150	AS (all services)	up to 371°C	Spiral wound	SS316
300 & 600	CS (all services, except H2)	up to 427°C	Spiral wound / RTJ	SS316
300 & 600	AS (all services, exceptH2)	above 371°C	Spiral wound/ RTJ	SS316+Grafoil
150,300, 600	SS (other than utilities	All	Spiral wound/ RTJ	SS316+GrC\foil (where trim material is*SS304/316)* 'SS316L+Grafoi (where trim material

				is SS304L1316L
300(*), 600(*),900, 1500,2500	CS	All	OCTAGONAL RTJ	Soft Iron
300(*), 600(*),900 1500,2500	AS	All	OCTAGONAL RTJ	5Cr-Alloy steel
300(*), (*), 1500, 2500 * only if RTJ is specially mentioned in PMS.	SS	All	OCTAGONAL RTJ	SS

Gasket material shall be asbestos free.

- Full face gaskets shall have bolt holes punched out.

Non-metallic ring gaskets as per ASME/ANSI B16.21 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME/ANSI B16.47 or AWWA for sizes> 24" unless otherwise specified.

- Spiral wound gaskets as per ASME B16.20 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME B16.47 series 'B' for sizes> 24" unless otherwise specified.
- Inner and outer rings requirement for spiral wound gaskets shall be as per PMS General notes.
- Inner ring shall be provided for the following:
  a) As per code. (B 16.20) requirement.
  b) For sizes 26" & above in all classes.
  c) For vacuum and hydrogen service.
  d) For SS321, SS347 and H grade SS classes.
  e) For classes where temperature is higher than 427°C.
  f) For 900# rating and above classes. (If PMS Specifies Spiral Wound Gasket)
- In case of RTJ gaskets, only octagonal section ring gaskets shall be used & shall have proper marking stamped. Material certificate shall be available for the gasket.
- Hardness of RTJ gasket shall be 20 BHN (min) less than the corresponding flange groove hardness.

6.5.2 **Stud, Bolts, Nuts and Jack Screws**

All bolting shall be as per ASME/ANSI 818.2.1 for Studs, M/C Bolts and Jack screws, and ASME/ANSI B18.2.2 for nuts. Machine Bolts shall not be used in piping flange joint, except for Butterfly Valves, which shall be lug type, having UNC Threads in lugs facilitating opening of flanges from both sides.

Threads shall be unified (UNC for; 1" dia and 8UN for> 1" dia) as per ANSI B1.1 with class 2A fit for Studs, M/C Bolts and jack screws, and class 2B fit for nuts.

Stud bolts shall be threaded full length with two heavy hex nuts. Length tolerance shall be in accordance with the requirement of table F2 of Annexure 6 of ASME B16.5.

The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.

The length of the studs/ bolts should be such that minimum two threads should be out of the nut on either side.

All stud bolts should have metallurgical certificates in case of Alloy/ SS metallurgy with identified color marking at the stud ends/ bolt side face.

In corrosive atmosphere like Acid chemical storage area, cooling towers area, where SS flanges are provided, fasteners should also be SS.

Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.

Wherever bolt tensioning is specified stud bolt length shall be longer by minimum one diameter do suit bolt tensioner. Excess threads shall be protected by a threaded cap.

6.6 **Valves**

6.6.1 Type

a) SW Valves up to 1-1/2 inch - up to 600# except ball & plug valves which shall be flanged for all sizes.

b) Flanged cast valve above 1-1/2" for 150#, 300#, 600#

c) Welded Valves - 900# and above

Criteria for Isolation Valves

Installation	Process Isolation	Drain/ Vent	Pressure Taping	Level Taping	Flow Element	Safety Valve	Control Valve	
150 / 300#	Single	Single	Single	Single	Single	Single	Single	
600 #	Single	Double	Double	Single	Double	Single	Single	

Above 600#	Double	Double	Double	Double	Double	Double	Single	

Note: For S/D & at battery limit, it will be as per process requirements

Criteria for Body Bonnet Joint & Ends of the Valves

	Body / Bonnet	Body / Bonnet	Ends	Ends
Rating	Size - < 1.5 “	Size - > 1.5 “	Size - < 1.5 “	Size - > 1.5 “
150 / 300#	Bolted T & G/M & F	Bolted T & G/M & F	SW	Flanged
600 #	RTJ	RTJ or Pressure seal	SW	Flanged
Above 600#	Pressure Seal	Pressure Seal	BW	BW

6.6.2 **General**

- Valves of Class 600 & above shall be pressure-seal type. Threaded and seal welded or welded bonnet may be employed up to sizes 1-1/2".
- All flanged valves (except forged) shall have flanges integral with the valve body.
- Valve Castings/Forgings purchased shall be from Local approved foundries/forging shop.
- Yoke material shall be at least equal to body material.

  Valves shall have pure graphite as gland packing material. Asbestos and other gland packing material shall not be used
- Forgings are acceptable in place of Castings but not vice-versa.
- No cast iron valves to be used in firewater or any other service.
- Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.

6.6.3 **Valve Dimensions**

- Face-to-Face/End-to-End dimension shall be as per ANSI B16.10. In case the same is not covered under B16.10, the dimension shall be as per BS 2080/manufacturer standard.

  Valve under cryogenic service (temp. below -45°C) shall be as per BS-6364 and shall be procured from pre-qualified vendor.
- Generally the valves are hand wheel or lever operated. However, suitable gear operator in enclosed gear box shall be provided for valves as follows:

  Gear operators shall be specified for gate, globe, angle, ball, butterfly and plug valves as follows:

Gate Valves:	
CL150	14”NPS and larger
CL300	10”NPS and larger
CL600 & 900	8”NPS and larger
CL1500 & CL2500	3”NPS and larger
Globe and Angle Valves:	
CL150	12”NPS and larger
CL300	8”NPS and larger
CL600	6” NPS and larger
CL900	4” NPS and larger
CL1500 & 2500	3” NPS and larger

Ball Valves:	
CL150 to 300	8” NPS and larger
CL600	8”NPS and larger
CL900 to 1500	3” NPS and larger

Butterfly Valves:	
CL150 to 600	8”NPS and larger
Plug Valves:	
CL150 to 600	6” NPS and larger

Spectacle blinds and paddle blinds/spacers shall be provided per the pressure class and size range divisions shown below:

Spectacle Blind	Paddle Blind/Spacer
CL150 14”NPS and below	CL150 16”NPS and above
CL300 10” NPS and below	CL300 12”NPS and above
CL600 8” NPS and below	CL600 10”NPS and above

- Hand wheel diameter shall not exceed 750mm and lever length shall not exceed 500 mm on each side. Effort to operate shall not exceed 35 kgf at hand wheel periphery. However, failing to meet the above requirement, vendor shall offer gear operation.
- Quarter-turn valves shall have "open" position indicators with limit stops.

6.6.5 **By-Pass**

A globe type valve (size as per ASME/ANSI B16.34) shall be provided as by-pass for the following sizes of the gate valves:

Class	**Size**
150	26" & above
300	16" & above
600	6" & above
900	4" & above
1500	4" & above
2500	3" & above

By-pass Piping, Fitting and Valves shall be of compatible material and design. Complete fillet welds for by-pass installation shall be DP/MP tested.

NDT of by-pass valve shall be in line with main valve.

6.6.6 Radiography of Cast Valves

- Quantity is considered for each size in each valve sheet.
- Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME/ANSI B16.34.
- All valve castings shall be of radiographic quality.

a) The minimum requirement of radiography for other than category 'D' service shall be as under:

Class	**Size**	**Qty.**
150	Up to 24”	5%
150	26” & above	100%

300	Up to 16”	10%
300	18” & above	100%
600	All	100%
900 & above	All	100%

Note: Radiography is required for category 'D' service classes.(Minimum 10 %)

b) Additional radiography requirement for casting sizes for special critical piping classes (Over and above the requirements covered in clause (a) above) shall be as follows:

i) For hydrogen / hydrogen bearing, oxygen, NACE, stress relieved caustic services:

Class	Size	qty.
150	up to 24"	50%
150	ABOVE 24"	100%
300	up to 16"	50%
300	ABOVE 16"	100%

ii) For LT / CRYO services:

Class	Size	qty.
150	up to 24"	10%
150	ABOVE 24"	100%
300	up to 16"	10%
300	ABOVE 16"	100%

iii) For alloy steel & stainless steel castings (Not covered in paras a, b (l) & b(ii):

Class	Size	qty.
150	up to 24"	20%
150	ABOVE 24"	100%
300	up to 16"	20%
300	ABOVE 16"	100%

6.6.7 **Ball/Plug/Butterfly Valves**

- Each valve shall be supplied with a lever/wrench except for gear operated/motor operated valves.
- Soft-seated Ball, Plug & Butterfly valves shall be supplied with antistatic devices.
- The ball of Ball valves shall not protrude outside the end flanges.

- Ball valves shall be floating ball type / trunnion mounted type as per following:

Class	Floating Ball	Trunnion Mounted
150	8" & below	10" & above.
300	4" & below	6" & above
600 & above	1½" & below	2" & above

- Use of soft seated ball/plug/butterfly valves shall be suitably selected based on temperatures handled.
- Butterfly valves shall be suitable for throttling application.

  As a rule, they shall be limited to water services only. Butterfly shall be lug type, body threaded only. Each butterfly valve shall be provided with the Bolts to be installed from both sides separately.

  Ball valves may be used in place of gate or plug valves with the following limitations:

  i) Operating conditions are within the permissible pressure - temperature range of seat materials.

  ii) Fire safe type is used for hydrocarbon services.

6.6.8 **Special Valves (Orbit. Y -body Globe, Jacketed, Valves of all types)**

SPECIAL VALVES shall strictly follow the requirements of Valve data sheet, Process data sheet/Specialty data sheet.

- Special Valves shall be made out of 100% radiographic casting/ 100% ultrasound forging.
- Jacketed Valves shall be tested to 100% DP/ MP check on Jacket welding, 100% radiography test of valve body, 100% hydro test of Jacket.

  Large diameter swing check valves shall be equipped with an anti-hunting device only where closing of the check valve could cause a surge.

6.7 **Traps**

- Vendor shall also furnish the performance curve indicating the capacity hi mass/hour at various differential pressures across the trap.
- Parts subject to wear and tear shall be suitably hardened. Traps shall function in horizontal as well as in vertical installation.
- Traps shall have integral strainers.
- All traps shall be hydrostatically tested to twice the design pressure.

6.8 **Hoses**

- Manufacturer shall guarantee suitability of hoses for the service and working conditions specified in the requisition, if the material is not specified in the Material Requisition for any particular service.
- All hoses shall be marked with service and working pressure at minimum two ends clearly.
- Hoses shall be resistant to ageing, abrasion and suitable for outdoor installations.
- Complete Hose assembly shall be tested at two times the design pressure
  Steam hoses shall be subject to steam resistance test.

6.9 **Expansion Joints**

- The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).
- Bellows shall be formed from solution annealed sheet conforming to the latest ASTM Spec. Any longitudinal weld shall be 100% radiographed. The finished longitudinal weld must be of the same thickness and same surface finish as the parent material.
- Circumferential welds are not permitted. Bellows are to be hydraulically or expansion (punched) formed. Rolled formed bellows are not acceptable. Noticeable punch or die marks resulting from expansion operation are not acceptable.
- No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable. .
- The out of roundness shall be limited to ± 3mm. This is the max. Deviation between the max. & min. diameter.
- The actual circumference of the welding end shall be maintained to ± 3mm of the theoretical circumference.
- Apart from the usual requirements, the vendor shall also furnish

  a) Design calculations to justify stiffness and fatigue life.
  b) Axial, lateral stiffness, angular stiffness, effective pressure thrust area.
  c) Installation/maintenance manual.

6.10 Supports & Spring Assemblies

- The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.
- Testing of springs shall be as per BS1726.

6.12 NDT Requirements

Depending upon the severity of application, extent of NDT shall be decided. As a rule, all oxygen, NACE and any other lethal service shall have 100% radiography on weld joints in all class ratings. Castings used in these services shall have 100% radiography.

For hydrogen and hydrogen bearing hydrocarbon services radiography shall be 50% in 150# and 300# class ratings. For high pressure applications, i e., 600# and above, 100% radiography on weld joints shall be employed. In 100% radiography classes any fillet welds employed shall have 100% DP/MP test in CS/AS classes and 100% DP test in SS classes.

Cat. 'D' service does not require radiography.

Classes in 150# for normal hydrocarbon service shall be subjected to 10% radiography and 10%DP/ MP test (for CS&AS) or 10% DP test (for SS) .

Classes in 300# for normal hydrocarbon service shall be subjected to 20% DP/MP test (For CS&AS) or 20%DP test (for SS).

For fire water service, IBR, etc., radiography shall be as per statutory requirement.

7.0 THERMAL INSULATION OF PIPING, EQUIPMENT & VESSELS

7.1 Hot Insulation

This consist of insulation for heat conservation, process stabilization, temperature maintenance, insulation for steam traced lines, jacketed lines, insulation for electrical traced lines insulation for fire protection for operating temperatures above ambient temperature for all sizes of lines. Wherever insulation for personnel protection is mentioned, the same shall be provided judiciously as per insulation specifications.

Preformed pipe sections shall be used for all sizes of piping and inspection windows shall be provided in insulation at critical locations to be decided at the time of execution.

All materials shall be of high quality and good appearance. Insulation materials shall be of low chloride content, chemically inert, non sulphurous, rot proof, vermin proof, impervious to hot water and steam, non-injurious to health and non-corrosive to steel and aluminum (even if soaked in 'water at ambient temperatures for extended periods). The use of insulation or finishing materials containing ASBESTOS in any form is not permitted.

The insulation of piping, equipments and vessels shall be carried out with the recommended insulating materials and the thicknesses as per process design basis. Hot insulation over austenitic stainless steel surfaces shall be inhibited with sodium silicate as per ASTM C-795. The inhibited insulation material shall be tested as per ASTM C-692. Restriction of reachable chloride to 10ppm (max,) shall be demonstrated as per the test

method ASTM C-871. The specifications of different types of hot insulating materials shall be as follows:

a) **Bonded Mineral Wool**

Lightly resin bonded Rock wool insulation shall conform to ASTM C592 class II for blanket and ASTM C547 class III for preformed pipe sections. Rock wool insulation as per IS 8183 and IS 9842 are also acceptable. The material shall be suitable for intended operational temperature range from ambient to 550 deg c. The physical requirement of bulk density and chloride content, thermal conductivity and PH value of the material shall be as follows:

Bulk density	140-150 kg/m3
Chloride Content	20 ppm (max.)
	10 ppm (max.) diffused over S.S surfaces.
Thermal Conductivity:	0.43mW/Cm˚C for mean temp 50°C
	0.52mW/ Cm˚C for mean temp 100°C
	0.62mW/ Cm˚C for mean temp 150°C
	0.68mW/ Cm˚C for mean temp 200°C
	0.80mW/ Cm˚C for mean temp 250°C
	0.90mW/ Cm˚C for mean temp 300°C
PH Value.	7.0 To 10.0

b) **Calcium Silicate**

Calcium Silicate blocks and pipe thermal insulation shall be composed principally of hydrous calcium silicate reinforced with mineral fibers (except slag wool).

The specification shall conform to ASTM C533 type-1 up to 550°C and as per ASTM C533 type-2 up to 760°C.

The physical requirement of bulk density, chloride content, thermal conductivity and ph value of the material shall be as follows:

Bulk density	240 to 280 kg/m3
Chloride content	20 ppm (max) & 10 ppm(max) if used over stainless steel.
Thermal Conductivity:	As per Code
PH Value	7 to 10.

c) **Polyisocyanurate**

Rigid Polyisocyanurate foam block pipe fittings insulation (Confirming to ASTM 591 TYPE II & III) shall be manufactured with polyester or polyether resins, flammability retarding agents, special catalysts and fluorocarbon blowing agent. This is suitable for use up to 125 deg C, Selection of samples for testing shall be as per ASTM C390 (Class IV frequency).

The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

Bulk density	40 to 64 kg/m^3 (Tested as per ASTM C303 and C302)
Chloride content	NIL
Thermal Conductivity	0.238 mw/Cm^{o}C at mean temp 10 deg C 0.245 mw/ Cm^{o}C at mean temp 24 deg C 0.252 mw/ Cm^{o}C at mean temp 38 deg C
PH Value	Neutral

d) **Cellular Glass (Foam Glass)**

Cellular glass foamed and fused into unicellular foam can be used up to temperature of 350°C. The testing of samples shall be as per ASTM C552. The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

Bulk density	110 to 150kg/m3 (Tested as per ASTM C303)
Chloride content	NIL
Thermal conductivity	0.58 mw/cm deg C at mean temp. 10°C 0.60 mw/cm deg C at mean temp. 24°C 0.62 mw/cm deg C at mean temp.38°9 0.73 mw/cm deg C at mean temp. 93°C
PH Value	Neutral.

7.2 **Weather Protection Jacket (Cladding) - Hot Insulation**

Aluminum jacketing shall be used as weather protection over insulation unless otherwise specified and shall be as per ASTM B 209 alloy 3003 H16 or IS: 737 designation 31000 (old NS3) condition H3 for flat sheets and H4 for corrugated sheets. Cladding shall be coated on the side in contact with bitumen anticorrosive paint. Where fire safe insulation material is required cladding and bands material shall be SS. The thickness of jacket shall be as follows:

	For Rock Wool	For all materials other than Rock Wool
For shell of vertical vessels, columns etc:	0.71 mm (22SWG) corrugated.	0.56 mm(24 SWG) Corrugated
Storage tanks & Tank Roofs	1.22mm (18SWG) Flat	0.56 mm (24 SWG) Flat
For all piping, other than grade piping in off sites	0.71mm (22SWG) Flat	0.56mm (24 SWG) Flat
For Horton sphere & horizontal vessels shell and heads, vertical vessel heads	0.71 mm(22SWG) Flat	0.56mm (24 SWG) Flat
For Removable covers	1.22mm (18SWG) Flat.	1.22 mm (18 SWG) Flat.
For Reactors and reactor piping (extent and thickness shall be decided during execution)	SS JACKET	SS JACKET
For grade piping in offsite	0.56mm (24 SWG) Galvanized Steel per IS 277 or equivalent with a coating requirement of 450 gms/m2.	0.56mm(24SWG) Flat

7.3 **Ancillary Materials-Hot Insulation (Band, Wires, Screws, Etc.)**

7.3.1 Aluminum Foil to protect stainless surfaces in Temperature below 0 deg c shall be 0.1 mm (42 SWG) thick per ASTM 8209 alloy 3003 H16 or IS-737 designation 31000 (0IdNS3) condition H3.

7.3.2 Bands/Wires for securing insulation shall be of ASTM 8209 Alloy 3003 H16 or 18-737 designation 31000 (old NS3) condition H3 or 18/8 Stainless steel. For securing aluminium foil on stainless steel surface 24 SWG thick x 20mm wide aluminium bands shall be used. For securing fibrous insulation on piping, 24 SWG X 12 wide, aluminium bands shall be used.

For securing fibrous insulation on equipments, 24 SWG X 20 wide aluminium bands shall be used.

For securing fibrous material on vertical storage tank, galvanized steel 40 mm wide X 3 mm thick flat shall be used.

For securing fibrous material on spheres, stainless steel bands of 25 mm wide X 0.8 mm thick shall be used.

For securing Rigid Insulation on pip up to 16" O.D., annealed galvanized steel wire of 16 SWG shall be used. Galvanising coating shall have 450g/m2 of surface area.

For securing rigid insulation on pipe 18" O.D., and above, galvanized steel band 20 mm wide X 24 SWG shall be used. Galvanising shall be 600 g/m2 of surface area.

For securing rigid insulation on vertical and horizontal vessels, galvanized steel band 20mm wide X 24 SWG shall be used. Galvanising shall be 450g/m2 of surface area.

Screws required for metal jacket secure-ment shall be of Stainless Steel.

7.3.3 For securing cladding on insulation on piping, aluminium band 12mm (min) X 24 SWG thick shall be used.

For securing cladding on insulation on equipment, aluminium band 20mm wide X 24 SWG shall be used.

For securing cladding on insulation for vertical storage tanks stainless steel band 25mm wide X 24 SWG shall be used.

For securing cladding on insulation for spheres stainless steel band 25mm wide X 24 SWG shall be used.

7.3.4 Rivets used for secure-ment of metal jacket shall be expanding aluminium "POP" blind eye type; 9.5 mm long x 5mm diameter.

7.4 **Cold Insulation**

Insulation material and specifications for cold insulation for operating temperatures up to (-)180°C and dual temperature (cold/hot) service where, upper temperature limit is 125˚C shall be as given below for all sizes of piping:

7.4.1 **Polyurethane Foam**

Preformed pipe section's and radial lags (for higher diameter pipe) of polyurethane foam of self extinguishing type shall be in accordance with ASTM C591 TYPE-II Grade 2.The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

Temp. Limit Bulk density	:	Upto (-)180°C & 120°C (max) 35.0 to *39.9kg/m3*
Chloride content	:	20 ppm (max)

Thermal conductivity : 0.221 *mw/cm˚C* at mean temp. 10 deg C

PH Value : Neutral.

Closed cell content 95% (min)

High density polyurethene foam block of bulk density more than 300 Kg/m^3 shall be used for supports in cold lines.

7.4.2 **Polyurethane Foam Cast-in-Situ**

Temp. Limit : Up to (-) 45^{o}C and 120^{o}C (max.)

For specification, refer Clause 7.4.1 above and for application procedure Contractor shall secure OWNER/PMC approval.

7.4.3 Polyisocynaurate

Temp. Limit : Up to (-) 180˚C and 125˚C (max.)

Refer Clause 7.1 c) for details.

Ancilliary materials and cladding for cold insulation shall be as follows:

Adhesive for bonding sections shall be Foster Fire Resistive Adhesive 81-33 or blown bitumen type *85/25* shall be used.
Vapour seal like Foster Fire Retardant Mastic 60-30 or equal shall be used.
Filler material shall be PUF dust or mineral wool mixed with specified adhesive shall be placed lightly so as to fill irregular voids and scalant shall be Foster Foam Seal Sealer 30-45. Glass cloth to be used for vapour barrier reinforcement shall be open weave 10 mesh having glass fiber thickness of 5 mils. Aluminium sheets as follows shall be used for cladding.

Application	**Minimum Sheet Gauge**
Pipes, vessels and equipments up to 500 mm nominal diameter	26 SWG
Pipes ,vessels and equipments above 500 mm nominal diameter	24 SWG
For valves ,flanges and other areas where mechanical change is likely to occur.	22 SWG

Where fire safe insulation is required cladding and bands material shall be SS.

7.5 Insulation Thickness

The insulation thickness and type of insulation (hot, cold and acoustics) to be applied on equipments and vessels shall be as per equipment data sheet.

Insulation thickness on piping shall be as per final approved line list /line schedule / insulation table in process design basis.

7.6 Extent of Insulation

Extent of insulation shall be as per final approved P&ID/ Line list /General Arrangement drawing / Isometrics and vessel and equipment data sheets.

Insulated piping system shall have straight pipe, bends, tees and pipe fittings completely insulated.

For all cold lines, all steam and condensate lines, all hot oil lines and trace heated & jacketed lines, the extent of insulation shall include valves and flange joints also.

For bucket and float type traps the inlet piping and trap shall be insulated.

For thermostatic and thermodynamic traps insulation shall terminate at approx. 500mm before trap.

Instrumentation such as level gauges, level controllers, level switches, DP cells, etc., shall have their fluid containing sections and associated piping completely insulated.

In case of hot insulation system, insulation shall not be applied to the following unless specifically asked otherwise.

a) Valves, including control valves, flanges in process lines below 300 deg C (Safety insulation shall be provided wherein required)
b) Pipe union fittings.
c) Steam Traps, sight flow indicators.
d) Steam trap outlet piping other than closed condensate recovery system except for personal protection reasons.
e) Pumps with operating temp below 200 deg c
f) Fans, compressors, blower or other rotating or reciprocating equipments.
g) Internally insulated or refractory lined equipment.
h) Turbine seal caps, shaft bearing housing, throttle valves, governors and supports.
i) Exchanger channel and covers, shell and channel flanges and expansion joints.
j) Nozzles, manholes and hand holds and flanges of equipment.
k) Surfaces of coolers and condensers.
l) Thermo well bosses and pressure tapings.

7.7 **Application**

All insulation work shall commence only after successful completion of hydro testing of piping and equipments including steam tracing systems.

Surfaces to be insulated shall be thoroughly cleaned, dried and made free from loose scale, oil or grease. Painting under insulation shall be applied to carbon steel, low alloy steel, stainless steel piping and equipments

No welding or drilling of equipments and piping shall be permitted for insulation application.

All projections, such as lifting lugs, trunnion, support lugs , support cleats shall be insulated to the same extent that of equipment or piping.

Cleats used for supporting of insulation shall not project outside insulation.

Insulation windows for inspection thickness survey are to be provided for insulated equipment and piping (piping size 4" and above) for 20% of bend locations. However for transfer lines the insulation windows shall be provided at all bend locations.

To ensure perfect water proofing, all cladding joints shall be packed with sealing materials which may either be in the form of a elastomeric sealing compound or fibre based bituminous felt strips.

Minimum overlap in sheet metal at joints shall be 100 mm.

Support skirts of vertical vessels and columns shall be insulated both from inside and outside to a minimum distance of 600 mm from bottom tangent line. The insulations must terminate at minimum 300 mm above support concrete or steel work.

Tank shell insulation shall have continuity in insulation cladding even at stiffener retainer ring location on shell.

Proper expansion/contraction joints shall be provided to allow movement of pipe or vessel without producing random cracking of all the insulation.

Vapour barrier shall be applied on piping and all the vessels & equipments in cold services and also for services up to 125 deg C.

8.0 PAINTING

8.1 Scope of Painting

8.1.1 The following surfaces and materials shall require painting.

a) All un-insulated C.S & A.S piping, fittings, valves, columns, vessels, drums, & storage tanks, heat exchangers etc. including painting of identification marks on insulated lines.

b) Identification color bands on all piping as required including insulated aluminium clad, galvanized, SS and non ferrous piping.

c) Pipes, fittings & valve surfaces under insulation of carbon steel and alloy steel insulated piping system.

d) Pipes, fittings, valves surfaces under insulation of stainless steel insulated piping system.

e) All structural steel works, supports, walkways, handrails and platforms etc.

8.1.2 The following surfaces and materials shall not require painting:

a) Un-insulated austenitic stainless steel and higher alloy piping.

b) Plastic and plastic coated materials.

c) Non ferrous material like aluminum, galvanized, brass, bronze piping etc.

8.2 Color Coding

Painting work shall require satisfying the requirements of the area where the plant is being setup. All painting and color coding shall be as per local painting manual.

8.3 Surface Preparation & Painting Application

Surface preparation and painting application shall be as per Std Specification

No surface shall be coated in rain, wind or in environment where injurious airborne element exists, where surface temperature is below 5 deg F above dew point, where relative humidity is greater than 90% and temperature is below 40 deg F.

Paint application shall follow the strict instruction of paint manufacturer whose paint is being employed.

All procedures from surface preparation to finish painting; including testing shall be well documented through a quality procedure approved by PMC/OWNER

8.4 Painting Materials

As. per STD Specification. (Refer Civil Section of Bid Document)

ANNEXURE – 1

TABLE OF BASIC SPAN

Pipe Size In.	SCH/Thk (in)	PIPE- VAPOUR INSULATION BASIC SPAN (L)M			PIPE- LIQUID INSULATION BASIC SPAN (L)M			BARE PIPE EMPTY		BARE PIPE WATER FILLED		Pipe size in.
		UPTO 175^0 C	176^0 C TO 315^{0}C	316^0 C TO 400^0 C	UPTO 175^0 C	176^0 C TO 315^{0}C	316^{0}C TO 400^{0}C	SPAN(L) M	WEIGHT KG/M	SPAN(L) M	WEIGHT KG/M	
3/4"	SCH 40	3.5	3.5	2.5	3.5	3.0	2.0	4.5	1.68	4.0	2.04	*3/4"*
1"	SCH 40	4.5	4.0	3.0	4.5	3.5	3.0	5.0	2.52	4.5	'3.07	1"
1-1/2"	SCH 40	5.0	5.0	4.5	5.0	4.5	3.5	6.0	4.08	5.0	.5.4	*1-1/2"*
2"	SCH 40	5.5	5.0	4.5	5.0	4.5	3.5	8.5	5.47	5.5	7.65	2"
2-112"	SCH 40	6.5	6.0	5.0	6.0	5.5	4.5	7.5	8.7	6.5	11.79	*2-112"*
3"	SCH 40	7.5	6.5	5.5	6.5	6.0	5.0	8.0	11.35	6.5	16.15	3"
4"	SCH 40	8.0	7.5	6.5	7.5	7.0	6.0	9.0	16.2	7.5	24.45	4"
6"	SCH 40	10.0	9.5	8.5	9.0	8.0	7.5	10.5	28.3	9.0	46.7	6"
8"	SCH 40	12.0	11.0	10.0	10.0	10.0	9.0	12.0	42.84	10.0	75.22	8"
10"	SCH 40	13.5	13.0	12.0	11.5	10.5	10.5	14.0	60.74	11.5	111.9	10"
12"	*3/8"* w	14.5	13.5	13.0	12.0	11.5	11.0	15.0	74.40	12.0	147.5	12"
14"	*318"*w	15.0-	14.5	13.5	12.0	12.0	11.5	16.0	82.5	12.5	172.05	14"
16"	*318"*w	16.0	15.5	14.5	13.0	12.5	12.0	17.0	94.5	13.0	213.15	16"
18"	*3/8"* w	17.0	16.5	15.0	13..5	13.0	12.0	18.0	106.5	13.5	258.3	18"
20"	*318"* w	18.0	17.5	16.0	14.0	13.5	12.5	19.0	118.5	14.0	307.5	20"
24"	*3/8"*w	20.0	19.0	17.5	14.5	14.5	13.0	21.0	1425	15.0	418.2	24"
3/4"	SCH 80	3.5	3.5	2.5	3.5	3.0	2.0	4..5	2.20	4.0	2.49	*3/4"*
1"	SCH 80	4.5	4.0	3.0	4.5	3.5	3.0	5.0	3.25	4.5	3.72	1"
1-112"	SCH 80	5.0	5.0	4.5	5.0	4.5	4.0	6.0	5.45	5.0	6.60	*1-112"*
2"	SCH 80	6.0	5.0	4.5	5.5	5.0	4.0	6.5	7.53	6.0	9.45	2"
2-112"	SCH 80	6.5	6.0	5.5	6.0	6.0	5.0	7.5	11.49	6.5	14.25	*2-1/2"*
3"	SCH 80	7.5	6.5	6.0	6.5	6.5	6.0	8.0	15.37	7.0	19.66	3"
4"	SCH 80	8.0	8.0	7.0	7.5	7.5	6.5	9.0	22.47	8.0	29.94	4"
6"	SCH 80	10.5	10.0	9.0	9.5	9.0	8.5	10.5	42.90	9.5	59.85	6"
8"	**½" w**	12.0	11.5	10.5	10.5	10.0	10.0	12.0	65.10	11.0	94.8	8"
10"	**½" w**	13.5	13.0	12.0	11.5	11.5	10.5	14.0	82.20	12.0	130.69	10"

12"	½" w	14.5	13.5	./, 3.0	12.5	12.0	11.5	15.0	98.13	13.0	168.64	12"
14"	½" w	15.0	14.5	13.5	13.0	12.5	12.0	16.0	108.15	13.5	194.4	14"
16"	½" w	16.0	15.5	15.0	13.5	13.0	13.0	17.0	124.2	14.0	240.0	16"
18"	½" w	17.5	17.0	.16.0	14.5	14.0	13.5	18.0	140.25	14.5	286.64	18"
20"	½" w	18.0	17.5	..:.17 .0.	15.0	14.5	14.0	19.0.	157.5	15.0	341.8	20"
24"	½" w	20.0	19.0	. 18.5	16.0	15.0	15.0	21.0	188.25	16.0	458.44	24"
1"	10S	4.0	3.5	3.0	4.0	3.0	2.5	4.5	2.08	4.0	2.7	1"
1-112"	10S	5.0	4.5	3.5	4.5	4.0	3.0	5.5	3.12	5.0	4.57	*1-112"*
2"	10S	5.0	4.5	3.5	4.5	4.0	3.0	6.0	3.94	5.5	6.33	2"
2-112"	10S	6.5	5.5	4.5	5.5	5.0	4.5	7.0	5.26	6.0	8.85	*2-1/2"*
3"	10S	7.0	6.0	5.0	6.0	5.5	5.0	7.5	6.45	6.0	11.91	3"
4"	10S	7.5	7.0	6.0	*6.p*	6.0	6.0	8.0	8.34	7.0	17.87	4"
6"	10S	9.5	9.0	8.0	8.0	7.5	7.5	10.0	13.82	8.5	34.54	6"
8"	10S	11.0	10.5	10.0	9.5	9.5	8.5	11.5	19.94	10.0	55.5	8"
10"	10S	12.5	12.0	11.0	10.5	10.0	9.5	13.0	27.S3	11.0	83.4	10"
12"	10S	14.0	13.0	12.0	11.0	11.0	10.0	14.5	36.00	11.5	114.6	12"
14"	105	14.5	14.0	13.0	11.5	11.0	11.0	15.5	41.18	11.5	132.6	14"
16"	10S	16.5	14.5	14.0	12.0	11.5	11.5	16.5	47.33	12.5	172.2	16"
IS"	10 S	16.5	15.5	14.5	12.5	12.5	11.5	17.5	53.18	13.0	212.1	18"
20"	10 S	17.5	16.5	15.5	13.0	13.0	12.0	18.5	68.50	13.0	264.5	20"
24"	10 S	19.0	18.0	17.0	14.0	13.5	12.5	20.5	94.37	14.0	376.8	24"

ANNEXURE – 2

ACCESSIBILITY FOR VALVES AND INSTRUMENTS

VALVES, INSTRUMENTS, EQUIPMENT TO BE OPERATED	CENTRELINE OF ITEM TO BE OPERATED, LOCATED LESS THAN 3.6m ABOVE GRADE, 2.75 m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM	CENTRELINE OF ITEM TO BE OPERATED, LOCATED MORE THAN 3.6m ABOVE GRADE, 2.75m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM
EXCHANGER HEADS	NIL	PLATFORM
OPER.VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
OPER. VALVES 3" & ABOVE	PLATFORM	PLATFORM
MOTOR OPERATED VALVES	PLATFORM	PLATFORM
CONTROL VALVES	PLATFORM	PLATFORM
RELIEF VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
RELIEF VALVES 3" & ABOVE	PLATFORM	PLATFORM
BLOCK VALVES 2" & SMALLER	PORTABLE LADDER	PLATFORM
BLOCK VALVES 3" & ABOVE	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)
BATTERY LIMIT VALVES	PLATFORM	PLATFORM
PRESSURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2m HEIGHT	FIXED LADDER
TEMPERATURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2 M Ht	FIXED LADDER
SAMPLE POINTS	PLATFORM	PLATFORM
GAUGE GLASSES	FIXED LADDER	FIXED LADDER
LEVEL CONTROLLERS	PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 2" & SMALLER	PORTABLE LADDER / PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 3" & ABOVE	PLATFORM	PLATFORM
MANWAYS/MANHOLES	PLATFORM	PLATFORM
HANDHOLES/INSPECTION HOLES	PLATFORM	PLATFORM
NOZZLES (process}	PLATFORM	PLATFORM
VESSEL VENTS	PORTABLE LADDER	FIXED LADDER
LINE DRAINS & VENTS	PORTABLE LADDER	PORTABLE LADDER
ORIFICE FLANGES	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)

NOTE -1:-BLOCK VALVES / ORIFICE FLANGES, IF LOCATED, WITH CENTRE LINES GREATER THAN 2 METER FROM THE OPERATING FLOOR / OPERATING PLATFORM, SHALL BE PROVIDED WITH PORTABLE PLATFORM OR CHAIN FOR OPERATION.

NOTE -2: PLATFORM SHALL BE PROVIDED FOR THE ORIFICE FLANGES ON PIPE RACK.

ANNEXURE-3

MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES

NOM PIPE SIZE IN INCHES	VERTICALSPACING METRES	HORIZONTAL SPACING METRES
1	6.0	6.0
1 ½	6.0	6.0
2	6.0	6.0
3	8.0	12.0
4	8.0	12.0
6	8.0	12.0
8	8.0	12.0
10	12.0	18.0
12	12.0	18.0
14	12.0	18.0
16	12.0	18.0
18	12.0	18.0
20	16.0	18.0
24	16.0	18.0
26 & ABOVE	16.0	18.0

NOTES:-

1. These spacings may be varied to suit column spacing of rack. The above spacing is for straight runs of pipe & does not include guides which are used for control of thermal movements, as decided by stress group.

2. The guide spacings given in the above table are indicative only.

ANNEXURE – 4

CLEARANCES

Minimum clearances for piping, equipment, structures, platforms, and supports shall be in accordance with the following table:

Item	Description	
Roads	Headroom for primary access roads wherever heavy duty crane movement is required.	9 M
	Headroom for primary access roads	7.5 M
	Width of primary access roads excluding shoulders.	Refer Civil
	Headroom for secondary roads	5 M
	Width of secondary roads excluding shoulders.	Refer Civil
	Clearance from edge of road shoulders to platforms, equipment, pipe associated with equipment, or similar features.	1.5 M**
Maintenance Aisles at Grade	Horizontal clearances for equipment maintenance by hydraulic crane (12t capacity)	3 M
	Vertical clearance for equipment maintenance by hydraulic crane (12t capacity)	3.6 M
	Horizontal clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Vertical clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Horizontal clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	1 M
	Vertical clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	2.4 M
Walkways	Horizontal clearance (not necessarily in a straight line)	750 mm
	Headroom (except for hand wheels)	2.2 M

Item	Description	
Platforms	Minimum width	1200mm
	Headroom from stairwell treads.	2.2 M
	Minimum clearance around any obstruction on the platform.	500 mm
Platforms	Headroom	2.2 M
	Maximum vertical distance between platforms	6 M
	Minimum toe clearance behind a ladder.	210 mm
	Minimum handrail clearance.	100 mm
Equipment	Minimum maintenance space required between flanges of exchangers or other equipment arranged in pairs.	500 mm
	Minimum maintenance space required for structural members or pipe.	300 mm
	Clearance from edge of road shoulder (the extreme projection)	1.5 M
Fired Equipment	Horizontal clearance from hydrocarbon equipment (shell to shell)	15 M
	Exception: Reactors or equipment in alloy systems shall be located for the most economical piping arrangement.	
	Clearance from edge of road to heater shell.	3 M
Valve Hand wheels	Clearance between the outside of the hand wheel and any obstruction.	25 mm*
Pipe (aboveground)	Clearance between the outside diameter of the flange and the outside diameter of pipe insulation.	25 mm*
	Clearance between the outside diameter of the pipe, flange or insulation and a structural member.	50 mm*
	Clearance between the outside diameter of the flange and the outside diameter of bare pipe.	25 mm*
	Minimum distance from underside of pipe to grade or platform.	300 mm
Control Valve Arrangement	Centreline of control valve above grade or platform.	450 mm

Item	Description	
	Minimum centreline of control valve from face of column or wall.	600 mm
	Where process conditions require steam or hydrocarbon vapours to be discharged to atmosphere at a safe location, the tail pipe shall terminate as below:	
	Distance above nearest operating platform.	3 M
	Within radius of nearest operating platform.	7.5 M
** Verify conformance with local regulations. * With full consideration of thermal movements		

ANNEXURE – 5

DESIGN PHILOSOPHY FOR STRESS ANALYSIS

1.0 PURPOSE

This design basis deals with the subject of Identification of Stress Critical pipelines and preparation of Critical line list. This procedure also defines the minimum requirements for performing stress analysis, design and location of spring, support and level of system

Analysis with the extent of documentation required for flexibility analysis.

Purpose of piping stress analysis is to ensure:
Safety of piping and piping components
Safety of connected equipment and supporting structure
Piping deflections are within the limits

2.0 SCOPE

This specification covers the supply of engineering services to perform a complete piping and pipe support analysis for piping systems for AMMONIA NITRATE (AN) MELT PLANT AT RCF, TROMBAY

3.0 DEFINITIONS

3.1 CRITICAL LINES / CRITICAL LINE LIST

Critical lines or Critical Line List as referred to in this procedure relates to Piping Stress Critical Lines and does not include or refer to process critical lines.

3.2 STRESS ANALYSIS TEMPERATURE

Stress Analysis Temperature refers to either “Maximum Operating Temperature” or “Steam-out temperature / hot nitrogen purging temperature” of the lines under review whichever is higher. In absence of the above values, it refers to the Design Temperature of the line under review. The Line List should be strictly followed in obtaining the above temperature values.

3.3 DESIGN PRESSURE

Design Pressure refers to the “Design Pressure” of the line under review as indicated on the Line List. Design Pressure is as defined in clause 301.2 of ASME B 31.3.

3.4 TEMPERATURE FOR FLEXIBILITY ANALYSIS

The temperature to be used for the flexibility analysis shall be taken as the maximum / minimum temperature which the pipe will see under any combination of different normal / abnormal operating conditions, as defined in clause 301.3 of ASME B 31.3. Where piping is exposed to direct sunlight, solar radiation temperature of 70 ^{0} C is considered in establishing the maximum temperature of piping. Even, for non-critical piping exposed to direct sunlight on

pipe rack or elsewhere, expansion loops, wherever essential, are provided to take care of pipe movements resulting from piping skin temperature due to solar radiation.

In general, unless there is a difference of more than 50 ^{0} C between working Temperature and the design temperature, the design temperature should be taken as Flexibility temperature. Ambient Temperature shall be considered as 21ºC the assumed piping installation temperature. The displacement stress range from this installation temperature to the minimum recorded ambient temperature of 0^{0} C being less than the same from installation temperature to the maximum operating temperature of hot piping in most cases, the later governs as per clause 319.2.3 of ASME B 31.3

The temperature under fire condition is normally not considered for flexibility analysis.

4.0 SELECTION

A line is selected and listed as a Critical Line provided it falls under any one of the categories defined below and is intended to include the special requirements of Piping Stress Engineer. It is hence defined as any line for which a flexibility review is required or where pipe supporting is deemed to be critical and needs review by a Stress Engineer. Line DN 50 and smaller is inherently flexible and is not normally considered critical unless built from non-metallic or non-ferrous materials. In case of more than one applicable line size, larger line size governs. Lines are classified as Level I, Level II & Level III according to the criteria listed below.

4.1 Level I [EXTENSIVE ANALYSIS]

Piping systems or lines that meet Annexure-5A criteria are deemed to be extremely critical. These lines are categorized as Level I and require careful study to ensure that the code compliance is met and the accurate determination of nozzle and support loads have been made. The routing of these lines is very important. They must be analyzed in the early stages of the project during routing studies so that the impact on the location of less critical lines is minimized. Normally, these systems require computer analysis. The general intent of the Level I analysis criteria is to study lines size DN 80 & larger that are affected by thermal expansion and / or a dynamic response, and that can't be evaluated by a weight-only analysis (as per the general intent of Level II analysis). Consideration has to be given to other special situations that augment the Level I general intent guidelines such as for lines that are excessively large and stiff.

4.2 Level II [NORMAL ANALYSIS]

Piping systems or lines that meet Annexure-5B criteria are moderately critical lines and often do not require such rigorous study to ensure code compliance or accurate determination of nozzle and support loads. These lines are smaller in size and operate at lower temperatures (in general) than the lines to be analyzed using Level I Criteria. Normally, only manual calculations, by use of appropriate monographs are required for analysis of these systems.

4.3 Level III [MINIMUM ANALYSIS]

All lines that are outside the purview of Level I or Level II criteria will be classified as level III and shall be reviewed by the Piping Engineer during the squad check of the piping drawings and or fabrication Iso's. If more detailed analysis is required, the Piping Engineer may change the level of analysis during the squad check as applicable. Normally, only visual analysis is required for these systems.

4.4 LINES DEEMED TO BE SUPPORT CRITICAL

Lines subjected to two-phase flow.
Cross country pipelines.
Lines with pipe thickness Sch 160 or greater.
Lines DN 400 and above with pipe thickness less than 8 mm.
Lines DN 250 and above with corrosion allowance 3 mm and above.
Lines with high concentrated loads such as heavy valves or fittings etc.
Lines downstream of Relief Valve / letdown Control Valves / bursting (rupture) discs.
Connecting to vent or flare systems or discharging to atmosphere
Liquid Blow down Lines.
Lined pipes
Non-metallic pipes

4.5 LINES NEEDING DYNAMIC ANALYSIS

There are instances where in the frequency of the applied load is comparable to the natural frequency of the piping system. Such systems tend to store the energy and release it according to certain scientific laws. Such a system is dynamic in nature and the study of the response of such a system is referred to as "Dynamic Analysis". Examples of such kind of systems are Relief Valve discharge lines, water hammer and surge in pipe lines, two phase flow in pipelines, reciprocating pumps and compressor piping, submarine piping etc.

5.0 RELATED DOCUMENTATION

5.1 CRITICAL LINE LIST FORMAT.

The critical line list shall be prepared from the project line list document by inserting following relevant fields such as Stress level, stress package no., stress analysis temperature, support critical nature of the line, dynamic loadings, steam out / purge temperature etc.

The list shall reflect analysis status of line that includes its input received date from design & output handover date to design and specific remark if any.

5.2 LINES AFFECTING THE FLEXIBILITY OF CRITICAL LINES

Non-critical Lines found to affect the flexibility of critical lines which have not been included during the initial review are subsequently added to the Critical Line List.

Non-critical Lines on which advice may be sought by the Lead Piping Engineer are not normally entered into the Critical Line List but covered verbally, or by a memorandum if a record is required.

6.0 PIPE STRESS ANALYSIS AND SUPPORTING

6.1 Piping system shall be properly supported taking in to account of the following points:

Piping stress analysis shall follow ASME B 31.3 and shall be complete to prevent overstressing of the pipe during operating conditions with wind and seismic loadings. During sustained, occasional (wind and seismic) & thermal expansion loading on piping, the material allowable stresses shall be as per ASME B 31.3 for ASTM materials. For DIN material specifications the allowable stress values shall be calculated as per ASME B 31.3 clause 302.3.2(d), wherein yield strength and ultimate strength values at temperature shall be taken from DIN material standards. For DIN material specifications, the other material properties viz. elastic modulus, density, coefficient of thermal expansion shall be taken from the respective DIN material standards.

6.2 Analysis shall include, but not be limited to the following; thermal, dead weight, internal pressure, wind and seismic, and a combination of these based on ASME B 31.3.

6.3 Piping shall be designed in accordance with the Indian Standard criteria for earthquake resistance design for structures IS: 1893 for seismic zone-IV (refer project design basis). As a minimum, two (2) orthogonal horizontal components and a vertical component of ground motion will be considered in the seismic analysis. For American standard, loading applied to piping would be in accordance with uniform building code (UBC).

The equivalent horizontal static force method shall apply in general .The contractor shall also carry out special designs and provisions as necessary for piping which is considered to be dynamically sensitive to earthquake.

Seismic analysis to be performed for lines equal to and above 12".Seismic load case shall ALGEBRIC combination with operating cases.

Heavy rigid masses like valves shall be restrained in their vicinity to avoid large seismic movements. Guides or snubbers as the case may be used for this purpose.

Horizontal seismic coefficient (Ah) to be considered as 0.26 and Vertical (Av) to be considered as 0.173.

6.4 Wind loads shall be calculated in accordance with IS-875 code of practice for structural safety of building – Loading Standards for Indian code requirement using basic wind speed as mentioned in project design basis. For American standard, wind load in accordance to ASCE 07 shall be calculated. Reduction in velocity pressure due to apparent shielding afforded by buildings and structure or terrain shall not be permitted.

Wind loading shall only be considered for lines larger than 20" OD at elevation higher than 10m above grade. Displacements due to wind and earthquake should be limited to 50 mm.

Both the horizontal directions shall be analyzed independently in two cases

+X, -X, +Z, -Z

Wind and seismic loading will not occur simultaneously.

6.5 Analysis of all nozzles loading on vessels within the piping boundaries is covered in this specification. Nozzle analysis shall follow the guidelines of ASME Section VIII, Division 1,and WRC 297 & 107 (latest editions). Nozzle stresses shall fall within the allowable per ASME.

6.6 Piping system shall have sufficient flexibility to avoid leakage at joints. Flanged joints imposed by external moments may be analyzed and the stresses evaluated by using the methods of equivalent pressure given in the ASME boiler and pressure code section III. Flange leakage shall be assessed as per “Pressure Equivalent Method”. In case of Failure in Pressure Equivalent Method, the Flanges shall be checked for leakage using Caesar Flange leakage Module. Flange leakage shall be assessed for all PSV flanges, Control valve flanges, High Pressure lines, and all steam lines. Also for equipment flanges where loads are high.

6.7 All forces on connections to equipment shall not exceed maximum allowable as specified by equipment vendor.

6.8 Pipe supports loads shall be based on the maximum loads determined by the piping analysis. Adjustments shall be made to the piping system and model such that the pipe supports loads are within a reasonable uniformity throughout the piping system.

6.9 Various Load cases built in Caesar II to check stress in piping system are listed below.

1	WW+HP	HYD	
2	W+T1+P1	OPE	
3	W+T2+P1	OPE	
4	W+T1+P1+U1	OPE	
5	W+T1+P1+U2	OPE	
6	W+T1+P1+U3	OPE	
7	W+T1+P1+U1	OPE	
8	W+T1+P1+U2	OPE	
9	W+T1+P1+U3	OPE	
10	W+T1+P1+WIN1	OPE	
11	W+T1+P1+WIN2	OPE	
12	W+P1	SUS	
13	W+P2	SUS	
14	L2-L12	EXP	
15	L3-L12	EXP	
16	L4-L2	OCC	
17	L5-L2	OCC	
18	L6-L2	OCC	
19	L7-L2	OCC	
20	L8-L2	OCC	
21	L9-L2	OCC	
22	L10-L2	OCC	
23	L11-L2	OCC	

24	L12+L16	OCC	
25	L12+L17	OCC	
26	L12+L18	OCC	
27	L12+L19	OCC	
28	L12+L20	OCC	
29	L12+21	OCC	
30	L12+L22	OCC	
31	L12+L23	OCC	

P1- Maximum Operating Pressure
T1- Maximum Operating Temperature
P2- Design Pressure
T2- Design Temperature
HP- Hydro test Pressure

W- Dead Weight
WW- Water Weight
WIN- Wind Load
U- Uniform Load
L2- Load case

SUS, EXP, OCC, HYD, OPE- Various load types, viz., sustained, occasional, hydro test, operating etc.

7.0 CODES AND STANDARDS

The following codes and standards shall apply in the design and analysis of the piping systems covered under this specification:

Allowable Stress	ASME B 31.3
Piping	ASME B 31.3
Nozzle Loadings	PMC's Standard, WRC297/107(Welding Research Council) /
Allowable	Vendor

Wind Analysis: ASCE-07 and / or IS 875

IBR piping system - ASME B31.1 & IBR.

8.0 SOFTWARE USED

The package used shall be latest version of CEASER-II / AUTO PIPE / SIMPLEX / CAEPIPE. Only one of these packages shall be used for the project & not a combination of the above packages.

9.0 DOCUMENT REQUIREMENT

9.1 A written report shall be submitted on the piping and equipment analysis. The report shall include all pertinent information that shall include but not be limited to the following.

Location and type of pipe supports with loads and movements.

Location of expansion joints and movements.

Vertical and horizontal loads including moments at all support points.

Vertical and horizontal loads including moments on all equipment and

Vessel connections.

Caesar II analysis report, which shall include as a minimum, restraint forces, movements

and stresses for all load cases. For flange connection, loaded with high bending moments and/or tensile forces in piping or at equipment connections, Caesar II flange leakage report will be provided. For piping analyzed, if subjected to hydro test, hydro test load case will be made in Caesar II to check for loading under hydro test & the requirement of any additional temporary supports for hydro test.

Detailed nodal model used for the stress analysis

All assumptions and limitations applied to the analysis

9.2 All dimensions and analysis shall be performed using metric and SI units.

9.3 The final report / stress package folder shall be submitted as follows:

1 Front sheet with Approval status

2 Isometrics with following information

- Node numbers
- Type of supports selected by stress engineer
- Springs / Bellows data required for procurement like spring rate, loads, tide/untied information and SM (special material) identification.
- Maximum Expansion and sustain stress values with node number
- Nozzle/Anchors initial movements and piping imposed forces and moments on the same
- Support loads (anchors, guides or rest) only they are above limit (The limit is defined in the beginning of the project in consultation with civil)
- Design and maximum operating conditions
- Coordinate axis system considered for inputs
- Dimensional details for piping designer to locate supports in piping model/layout.

3 Checklist as per Work instructions.

4 Following outputs

- Load Cases
- Restraint summary
- Spring hanger report, if any

5 Stress critical line list extract for the lines analysed

6 Piping material specifications

7 Equipment drawings with allowable loads, if available

8 PID

ANNEXURE-5-A

CRITERIA FOR IDENTIFING EXTREMELY CRITICAL LINES (LEVEL I)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	All	All	Piping which will undergo hydraulic shock, auto-ignition or is in service.
All	DN≥80	All	Category M (Lethal) fluid service per ASME B31.3 (No cyclic service).
All	DN≥80	All	Piping which is openly exposed to winds> 75 mph.
T<-29	DN≥80	Carbon Steel	All Services.
T<-45	DN≥80	All	All Services
T≥65	DN≥80	Non-Metallic	All Services
T≥65	DN≥80	All	Lines with pressure≥900 psig.
T≥150	DN≥80	All	All Services
ALL	DN≥400	All	All Services.
T≥260	ALL	ALL	ALL Services.
-29≥T≥65 OR -7≥T≥50	DN≥80 DN≥100	All	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1).
ALL	ALL	All	Lines requiring expansion joints or flexible connectors.
DELTA T≥27 (NOTE 2)	DN≥80	All	Jacketed piping.
-29≥T≥65	DN≥100	All	Internally lined pipe (except glass).
All	ALL	All	Glass lined piping.
All	DN≥80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
-40≥T≥80 -29≥T≥70	DN≥100 DN≥200	Metallic Metallic	Underground Piping

NOTES:

1) Load sensitive equipment include lined vessels with lining of brittle material, non-ferrous equipments, graphite heat exchangers, plate & frame heat exchangers, etc.
2) This criterion is not to be applied to auxiliary piping such as seal flush; bearing cooling, etc. delta T refers to the differential temperature between the process piping and jacket.

ANNEXURE-5-B

CRITERIA FOR IDENTIFING MODERATELY CRITICAL LINES (LEVEL II)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	DN<80	All	Lethal fluid service.
T<-29	DN<80	Carbon Steel	All Services.
T<-46	DN<80	All	All Services
95<T<150	80<DN<200	All	All Services
T≥65	DN<80	Non-Metallic	All Services
T≥65	DN<80	All	All Services
T≥65	DN<80	All	Lines with pressure≥900 psig.
T≥150	DN<80	All	All Services
ALL	200<DN<400	All	All Services.
T≥260	ALL	ALL	ALL Services.
ALL	ALL	ALL	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1 of Table-1).
DELTA≥27(NOTE 2 of Table-1)	DN<80	All	Jacketed piping.
All	ALL	All	Internally lined pipe (except glass).
All	DN<80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
All	ALL	All	Underground Piping
All	ALL	All	Piping connected to pressure relief valves
All	ALL	All	Close coupled interconnecting piping between equipment with differential movement greater than 6.0mm.

ANNEXURE-6

DESIGN PHILOSOPHY FOR 3-D MODELLING

1.0 INTRODUCTION

The LSTK Contractor shall carry out Detailed Engineering of the plant areas specified in the scope elsewhere using 3D intelligent software.

2.0 SOFTWARE

Anyone of the following two software with Oracle database shall be used by the LSTK Contractor.

i) PDS by Intergraph USA on Windows with design review through dynamic walkthrough.

ii) PDMS by AVEVA UK on Windows with design review through dynamic walkthrough.

Isometrics shall be generated using ISOGEN Software. Latest version of all the software released as on the date of ITB shall be used by the Contractor. The LSTK Contractor shall clearly specify in his bid the software to be used with version number.

3.0 OBJECTIVE

The objective of 3D modelling is to carry out detail engineering and produce deliverables using 3D tools and conduct reviews for obtaining approvals from Owner/PMC. 3D model shall be developed and demonstrated with dynamic walk through facility to check any interference requirements of operation and maintenance for getting the approval of the Owner. LSTK contractor shall deliver to Owner/PMC a complete 3D model which shall be utilised for all future maintenance, operation, revamping and any de-bottlenecking of the plant. The 3D Design Reviews through dynamic walkthrough, through LCD projector system shall assist the Owner's operation and maintenance personnel in reviewing the project prior to construction and suggest modifications for efficient operation of the plant. Owner/PMC/ shall use it for review of design.

4.0 DEFINITIONS

4.1 EXACT GEOMETRY

The geometry of the object should be exactly as shown in vendor drawings or as per standard drawings as given in codes e.g. Pipes. Flanges. Valves, beams, etc. the geometry of the items to be modelled should be such that it serves the purpose of clash checking as well as identification of object in 3D.

4.2 NEAR EXACT GEOMETRY

SPECIAL items like bellows, traps, etc does not call for exact geometry. The provision should be made for clash checking and 3D representation of the item. A box. Instead of bellows, traps, etc is not acceptable.

4.3 APPROXIMATE GEOMETRY

Items like transmitters, floor stand mounted instruments where boxes instead of exact shape can be shown. The nomenclature of such items should be clearly distinguishable for easy identification.

5.0 EXTENT OF MODELLING / SCOPE OF WORK

5.1 PIPING

5.1.1 All design within Unit, Facility battery limit above ground and underground piping inclusive of fire fighting lines and sprinkler system, big bore and small bore, except tubing, for all piping materials shall be modelled. Details shall include all pipes, valves, flanges, fittings, reducers, spectacle blinds, drains, temperature/pressure connections, sample points, drip legs jacketed pipes, fittings and flanges etc. Existing lines inside the battery limit (If any) along with tie-in points shall also be modelled.

5.1.2 All in line instruments like control valves, safety valves, rotameters, orifice plate etc. with near exact geometry.

5.1.3 All piping special items like expansion bellows, slide valves, special valves with purge points, steam traps, strainers etc. with near exact geometry.

5.1.4 Complete vessel trims with level gauges, level switches, level transmitters, equipment, instrument, vent/drains utility connections, pressure gauges etc. with exact geometry.

5.1.5 Steam supply and condensate recovery stations up to the first valves in tracer lines

5.1.6 All pipe supports to be Physical modelled for all sizes with secondary steel sleeper way as follows.

a) All spring hangers, roller supports to be modelled with all details.
b) Pipe supports along with concrete pedestals, Type of support
c) Details of the spring hanger's i.e. operating load, travel, spring constant should be keyed in as user-defined attributes.
d) Details of expansion bellows i.e. type, axial/lateral deflections, stiffness etc to be keyed in as user defined attributes.
e) Structural steel members used for the pipe supports to be modelled in complete details.

5.1.7 All equipment to be modelled with exact geometry including but not limited to: manholes with davits, pipe davits on top platforms, nozzles, stiffener rings, bellows, break flanges, platforms, ladders, handrails, lifting lugs, etc. for all the equipment in the plant like vessels, columns, reactor, receivers, pumps with motors, compressors with details of volume bottles, cylinders etc., blowers, centrifugal compressors, furnaces with soot blowers, burners and peep holes, air coolers with motors and fans, filters, blow down drums, all equipment within packages and heat exchangers etc.

a) Maintenance areas around equipment, davit swing areas, swing elbows sweep areas, tube bundle removal areas for heat exchangers, rotor removal areas, drop out areas to be modelled as soft envelopes and should be used for clash detections.

b) Equipment supports: skirts, support legs/lugs, saddles to be modelled along with the. Equipment.

c) Insulation type (hot, cold, tracing, jacketed, etc). Insulation thicknes operating/design. Pressure /temperature, hydro test medium/pressure to be given.

d) Equipment 3D model shall include all attachments like platforms. Nozzles, ladders. Pipe supports, etc.

5.1.8 Skid mounted Equipment / Package units (if applicable) shall be modelled as a Block and Piping connections at Skid/Package unit battery limit to be precisely modelled depicting complete connectivity.

a) Skid to be tagged as main equipment.

b) All sub-equipment of all skids to have skid tag as a prefix.

c) All sub-equipment to be modelled with exact geometry.

d) Complete internal Piping of the skid with all inline and online instruments to be modelled as per the details in 5.1.1 to 5.1.7.

e) All pipe supports with the skids are to be modelled as per para 5.1.7.

5.1.9 Tagging of all line nos., Instrument nos., special items. Equipment nos. shall be as marked in the P&ID·s.

5.1.10 Complete underground piping man hole vent piping to atmosphere. catch pits, cable trays etc. to be modelled. Envelopes to be modelled on top of manholes and catch pits and shall be used for interference detection.

5.1.11 Material handling equipment e.g. Catalyst loading chutes. Drums. Etc to be modelled in near exact geometry.

5.1.12 Hard stands, fabrication space for tall columns, erection access for tall structures considering crane boom and movement, crane access. unit approaches from main roads. Main roads outside the units shall also be modelled.

5.1.13 Line information required in 3-D model.

The following attributes must be keyed in while modelling:

a) Line operating/design, temperature/pressure in deg. C and kg/cm2g respectively

b) Liquid state i.e. vapours liquid, 2-phase.

c) Insulation thickness and type i.e. IH/IC/IJ/IC etc.

d) Hydro test pressure in kg/cm2g and medium.

g) Line number label should be as per the P&ID with the following attributes: Line size + unit no + line sequence no + sub-line no + piping material specification + insulation type. User Defined Attributes (UDA's) to be generated for keying in this information in PDMS.

h) Hydro test loop no.

i) Piping stress analysis system number allocated at the time of generation of critical line list for stress analysis (through UDA's in PDMS)

5.1.14 Incorporation of site changes during fabrication and erection with 3D Model!

in order to deliver a complete as built model to Owner.

5.1.15 General Arrangement Drawing Extraction

a) Piping General Arrangement Drawings are to be extracted from the 3D model on AO size with a scale of 1 :33 / 1 :50 for rack Vital installations and battery limits shall be marked with coordinates.

b) All locating dimensions like spacing for equipment, structural columns, pipe-to-pipe etc. shall be marked on the GAD's. Equipment tag numbers, line numbers, instrument and speciality item tag numbers shall be marked on the GAD's. Electrical instrument ducts shall be marked and labelled. Access ways, maintenance corridors, dropout areas, bundle removal areas catalyst-handling areas shall be marked on the GAD's.

5.1.16 ISOMETRIC EXTRACTION

Isometrics shall be extracted from 3D model using ISOGEN Software along with Bill of Material and logical pipe supports.

5.1.17 Interference Detection shall take care of Hard-Hard clashes and Hard-Soft clashes for all the disciplines.

5.2 STRUCTURAL

The scope of modelling for structural shall include but not limited to the following:

i) Main steel/secondary steel equipment support beams, bracing, columns with footings, stiffener plates, platforms, ladders, pipe racks, stair cases, walkways, supporting structure for all coolers with operating platforms ,handrails and staircase, monorails, EOT support. Including fire proofing shall be modelled in exact geometry. Existing structures inside the working battery limit to be modelled.

ii) Equipment and structure foundations, technological buildings, equipment supporting structure, flue gas stack and any other concrete structure to be modelled in exact geometry with exact locations of all insert plates.

- Foundation and structure for platforms, gratings, handrails etc. for packaged item and items are also included.

5.3 INSTRUMENTATION

i) Instrument ducts, cable trays greater than or equal to 300 mm width, Instrument Junction boxes to be modelled in exact geometry.

ii) Transmitters and other floor stand mounted instruments on grade/platform to be modelled in approximate geometry with tag nos. as per P&ID's.

5.4 ELECTRICAL

i) Electrical cable trays greater than or equal to 300 mm width. Electrical cable trenches all sizes, junction boxes to be modeled in exact geometry.

ii) Electrical stop/start switches for motors, to be modelled in approximate geometry.

iii) Lighting details, earth pits.

iv) Fire alarm system, e.g. fire detection point, hooters, etc.

6.0 MODEL SPLIT

6.1 Separate models to be generated for each discipline.

Discipline	Model Identifier
Piping above ground	P
Piping under ground	U
Equipment	E
HVAC	H
Structural	S
Architectural	A
Electrical	L
Instrumentation	I

6.2 Within each discipline models are to be generated based on the area division in piping key plan. The naming conventions for model in the PDS and Database in PDMS shall be as follows.

X	X	=	XX
Model identifier as given in 6.1	Model Identifier as Levels (given below)	Under score	Area number form Key Plan

A – Grade
B – First Level above grade
C – Second Level above grade
X – All levels in one model
U – Under ground

- Above ground and underground piping shall always be in different models.

6.3 Database Hierarchy in PDMS

i) Piping

a) PIPE NAME:

Line no. Label Specified in 5.1.15)	-- Under score	PX Model no.	-- Under score	XX Area no. From Piping Key Plan.

b) Branch Name:
PIPE NAME / B1, B2

c) TAX NOS. For all Inline Instruments, Special Items as component Name in PDMS. Same tag numbering philosophy to be followed in PDS.

XXX	=	XXX	XXXX	X
UNIT No.	DASH	INST. Type i.e. PSV, FV, PV	INST. No. / special item no.	Only if same no. is getting repeated.

- Comments to be written in components S Text attribute.

ii) Other Disciplines

Basis shall be similar to that given for piping. LSTK Contractor shall develop the Hierarchy and submit it for Owner/PMC approval prior to start of modelling

7.0 DELIVERABLES

7.1 Complete 3D model as built along with as built GAD's, Isometrics, and MTO reports, all extracted from the model, nozzle orientations for Piping and 3D models for all disciplines as specified in 7.1 to 7.6 with any other document generated from 3D model and naming conventions as per 7.0 to 7.3 with "As built" updates along with complete reference databases, component catalogues for all the size range in the approved specifications shall be furnished by the LSTK Contractor in electronic form.

In addition, contractor shall submit the 3D model in electronic form after completion of final review of 3D model duly updated as per comments/observations and agreed of MOMs of review sessions.

7.2 Review Models shall be installed at site having latest version of design review software and all other pre requisite software and any other software required for smooth running) and minimum configuration as stated in by the Contractor sufficiently at start of Mechanical work and & plotter at site shall be decided in consultation with Owner.

Model and Isogen will not be installed at site. Only review data will be available on review station

In addition LSTK Contractor to Minimum Install.

- ► One number of A3/A4 duplex laser printer
- ► One number of A0 inkjet plotter

7.3 **Reference Data Bases**

7.3.1 P.D.S.

The complete reference Data base developed for the FACILITIES by the LSTK Contractor on PDS and delivered shall include but not limited to the following:

7.3.1.1 Piping

1. Piping material class
2. Piping Commodity data files.
3. Short or Long material description library.
4. Specialty material description library.
5. Standard note library.
6. Label description library.
7. Piping assembly library.
8. Graphic commodity library.
9. Physical data library.
10. Formats files for MTO

11. Isometric set-up (option) files.
12. Piping job specification library.
13. Write-up of all project specific code lists, which have been, added to the standard code lists.

7.3.1.2 Other disciplines

Complete reference database with all the libraries. LSTK Contractor shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.3.2 PDMS

The complete material specifications and component catalogues developed by the LSTK Contractor on PDMS and delivered shall include but not limited to the following.

7.3.2.1 Piping

1. Piping material specifications.
2. Insulation specifications
3. Bolt specification
4. Nozzle specifications
5. Complete Piping component catalogues with write-up on naming conventions used for CATALOGUE references, component references for Property Database. Bolt References for single and multiples.
6. Detail texts along with the symbol keys & R Texts
7. Material texts with X Texts
8. Any symbol key library developed for special items where Isometric Symbols by CAD Centre were not available.
9. Property database with nominal bore and outside diameter developed for the project.

7.3.2.2 Other Disciplines

Complete reference database with all the libraries. LSTK Contractor shall prepare a comprehensive list of these files separately for each discipline and submit it for PMC review prior to start of 3D modelling.

7.4 During the period of construction the above workstations and software at site shall be manned and maintained by LSTK Contractor personnel up to the completion of the Project.

7.5 Costs for all the hardware, software, networking, model transfers, ISDN link etc shall be borne by the LSTK Contractor.

7.6 Review by PMC/Owner/Licensor.

LSTK Contractor shall be responsible for arranging 3D review sessions at his design center with Dynamic walkthrough with overhead projector system, for Owner/ PMC/ Licensor

comprehensive review of the 3D Models. Simultaneously a Technical Audit of the Reference Database, Component Libraries and Project Database shall be carried out by PMC. LSTK Contractor shall make one workstation available for the entire duration of the Technical Audit to the audit team along with Contractors support team, without any extra cost to PMC/Owner. Incorporation of the comments of the Technical Audit shall be done by the LSTK Contractor without any cost or time impact. LSTK contractor shall send fortnightly updates of the model using latest version of 3D modelling software (compatible to the one at OWNER /PMC Office) for the review status monitoring of the models. LLSTK Contractor shall propose the dates and duration at least 4 weeks in advance for these 3D reviews by Owner/PMC.

7.7 **REVIEW STAGE**

There shall be minimum 3 review stages to be done as follows. 4th and 5th further reviews shall be required after all comments are incorporated by the LSTK Contractor.

1. Equipment layout review from erection, construction, operation and maintenance point of view & Conceptual review of critical lines (thermal & process critical) (30%).
2. Before issue of model for engineering (60%).
3. Before issue of model for construction (before isometric generation commences) (90%).

3-D modelling review for sprinkler system for pumps where monorail is provided. shall be done with sprinkler system in place.

3-D modelling review for material requirement has to be fine tuned as per 3D modelling and report of such material requirement shall be forwarded to PMC/OWNER for their information on regular interval.

Any operational requirements such as platforms, approaches for equipment I technological structure if required during the 3D model review as above, the same shall be provided by the LSTK contractor without any time delay and cost implications.

8.0 PROVEN TRACK RECORD

The LSTK Contractor or his Engineering sub-Contractor must have carried out extensive 3D modelling and data base management for a project of similar nature with the following as a minimum.

LSTK Contractor should demonstrate their capability through walk through of one such 3D model developed by them.

Owner/PMC reserve the right to verify the above at the premises (as applicable) including experience of personnel deployed on the project

Owner/PMC decision shall be final and binding on the LSTK Contractor in this regard.

PART-II, TECHNICAL

SECTION – 10

DESIGN PHILOSOPHY – ELECTRICAL

NEW AMMONIA NITRATE (AN) MELT PLANT

AT RCF, TROMBAY

CONTENT

SECTION NUMBER	DESCRIPTION
1.0	Scope
2.0	Basis of Design
3.0	Area Classification
4.0	System Details & Utilisation Voltages
5.0	Power Supply Distribution
6.0	Sub Station
7.0	Protection & Metering
8.0	Control and Monitoring
9.0	Equipment Specification
10.0	Cabling
11.0	Illumination System
12.0	Earthing and Lightning Protection
13.0	Cathodic Protection System
14.0	Capacitor Bank
15.0	Communication System
16.0	Fire Alarm System
17.0	Electrical Heat Tracing System
18.0	Spares
19.0	Vendors' Services
20.0	Testing & Inspection
21.0	Documentation
22.0	Training
23.0	Vendor List
24.0	Installation, Testing and Commissioning
25.0	Coordination With Other Contractors
26.0	Deviations
Annexure- I	Illumination Levels & Type of Fixtures

LIST OF ATTACHMENTS

Technical Specification No.	Description	No. of Sheets
TS-8037	Public Address System	8
TS-8040	Uninterrupted Power Supply System	14
TS-8043	Power Transformers	13
TS-8044	Neutral Earthing Resistor	8
TS-8046	Capacitor Bank & Associated Equipment	11
TS-8048	Auxiliary Service Transformer	8
TS-8060	Medium Voltage Switch Boards	20
TS-8061	High Voltage Switch Boards	16
TS-8062	Medium Voltage Bus Duct	9
TS-8080	Sheet Steel Distribution Boards	14
TS-8083	Lighting Sub Distribution Boards	8
TS-8102	Induction Motors	14
TS-8120	Interlocking Sw. Socket and Plug	8
TS-8123	Lighting Fixtures & Accessories	13
TS-8140	Battery Charger	14
TS-8142	Battery	6
TS-8160	Cables	7
TS-8200	Local Control Stations	9
TS-8201	Junction Box	7
TS-8205	Ventilation System	12
TS-8206	Passenger cum Goods Lift	16
TS-8208	Electricals for Over Head Cranes and Hoists	13
TS-8211	Diesel Generator Set	18
TS-8301	Soft Starter	8
TS-8302	Variable Frequency AC Drives	20
TS-8303	Cathodic Protection for Plant Piping and Buried Facilities	23
TS-8304	Cathodic Protection Power Supply Module (CPPSM)	14
TS-8305	Cathodic Protection Transformer Rectifier Unit	14
TS-8306	Fire Detection and Alarm System	21
TS-8307	Communication & Fire Alarm Cables	10
TS-8308	High Mast	10

Schematic Diagram	Description	Sheets
PC185-1201	Schematic Diagram for HV switch Board	19
PC185-1202	Schematic Diagram for 415V switch Board	16

Electrical PDS No.	Description	Sheets
PDS:E 113	Foundation Details of 11/0.433kV or 3.3/0.433kV Transformers	1
PDS:E 115	Typical details of transformer room door	1
PDS:E 116	Sump Pit for Transformer Oil	1
PDS:E 119	Typical Foundation Arrangement for Panels in Sub-Station	1
PDS:E 120	Typical Foundation Details for HT/LT Circuit Breaker Panels	1
PDS:E 201	Fixing Arrangement of Air Obstruction Light	2
PDS:E 203	Steel Tubular Lighting Pole	3
PDS:E 204	Installation of Electrical Poles	1
PDS:E 206	Installation Arrangement Street Lighting Fixtures	1
PDS:E 207	Details of Bracket Arm for Street Lighting Pole	1
PDS:E 208	Installation Arrangement Area Lighting Fixtures	1
PDS:E 210	Junction Box for Street Lighting Pole	1
PDS:E 211	Installation of Junction Box for Street Lighting Pole	1
PDS:E 213	Typical Street Lighting Pole	1
PDS:E 402	Component rating for DOL starter	1
PDS:E 404	Component rating for AC feeders	1
PDS:E 412	Schematic Diagram AC Control Supply through Control Transformer for Switch Boards with bus coupler	1
PDS:E 464	Schematic Diagram Panic Light	1
PDS:E 510	Details of Concrete Cable Trench	1
PDS:E 511	Cable Rack Arrangement in Trenches	1
PDS:E 512	Fabrication Details of Cable Rack in Trench & Duct	1
PDS:E 516	Typical Arrangement of Cables burried in slit	1
PDS:E 525	Fixing Arrangement of Perforated Cable Tray (Horizontal Formation Ceiling Supported)	1
PDS:E 526	Fixing Arrangement of Perforated Cable Tray Horizontal Formation Wall / Structure Supported	1
PDS:E 527	Fixing Arrangement of Perforated Cable Tray Vertical Formation	1
PDS:E 531	Pre-Fabricated Cable Tray Horizontal Tee	1
PDS:E 532	Pre-Fabricated Cable Tray Horizontal Cross	1

Electrical PDS No.	Description	Sheets
PDS:E 533	Pre-Fabricated Cable Tray 90^0 Horizontal Bends	1
PDS:E 534	Pre-Fab. Cable Tray 90^0 Vertical Bend Bending Rad. 1000 mm	1
PDS:E 535	Pre-Fabricated Cable Tray 90^0 Vertical Bend Bending Radius 600 mm	1
PDS:E 536	Pre-Fabricated Cable Tray Coupling Arrangement	1
PDS:E 537	Pre-Fabricated Cable Tray Fixing Arrangement	1
PDS:E 538	Pre-Fabricated Cable Tray Reducing Coupler Plate	1
PDS:E 602	Earthing Conductor Details	2
PDS:E 603	Arrangement of Connections of Earth Conductors	6
PDS:E 604	Typical Details of Connection in Earth Pit	1
PDS:E 605	Earth Pit Details	2
PDS:E 606	Typical Arrangement of Earthing for Motor and Start Stop Push Button	2
PDS:E 610	3.8 M GI Electrode for Earthing	1
PDS:E 611	GI/Al Accessories for Earth Electrode	2
PDS:E 613	Earthing of storage tank & vessel	1
PDS:E 615	GI Earth Bus	1
PDS:E 617	Typical Arrangement for Neutral and Equipment Earthing	1

1.0 SCOPE

1.1 This scope of works covers the complete design, engineering, manufacture, testing at works, supply of all electrical equipment, dispatch, storage, handling, erection, testing and commissioning at site of complete electrical system required for setting up a new Ammonia Nitrate (AN) Melt Plant at RCL, Trombay, India.

1.2 The electrical system shall comprise of receiving power from existing AN Melt Plant, emergency power generation, primary and secondary power distribution up to consuming apparatus, lighting, earthing, lightning protection, public address system, FA System, cathodic protection system etc. necessary for satisfactory and safe operation of complete plant.

11KV power will be supplied or only 11KV power will be provided further step down to different voltage level is in contractor's scope. Owner's feeder modification to meet the system / NIT requirement, relay setting shall be in contractor's scope. Contractor may visit the site for better understanding. The power so received at Main Receiving Substation (MRSS) shall be used to distribute power to various substations through double feeder line by the contractor. **Bidder to indicate total power requirement along with the requirement of the number of feeders at different voltage level and current rating for modification of the same (if required) at upstream to be indicated with the bid.**

Existing equipment, if any, which will be used in the new plant by the contractor for operation of new plant shall be shifted in the new panel at discretion of RCF Engineer and to be decided during the design stage. (e.g. Tanker loading/unloading). Below is the list of motors which may require shifting for the operation of the new plant as envisaged by the owner. Further detailed engineering shall be in LSTK Contractor's scope.

Sr. No.	Equipment description	Rating	Installed qty
1.	AN Tanker loading pumps(17-11-18/98)	15 KW	2
2.	Water booster Pump (40-11-13/73/93)	55 KW (1DOL and 2 no. VFD)	3
3.	CCT ID Fan North/South	55 KW	2
4.	CCT Cooling water pump B	160 KW	1
5.	Instrument air heater	55 KW	1
6.	Tanker unloading pump	18.5 KW	1
7.	Drinking water pump East & West	5.5 KW	2
8.	RO Reject water pump East & West	30 KW	2
9.	Effluent pump East and west	45KW (VFD)	2
10.	Effluent agitator	11Kw	1

1.3 This design philosophy contains specifications of the major equipments to indicate the basic requirement and serve as a guideline. However, it shall be the responsibility of the contractor to offer a complete electrical system of superior quality, even if the specifications of certain items are not given.

1.4 The bidder shall offer the best and most suitable type of energy efficient equipments manufactured by well known reputed manufacturers as per vendor list appended elsewhere in this bid package. However for the sake of standardization of the electrical equipment and material used for the electrical installation, the bidder shall be ready to supply the equipment of a particular type and or make.

1.5 Construction power shall be provided by the owner at one point on chargeable basis on actual to the contractor. Further distribution through adequately rated distribution and sub distribution boards/feeder pillars, power supply cables and other associated materials for feeding loads to carry out construction and fabrication activities shall be in LSTK Contractor's scope. **Bidder to indicate the construction power requirement with the bid.** Power rates to be as per prevalent RCF power rates and the Distribution board with RCCB of suitable rating for protection, along with calibrated energy meter will be in contractor's scope. LSTK contractor shall arrange emergency power (suitably rated DG Set) at his own cost during construction in case of construction power failure to ensure the safety of personnel at site.

1.6 Contractor shall provide adequate area lighting at site of construction, fabrication yards and office etc. by means of suitable lighting fixture, lighting masts, flood lighting poles etc. which are to be supplied and maintained by the contractor as per safety aspect.

1.7 Electrical system studies, like load flow study, transient stability analysis, short circuit study, motor starting study, relay co-ordination study, harmonic studies etc. of the entire electrical installation shall be conducted by the contractor at appropriate stage of design-engineering.

1.8 All design calculations and the applicable standards to be submitted used for calculations for arriving at specifications.

1.9 Mandatory Electrical spares for operation and maintenance of the electrical system shall be supplied by the contractor as listed elsewhere in this bid package.

1.10 Spares and consumables required and first oil fills including short fall during erection, testing, cold trials, commissioning, performance evaluation tests, guarantee tests etc. and till handing over of installation.

1.11 The scope shall also include obtaining all required statutory approval from all statutory bodies. Contractor shall carry out all modifications/alterations required by local statutory bodies.

1.12 Anchor fastener and any other external hardware used for support shall be of Stainless Steel to avoid corrosion.

1.13 All the sub stations shall be provided with following equipment :

- CO2 fire extinguishers (4.5 litre capacity) as per applicable NFPA.
- Synthetic insulating mats on front and back side of the switchboards (LV as well as HV) as per latest IS.
- Framed single line diagram in Aluminium frame with glass.
- Do's & Don't chart as per Indian Electricity Rules in Aluminium frame with glass.
- Shock treatment chart written in English and Local language duly framed and approved by engineer-in-charge.
- Caution boards / dangers boards written in ENGLISH & HINDI for all the voltage levels.
- CPR (CARDIO PULMONARY RESUSCITATION) Charts.
- High Voltage / Low Voltage danger signage (Skull & bones).
- Exit Route / Emergency Exit Route Signage.
- Cable Route Marker
- Earthing rod- Minimum 1 No. for each Voltage level.
- Sets of Sand buckets with stand (each with at least 3 sand buckets) for substations and transformer yards.
- HT discharge rod.
- HT and LT megger
- Earth megger
- HT and LT hand Gloves (3 Sets each for each substation).
- HT line tester
- A Type FRP ladder 3 feet & 8 feet – 1 no. each type for each substations.
- First Aid Box
- 2 nos. non contact voltage detector to be provided as spare for voltage level 240V-22 kV or above

Other requirement or any other unforeseen which may arises during detailed engineering shall also be in LSTK Contractor's scope

1.14 In case of any discrepancies between Design Philosophy – Electrical and Technical Specification of equipment / item / work in respect of description of equipment / item / work, the details indicated in the Design Philosophy – Electrical shall prevail. Also in case of any further discrepancy the job to be carried out as per IS/IEC/BS/IEEE standards whichever applicable or as per RCF standard practice after obtaining approval from RCF.

2.0 BASIS OF DESIGN

2.1 General

2.1.1 The electrical installation shall be designed to provide:

- Necessary amount of power
- Flexibility
- Service reliability
- Ease of expansion
- Ease of operation and maintenance & inter changeability of equipment
- Safety of personnel

The design of electrical installation shall ensure provision of a safe, efficient and reliable supply of electricity at all times. Safe conditions shall be ensured under all operating conditions including those associated with start up and shut down of plant as well as those arising out of failure of electrical equipment. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety.

2.1.2 System shall be designed considering following aspects in general:-

- To facilitate inspection, cleaning and maintenance with the care to safety in operation and personnel protection.
- To minimise turnaround times.
- To provide safety, reliability and flexibility of service.
- Adequate provision for future extension and modification.
- Maximum interchangeability of equipment.
- Desired level of operator interface to achieve coordinated efficient and fail-safe operation, data logging and maintenance of the equipment.
- To decide redundancy, stand by, spares and overload capacities to achieve desired reliability and flexibility requirement.

- To get cost effective and techno commercially proven technology. Economic considerations shall cover capital and running costs and an assessment of the reliability and consequent availability of the system.

2.1.3 All the electrical consumers within the battery limit shall be correctly identified and listed to have complete details of rating, efficiency, power factor, operating duty cycle (continuous, intermittent, standby), category of supply required (emergency, normal, critical) etc.

2.1.4 Required redundancy (based on specific process/operating needs) shall be built in substation which feeds power supply to process units/important facilities so that in case of tripping of one feeder, the unit may not be adversely affected and continuity in operation at full capacity is achieved.

2.1.5 While sizing the system necessary consideration shall be given to restrict the system voltage drop within permissible limits during starting of large rated motor. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears. For this purpose current limiting reactors/unit ratio transformers if required may be used. Reduced voltage starting (soft starter feature) for motors may be considered as per system requirements. Critical motor to have bypass contactor feature for the soft starter to enable the operator to start the motor in case of soft starter failure and reduce the downtime of motor and plant.

2.1.6 LSTK contractor while performing design and engineering activities shall adhere to following guidelines.

a) If any equipment is not covered in this design philosophy but required for successful operation of the project, LSTK contractor shall prepare additional specifications for equipment or bulk material taking reference of Indian/International Codes and good engineering practices prevalent in fertilizer industry and obtain owner's approval for the same.

b) The standard drawings attached with this package define the basic system design and distribution philosophy for the package. This is for guidance purpose only. LSTK contractor shall develop detailed drawings and submit for owner's approval.

c) LSTK contractor may note that equipment ratings, wherever specified in the bid package, shall be considered indicative. LSTK contractor shall be responsible to verify the rating and consider providing equipment with adequate rating but not less than the specified rating. Compliance should be without any extra cost and time implications.

d) LSTK contractor shall consider any other requirement which is not covered in this bid package, but required for successful operation of the plants without any extra cost and time implications.

e) Contractor shall obtain approval from all statutory authorities such as Central Electricity Authority (CEA)/Electrical Inspectorate, Chief Controller of Explosives (CCoE), CPCB etc. for all electrical facilities including electrical switchboards & panels supplied and installed by LSTK contractor.

f) LSTK contractor shall assist in Liaison and in all interface coordination with contractors of other units of project at construction, erection, testing & commissioning phase for any common facility.

g) Equipment specification sheet/data sheets for all equipment shall be prepared by the contractor based on relevant codes and specifications. Data sheet shall contain all technical data and information which are essential for review and technical acceptability, detailed engineering, installation, testing, repair and maintenance, replacement etc.

h) Contractor shall clearly specify in their purchase specifications, the requirement of conducting other special tests/type tests, which are envisaged for various electrical equipment, which shall have no impact on cost and time.

i) Bidder shall visit the site and collect all relevant information required for designing of complete system before quoting.

j) All the electrical equipments shall be of proven design and technology.

Load Summary shall be prepared by LSTK contractor to determine ratings of electrical equipments (DG set, transformer, switchgears, cables etc.), to evenly distribute plant loads among the various substations and switchgear, and to evaluate the need for power factor correction. All calculation shall be necessarily reviewed / approved by Owner / Consultant.
The maximum normal running load and the peak load shall be calculated as follows:
Maximum Normal Running Load = (100% of sum of all continuous load) + (40% of sum of all intermittent loads or largest intermittent load, whichever is higher) + (10% of sum of all standby loads or largest standby load, whichever is higher).

All the electrical equipments shall be designed / sized considering motor input power (i.e. BKW divided by motor efficiency).

Line loss of 2% to be considered for equipment sizing.

All the electrical equipments like Transformers, DG Set, Switchboards etc. shall be suitable for starting of the largest motor, while other loads are running, considering peak load condition.

k) Electrical equipments i.e. DG Set, Transformers, Switchgears, MCCs, PCCs etc. shall have capacity for future requirements. The Margin shall be as follows:

i) DG Set sizing: 25% is added to the Maximum Emergency Load.

ii) HV Transformer: 25% is added to the Maximum Normal Running Load.
LV Transformer: 30% is added to the Maximum Normal Running Load.

iii) Switchboard: Switchboard bus bar current rating as well as breaker shall be equivalent (nearer or higher standard rating size) to full load current of upstream transformer.

iv) Switchboards and MCCs fed from other switchboards shall be rated for 125% of peak load.

2.2 Statutory requirement Codes and Standards

The design and the installation shall be in accordance with established codes, good engineering practices and shall conform to the statutory regulations applicable in the country. LSTK contractor shall be responsible for obtaining necessary approvals from the statutory authorities e.g. Electrical Inspectorate, PESO (earlier CCoE) as applicable before commissioning of electrical facilities. The CEA clearance for electrical equipment and components thereof shall be obtained by the contractor.

2.2.1 Latest version of main codes, standards and statutory regulations shall be considered as minimum requirements are as given below:

- Indian Standard Specification
- Indian Electricity Act
- Indian Electricity Rules
- International Electro-Technical Commission
- The Factory Act
- API Standards/IEEE

2.2.2 Some of the bare minimum relevant Indian Standards are as listed below. However, system/equipment design shall be in line with latest edition of all applicable standards.

IS: 722	AC electricity meters
IS: 732	Code of practice for electrical wiring installations system voltages not exceeding 650V
IS: 1248	Direct acting analogue electrical measuring instruments and their accessories: Part. 1 General requirements
IS: 1646	Code of practice for fire safety of buildings and electrical installations
IS: 1913	General and safety requirements for Luminaires (Tubular fluorescent Lamp)

IS: 2148	Electrical apparatus for explosive gas atmospheres - Flameproof enclosures “d”
IS: 2409	Code of practice for the protection of buildings and allied structures against lightning
IS: 2705	Current Transformers
IS: 3034	Code of practice for fire safety of industrial buildings, electrical generating & distributing stations
IS: 3043	Code of practice for earthing
IS: 3156	Voltage Transformers
IS: 3646	Interior illumination: Part I & Part II
IS: 3716	Application guide for insulation co-ordination
IS: 4691	Degree of protection provided by enclosure for rotating electrical machinery
IS: 5571	Guide for selection of electrical equipment for hazardous areas
IS: 5572	Hazardous areas other than mines for electrical insulations area having flammable gases and vapours
IS: 5578	Guide for marking of insulated conductors
IS: 6362	Designation of methods of cooling of rotating electrical machines
IS: 6381	Construction and testing of electrical apparatus with type of protection “e”
IS: 6665	Code of practice for Industrial lighting
IS: 7689	Guide for control of undesirable static electricity
IS: 8084	Interconnecting Bus bars for AC voltage above 1 KV upto and including 36 KV
IS: 9628	Specification for three phase induction motor with type of protection “n”
IS: 9676	Reference ambient temperature for electrical equipment
IS: 11353	Guide for uniform system of marking & identification of conductor & apparatus terminals
IS: 12360	Voltage bands for electrical installations including preferred voltage and frequency
IS: 12459	Code of practice for fire protection of cable runs
IS: 13234	Guide for short circuit calculations
IS: 13346	General requirements for electrical apparatus for explosive gas atmosphere
IS: 13408	Code of practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
SP: 30	National Electrical Code (NEC) - BIS Publication

2.2.3 Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

2.2.4 In case of any conflict/deviation amongst various documents the order of precedence shall as be as follows:

- Statutory Rules/Regulations
- Design Philosophy
- Engg. Standard Specifications/Installation Standards etc.
- Applicable IS/IEC standards

In case of contradiction / conflict among documents and statutory requirement, LSTK Contractor shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner's approval. Owner decision shall be considered as final.

2.3 **Site Conditions**

The equipment shall be designed for the following site conditions:-

A.	Maximum ambient temperature	45°C
B.	Minimum ambient temperature	7°C
C.	Design Reference Temperature	50°C
D.	Relative Humidity	100%
E.	Altitude above mean sea level	5 M
F.	Atmospheric pollution	Dusty and corrosive due to presence of vapours of Ammonia.
G.	Seismic Zone	Zone-III, IS: 1893-2002
H.	Design Wind Speed	160 Km/hr

3.0 AREA CLASSIFICATION

3.1 The hazardous zones within the project area shall be classified according to the requirement of IS/IEC. The bidder shall furnish area classification drawing.

3.2 All electrical equipments installed in the areas classified as hazardous shall be certified for such use by a recognized international certifying authority such as CIMFR (earlier CMRI), Dhanbad/PESO (earlier CCoE), Nagpur etc.

For those items where overseas OEM vendor will supply the electrical equipment certificate from international authority can be accepted but the certification shall be approved by PESO (earlier CCoE), Nagpur India.

4.0 SYSTEM DETAILS AND UTILIZATION VOLTAGES

4.1 The various voltage levels for in plant power generation and distribution shall be as follows:

In this Design Philosophy LV system voltages have been indicated as 415V, 3 phase and 240V, single phase. However, LSTK contractor shall consider system voltage 400V or 415V as per latest amendment of relevant Indian Standard.

A. Normal Power	11kV power will only be supplied. Further downstream distribution will be in party scope.
B. Emergency Power	Through 1 No. Diesel Generator Set to be provided by the LSTK Contractor
C. Distribution Equipment	a) 11KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral b) 3.3KV ± 10%, 50 Hz ± 5%, 3 Ph, 3 W with resistance earthed neutral c) 415V ± 10%, 50 Hz ± 5%, 3 Ph, 4 W solidly grounded neutral. d) 415V ± 10%, 3 Ph, 4 W/240V ± 10%, 1 Ph, 2W, 50 Hz ± 5% solidly grounded neutral.
Voltage Variation	± 10%
Frequency Variation	± 5%
Combined variation in voltage & frequency	± 10%
Control Supply for: - 415V motors - Switch Gear: a. Closing & tripping b. Auxiliary power	 AC 240V ± 10%, 50 Hz ± 5%, 1Ph (For contactor controlled motors) DC 110V ± 5% (For breaker controlled motors) DC 110V ± 5%, 2 W AC 240V ± 10%, 50 Hz ± 5%, 1Ph, 2W
- Instrumentation and Automation, DCS & auxiliaries	AC 115V ± 5%, 50 Hz ± 2% 1Ph, 2W
Voltage Ratings - Motors above 1000 KW	 11 KV, 3 Ph AC
- Motors above 150 KW up to 1000 KW	3.3 KV, 3 Ph AC
- Motors upto 150 KW - Heaters - Space heaters - Lighting - Panic Lights - Power Sockets/Receptable - Portable safety lamps & Tools	415V, 3 Ph AC To Manufacture's requirement 240V, 1 Ph AC 415V/240V AC 110V DC 415V, 3 Ph AC/240V, 1 Ph AC 24V AC

4.2 Electrical System Studies

4.2.1 Contractor shall carry out following Electrical System Studies of the entire electrical installation using latest software preferably ETAP latest version and the result of the same shall be furnished. ETAP Native file (editable copy) along with its base file & complete library shall also be submitted for owner's review as well as with final documentation.

Load Flow Studies
Short Circuit Studies
Transient Stability Studies

Motor Starting Studies
Relay Co-ordination
Harmonic Studies etc.

4.2.2 Bidder to indicate the actual fault levels arrived at on the basis of incoming power source, transformers, contribution of motors, etc. in the bid.

All switch boards of the same voltage shall be rated for identical fault level. Minimum fault level to be considered for design and selection of equipment shall be as follows:
For 11KV supply – 40KA for 3 sec.
For 3.3KV supply – 26.24KA for 3 sec.

However, fault level for 415V switchboards shall be 50KA for 1 sec.
11KV/0.433KV or 3.3KV/0.433KV Transformer rating shall not be more than 2000kVA.

4.3 **System Earthing**

The neutral of 11 KV and 3.3 KV systems shall be non-effectively earthed through resistance. The earth fault current of 11 KV and 3.3 KV shall be limited to full load current of the transformer or 400 A, whichever is less.

The neutral of 415V supply system shall be solidly earthed. The DC system shall have positive pole earthed through high impedance. Prospective touch voltage earthing shall comply with the requirements of relevant Indian/IEC Standards.

5.0 POWER SUPPLY DISTRIBUTION

5.1.1 The total power requirement of new AN Melt Plant at RCF, Trombay shall be met through existing Gas Turbine Generator (GTG). RCF will provide only 11kV supply, contractor to install transformer for step down and further distribution including laying of cable, cable termination at both end, owner's feeder modification to meet the system / NIT requirement, relay setting shall be in LSTK Contractor's scope.

5.1.2 The electrical system shall be designed for a high degree of reliability and availability. Double radial mode of power distribution shall be adopted up to all major distribution switch boards.

5.1.3 Power supply from 11 KV switch board in Main Receiving Substation (MRSS) to all substations shall be fed by double feeder lines through cables separately.

Further distribution to equipment at 11kV, 3.3 KV, 415/240 V, 115 V (UPS) AC, 110 V DC etc. through proper type and size of cables, their supply, erection, testing and commissioning etc. shall be in Contractor's scope. Contractor shall consider 11KV/3.45KV, 11KV/0.433KV or 3.3 KV/0.433KV transformers for downstream distribution. The supply system shall be designed for maximum power requirement of the plant.

5.1.4 In the event of failure of normal power in the plant, the plant shall be brought to safe shut down condition through Emergency power. Emergency power shall cater to the load of emergency lighting, UPS system, battery charger, motorized valves, Fire alarm system, PA & Paging system etc. in addition to the process loads for safe shutdown of the Plant and wherever required as per detail design.

5.1.5 The Emergency power shall be arranged by the LSTK contractor through one number suitably rated DG Set. The capacity of DG Set shall be finalized by the LSTK contractor to meet the emergency power requirement of new AN Melt Plant and internal consumption of the DG Set keeping a margin of 25% over the actual requirement. **Bidder shall indicate the DG Set ratings in their bid.**

DG Set and its Auxiliary Service Distribution Board / MCC shall be housed inside a building with RCC roof.

DG Sets & Diesel tanks shall be located at centralized place at a minimum safe distance from substations as per relevant IS/IEC of hazardous area classification. Emergency power shall also cater to the load of emergency lighting, AC UPS system, DC battery charger, HVAC for control room etc.

Further distribution to all emergency equipments at 415V/240V AC through proper type and size of cables, their supply, erection, testing & commissioning etc. shall also be in contractor's scope.

5.1.6 The electrical system layout and interconnections (power as well as control) shall be such that the problem in electrical system of one plant should not affect the electrical system of other plant and vice versa.

5.1.7 The insulation system of cable, 11 KV & 3.3 KV equipments shall be based on unearthed system only.

5.1.8 Each incoming feeder shall be sized for 125% load of the switch board. The outgoing feeders shall be sized for the nominal load.

5.1.9 Primary connections of transformers shall be provided with cables of suitable size and secondary connections shall be through cables/bus duct.

5.1.10 The entry of cables in the switchboards shall be from bottom only.

5.1.11 All switchboards shall be provided with minimum two incoming feeders and one bus tie having auto/manual changeover facility.

5.1.12 Momentary paralleling of the system shall be possible for changeover without supply interruption in 3.3kV/11kV/415V panels.

5.1.13 The normal operation of the 11 KV, 3.3 KV Switchgears, Power Control Centre (PCC) and Motor Control Centre (MCC) shall be as under:

i) Bus coupler shall be provided between all the sources. Incomer and bus coupler breaker rating shall be same for all the switchboards. 11 KV, 3.3kV switchboard outgoings breaker rating shall be same considering provision of inter-changeability.

ii) Each incoming feeder shall independently feed the loads on respective buses with full rated bus tie breaker open and the load on each bus balanced. In order to ensure maximum degree of reliability and continuity, automatic transfer from one incoming feeder to other shall be possible through auto/manual closing of bus tie breaker in case of sustained loss of power on any bus section.

iii) The bus tie breaker shall be provided with auto/manual selection. The bus tie breaker shall be independent in manual mode. In auto selection mode, the bus tie breaker is electrically interlocked with incoming circuit breakers, so that it cannot be closed unless one of the incoming breakers is open.

iv) When one of the incoming feeder trips, the bus tie breaker is closed automatically based on the philosophy described below and the total load is transferred to other healthy incoming feeder which is capable of carrying the entire load. Sufficient switchgear capacity is to be provided. Time for changeover is suitably selected based on downstream system requirement of reacceleration of motors etc.

v) No under voltage tripping to be provided to incomer/buscoupler or power feeder breakers. Auto changeover provision to be made provided with bypass selection.

vi) Momentary Paralleling of the breaker to be made possible with auto changeover facility to trip the desired breaker without interruption of power. All the panel, transformer and other switchboard to be designed as per this requirement

vii) Tripping of incomer breakers shall be prevented in case of loss of power of both the incomers.

5.1.14 HV/LV emergency board shall have 2 nos. normal power incomer and 1 no. emergency power incomer and 2 bus couplers.

5.1.15 EPMCC shall have 3 incomers (2 nos. normal power incomers & 1 no. emergency incomer from DG Set) and 2 bus couplers for feeding critical load of plant whereas PMCC & MCC shall have 2 nos. normal power incomers. DC Battery Charger, UPS System etc. shall be fed from EPMCC. PMCC shall fed breaker controlled feeders and various power feeders whereas MCC shall fed contactor controlled load and various power feeders. PMCC and MCC shall be separate.

MCC's should have redundant control supply, out of which single supply from one source will run throughout the panel with auto changeover contactor for the same in case of supply failure from any of the incomer feeder.

5.1.16 DC Battery Charger, AC UPS and HVAC for control room shall be fed from emergency switchboard.

5.1.17 ASPB shall have two incomers from both the feeders with buscoupler arrangement to enable the shifting of load without interruption. Breaker need not be supplied. Suitable rated SFU will suffice the job of incomer as well as buscoupler.

5.1.18 For the use of the owner during plant shut down period, each area shall be provided with feeder pillar suitable for outdoor installation, which shall be located away from hazardous area. The feeder pillar shall be fed from the 415 V switchboard (PMCC) of the nearby substation. Each feeder pillar shall comprise of 1 No. 630 A TPN Switch incomer, 2 Nos. of 250 A TPN switch-fuse outgoing feeders, 2 Nos. 125 A TPN switch-fuse outgoing feeders and 4 Nos. 63 A TPN switch-fuse outgoing feeders. Other construction details shall be as per specification of sheet steel distribution board (TS: 8080).

5.2 **Instrumentation Power**

5.2.1 The power supply for instrument shall be made available at 115V, 1Ph from UPS system.

5.2.2 Provision for 240V, 1 Ph power for lighting of instrument panels shall be provided from LSDB.

5.3 **Lighting Distribution**

5.3.1 In each substation a Main Lighting Distribution Board (MLDB) shall be provided. The MLDB shall consist of two bus sections, namely Normal and Emergency. The normal lighting bus shall receive power from non-essential bus of ASPB and emergency lighting bus from essential bus of ASPB through 415/433 V lighting transformers of suitable rating. However, in the areas where ASPB is not envisaged, the Lighting Distribution Boards shall receive power from PCC/MCC through 415/433 V lighting transformers of suitable rating. One-third lighting load shall be connected to the emergency power to provide certain light during failure of normal power. **Contractor to provide the lighting load (Normal + Emergency) of entire complex (New AN Melt Plant).**

5.3.2 Both normal and emergency section of MLDB shall have separate sections of bus bars for indoor and outdoor lighting. Outdoor bus sections shall be connected by means of suitably rated contactor operated through photo-cells/clock timer. Timer shall be manually adjustable to adjust the timing as required. If photocell is provided the lux level on which the lighting will start shall be adjustable.

5.3.3 Manual by-pass circuit for outdoor lighting shall be wired up to a switch located in electrical control room/shift office, so that outdoor lighting can be switched ON or OFF manually to override the automatic switching.

5.3.4 All outdoor lighting fixtures including aviation lights and outside lighting of Sub-Stations, Offices, Control Rooms etc., shall receive power from outdoor lighting bus.

5.3.5 Main Lighting Board shall feed Lighting Sub Distribution Board having 63A TPN MCB as incomer and 16 Amp as SPN MCB and RCCB as outgoing. 6, 9, 12 or 18 way Lighting Sub Distribution Board shall be used.

5.3.6 Both the lighting transformers feeding MLDB and their respective circuit breakers shall have same rating. Both the lighting transformers shall be designed for 100% load of MLDB.

5.4 **DC Power**

5.4.1 110 V DC system shall be provided for control of circuit breaker feeders and panic lighting.

5.4.2 It shall be obtained from Ni-Cd batteries to be located in a separate room in the Sub-Station. Separate Battery Charger shall be provided in each substation.

Separate dedicated Battery and Battery Charger shall be provided for DG Set.

5.4.3 The battery shall be provided with SCR controlled automatic rectifier-cum-chargers and shall consist of load-cum-float-cum-boost charger and stand by unit for these.

5.4.4 Each rectifier-cum-charger shall have independent power supply to be fed from the emergency source.

5.4.5 DCDB shall have 2 incomer for redundancy from individual battery charger for connection and provision of B/C to extend the supply.

5.4.6 The DC power requirement of UPS system shall be obtained from separate battery banks and charger dedicated to UPS.

6.0 SUB-STATION

6.1 The Sub-Stations shall be located near the load centres but away from hazardous areas as per IS/IEC. The substations shall also be provided with toilet with wash room facility. Tentative sizes of the substations marked on plot plan indicate minimum dimensions required. However, actual size of substations shall be based on the final dimensions of substation equipment. If more space is required during detail engineering the contractor may increase the size as per the actual requirement.

6.2 The sub-station building shall have double storey construction. The ground floor shall have cable gallery and first floor shall have all switchboards, control panels etc. The switch room shall have Kota stone flooring. False ceiling shall be provided in VFD room, staff room & Engineers room.

6.3 The cable gallery shall have a minimum clear height of 3.0 M and shall house all cable trays and their supports. Also minimum elevation of bottom most cable tray shall not be less than 1.5 meter to allow access for man movement.

6.4 Transformer floor shall be at least 300 mm above the finished floor level of cable cellar room.

6.5 Substation shall have three fold door of adequate size at one side for equipment shifting (no rolling shutter is to be provided).

6.6 Sub-station wall adjacent to the transformer/capacitor bays and walls separating transformers/capacitors shall be 355 mm thick (inclusive of plastering) in case of brick construction or 240 mm thick in case of RCC construction. RCC roof slab shall be provided for Transformer, Series Reactor, Capacitor Bank and Cathodic Protection Equipments.

6.7 Sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization.

6.8 The layout of equipment shall be such that it shall have adequate space for installation, operation, maintenance and future expansion.

The clearance of equipment from the walls/other equipment shall be adequate to ensure safety of working personnel. Generally the following norms shall be maintained:

i. 11KV Switch Boards / 3.3KV Switch Boards / PCC / PMCC:

a) A clear space of 1.25M behind the deepest panel.

b) A clear space of 3M between the two boards facing each other.

c) A clear space of 2.5M on either side at entrance / exit.

d) A clear space of 1.5M between two boards in same line.

ii. MCC / Distribution Boards:

a) A clear space of 1.5M behind the double front switchboards and 1M for single front.

b) A clear space of 2.5M between the two boards facing each other.

c) A clear space of 2.5M on either side at entrance/exit.

d) A clear space of 1.5M between two boards in same line.

6.9 The substation shall be provided with pressurisation and ventilation system with air filter and water washer arrangement such that final temperature and humidity of the switchgear room shall not be more than 35 degree Celsius and 65 percent respectively. Air pressure inside the switchgear room shall be slightly more than the outside pressure (i.e. equivalent to 3 mm of water column above the atmospheric pressure). Pressurisation and ventilation system shall be located at ground floor.

6.10 The sub-station shall have double storey construction. The ground floor shall have cable gallery and first floor shall have all switchboards, control panels etc. The switch room shall have Kota stone flooring. False ceiling and air conditioning shall be provided in VFD room, Engineers room and Staff room.

6.11 The battery room shall form a part of the sub-station. Battery room shall be provided with minimum two exhaust fans and louvered opening in opposite wall/door. A sink with water tap shall be provided with water connection. Floor of the battery room and walls up to 2.0 M height shall have acid resistant protective epoxy coating. Light fittings, exhaust fan, on/off switches etc. in this room shall be chemical resistant type and flame proof type.

6.12 All doors and windows shall have anodised aluminium frame and provided with toughened glass.

6.13 Staircases and other rooms shall be paved with Kota stone.

6.14 Continuous fixed type glass ventilators on all sides shall be provided near the ceiling height for natural lighting.

6.15 Arrangement shall be provided for lifting heavy equipment to be brought into the sub-station.

6.16 Sufficient nos. of entrances (min. 2) shall be provided for each floor.

6.17 The sub-station shall house all the electrical power, control and monitoring equipment except those required for operation in the field. The equipment shall broadly include the following:-

- Step down Transformers, Capacitor Banks each located in separate chamber outside the substation.
- High Voltage Switch Boards
- Power Control Centres
- Power cum Motor Control Centres
- Motor Control Centres
- Auxiliary Service Panel Boards
- Lighting Transformer (Indoor / Outdoor as per requirement)

- Lighting Distribution Boards
- Battery Sets
- Rectifier-Cum-Battery Charger
- DC Distribution Boards
- Neutral Earthing Resistors (Indoor / Outdoor as per requirement)
- Input / Output Panels
- VFD System
- Any other equipment required

6.18 All static devices such as Rectifier-Cum-Battery Chargers, Variable Speed Drive Panels etc., shall be housed in air conditioned room. Heat load for panel to be taken by panel manufacturer.

6.19 Separation walls between transformers/capacitor banks in all substations.

6.20 Transformers shall be located in bays adjacent to the sub-station building. All bays shall have well drained floor, surfaced with gravel or other suitable material.

6.21 In order to prevent leaking oil from reaching and polluting the water bearing stratum, transformers shall have the following provisions:

For more than one transformer located in row, each individually having less than 2000 litres of oil volume but collectively more than 2000 litres of oil volume shall be provided with oil soak pit. A typical arrangement of oil soak pit is as shown in Drg. No. PDS: E113 & PDS: E116.

Transformers having individually more than 2000 litres of oil capacity shall be provided with oil sump pit. A typical arrangement is as shown in Drg. No. PDS: E114 & PDS: E116.

Even if one transformer is having more than 2000 litres of oil capacity among the group of transformers located in a row, for uniformity all transformer rooms shall have sump pit similar to the one shown in Drg No. PDS: E114 and a separate sump pit as shown in Drg. No. PDS: E116.

Capacity of the common oil sump pit shall be sufficient to contain the entire oil content of the biggest transformer. A typical arrangement is as shown in Drg. No. PDS: E116.

6.22 Transformer above 10MVA or having oil more than 2000 litres shall be provided with high velocity water sprinkler system to meet the CEA norms.

6.23 Transformers installed adjacent to sub-station shall be provided with a layer of pebbles of about 40 mm granulation as per Drg. No. PDS: E 113 & PDS: E 114.

6.24 The front of the transformer rooms shall be open type having expanded metal door with wicket gate. A typical arrangement is as shown in Drg. No. PDS: E115.

6.25 In front of transformer rooms, 1 mtr. wide continuous platform shall be kept or suitable ramp shall be provided.

6.26 In all substations/MCC rooms, space for future extension of switchboards shall be provided. One panel extension space on each side (for each bus section) or two panel extension space on one side (in exceptional cases) shall be provided for all HV Switchboards, PMCCs, PCCs, MCCs and ASPBs. In addition, space for future extension of the substation/MCC room building shall be considered.

6.27 Fire protection for transformers, switchgear room & cable cellar shall be provided to comply with requirements of Indian Standard.

Substations shall be provided with smoke detectors and fire alarm system as specified elsewhere in the ITB and as per relevant Indian Standard.

6.28 Fire barriers shall be provided at cable entry/exit point. Cables shall have fire protection paint for 1 m length at building entry points for above ground cables.

7.0 PROTECTION & METERING

7.1 Selection and co-ordination of protection and metering system shall be such as to ensure:

- Selective, sensitive and reliable protection of equipment against damage due to internal or external faults or atmospheric discharge.
- Isolation of fault in the shortest possible time.
- Simplicity of the scheme with maximum protection.
- Uninterrupted operation of healthy system.
- Personnel & plant safety.

7.2 Protective relays shall be of latest version, microprocessor based numerical type with communication port. 100% redundancy shall be provided for communication. Numerical Relay shall have communication on IEC-61850 protocol in redundant mode and meters shall have communication on MODBUS protocol.

7.3 Numerical relay shall have future provision for connecting with substation HMI. Separate multifunction meter with communication shall be used and shall not be part of protective device.

7.4 Relays shall support features like remote relay parameterization, disturbance recorder etc. It shall be possible to set/operate the relay from the front facia. Lock out relay shall be conventional type with hand reset facility.

7.5 Special protection if required for any feeder such as differential, restricted earth fault, directional distance power relays etc. shall also be through numerical relay having serial port for monitoring.

7.6 Trip circuit supervision relay shall be VAX-31 and Lock out relay shall be VAJHM.

7.7 In general, fast acting relays (with time delays if required) shall be used and all fault tripping shall be done through high speed tripping relays.

7.8 Bare minimum protection for power distribution system shall be as indicated below. However, LSTK contractor shall provide any other necessary protection required for complete protection of system:

Type of Protection	**Transformer Feeder (Primary Side)**		**Motor Feeder**	**Outgoing Feeder**		**Incomer**	
	(With Secondary winding 3.3 KV)	(With Secondary winding 0.433 KV)	HT	HT	LT PCC/ PMCC	HT	LT PCC/ PMCC
51 - IDMTL over-current	Yes	Yes	-	Yes	Yes	Yes	Yes
51N - IDMTL earth-fault	No	No	-	Yes	Yes	Yes	Yes
51G - backup E/F (secondary neutral)	Yes	Yes	-	No	No	No	No
Motor protection with locked rotor feature 50, 50N, 46, 49, 50L/R etc.	No	No	Yes	No	Yes (5)	No	No
64R - instantaneous restricted earth-fault (secondary side)	Yes	Yes	-	No	No	Yes (17)	Yes (17)
50 - instantaneous over-current	Yes	Yes	-	No	No	No	No
50N - instantaneous earth-fault	Yes	Yes	-	No	No	No	No
87 - differential protection	Yes (1)	No	Yes (2)	No	No	Yes	No
86 - tripping	Yes	Yes	Yes (10)	Yes	Yes (10)	Yes	Yes
95 - trip circuit supervision	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Type of Protection	Transformer Feeder (Primary Side)		Motor Feeder	Outgoing Feeder		Incomer	
	(With Secondary winding 3.3 KV)	(With Secondary winding 0.433 KV)	HT	HT	LT PCC/ PMCC	HT	LT PCC/ PMCC
63 - Auxiliary Relay including pressure release device (Transformer)	Yes (16)	Yes (16)	-	No	No	No	No
27, 2- under-voltage with timer	-	-	Yes (8)	-	-	Yes (3)	Yes (3)
25 - check synchronisation relay	-	-	-	-	-	Yes (6)	Yes (6)

Notes :-

1. For transformers rated 10 MVA and above including primary & secondary bus duct/cables also.
2. For motors rated 2000 KW and above.
3. For switchgears where auto transfer feature is provided.
4. Directional IDMTL earth fault 67 N shall be provided for transformer with star primary.
5. For motor feeders rated 75 KW and above.
6. For switchgears having bus transfer scheme. Where continuous or momentary paralleling is envisaged. Check synchronising relay shall be integrated with overall paralleling scheme.
7. The bus tie feeder in switchboards shall be provided with 51, 51N, 86 and 95 relays.
8. HT breaker controlled motor feeders with DC control supply. U/V tripping of motors in 3.3 KV system shall be based on critical/non-critical selection (0.5/5 sec).
9. One no. DC supply supervision relay (80) shall be provided for each incoming DC supply to the switchboard with audio/visual annunciation.
10. Two sets of 86 relays shall be considered for each HT motor feeder. One for electrical tripping and other for process tripping. 86 relay for process trip shall be of self reset type with flag.
11. Pilot wire protection (85) shall be provided for inter substation incomer cables.
12. PT fuse failure relays in HT/LT panels and busbar differential supervision relay (VTX31) shall be provided.

13. Value of stabilising resistor for differential relay (CAG 14) to be selected suitably based on fault level.
14. The breaker contacts for critical logic (upstream/downstream tripping, changeover etc.) shall be provided directly from breaker auxiliary contacts and not from auxiliary contactors.
15. Memory/History of the Numerical relay shall not get erased due to loss of auxiliary supply of the relay. Preferably similar make of relays to be installed in one particular substation.
16. Transformer auxiliary protection: Buchholz, OT, WT, MOG, OLTC alarm/trips to be provided.
17. For transformer secondary side.

7.9 Metering instruments shall be provided to keep record of power consumption and supervision of all concerned parameters like current, voltage, power (Active, Apparent and Reactive), frequency, power factor, Energy (Active & Reactive) etc. All the instruments shall be flush mounted. All meters shall be digital multifunctional meters with communication port. Additionally analogue type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated below:

Feeder Type	A	V	Hour Run	Digital Multifunctional Meter
HT Incomer	✓	✓	-	✓
HT Bus Tie	✓	-	-	-
HT Transformer	✓	✓	-	✓
HT Bus P.T.	-	✓	-	-
HT Plant Feeder	✓	✓	-	✓
HT Motor	✓	-	✓	✓
HT PFIC	✓	-	-	✓
PCC/MCC Incomer	✓	✓	-	✓
PCC/MCC Bus Tie	✓	-	-	✓
PCC Bus P.T.	-	✓	-	-
ACB Outgoing	✓	✓	-	✓
LT Motor (ACB Controlled)	✓	-	✓	✓
MCC/ASB Incomer	✓	✓	-	✓
MCCB/SFU Outgoing (≥ 250 A)	✓	-	-	-
LDB Incomer	✓	✓	-	✓

Energy management system shall be provided which will calculate the energy consumption and motor running hours of all the equipments and provide daily and monthly/yearly energy consumption enabling use of the data in ISO-50001 energy audit.

8.0 CONTROL AND MONITORING

The following provision shall be made for control and monitoring of following electrical equipments.

8.1 Transformers

- TNC switch in primary & secondary side of switchgear.
- Emergency trip from secondary side for tripping primary side of transformer.
- ICOG VCB panel shall be provided on transformer primary side (only where primary side circuit breaker is not located in the same sub-station).
- Lockable 'OFF' push button in transformer room to trip sending end switchgear.
- Indication lamp for 'ON' 'OFF' 'Auto-trip, 'Non-trip' and 'Trip Circuit Healthy'.
- Ammeter and voltmeter on both primary and secondary side.

8.2 Motors Controlled Through Circuit Breakers

- Ammeter in LCS and in switchgear.
- Current monitoring at DCS, where required from process point of view.
- Indication Lamps in switchgear for 'ON', 'OFF', 'Auto-trip' and 'Trip Circuit Healthy'.
- Emergency trip in switchgear.
- Winding and bearing temperatures of motors shall be available at DCS in control room.
- Process interlock in CCR, where required.
- Motor Space Heater Ammeter
- TNC switch, L/R switch, Indication lamp for ON, OFF, Trip, Space Heater ON, Motor Ready to Start shall be provided on LCS.
- Motor feeder shall have test/run switch to bypass the process interlock for testing of motor.

8.3 Medium Voltage Motors Controlled Through Contactors

- Ammeter in LCS for motors of 5.5 KW and above or as required from process point of view.
- Current monitoring of all the motors shall be provided in DCS.
- Emergency Trip in PCC/MCC.
- Process interlock in CCR, where required.
- Indication lamp for 'ON', 'OFF' and 'Fault' in switchgear.
- Indication lamp for 'ON', 'OFF' in remote (DCS/PLC etc.)

- Start PB, Stop PB, L/R switch, Indication lamp for ON, OFF, Space Heater ON (motor rated 30KW & above), Motor Ready to Start (for all critical motors) shall be provided on LCS.
- Motor feeder shall have test/run switch to bypass the process interlock for testing of motor.

9.0 EQUIPMENT SPECIFICATION

9.1 General Constructional Features

9.1.1 The equipment shall be suitable for tropical climate conditions and corrosive and saline atmosphere.

9.1.2 The equipment to be installed in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP 54 as per relevant Indian Standards/IEC.

9.1.3 The equipment to be installed in outdoor plant area shall have IP 55 enclosure.

9.1.4 All external hardwares of shall be of stainless steel.

9.1.5 All electrical equipment installed outdoor shall be provided with rain protection hood / canopy (2 mm thick aluminium sheet bent to shape). PA stations shall have acoustic hood.

9.1.6 The switch boards, to be installed inside the building shall have enclosure IP 4X for HV switchgear, for LV switchgear degree of protection shall be IP 52 up to 1600A rating and IP-4X above 1600A rating. Equipment requiring ventilation opening such as battery charger/UPS etc. located in air conditioning room may have IP 43 enclosure however, opening for the ventilation shall be covered with fine wire mesh.

9.1.7 Creepage distance shall be 31mm/kV (for highest system voltage) for all equipment.

9.1.8 The equipments to be located in hazardous areas shall be suitable for hazard involved and shall have the following additional explosion protection:

Equipment		Zone-1	Zone-2
i)	Motors	Exd	HV motor - Exd LV motors - Exe
ii)	Starter panels	Exd	Exd
iii)	Control panels	Exd/Exp	Exd
iv)	Local Control Stations	Exd	Exd
v)	Lighting fixtures, hand lamps	Exd	Exe/Exd
vi)	Switch sockets	Exd	Exd
vii)	Switches/Isolators	Exd	Exd
viii)	Junction Boxes	Exd	Exd
ix)	Exhaust Fan	Exd	Exd

Equipment		Zone-1	Zone-2
x)	Other equipments producing sparks under normal operation	Exd/Exp	Exd
xi)	Other equipments not producing sparks	Exd/Exp	Exn/Exe

9.1.9 Motors for hazardous area application, when fed from VFD shall have enclosure protection flameproof Ex'd' irrespective of area classification.

9.1.10 All electrical equipment installed inside a compressor shed where hydrogen is being processed/handled shall be flameproof type suitable for gas group-IIC irrespective of gas group (IIA/IIB/IIC) and area being classified as Zone-1 or Zone-2.

9.1.11 All electrical equipment installed for an analyser room shall be flameproof type suitable for gas group-IIA, IIB, IIC irrespective of the area being classified as Zone-1 or Zone-2.

9.1.12 Vibration of all equipments shall be as per ISO 10816/3.

9.1.13 All the electrical equipment shall be provided with stainless steel heavy duty double compression industrial type cable glands and copper crimping lugs for the cable terminations.

9.1.14 The outside surface of all equipment shall be painted after suitable pre-treatment by the application of two coats of anti-rust and corrosion resisting epoxy based paints.

9.1.15 Paint shade of all the electrical equipments shall be RAL 7035.

9.1.16 DFT (Dry film thickness) test shall be done for all the panels, transformer etc. before supply of the same.

9.2 **DG Set**

9.2.1 The Emergency power shall be arranged by the LSTK contractor through one number suitably rated DG Set. The capacity of DG Set shall be finalized by the LSTK contractor to meet the emergency power requirement of new AN Melt Plant and internal consumption of the DG Set keeping a margin of 25% over the actual requirement.

9.2.2 The starting of engine of DG Sets shall be electric type. System should be capable of minimum 3 starts.

9.2.3 DG Set shall be of continuous duty.

9.2.4 DG Set shall be suitable for Black start.

9.2.5 The DG Set control shall have PLC based latest state of art technology. Brushless excitation system shall be used in generator.

9.2.6 DG Set shall have all its auxiliaries installed and controlled from same place. The control of DG Set shall be based on 110 V DC which shall be supplied from the DC panel. Separate DC battery bank with battery charger shall be provided.

9.2.7 The auto starting time (time between actuation of loss of power contact to availability of emergency power) in case of failure of main power shall be in accordance with the requirement of process parameters. The DG power shall be made available in such a time that any plant is not affected due to failure of normal power.

9.2.8 The auxiliary power supply board / MCC to feed the auxiliaries of DG Sets shall have dual power supply, one from the normal power supply source of plant and other from the DG Set itself. There shall be a provision of auto changeover in the incoming supply of auxiliary power supply board of DG Set. The emergency power distribution board shall be kept in a separate room near to engine room of DG Set. The incomer and larger rated feeders shall be provided with air circuit breaker. A comprehensive electrical protection system shall be provided to protect the generator as well as individual feeder. The incomer shall have a KWH meter along with ammeter, voltmeter etc.

9.2.9 There shall be a separate control panel to control the auxiliaries, and comprehensive alarm and fault indication system shall be provided to indicate the status of auxiliaries as well as Diesel Generator Set.

9.2.10 The quick start auto-mains failure DG Set of adequate rating shall be compressed air started and radiator cooled type suitable for supplying emergency load.

9.2.11 DG Set shall be supplied with day oil storage tank (12 hr. capacity at full load continuous operation), bulk oil storage tank, associated piping, valves, accessories, earthing of all equipments, all power and control cables as required.

9.2.12 The bidder shall also include relevant spares as recommended by the manufacturer for two years trouble free operation of DG Set.

9.2.13 DG set to meet the national clean air programme norms as applicable to the relevant city.

9.2.14 DG Set shall be provided with suitable acoustic enclosure to restrict the noise level to 85 dB at 1 metre.

9.2.15 DG Set shall be suitable for starting of the largest emergency motor.

9.2.16 DG Set shall be provided with digital multifunctional meter with communication port for energy management at remote location. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately.

9.2.17 Bare minimum protection devices for DG Set have been as indicated below, however LSTK contractor shall provide any other necessary protection relays required for

complete protection of system.

Differential, Stator Earth Fault, Rotor Earth Fault, Phase Unbalance, Field Failure, Over Current (Voltage Restrained), Over Voltage, Winding Temp. Alarm, Bearing Temp. Alarm, Under Frequency, Over Frequency, Reverse Power. A microprocessor based composite generator management relay shall be used for the above mentioned protections. Provision for Winding Temperature Alarm and Trip, Bearing Temperature Alarm and Trip shall also be there.

9.2.18 For all other specification refer TS-8211.

9.3 **Power Transformers**

9.3.1 The transformers shall be double wound, copper conductor, dyn11 type. Transformers shall have 11 KV and 3.3 KV primary windings. Transformer with 3.3 KV primary winding shall be considered for that substation only, where 3.3 KV switchboard is to be installed for feeding 3.3 KV motors.

9.3.2 The rating of power transformers shall be selected on the basis of load and future load growth. For future load growth the following provision shall be made:-

- 25% spare capacity in HV transformers

- 30% spare capacity in LV transformers

9.3.3 The transformers shall have 'OFF' load tap changers. Further, to compensate for the voltage regulation, the no load voltage of the secondary side shall be kept as per IS.

9.3.4 Special consideration shall be given in specifying the percentage impedance of the transformers to suit the switchgear short-circuit capacity available.

9.3.5 Transformers generally up to 10 MVA shall have ONAN cooling, while ratings above 10 MVA shall be ONAN/ONAF cooled.

Bare minimum protection devices for transformer have been as indicated below, however LSTK contractor shall provide any other necessary protection relays required for complete protection of system.

Primary Side

IDMTL Over Current, IDMTL Earth Fault, High Set Over Current, Instantaneous Earth Fault, Differential (for sizes of 10 MVA and above), *Buchholz Alarm and Trip,*Winding Temperature Alarm, *Oil Temperature Alarm, *Oil Level Alarm, *Trip for Winding Temperature and Oil Temperature.

Items marked with asterisk (*) shall be provided on secondary side, if the primary side circuit breaker is located in other sub-station.

Inter-tripping of primary and secondary circuit breaker of transformer shall be provided for all faults through lockout relays.

9.3.6 For all other specification refer TS-8043.

9.4 **Neutral Earthing Resistor (NER):**

9.4.1 The NER shall be provided to earth the neutral of 11 KV and 3.3 KV systems. Neutral of 415V supply system shall be solidly earthed.

9.4.2 Neutral earthing resistor shall be made of AISI 304/406 stainless steel. The earth fault current of 11 KV & 3.3 KV shall be limited to full load current of transformer or 400 A, whichever is less.

9.4.3 All NER not requiring operation shall be provided with isolator.

9.4.4 For all other specification refer TS-8044.

9.5 **Switchboards**

9.5.1 **General**

9.5.1.1 There shall be three positions for Breaker/Contactor trolley: - Service, Test and Isolate. In service position, the power connections shall be made; but in test and isolate mode, the power connection of bus bars shall be automatically removed.

9.5.1.2 ACB feeder for PCC, PMCC & MCC shall be single front for ease of operation & maintenance. Non-ACB feeders for motors or power may be double front type.

9.5.1.3 Breaker duty cycle shall be O-0.3sec-CO-3min-CO for HV Switchboards.

9.5.1.4 Separate CT shall be provided for differential/REF protection.

9.5.1.5 LV circuit breaker shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole type.

9.5.1.6 Suitable shutter arrangement shall be provided to protect the person from accidental contact with live bus in trolley chamber.

9.5.1.7 The degree of protection shall be IP 4X for HV switchboards and Degree of protection shall be IP-52 for LV switchboards up to 1600A rating and IP-4X for LV switchboards above 1600A rating.

9.5.1.8 All Switchboards shall be LOTO compliance.

9.5.1.9 All switchboards shall be suitable for closed door operation.

9.5.1.10 HV Switchboards shall conforms to IS/IEC 62271-200, IAC-A FLR-40KA 1 Sec., PM, LSC 2B which means that the switchgear panels shall be four side internal arc tested, shall have metal partitions and shall confirm to loss of service continuity.

9.5.1.11 LV switchboard shall conform to IEC 60947. LV switchboard shall be TOTAL TYPE TESTED (TTA) design as per IEC 61439-1/2. Type Test Certificates for short circuit withstand of 50kA for 1 sec. along with ACB mounted in the switchboards shall be provided.

9.5.1.12 LV switchboards shall comply with Internal Arc Containment test as per IEC 61641.

9.5.1.13 Bus bars shall be made of high conductivity aluminium alloy and shall be provided with heat shrinkable Raychem sleeves.

9.5.1.14 FRP supports shall be used for bus bars with adequate clearances and creepage distance to prevent flash over due to effect of dust moisture.

9.5.1.15 Protective relays shall be mounted on the front of the switchgear panel.

9.5.1.16 Protective relays for incoming feeders, bus ties, outgoing feeders and motor feeders shall be microprocessor based numerical type with communication facility.

9.5.1.17 All meters shall be digital multifunctional meters with communication port. Additionally analogue type ammeter, voltmeter and hour meter shall be provided separately for various feeders as indicated under clause No. 7.9 above.

9.5.1.18 The motor feeders controlled through vacuum circuit breakers shall be provided with surge arrestors.

9.5.1.19 A continuous ground bus shall be provided at the bottom of the switchgear and in cable connection side for grounding the switchgear, breaker trolley as well as to ground the cable glands.

9.5.1.20 Doors of each MCC/PMCC/HV/LV board shall be properly earthed.

9.5.1.21 The minimum thickness of sheet steel used in HV and LV switchgear including charger, UPS, ASPB etc. shall be as under:-

a) Base Channel minimum 3.0 mm
b) Load Bearing Members minimum 2.0 mm
c) Doors and covers minimum 1.6 mm

9.5.1.22 The switch boards shall have adequate short-circuit ratings and be suitably sized for the load and spare capacity foreseen. The short time rating of busbar shall be 3 seconds for HV switch boards and 1 second for other boards.

9.5.1.23 HV switchboards shall have sufficient no. of spare outgoing feeders to the extent of min. one no. for each type & rating.

9.5.1.24 LV switchboards shall have sufficient no. of spare outgoing feeders to the extent of min. 20% for each type & rating rounded off to next higher digit.

9.5.1.25 The switch boards shall have PVC insulated busbar system suitable for rated voltage. At joints of these busbars removable shrouds shall be provided.

9.5.1.26 All switch boards shall generally have two sections operating independently with two 100% rated incoming feeders and with bus coupler open having facility for changeover in the event of failure of either of the incoming circuit breakers.

9.5.1.27 No common alarm circuit (except hooter/bell) in bus coupler feeders as each feeder will have its own microprocessor based annunciator.

9.5.1.28 No under voltage tripping to be provided to incomer/buscoupler or power feeder breakers. auto changeover provision to be made provided with bypass selection.

9.5.1.29 Momentary Paralleling of the breaker to be made possible with auto changeover facility to trip the desired breaker without interruption of power. All the panel, transformer and other switchboard to be designed as per this requirement

9.5.1.30 Auto changeover shall also be provided on switchboards catering to emergency loads.

9.5.1.31 Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply.

9.5.1.32 Every enclosure door that provides access to live parts operating at 240 V AC and above shall be mechanically interlocked with a circuit interrupting device on the supply side such that when the door is open, the equipment is de-energised.

9.5.1.33 Control supply for motor feeders having switch-fuse units in PMCC/MCC and VFD panels etc., shall be taken from panel itself and motor controlled with breaker shall have 110 V DC control supply irrespective of its being HT or LT.

9.5.1.34 For motors with auto-starting provision, trip of a running motor will start standby motor automatically. To be provided for critical motor applications along with the interlock provision for suction valve open/discharge valve open and suction pressure etc. to avoid damage to pump and motor due to dry running.

9.5.1.35 All the HT/LT switchgear shall be fed through two separate transformers, each transformer having capability to take care of 100% load of the associated switchgear and shall have the facility of auto changeover in case of failure of one transformer as well as option of manual changeover for maintenance purpose. Transformer to be designed for momentary paralleling.

9.5.1.36 Cross ferruling shall be considered.

9.5.1.37 All cable glands shall be of Stainless Steel. Aluminium cable glands shall not be used.

9.5.1.38 All lugs shall be of Copper. Aluminium cable lugs shall not be used. Hydraulic crimping tool shall be used for crimping the lugs.

9.5.1.39 Bimetallic washer of suitable size shall be used where Aluminium and copper terminations are to be done.

9.5.1.40 Switchboard panels width shall not be less than 800mm.

9.5.1.41 Finishing shade of all panels shall be RAL 7035.

9.5.1.42 Paining of the panel shall be done through 7 tank process or as per applicable IS/IEC standards.

9.5.1.43 For all other specifications, refer TS-8060, TS-8061, TS-8080 and TS-8083. Schematic diagram {Drg. Nos. PDS-1201 (Sh. 1 to 19) and PDS-1202 (Sh. 1 to 16)} shall also be referred as general guideline for designing the control schemes for various types of feeders.

9.5.2 **11 KV Switch Board**

9.5.2.1 The 11 KV switchboard shall be indoor, metal enclosed, drawout type, equipped with VCB's, stored energy mechanism working on 110 V DC and shall feed power to the various substations through transformers and other outgoing feeders.

9.5.2.2 Degree of protection shall be IP4X. Switchgear sizes and configuration shall be rationalised to minimum spare holding.

9.5.2.3 Vacuum circuit breakers shall be used for incoming feeders, bus couplers and outgoing feeders.

9.5.2.4 A study shall be conducted by LSTK contractor to determine the rated short circuit capacity for the selection of equipment. However, rated short circuit breaking capacity shall be as determined by the study or 40 KA for 3 sec, whichever is higher.

9.5.2.5 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy indications.

9.5.3 **3.3 KV Switch Board**

9.5.3.1 The 3.3 KV switchboard shall be indoor, metal enclosed, drawout type, equipped with Vacuum Circuit Breakers (VCB) for all feeders.

9.5.3.2 The minimum degree of protection shall be IP4X to IS 3427/IEC 60298. Switchgear sizes and configuration shall be rationalised to minimum spare holding.

9.5.3.3 For incomers and bus tie vacuum circuit breakers shall be used.

9.5.3.4 A study shall be conducted LSTK contractor to determine the rated short circuit capacity for the selection of equipment. However, rated short circuit breaking capacity shall be as determined by the study or 26.24kA for 3 sec, whichever is higher.

9.5.3.5 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy indications

9.5.3.6 Control supply shall be 110 V DC.

9.5.3.7 No under voltage tripping shall be provided to any incoming/transformer/outgoing feeder.

9.5.3.8 Line PT with voltmeter shall be provided 3.3kV incomer to ensure availability of incoming supply. Bypass arrangement for synchrocheck shall be provided.

9.5.3.9 Automatic racking rack out system for HT breaker to be envisaged.

9.5.4 **Low Voltage Switchgears**

9.5.4.1 415 V switchboards shall include the following:

a) Power Control Centres (PCCs)

b) Power-cum-Motor Control Centres (PMCCs)

c) Motor Control Centres (MCCs)

d) Main Lighting Distribution Boards (MLDBs)

e) Auxiliary Services Power Boards (ASPBs)

f) Emergency Power Distribution Boards

9.5.4.2 Low voltage switchboards shall be metal clad, arranged with self supporting units and assembled together in a row. The degree of protection shall be IP 52.

9.5.4.3 The switchboards shall be suitable for extension at both the ends.

9.5.4.4 The main bus bars of LV switchboards shall have heat shrinkable insulated sleeves and shall be made of high conductivity aluminium alloy.

9.5.4.5 Bus bars shall be of uniform cross section and supported on non-hydroscopic FRP insulators with adequate clearances and creepage distance to prevent flash over due to effect of dust/moisture.

9.5.4.6 Sufficient bus supports shall be given to give adequate mechanical strength during short circuits.

9.5.4.7 A continuous ground bus shall be provided at the bottom in the PCC/MCC for grounding the PCC/MCC.

9.5.4.8 Rated short circuit breaking capacity shall be minimum 50 KA for 1 sec.

9.5.4.9 All feeders of PCC and incoming and bus coupler feeders of PMCC shall be provided with draw out type air circuit breakers.

9.5.4.10 Motor rated below 75 KW rating shall be contactor controlled and 75 KW and above shall be ACB controlled with combined motor protection relay. All other feeders of 415 V switchboards shall be provided with switch-fuse units. All outgoing feeders shall be drawout type in all the switchboards.

9.5.4.11 Switchboards shall be provided with thermostatically controlled anti-condensation heaters.

9.5.4.12 All units in the MCC shall be completely accessible and removable from front. Both power and control connections shall be plug-in/stab-in type.

9.5.4.13 Busbar clearances shall conform to relevant Indian Standard/IEC for equipment voltages up to and including 500 V AC.

9.5.4.14 The draw out modules shall be standardized and it shall be possible to interchange any module with a module of same size. The components to control the equipment like switch, starter, fuse, auxiliary relay etc. shall be wired as a unit on the individual module. Safety shutter shall be provided to prevent direct access to live parts when the chassis is removed.

9.5.4.15 The entire draw out construction should be designed for safe operation during placement or removal of chassis. An earthing arrangement shall be provided which will make contact first before the power contacts are made and break last. Each module shall control one motor in general.

The door shall be interlocked so that it cannot be opened unless the isolating switch on that module is OFF. However, it shall be provided with a door defect mechanism for intentional opening when on line for testing and inspection purpose.

9.5.4.16 Control switches for breaker control shall be provided in each breaker cubicle. Circuit breaker shall be interlocked to prevent withdrawal of a closed breaker or insertion of a closed breaker. Each breaker shall be provided with anti pumping device.

9.5.4.17 Provisions shall be made to manually close/trip circuit breakers on loss of control voltage.

9.5.4.18 All low voltage switchboards shall be provided with 20% spare outgoing feeders rounded off to next higher digit of each type & rating (fully wired) and with all the components.

9.5.4.19 All ACB feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy indications.

9.5.4.20 All motor feeders shall have test/run selector switch. Test will bypass all the process interlock and enable the operation of motor in test. Run selection will take the process interlock in line.

9.5.4.21 Flag type relay shall be provided for motor getting tripped on process interlock to enable the cause of tripping of motor.

9.5.4.22 No under voltage tripping shall be provided to any incoming/transformer/outgoing feeder.

9.5.4.23 Line PT with voltmeter shall be provided. Momentary paralleling with bypass arrangement to be provided for changeover without interruption of power supply. Synchrocheck relay bypass arrangement shall be provided.

9.5.4.24 The control supply to LCS shall be fed through MCB. Use of Fuses shall be restricted.

9.5.4.25 Process fault / electrical fault flag shall be provided for motor tripping.

9.5.5 **Auxiliary Supply Power Board**

The ASPB shall generally be double front, non-drawout type having essential and non-essential bus. Non-essential bus shall be disconnected in case of failure of normal supply through a contactor. ASPB in single front execution also may be adopted.

9.5.6 **Distribution Boards**

The Distribution Boards shall be single/double front, non-drawout type and shall feed the auxiliary supplies as per requirement.

9.6 **Direct Current Distribution Boards**

9.6.1 The Direct Current Distribution Boards (DCDBs) shall be single front, non-drawout type for supply of 110 V DC control power to switchgears and panic lighting.

9.7 **Motors**

9.7.1 The rating of LV and HV motors shall be selected from the sizes as recommended in relevant Indian Standard/IEC.

9.7.2 The margin between the installed power and absorbed power shall be as recommended by the driven machine supplier but shall not be less than the following:-

Motor Rating	Margin above Driven M/C Absorbed Power
Less than 22 KW	25%
22 KW to 55 KW	15%
75 KW and above	10%

9.7.3 Voltage rating for the motors of different ratings shall be as below:

Up to 150 KW	: 415 V, 3-phase, 50 Hz AC
Above 150 KW - 1000 KW	: 3.3 KV, 3-phase, 50 Hz AC
Above 1000 KW	: 11 KV, 3-phase, 50 Hz AC

9.7.4 The motors shall have maximum rated duty as per relevant Indian Standard/IEC. Consideration shall be given for special duty motors wherever required e.g. cranes etc.

9.7.5 All LV motors shall be TEFC type as per relevant Indian Standards/IEC while HV motors shall be TEFC/CACA type. All motors shall be Class-F insulated with temperature rise limited to that of Class-B.

9.7.6 Normally the motors shall be suitable for DOL starting. However, motors started through VFD shall be suitable to run at 30% to 100% of rated speed and compatible with the VFD.

9.7.7 VFD drive supplied to be one rating higher than the motor fed by the VFD.

9.7.8 All motors 30 KW and above shall have space heater provision.

9.7.9 All HT motors shall have winding, hot air and bearing RTDs.

9.7.10 All HT motors shall have safety factor 1.1.

9.7.11 All LV motors shall be energy efficient type having efficiency class of ‘IE2’ as per IS 12615: 2011 and high power factor type.

9.7.12 The starting current i.e. breakaway current of 415 V Motors shall not exceed the values indicated in IS: 12615. Also there shall be no further positive tolerance on the values of breakaway current.

9.7.13 The starting current of 11 KV & 3.3 KV motors shall not exceed 500% of FLC.

9.7.14 Type test certificate of similar motor for use in specified hazardous area (if applicable) shall be furnished.

9.7.15 The duty cycle of the motor shall meet the process and driven machine requirement.

9.7.16 In case of 11 KV & 3.3 KV motor, the terminal box shall be suitably designed for proper termination of XLPE insulated cables through heat shrink termination kit.

9.7.17 The mechanical parameters such as duty, mounting type, shaft extension, direction of rotation, starting torque requirements etc. shall be adequate for the application.

Sleeve or anti friction type bearings shall be used. Vertical motors shall have thrust bearings suitable for the load imposed by the driven machinery. Motors with sleeve bearings may require proximity probes to measure shaft vibration adjacent and relative to the bearings. Generally, all motors, except for application such as crane, hoist, turbine/engine starting, shall be designed for continuous duty with rated load.

9.7.18 Motor and pump alignment shall be carried out by laser alignment for better accuracy.

9.7.19 Bearing list for DE/NDE side for all motors to be provided with supply of motor.

9.7.20 Motor rated above 30 KW shall have on line greasing provision and for motor rated above 45 KW, grease outlet feature shall be provided.

9.7.21 For all other specifications of EOT crane, refer TS-8208.

9.7.22 For all other specifications, refer TS-8102.

9.8 **Rectifier-Cum-Battery Charger**

9.8.1 The battery charger shall be microprocessor based and the battery charger configuration shall be 2FC+1FCBC to supply continuous load and keep the battery in state in float mode. In Boost mode, for initial charging of Battery and after power restoration subsequent to failure, to recharge the battery while simultaneously supplying load current.

9.8.2 Battery Charger shall have at least 30% extra capacity for future load requirement. Battery Charger shall have 110 V DC system.

9.8.3 For all other specifications, refer TS-8140.

9.9 **Battery Sets**

9.9.1 The batteries shall be Ni-Cd type of suitable AH capacity at 10 hour rate of discharge.

9.9.2 Battery back-up time shall be one hour.

9.9.3 For all other specifications, refer TS-8142.

9.10 **Uninterruptible Power Supply System (UPS)**

9.10.1 UPS shall be used to feed 115 V AC, 50 Hz, 1 phase power supply to the instrumentation system, DCS and other auxiliary loads.

9.10.2 The UPS system shall be IGBT type and shall be backed up by Ni-Cd battery.

9.10.3 Each battery bank shall be rated to feed UPS load for one hour at rated capacity of the UPS in the event of outage of normal power.

9.10.4 UPS system shall be located in the control room along with associated battery and UPS distribution board. UPS shall have extra 30% spare capacity.

9.10.5 The UPS shall have REDUNDANT SCHEME WITH BYPASS. Under normal operating conditions, both inverter units shall run in parallel sharing 50% load in synchronism with by-pass power and supply uninterrupted A.C. power to load. On failure of one of these inverters, the faulty inverter shall get automatically disconnected from the load and healthy inverter shall supply 100% load in synchronism with bypass supply. In the event of second inverter also developing a fault, a no-break load transfer to bypass supply shall take place through static switch.

9.10.6 All three sections, i.e. Rectifier-I, Rectifier-II and Bypass shall be fed through three separate feeders of two different sections of PMCC in such a way that bypass section is fed from emergency bus.

9.10.7 UPS shall be PWM based using IGBT. Each charger and SCVS shall have isolating transformer at the input.

9.10.8 The salient features of the UPS shall be as under:

a) High Efficiency
b) Compatible to feed nonlinear, high crest factor loads
c) Microprocessor based monitoring system for UPS status and fault indications
d) High transient performance
e) Low audible noise

9.10.9 Each UPS shall be provided with SNMP software so that all the parameters of UPS and alarms/faults can be viewed into the remote computer. These logs/trends of load can later be printed. Web based parameter and status monitoring shall be used. It shall be hooked to LMS and DCS System.

9.10.10 The transfer time of UPS from inverter to bypass, in case of failure of both inverters, shall be so selected that during this transition period, instrumentation/DCS etc. which leads to tripping of plant shall not fail. Typically, it shall be less than 20 ms.

9.10.11 The technical parameters of UPS shall be as under:

Input

a) Rated Voltage 415 V ± 5%
b) Rated Frequency 50 Hz ± 5%

Output

a) Rated Voltage 115 V AC

Voltage regulation:

Static (0-100% load) ±1%

Dynamic for 100% load change: ±5%

9.10.12 For all other specifications, refer TS-8040.

9.11 **Variable Speed Drives (VSD/VFD)**

9.11.1 Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with ECS/DCS. It shall be possible set speed from process DCS for optimum performance through 4-20 mA signal. Speed/current/status feedback to DCS may be provided. Drive will run at preset speed in the event of loss of signal from DCS.

9.11.2 System shall be highly reliable, efficient and shall provide high power factor, low harmonic distortion, low noise level etc.

9.11.3 System shall be provided with complete by pass circuit to ensure the power supply reliability in case of VSD/VFD failure.

9.11.4 The system shall be suitable for load characteristics, continuous speed control and shall be with soft start feature. Drive shall be able to accelerate the load over the full speed range (0–100 %) with incoming line voltage regulation of 10%.

9.11.5 The system shall be designed for 150% over current withstand for 1 minute. The system shall be equipped with an automatic restart facility which will restart the system in case of voltage dip over 20% or power interruptions less than 4 seconds and recovery of voltage to 95% with a facility to block the automatic restart.

9.11.6 The system shall be suitably designed with due care for long length of cables, output filters, chokes, motor insulation, cable voltage grades etc.

9.11.7 The VSD panel shall be located in the clean air conditioned room in the sub-station. Required local control equipment shall have start, stop speed raise and lower push buttons, ammeter, speed indicator, ON/OFF/READY status selector switches as required and shall be installed near the motor.

9.11.8 The VFD shall be provided with Input and Output Choke.

9.11.9 "Auto Restart" facility for drive system within preset time, typically 0-15 seconds, in case of supply system dip or complete loss of power shall be provided.

9.11.10 Harmonic Distortion shall be as per IEEE519/IEC61800 and harmonic study shall be done with all VFD in line and without VFD in line. The total I_{thd} to be less than 10% and V_{thd} less than 5% at the point of Coupling. Contractor shall meet this harmonic content in the PCC and if the VFD is not able to maintain such Harmonic level. Active/Passive Harmonic Filters shall be provided for the same.

9.11.11 Preferably screened type cables or cables as recommended by VSD/VFD vendors shall be used for VSD/VFD systems.

9.11.12 The VSD/VFD panels to be supplied shall be of proven model.

9.11.13 Training of VSD/VFD shall be provided to owner personnel.

9.11.14 For all other specifications, refer TS-8302.

9.12 **Local Control Stations**

9.12.1 Local Control Stations shall be provided for all motors except motors controlled through Local control panels. LCS enclosure shall be certified for Ex-d with internal components suitable for safe area.

9.12.2 Provision for pad locking in OFF position shall be provided.

9.12.3 Local control stations for breaker controlled HV and LV motors shall be provided with T-N-C switch, L/R Switch, Indication lamp for ON, OFF, Trip, Space Heater ON, Motor Ready to Start and ammeter. Moreover, space heater ON indication lamp, trip indication lamp shall also be provided at the switchgear panel.

9.12.4 Local control stations for contactor controlled LV motors shall be provided with start push button, stop push buttons, L/R switch and ammeters for the motors rating 5.5 KW and above. If required from process point of view, ammeter shall be provided for motors below 5.5 KW also. Space Heater ON indication lamp shall be provided for motor rated 30KW and above. Indication lamp for ON, OFF, Motor Ready to Start (for all critical motors) shall be provided on LCS.

9.12.5 Each element for start and stop shall be provided with 1 NO + 1 NC contact. The push button construction shall be such to avoid mal-operation due to vibrations.

9.12.6 All local control stations shall have weather proof IP-55 enclosure and be suitable for installation in relevant hazardous area, gas group and temperature class. Canopies of suitable size shall be provided with all local control stations.

9.12.7 Two numbers of LCS shall be provided for the motors, which are installed at elevated platforms, such as cooling tower fan etc. One shall be installed at ground level and the other near the motor.

9.12.8 The ammeter shall be flush mounting, moving iron spring controlled type, of accuracy class 1.5 as per IS: 1248, with square face of minimum size 72 mm x 72 mm having scale range 0-240 degree. The ammeter shall be provided with uniform scale up to CT primary current and compressed end scale up to the 6 times the C.T. primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1 Amp. CTs only.

9.12.9 For all other specifications, refer TS-8200.

9.13 **Industrial Goods Lifts**

9.13.1 Lifts shall have automatic centre opening doors, SS cabin with aluminium chequered plate flooring cabin and Polyurethane steel belts (rope), closed loop VFD, A low – inertia gear less machine with a permanent magnet (PM) synchronous motor, battery-operated rescue system with electronic speed monitoring, machine on the rails to transfer loads down to the pit.

9.13.2 Automatic Rescue Device shall be capable of moving the lift to the nearest landing on main power failure.

9.13.3 Lift Machine room shall be located above the Lift shaft.

9.13.4 Following Control & Indication shall be provided on all landings and ground floor:
- Digital Car position indicator for each lift on top as well as on side wall
- Audio alarm & direction indicator for each lift
- Common up/down call buttons
- Fireman switch
- Braille marking on all buttons

9.13.5 Following Control & Indication shall be provided in car:
- Braille marking on all buttons inside the car
- Voice announcement system with all necessary equipments.
- Appropriate positioning of Car Operating Panel
- Floor selector button
- Emergency stop and alarm button
- Combined digital position and direction indicator.
- Wiring for telephone and telephone instruments (intercom) in lift car, machine room and ground floor, lift lobby
- Lighting, emergency alarm and fan to be provided with emergency supply through inverter having at least half an hour battery backup.
- Car Operating Panel (COP) should be on the front panel as approved by the owner.

9.13.6 No. of level of landing shall be as per operational requirement.

9.13.7 For all other specifications, refer TS-8206.

9.14 **Soft Starters**

9.14.1 Soft Starter shall be considered for large sized motors to overcome the problems of voltage drop during starting and also over sizing of transformer and generator.

9.14.2 The soft starters shall be solid state microprocessor control/Flux Compensated Magnetic Amplifier (FCMA) type with self torque adjustment (during controlled start)

feature with bypass contactor. Soft starters shall be communicable type and shall be able to communicate with ECS.

9.14.3 Soft starter shall be designed with starting current limited to 350% to 415% (However LSTK contractor shall ensure that this reduced starting voltage is suitable to develop necessary starting torque requirement of the respective motor). The soft starters shall be designed for the optimum voltage drop during starting such that the drive motor and the load get the required accelerating torque.

9.14.4 Soft starter shall be as per standards IEC 34/BS 4999/IS 325/BS 5000.

9.14.5 The LSTK contractor shall super impose the motor torque vs speed curve at reduced voltage (to motor terminals at starting) on torque vs speed characteristics of the driven equipment to confirm correct operation i.e. acceleration to rated speed. The LSTK contractor shall also calculate acceleration time at reduced voltage (based on these torque vs speed curves) required for accelerating the drive, to full rated speed. This acceleration time shall be sufficiently less than the hot withstand time of the motor.

9.14.6 System shall be provided with complete by pass circuit to ensure the power supply reliability in case of Soft Starter failure.

9.14.7 For all other specifications, refer TS-8301.

9.15 **Switch Sockets**

9.15.1 Sufficient number of inter-locked type 125A/63A, 415V, 3 Ph and 32A, 240V, 1 Ph switch sockets shall be provided in various plant locations as per hazardous area classification to facilitate the maintenance work. Supply to switch-sockets shall be taken from ASPB through suitably rated RCCB.

9.15.2 32/63A, 30mA, single phase switch sockets with RCCB shall be provided at the desired intervals as per the area of plant. Layout of the switch socket shall be approved by RCF.

9.15.3 For all other specifications, refer TS-8120.

9.16 **Bus-duct**

9.16.1 Bus bars shall be of electrolytic grade aluminium.

9.16.2 It shall be suitably supported at regular intervals and both bus bars and supports shall be adequately sized and clamped to withstand rated short circuit current without permanent deformation.

9.16.3 The bus insulators shall be non-hygroscopic, non-inflammable material. Earth bus shall run along the full length of bus duct without any break.

9.16.4 Outdoor bus duct shall be weatherproof to IP-55 and shall be provided with canopy, silica gel breather.

9.16.5 Bus duct shall be supplied with bus bar flexible links for connection at both the ends and expansion joints for every 3M of bus duct and bus duct support materials.

9.16.6 Openings with cover at suitable locations shall be provided on bus duct for accessing the bus bars for maintenance.

9.16.7 For all other specifications refer, TS-8062.

9.17 **FRP ladder type cable tray and accessories**

9.17.1 FRP cable tray shall be corrosion resistant polyester flame retardant U.V. stabilized resin system.

9.17.2 The FRP cable tray shall be ultra violet resistant. FRP cable trays shall be manufactured in accordance with NEMA FG-1-1984-1993 (Current Issue) and Standards IS-6746 and ASTM E84. Manufacturing process shall be pultrusion using automated pultrusion machines. Resin to be used shall be ultraviolet resistant polyester resin.

9.17.3 FRP cable tray shall comply with the requirements of latest relevant standards:

ASTM-D149	Standard test method for dielectric breakdown voltage and dielectric strength of solid electrical insulating materials at commercial power frequencies
ASTM-D256	Standard test methods for determining the lzod pendulum impact resistance of plastics
ASTM-D635	Standard test method for rate of burning and/or extent and time of burning of plastics in a horizontal position
ASTM-D638	Standard test method for tensile properties of plastics
ASTM-D790	Standard test methods for flexural properties of unreinforced and reinforced plastics and electrical insulating materials
ASTM-D2863	Standard test method for measuring the minimum oxygen concentration to support candle-like combustion of plastics (oxygen index)
ASTM-E84	Standard test method for surface burning characteristics of building materials
IS 6746	Unsaturated polyester resin system for low pressure fibre glass reinforced plastic
NEMA FGI	National Electrical Manufacture's Association - Fibre glass cable tray system
UL 94	Standard for safety of flammability of plastic materials for parts in devices and appliance testing

9.17.4 Cable tray accessories shall include bends, tees, crosses, reducers, splicers, clamps and necessary hardware etc.

9.17.5 Cable trays and accessories shall be corrosion / chemical resistant, weather resistant, easy to drill and cut, Lightweight, high strength and flame retardant v0 in accordance with ASTM E – 84 – Class 1 Rating and as per IS-6746 – Very Low Flammability. An additive material shall be mixed with the FRP to make them resistant to ultraviolet light. The oxygen index shall be minimum 30 as per ASTM-D-2863.

9.17.6 The minimum glass content in the FR material shall be 65%.

9.17.7 The Ladder type trays shall have side rails and horizontal rungs. Both of these shall be of same material i.e. the FRP with additive material. Rung spacing shall be 300mm. The side runner Height and the thickness (min. 3mm with no negative tolerance) of FRP channel can be decided based on the support span and loading. The rungs to side member are connected to the Larger portion of the side rail by using pin made of fiberglass reinforced thermoplastic, and should have both mechanical & structural adhesive Lock.

9.17.8 The cable trays shall be supplied in standard length of 3000 mm.

9.17.9 Max. width of cable tray shall be 600 mm.

9.17.10 For tray system design in addition to self-load following guideline for design shall be considered:

LADDER TYPE:

Support Span: 2000 mm
Cable load for:
150 mm Width: 30 Kg / Linear Meter
300mm Width: 60 Kg / Linear Meter
600mm Width: 90 Kg / Linear Meter

In addition to this, the Ladder type cable trays shall be suitable for 70kg concentrated load at the centre span and deflection should be measure as ≤ L/200mm (Where L stand for Support Span)

9.17.11 Tolerances in various dimension shall be follows:

Length		± 5 mm
Width		± 2 mm
Height		± 1 mm
Bend		± 1 mm
Thickness		+ 0.2 mm

Positive tolerance on total quantity up to 5% is acceptable. However, negative tolerance on total quantity is not acceptable.

9.17.12 The tray construction shall be such as to facilitate easy handling and to ensure easy laying of cables without causing damage to cables. The inside surface shall be free from sharp edges, burrs or projections.

9.17.13 Each section of tray shall be complete with necessary connector plate and hardware (refer installation PDS). All hardware (Nuts, bolts, washers etc.) shall be of Stainless Steel Material Grade: 316 for FRP trays joining plates. The bends, tees, reducers, crosses and droppers shall have required bending radius but not less than 300mm.

9.17.14 The side rails and all accessories shall have the holes on each end for fixing connector plates. The connectors between two sections of cable trays or a Section of cable tray with associated accessories shall be done by bolting only. For strength in Ladder Cable Trays inside & outside connector plates shall be provided with 8 sets of hardware for trays with width 450mm & above and 4 sets of hardware for trays with width 300mm / 150mm.

9.17.15 Installation of Cable Trays shall be done exactly as per NEMA standard with the position of supports as per NEMA standards and the support span as decided in the specifications. A pictorial description is given for better understanding

For Vertical & Transverse laying of cable trays support span shall not be more than 1.5 meter and all the cables must be tied to the rungs with the help of cable ties. Moreover the cable trays shall be fixed to the support with the help of hold down clamps.

If cable trays are to be laid in the transverse direction then utmost care must be taken while installation as faulty installation can lead to cable load coming on the bottom side resulting in the breakage of cable trays. Furthermore all cable trays must be clamped with hold down clamps to the support.

All FRP cable trays which are to be installed in the transverse direction shall be of minimum 6mm thickness.

9.17.16 Testing and inspection of cables trays shall include but not necessarily be limited to the following:

Characteristics	Type of Check	Standard	Required Value
Chemical Composition	Glass Content	ASTM D5630	≥65%
FRP Property Indicators	Flammability Test	IS 6746 / UL 94	Very Low Flammability / v0
	Rate of Burning	ASTM D 635	≤25mm

	Flame Spread Index & Smoke developed Index	ASTM E 84	Class 1
	Water Absorption	ASTM D 570	≤0.25%
	Izod Impact Strength	ASTM D 256	>130 Kg-cm/cm
	Tensile Strength	ASTM D 638	2500-6000 Kg/cm^2
	Flexural Strength	ASTM D 790	2500-10000 Kg/cm^2
	Compressive Strength	ASTM D 695	1500-4000 Kg/cm^2
	Oxygen Index	ASTM D 2863	Minimum 30%

FRP trays shall be tested as per NEMA-FG1-1984-1993 (Current Issue). Following tests shall also be carried out on each type of cable tray system.

a) Deflection Test: L/200mm (L = Support Span) for Ladder type trays.
b) Destruction Load Test for Ladder type trays.

10.0 CABLING

10.1.1 All HV & LV power and control cables for HV/LV switchgear shall be supplied and laid by the contractor. Terminations at switchgear end and at the equipment end shall be in contractor's scope. Supporting and laying of these cables shall also be in contractor's scope. Termination of HV/LV cables at HV/LV motor end and HV switch gear end including supply of heat shrink type termination kit of Raychem make for HT cables shall be in contractor's scope.

10.1.2 Cables shall be sized considering the following factors.

- Maximum continuous load current
- Voltage drop
- System voltage
- Laying conditions
- Derating due to ambient air temperature, ground temperature, grouping and proximity of cables with each other, thermal resistivity of soil etc. shall be taken into account
- Short circuit withstand criteria for HV cables.
- Max. FLC of the motor connected.

10.1.3 All HV power cables shall be made of stranded aluminium conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type, conductor screen, insulation screen and construction as per IS: 7098 (Part 2). HV cables shall be of unearthed type.

10.1.4 All LV power cables shall be with stranded aluminium/copper conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Power cables with conductor size upto and including 6 sq. mm shall be with copper conductor, conductor size above 6 sq. mm shall be aluminium conductor. LV cables shall be 1.1kV grade and suitable for earthed & unearthed system.

10.1.5 All control cables shall be with 2.5 sq. mm, stranded copper conductor with XLPE insulation, PVC inner sheathed, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Control cables shall be twisted pair or shielded wherever electro-magnetic/electrostatic interference is anticipated. Control cables shall be 1.1kV grade and suitable for earthed & unearthed system.

10.1.6 All control cables shall have 20% spare cores. All cores shall be identified with numerical core numbers printed on core instead of colours.

10.1.7 All cables shall be armoured and shall have extruded inner and outer sheath.

10.1.8 Cables connected in parallel shall be of the same type, cross section and terminations.

10.1.9 All power and control cables shall be in continuous lengths (except for very long feeders) without any joints. The cables used for lighting and wires in conduits shall have appropriate junction boxes with adequately sized terminals. Cable joints in hazardous areas shall not be permitted.

10.1.10 The maximum voltage drops in various sections of the electrical system shall be within limits stated in the following table:

Sr. No.	System Element	Maximum Permissible Voltage Drop
1.	High voltage cables for general distribution	1 %
2.	Bus duct between transformer secondary and switchgear (HV/LV)	0.5 %
3.	Cables between PCC/PMCC and MCC or auxiliary switchboard	
	i) Location of switchboard: Near PCC/PMCC	0.5 %
	ii) Location of switchboard: Remote	2.5 % (Max.)
4.	Cables between HV Switchgear and HV motor	3 %
5.	Maximum Voltage drop up to LV motor terminal:	
	During running condition	5 %
	During starting condition	10 %

Sr. No.	System Element	Maximum Permissible Voltage Drop
6.	Cables between auxiliary switchboard and lighting panel	Max. 1.5 %
7.	Circuit between lighting panels and lighting points	4 %
8.	DC supply circuits/UPS circuits	5 % and/or as per instrumentation requirement

The voltage available at the motor terminals during start-up must be sufficient to ensure positive starting or re-acceleration of the motor (even with the motor fully loaded, if required) without causing any damage to the motor.

For HV motors, the voltage available at the motor terminals must not be less than 85% of the rated value during start-up or re-acceleration. For LV motors, the voltage available at the motor terminals must not be less than 80% of the rated value during start-up or re-acceleration.

10.1.11 For FO cable (Electrical application) refer Design Philosophy-Instrumentation attached with the NIT.

10.1.12 **Design Criteria for Cables/Bus Duct & Short Circuit Withstand Time**

a) Design criteria for cables/busduct

Sr. No.	Design Criteria	3.3KV/11KV	415V
1.	Loads beyond 1000A rating	Bus duct	Bus duct
2.	Loads located beyond 1 KM	Cable	N.A.
3.	Loads located up to 1000 M	Cable	Cable
4.	Recommended limiting size of multi-core cable (mm^2)	3 Core x 400	4 Core x 300
5.	Insulation voltage grade	3.3KV/11KV Unearthed	1100V suitable for earthed and unearthed system
6.	Type of cable insulation	XLPE	Power: XLPE Control: XLPE

Suitable derating factors based on the site ambient conditions, method of laying and the no. of cables laid together shall also be applied.

b) Short circuit withstand time (seconds) shall be as follows for Breaker controlled feeders.

Bus duct	1 sec.
Feeders to motors and transformers	0.25 sec

Feeders from PCC/PMCC to MCC	0.5 sec
Main 11 KV primary distribution feeders	0.7 sec
11 KV cable from transformer to switch board	1 sec

10.1.13 The minimum size of power cables shall be 2.5 sq. mm (Cu).

10.1.14 The control cables shall be 2.5 sq. mm (Cu). However, wiring in the panel/switch boards may be by means of 1.5 sq. mm (Cu) cables except for CT wiring which shall be 2.5 sq. mm.

10.1.15 For all other specifications, refer TS-8160.

10.2 **Cable Laying**

10.2.1 The cables shall generally be laid on overhead racks. Pipe racks where available, shall be used to support the cable racks.

10.2.2 The cable racks shall be heavy duty FRP (fire retardant and UV stabilized) ladder type.

10.2.3 HT power cable shall be laid on cable tray in single layer having 1D spacing between the cables.

10.2.4 LT power & control cable and space heater cable shall be laid on cable tray in single layer in touching formation.

10.2.5 Walkway to be considered for access to Electrical cables.

10.2.6 FO cable (Electrical application) laying shall be as per Design Philosophy-Instrumentation attached with the NIT.

10.2.7 Cable trays shall be designed considering 25% margin for future use.

10.2.8 MRSS to various substations and further to various electrical consumers cable shall be laid overhead. However, wherever overhead cable routing is not feasible bidder can go for cable trench / slit (Refer PDS attached with the NIT) as per the site requirement.

Wherever, pipe rack is not available and space for overhead cable laying is possible then dedicated structure for cable shall be made for cable laying.

10.2.9 Following minimum clearance to be maintained for lowermost tier (B.O.T.) of cable trays in all cable tray installation :

a. 2700 mm above FGL for overhead cable trays.

b. 300 mm above FGL for cable trays installed along with pipe sleepers.

c. 7000 mm above FGL at road crossing.

10.2.10 Cable tray vertical support shall be provided at every 1 meter. Support for cable trays shall be MS with FRP.

10.2.11 3 mm thick tray cover allowing adequate ventilation shall be provided.

10.2.12 All cables shall be terminated using suitable cable lugs.

11.0 ILLUMINATION SYSTEM

11.1 General

11.1.1 LED type lighting shall be provided. Average illumination levels and type of fixtures in the various sections of the plants shall be as indicated in Annexure-I. All the plants and area lighting shall be energy efficient.

11.1.2 The specified illumination level shall be maintained after considering maintenance factor 0.6 for plant & outdoor areas & 0.7 for indoor areas and utilisation factor as per manufacture catalogues for size of room & type of fixture.

11.1.3 Separate area wise panic lights, fed from 110 V DCDB, shall be provided at strategic locations for safe evacuation of operation personnel. These shall be switched 'ON' automatically on failure of power supply to main lighting board and shall switch 'OFF' automatically on resumption of mains or after 1 hour of power failure to avoid draining of the battery. Location of these lights shall be judiciously decided from safety considerations. The outdoor lighting shall be photocell/timer controlled.

11.1.4 Aviation lights shall be provided on tall structures and all isolated structures as per statutory requirements. Aviation lights shall be LED based.

11.1.5 Plant lighting circuits shall be single phase (Phase & Neutral) rated 240 V AC. Each circuit shall be rated to 16A. A minimum of 25% of MCBs of each board shall be left as spares. The load on one lighting sub-circuit of lighting sub-distribution board and junction box shall be limited to 500W approx.

11.1.6 The lighting sub-distribution board for control of lighting shall be standardized as 18-way, 15-way, 12-way, 9-way and 6-way type.

11.1.7 In plant office rooms, wall mounting boards shall be installed to control the lighting. These boards shall include switches for lights, fans, 16A/6A plug sockets and fan regulators etc.

11.1.8 16A/32A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/junction box.

11.1.9 For more details, refer PDS attached.

11.2 **Street Lighting And Security Lighting**

11.2.1 63A TPN outlet from outdoor lighting bus of main lighting board shall be taken direct to the TPN junction box to be mounted on pole through cable and looped from pole to pole.

11.2.2 Hot dip GI octagonal poles of suitable mounting height shall be used for street light. However, for plant lighting (platforms / structures / access ways / walk ways / pump house / pump bay etc.), steel tubular poles of suitable mounting height shall be used

11.2.3 The poles shall be subjected to min. following tests:

- Thickness of galvanising
- Drop test as per IS: 2713
- Deflection test as per IS: 2713

11.2.4 Hot dip galvanized octagonal high mast lighting shall be used for yard and general area lighting. LED type fittings may be used.

11.3 **LED LIGHTING FIXTURES & ACCESSORIES**

11.3.1 **General**

11.3.1.1 The fixtures shall be complete with all accessories including the lamps, driver, heat sensor and all other accessories. The lighting fixtures shall also conform to the specification sheet for lighting fixture of this specification.

11.3.1.2 The fixtures shall be provided with cable glands and a terminal block suitable for termination of copper conductor up to 2.5 sq. mm size.

11.3.1.3 The fixture shall be so designed that it shall be possible to maintain or replace different accessories without difficulty, including replacement of lamps.

11.3.1.4 Unused holes in control gear box and junction box shall be packed with blanking plugs.

11.3.1.5 All lighting fixtures shall be provided with suitable double compression Al cable glands along with termination lugs and blanking plugs for unused entry.

11.3.1.6 All hardware used in lighting fitting, JBs shall be of Stainless Steel only.

11.3.1.7 LED Luminaries shall be suitable for single phase 240V±10%, 50Hz±5% AC input and ambient condition indicated elsewhere in the NIT.

11.3.1.8 Minimum Impact Resistance for outdoor fittings shall be IK-05.

11.3.1.9 The fixture shall be so designed that it shall be possible to maintain or replace the different accessories without difficulty, including the replacement of the lamp.

11.3.1.10 Flameproof light fittings shall be certified for use in specified hazardous area and the flameproof certificate shall be submitted along-with the offer. Explosion proof certificate from PESO shall be submitted before or along-with supply of such light fittings.

11.3.1.11 For High Mast specification refer TS: 8308.

11.3.2 **LED CHIPS**

11.3.2.1 LED efficacy shall be greater than 140 Lumens/watt at 350mA driver current. In respect of higher power rating LED, driver current greater than 350 mA can be accepted if LED's LM 80 / IS: 16105 test reports are attached.

11.3.2.2 LED type can be SMD (surface mounted device) of COB (chip on board) type depending on the application. COB type to be considered only for applications such as Highbays, Flood Lights & Flameproof Light Fittings.

11.3.2.3 Test report/LM80 report for ambient temperature of 55/85/105 Deg. C at rated and maximum current shall be submitted.

11.3.2.4 TM 21 life projection calculations along with LM80 for ambient temperature of 55/85/105 Deg. C as per applicable standard shall be submitted to substantiate life of LED. Reported Life span of LEDs shall be greater than 50000 Hrs at a soldering temperature of 85 Deg. C at rated driver current.

11.3.2.5 Colour temperature of white colour LED shall be from 5700K (5665K+/-355K) to 6500K as per ANSI standard C78.377A.

11.3.2.6 Colour rendering Index for colour ranges from R1 to R15 shall be greater than 80.

11.3.2.7 LED shall comply to Photo biological safety norms as per IEC 62471/EN62417/IS: 16108 and should fall in the exempt group for indoor luminaries and in exempt of low risk category for outdoor LED luminaries.

11.3.3 **LED DRIVER**

11.3.3.1 Minimum efficiency of LED driver shall be 85% for driver output rating of <= 40W and 87% for driver power output rating of > 40W.

11.3.3.2 Power factor of complete fitting shall be greater than 0.90.

11.3.3.3 In built high voltage cut-off for voltage above 290 Volt shall be provided.

11.3.3.4 Short circuit protection and Open load protection shall be provided.

11.3.3.5 Surge protection device shall be provided for minimum of 2 KV in indoor luminaries and minimum of 10 KV for outdoor luminaries. SPD should be series type with fail safe.

11.3.3.6 Total Harmonic distortion (THD) shall be less than 10%.

11.3.3.7 Isolated LED driver should be used. The input (AC side) and output (LED side) are separated by power transformer for galvanic isolation.

11.3.3.8 Power supply of LED PCB should be through proper connectors.

11.3.3.9 Driver shall comply EMI/EMC standards CISPR 15/ IS 6873 (CE, RE, CDN) and IS 61547.

11.3.3.10 Driver shall comply with safety standards IEC 61347-2-13/EN 61347-2-13/IS: 15885-2-13.

11.3.3.11 Driver shall comply with performance standards IEC: 62384/IS: 16104.

11.3.4 **LUMINAIRE**

11.3.4.1 Circuit boards and electronic components rating/type should be suitable to provide reliable functioning.

11.3.4.2 Luminaire shall have LM-79/IS: 16106 test report from a NABL accredited laboratory.

11.3.4.3 Minimum system efficacy of luminaire shall be greater than 100 Lumens/watt.

11.3.4.4 Potting of LED luminaire along with driver is mandatory.

11.3.4.5 Average Duty cycle to be 12 hours (Dusk to Dawn).

11.3.4.6 Working temperature to be in the range of – 5 Deg. C to 60 Deg. C.

11.3.4.7 Working humidity to be in the range of 10% to 100 % RH

11.3.4.8 Housing of indoor fixtures to be made of CRCA/PC/Aluminium Extrusion and for outdoor fixtures shall be pressure die cast LM6/ADC12/LM24.

11.3.4.9 Lumen maintenance of fixtures shall be 50,000 Hrs at L70.

11.3.4.10 LED luminaires shall be completely glare free.

11.3.4.11 View Angle should be typical 120 Deg.

11.3.4.12 Cover type of indoor fixtures shall be UV stabilised poly carbonate type and outdoor type fixtures to be Toughened glass or UV stabilised poly carbonate type as applicable.

11.3.4.13 Temperature rise for driver at soldering point should not exceed 85 Deg. C. For Heat shrink temperature rise, maximum of 20 Deg. C over ambient temperature is allowable. Heat shrink to be designed accordingly.

11.3.4.14 Flameproof light fittings shall be certified for use of hazardous area as per area classification and flameproof certificate shall be submitted along with the offer. Explosion proof certificate from PESO shall be submitted before or along with supply of fittings.

11.3.4.15 Luminaire should have BIS approval for surface mounted luminaire as applicable.

11.3.4.16 Housing ingress protection shall be as per table below:

Application Type	**Minimum Ingress Protection Required**
LED Street Light, Flood Light, Outdoor Industrial	IP66
Industrial Indoor (High Bay, Medium bay)	IP54
Toilet Fixtures	IP44
Domestic & Commercial Indoor type LED	IP20

11.3.4.17 Approve makes for different LED technologies to be as per table below:

LED Technology/type	**Approved make**
LED Chips SMD (Surface Mounted) type	Nichia, Osram, Lumileds, CREE
LED Chips COB (Chip on Board) type	Citizen, Bridgelux
Domestic/Decorative	Everlight Taiwan, Edison Taiwan, Samsung Korea
Luminaries	Osram, Nichia, Lumileds, CREE

11.3.5 OTHER CONDITIONS

11.3.5.1 Type Test Report/Certificate from NABL accredited labs as per relevant standards on selected sample including endurance test as per IS10322 and safety test on drivers as per IS 15885.

11.3.5.2 Vendor shall carry out third party inspection from approved TPI agency. TPI to be carried out on 10% material of each item on random basis as per scope of tender.

11.3.5.3 Vendor shall guarantee for full replacement of material (free of cost) due to any failure in 24 months from date of commissioning. Failures shall include failure/deterioration of LED's in terms of performance like guaranteed luminous efficiency as per LM80 report, abnormal lumen depreciation, failure of driver unit, etc.

11.4 AVIATION OBSTRUCTION LIGHT

11.4.1 LED type Aviation Obstruction Light for installation in non-hazardous area suitable for 240V, 50 Hz supply shall be used. It shall be covered under Indian patent act (Govt.

of India) No. 188995. Degree of protection shall be IP-65. Type, intensity and colour of Aviation light shall be as per the standard and safety norms followed in India.

11.4.2 The fixtures shall have body of corrosion resistant aluminium alloy casting and shall be suitable for outdoor use and mounting on 40 mm NB G.I. pipe. Necessary electrical threading shall be tapped in the fixture for mounting.

12.0 EARTHING AND LIGHTNING PROTECTION

12.1 Earthing

12.1.1 Complete earthing installation shall be done as per IS: 3043.

12.1.2 Common underground earthing grid shall be provided covering generating station, sub-stations and plants. The overall earth resistance (dry) shall be limited to 1 ohm.

12.1.3 Earthing rings shall be provided around sub-stations and plants which in turn shall be connected to the common earthing grid. Minimum size of main grid shall be 75mmx10mm.

12.1.4 Earthing grid/ring shall comprise of buried GI earth strips and GI pipes/electrodes.

12.1.5 Separate earth electrodes shall be provided for system neutral earthing. For equipment earthing, minimum two numbers of electrodes shall be provided around each plant/section. However, all these earth electrodes shall be inter-connected.

12.1.6 Inter-connecting pits having an earth bus in an enclosed brick chamber without earth electrode shall be provided in the common underground earthing grid for convenience of taking earth conductors inside the plants.

12.1.7 As far as possible, the reinforcement rods inside concrete column shall be connected to the earthing grid/ring to reduce the overall earth resistance.

12.1.8 Individual electrical equipment shall be earthed by GI strip/GI wire/Cu/Al cable. Earth buses shall be provided in plants for earthing groups of electrical/non-electrical equipment to earthing grid/rings.

12.1.9 Size of earthing grid/ring and earth conductors of equipment for generating station and sub-stations shall be as per relevant standards. The fault current magnitude shall be decided based on system fault level. The time duration shall be taken as 1 second.

12.1.10 All equipment rated above 250 V shall have two external earth connections and those rated up to 250 V shall have one external earth connection. However, for lighting fixtures, earthing shall be done through 3rd core of the cable in safe as well as in hazardous area.

12.1.11 Flameproof equipment, in addition, shall have one internal earth connection. This means that 4 core cables to be used for all the flameproof equipments and 3.5 core cables to be used for all flameproof motors located at hazardous area.

12.1.12 Motor shall have double earthing.

12.1.13 All steel structures, tanks, vessels, pipes, pipe joints, valves etc. shall be earthed against static charge accumulation by 50x6 mm GI strip. The no. of earth connections shall be as follows:

Equipment having diameter	Hazardous area	Non hazardous area
30 M	2	2
More than 30 M	3	2

12.1.14 Wherever process equipment are mounted on steel structures, the structures shall be earthed instead of earthing the individual equipment.

12.1.15 The pipe structures shall be earthed at not more than 25M apart.

12.1.16 For all equipment in hazardous area, in addition to external earthing one internal earthing shall be provided.

12.1.17 Minimum sizes of earth conductors to be used shall be as given below. However, vendor to calculate the actual size:-

Sl. No.	Equipment	GI conductor size	Al conductor size
1.	HV/LV switch board, transformers, HV motors	50mmX8mm	150 sq. mm
2.	Motors rated 75 KW and above	--	150 sq. mm
3.	Motors rated 30 KW to less than 75 KW	--	95 sq. mm
4.	Motors rated 5.5 KW to less than 30 KW	--	25 sq. mm
5.	Motors less than 5.5 KW	--	6 sq. mm
6.	All minor equipment rated 250V & below	--	6 sq. mm

All GI conductors shall meet the galvanizing requirement as per IS.

12.1.18 Cable tray earthing shall be provided with continuous run of GI strip along with cable trays. Cable racks/risers/trays shall be electrically continuous by bonding the joints between the runner members of the adjacent sections. The cable tray shall be connected to the earthing grid at suitable interval.

12.1.19 Cables racks/risers/trays shall be electrically continuous by bonding the joints between the runner members of the adjacent sections. The cable racks shall be connected to the earthing grid at suitable intervals.

12.1.20 Spacing between two earth pits shall not be less than 10 m & these may be located about 4m away from the building / structure.

12.1.21 As far as possible, the earth conductors shall be taken along power & control cable routes.

12.1.22 The earth pit shall be maintenance free earth electrode. Also the earth pit shall have name plate describing the function of earth pit i.e. BEP/NE, earth resistance and earth pit testing date and due date etc. as instructed by RCF.

12.1.23 GI strip shall be laid up to the foundation of motors and suitable size cable for earthing to be used for connection of the earthing strip and motor. Double earthing to be provided to the motor from two different earth strip of suitable ratings.

12.2 **Lightning Protection**

12.2.1 All structure shall be protected against lightning strokes by suitable lightning protection system to be designed and installed as per IS/IEC-62305.

12.2.2 The number of down conductors shall be minimum two.

12.2.3 Bare metallic structures shall not have any air termination rods at the top. The earth connections shall be welded to the bottom of structure at 300 mm above floor level. However, tall metallic columns with insulation at top shall be provided with air termination rods. Separate earth electrodes shall be provided for each down conductor of lightning protection. However, these shall be inter-connected with the other electrodes in main grid.

12.2.4 Lift shaft shall not be used for fixing the down conductor.

12.2.5 In case earth pits for connecting the down conductors are not available in the beginning of fabrication/erection of such structures/vessels/tanks, their bases shall temporarily be connected to nearby steel column. Electrical continuity of the structures, however, shall be checked and ensured.

12.2.6 For all high rise concrete structures, temporary lightning protection need to be provided during construction and maintained till permanent lightning protection is installed. For this purpose the vertical reinforcement, projecting over each lift, shall be connected to earth pits by means of 2 nos. flexible copper conductor cables each of the flexible cable shall be of 95 sq. mm. size having one end permanently connected to earth pit and other end provided with a clamp for connecting to the exposed reinforcement.

13.0 CATHODIC PROTECTION SYSTEM

13.1 Entire underground pipe work including those laid in concrete trench and filled with sand, the steel structures, tank bottom of above ground storage tanks, underground vessels etc. shall be provided with cathodic protection. The scope shall include, site surveying to collect required information, design, detailed engineering, supply, installation, testing, commissioning, maintenance & monitoring till the site is handed over to the owner and performance guarantee of impressed current cathodic protection system as per relevant Indian/IEC/BS/NACE Standards and codes of practices.

13.2 Following shall be excluded from Cathodic Protection System:

a) Underground Pipes with SS material,

b) Above Ground reinforcements bars of reinforced concrete,

c) Reinforcements bars of reinforced concrete Foundations,

d) Reinforcement bars in concrete piles.

13.3 SACP shall be provided during the construction period till ICCP starts working.

13.4 For all other specifications, refer TS-8303, TS-8304 & TS-8305.

14.0 CAPACITOR BANKS

14.1 The LSTK contractor shall ensure that the power factor remains minimum 0.92 lag (inductive) at all the buses of HV, MV & LV Switchboards. Capacitor bank shall be designed and installed at 415V voltage level in all the substations. The capacitor bank shall utilize the Automatic Power Factor Controllers to maintain the power factor of individual substation. Under no circumstances power factor shall become leading (capacitive) and all necessary protections to avoid this shall be used.

14.2 For all other specifications, refer TS-8046.

15.0 COMMUNICATION SYSTEM

15.1 Public Address system suitable to provide reliable and quick source of communication among operating personnel shall be provided. The system shall be microprocessor based with modular construction for ease of expansion of capabilities and capacity. The system shall have speakers, calling points etc. suitable to area of classification for that location. PA system shall be located in respective control room. All required furniture, PC console with chairs for complete PA System shall be in scope of LSTK Contractor.

15.2 Close talk mode shall be provided for conversation between two or more stations through close talk channel. Speeches from any hand set shall be heard over all the speakers. The system shall have the following facility:-

i) Alert tone facility

ii) Paging facility

iii) Private conversation facility

iv) Loud speaker mute facility

v) Emergency tone facility

15.3 Paging speakers provided in areas having ambient noise levels shall produce a paging sound level at least 10 dB above the anticipated ambient noise level. Where it is not possible to achieve the sound level of above 10 dB above the ambient, rotating beacons shall be installed such a way that that the operator is alerted in the area. Acoustic hoods shall be provided for call stations located in high noise areas.

15.4 The design of the system shall be such as to provide two channel communication i.e. Page & Party in each zone. Page & Party system shall comprise of one channel for paging & one channel for party talk.

15.5 The system may be centrally located at a particular plant but the location shall in no way affect the performance of system. If required separate but interconnected system shall be provided. The microphone system shall be capable to suppress the environmental noise which will be present in the plant due to machineries.

15.6 It shall be possible to have automatic testing, monitoring, fault diagnosis etc. through interface PC. The system programming shall be user friendly through interface PC.

15.7 It shall be possible to communicate between two field stations without the interference of the MCS / operator. Also it shall be possible to have direct communication with the MCS.

15.8 The equipment shall be sturdy, impact resistant, dust & damp proof generally conforming to minimum IP 55 degree of protection. For classified hazardous areas flameproof equipment shall be provided duly certified by recognised certifying authority for the area of installation.

15.9 3 sets of explosion proof walkie talkie shall be provided.

15.10 Communication system shall be able to work automatically from standby DC source when AC supply is ‘OFF’.

15.11 Paging system shall be interfaced with EPABX and Fire Alarm System.

15.12 Each PA System shall have 20% spare capacity.

15.13 Contractor to consider hooking up of existing PA System (seamless integration) with new PA System. Provision for seamless integration in new PA System, required hardwares, cabling and other related job shall be in LSTK contractor's scope.

15.14 For all other specifications refer TS-8037.

16.0 FIRE ALARM SYSTEM

16.1 LSTK contractor shall provide the Fire Detection and Alarm System which shall be an independent system comprising of manual call points (glass break type MCP shall not be provided instead MCP shall be pull and reset type), automatic sensors e.g. smoke and heat detectors, main panel, repeater panel, hooter, battery, battery charger and any other hardware.

16.2 The system shall be designed to provide audio-visual indication at the main panel to be located in sub-station and repeater panels shall be provided in fire station.

16.3 The manual call points shall be provided at strategic locations with access of 60 M along all exit routes and roads.

16.4 Electrical sirens shall be provided to cover entire plant area. Hooters and exit lights shall be provided at required locations in the buildings.

16.5 Panel design and component selection shall be done for future extension upto 10% of specified zones or one zone, whichever is maximum in each panel. The design of common facility and hardware shall be provided for required future extension of zones.

16.6 The fire detection system shall be interfaced with fire suppression system, wherever specified.

16.7 Supply, installation, testing and commissioning of above mentioned components/equipment for plant area, substation & control room shall be by the LSTK contractor along with necessary supply and laying of required signals cables.

16.8 The required nos. of MCPs and detectors in substation & control room shall be calculated as per IS norms and contractor shall get approval from owner during detailed engineering stage.

16.9 Any other specifications refer TS-8306 & TS-8307.

17.0 ELECTRIC HEAT TRACING SYSTEM

17.1 Electrical trace heating of pipelines, instruments and equipment for process temperature maintenance shall be considered if required from process point of view.

17.2 Electrical trace heating system shall be designed according to IEC 60079-30 and shall be based on the use of self-regulating cables, suitable for installation in accordance to hazardous area classification.

17.3 Mineral insulated cables shall be used only where process temperature maintenance high values would not allow the use of self-regulating cables.

17.4 All self-limiting parallel resistance type heater cables shall be covered with a metal braid and a polymer over jacket for mechanical protection and corrosion resistance.

17.5 Cable sheaths, conductor and termination materials, and cable support clamps shall withstand the maximum operating temperature, temperature cycling and thermal expansion of the piping or equipment to which is applied.

17.6 The design of the heating system shall be such that the heater element temperature does not exceed the temperature classification of the hazardous area.

17.7 Heat tracing system shall be fed through a separate control station approachable to operator and suitable ammeter shall be provided to ascertain that heat tracing cables are working.

17.8 System shall be designed for tripping in case of leakage to earth or pipe for human safety.

18.0 SPARES

18.1 Contractor shall supply mandatory spares for electrical equipments for operation and maintenance as per the list attached with this bid package.

18.2 LSTK Contractor shall recommend 2 years Operational Spares for all the equipment (item-wise) with recommended quantity & unit price. The item-wise price shall be with validity of 2 years. The same shall not be part of LSTK price.

18.3 All spare parts shall be identical to the parts used in the equipments.

18.4 Any other spare parts or special tools not specified, but required, shall also be quoted along with the offer.

19.0 VENDORS' SERVICES

19.1 The bidder shall consider the services of major equipment suppliers during installation and commissioning in their scope as required.

19.2 The services of engineers of following equipments' manufacturers are envisaged required during installation and commissioning:

Switchgears

Numerical relay

AC UPS

DC Panels

Variable Speed Drives

Soft Starter

Cathodic Protection System

Public Address System

Fire Alarm System

Lifts

19.3 Site testing, parameterization and commissioning of the Numerical relays shall be done by OEM expert only.

20.0 TESTING & INSPECTION

20.1 Testing of electrical equipments shall be done in accordance with relevant IEC/BIS codes.

20.2 The bidder shall submit the certificates of type tests performed on identical equipment as evidence of the compliance of the equipment with the type tests.

20.3 The bidder shall submit the certificates of routine and acceptance tests conducted on the purchased equipments.

20.4 All the routine/acceptance tests shall be performed at the manufacturer's works in the presence of owner's representative.

20.5 The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.

20.6 The bidder shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

21.0 DOCUMENTATION

21.1 The bidder shall submit the documents for electrical equipments as per the drawing and documentation schedule as given in this bid package.

21.2 A dedicated PC with licensed copy of documentation software shall be included in the scope of bidder for documentation of Electrical Engineering.

21.3 The software shall be used for preparing and updating the various documents such as general arrangement drawings, cable schedules, single line diagrams, control system drawings and equipment specifications etc.

21.4 The documentation software shall be same which is used by the bidder for electrical documentation.

21.5 The details of the documentation software shall be furnished in the technical offer.

21.6 Native files (editable copy) of all the electrical equipment sizing calculations or any other calculations, Load List etc. shall be submitted for owner's review and as final documentation.

21.7 Native file (editable copy) of AutoCAD or any other software used for preparing Engineering drgs. & docs. of all Engineering drgs. & docs. shall be handed over as final documentation.

21.8 ETAP Native file (editable copy) along with its base file & complete library or of any other software used for Electrical System Study shall also be submitted for owner's review as well as with final documentation.

22.0 TRAINING

22.1 Training shall be imparted to owner's personnel at manufacturer's works as under:

a) AC UPS: Two engineers for one week.

b) Variable Speed Drive: Two persons for one week.

c) Soft Starter: Two persons for one week.

d) Numerical relay: Two persons for one week.

23.0 VENDOR LIST

23.1 Make of all electrical equipment shall be as per the vendor list attached with this bid package.

23.2 Any other vendor shall be subject to PDIL/owner's approval.

23.3 Bidder shall indicate the make of all equipment in their offer.

24.0 INSTALLATION, TESTING AND COMMISSIONING

24.1 The bidder shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturers, drawings approved by the owner or owner's representative, direction of engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.

24.2 The bidder shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.

24.3 Bidder shall furnish field inspection and test data sheets for all equipments for owner's approval.

24.4 The bidder shall obtain the necessary certificate of compliance/completion certificate with test results from statutory authorities as required. All necessary drawings and test certificates as required by them shall be furnished by the vendor.

24.5 At least following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.

a) Insulation Test
b) Continuity Test
c) High Voltage Test
d) Simulation Test
e) Earth Resistance Test

25.0 COORDINATION WITH OTHER CONTRACTORS

25.1 The successful vendor shall coordinate with Owner's other vendors and shall freely exchange all technical information required for this purpose.

25.2 All civil works connected with electrical installation shall be under the bidder's scope.

26.0 DEVIATIONS

26.1 Deviations, if any from this standard (clause wise) shall be clearly indicated in the offer with reasons thereof. In the absence of any such deviation the compliance to the clauses shall be deemed automatically.

26.2 Successful Bidder shall also note that all those deviations mentioned in bid but not accepted by Owner/Consultant in writing shall be considered as withdrawn by bidder.

26.3 Any and all deviations mentioned anywhere else in the bid but not specifically and unambiguously mentioned under specific section 'List of deviations' shall not be considered.

ANNEXURE-I

ILLUMINATION LEVELS & TYPE OF FIXTURES

Average illumination levels and type of fixtures to be used for various areas shall be as follows:

Sl. No.	AREA	LUX	TYPE OF LED FIXTURES
1.0	**ROADS**		
1.1	Plant roads	15	90W LED street lighting fixtures
1.2	Security roads	6	90W LED street lighting fixtures
2.0	**YARD**		
2.1	Marshalling yard	12	90/125W LED flood light
2.2	Loading/unloading areas	15	90/125W LED flood light
2.3	Open areas	5	90/125W LED flood light
3.0	**PLANT**		
3.1	Operating platforms	100	50W LED
3.2	Non-operating platform / general process areas & walk ways	50	50W, 2X18W LED
3.3	Compressor house	150	50/90/125W, 2X18W LED
3.4	Turbine Hall	150	90/125 W LED
3.5	Pump house/Pump bay	150	90/125W LED
3.6	Top of cooling towers	50	90W LED
3.7	Boiler gallery	50	90W LED
3.8	DG Set Room	150	90/125 W LED
4.0	**SUB-STATION**		
4.1	Switch room - Front of panel	100	2X18W mirror optics surface mounted LED type
	- Back of panel	100	2X18W mirror optics surface mounted LED type
	- Battery room	70	2X18W corrosion proof industrial LED type
4.2	Transformer room, cable room.	70	2X18W industrial LED type
4.3	Outdoor/transformer bay	70	45/90W street lighting LED fixtures
5.0	**CONTROL ROOMS**		
5.1	Front of panel	400	2X18W Recessed Mounting Decorative LED
5.2	Back of panel	200	2X18W Recessed Mounting Decorative LED
6.0	OFFICES	300	2X18W Recessed Mounting Decorative LED
7.0	**STORES, BATH ROOM**	100	2X18W LED
8.0	**STAIR CASES**		
8.1	Safe areas	100	2X18W LED
8.2	Hazardous areas	100	90W LED
9.0	**PANIC LIGHTING**	-	24W/36W LED suitable for 110V DC
10.0	Diesel Oil Storage	100	90W LED

Wattage of LED fixture is tentative and may be changed to meet LUX requirement and necessary calculations shall be furnished during detailed engineering for review / approval.

PART-II, TECHNICAL

SECTION – 5.3

TECHNICAL SPECIFICATION – ELECTRICAL

Technical Specification No.	Description	No. of sheets
TS-8037	Public Address System	8
TS-8040	Uninterrupted Power Supply System	14
TS-8043	Power Transformers	13
TS-8044	Neutral Earthing Resistor	8
TS-8046	Capacitor Bank & Associated Equipment	11
TS-8048	Auxiliary Service Transformer	8
TS-8060	Medium Voltage Switch Boards	20
TS-8061	High Voltage Switch Boards	16
TS-8062	Medium Voltage Bus Duct	9
TS-8080	Sheet Steel Distribution Boards	14
TS-8083	Lighting Sub Distribution Boards	8
TS-8102	Induction Motors	14
TS-8120	Interlocking Sw. Socket and Plug	8
TS-8123	Lighting Fixtures & Accessories	13
TS-8140	Battery Charger	14
TS-8142	Battery	6
TS-8160	Cables	7
TS-8200	Local Control Stations	9
TS-8201	Junction Box	7
TS-8205	Ventilation System	12
TS-8206	Passenger cum Goods Lift	16
TS-8208	Electricals for Over Head Cranes and Hoists	13
TS-8211	Diesel Generator Set	18
TS-8301	Soft Starter	8
TS-8302	Variable Frequency AC Drives	20
TS-8303	Cathodic Protection for Plant Piping and Buried Facilities	23
TS-8304	Cathodic Protection Power Supply Module (CPPSM)	14
TS-8305	Cathodic Protection Transformer Rectifier Unit	14
TS-8306	Fire Detection and Alarm System	21
TS-8307	Communication & Fire Alarm Cables	10
TS-8308	High Mast	10

TECHNICAL SPECIFICATION

PUBLIC ADDRESS SYSTEM

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATIONAL REQUIREMENTS
5.0	TECHNICAL REQUIREMENTS
6.0	POWER SUPPLY
7.0	CABLES
8.0	CABLING
9.0	JUNCTION BOXES
10.0	EARTHING
11.0	ERECTION AND COMMISSIONING
12.0	DRAWINGS AND DOCUMENTS
13.0	SPARES
14.0	PACKING
15.0	DEVIATIONS
ANNEXURE - I	DOCUMENTION FOR PUBLIC ADDRESSS SYSTEM

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing, delivery installation at site and commissioning of Public Address System along with all accessories on turn-key basis.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of public address system and their accessories covered by this standard shall comply with the latest issue of the following and other relevant Indian Standards Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 1881	-	Code of practice for installation of indoor amplifying and sound distribution systems.
IS: 1882	-	Outdoor installation of public address system-code of practice.
IS: 1301	-	Code of safety requirements for electric mains-operated audio amplifiers.
IS: 8061	-	Code of practice for design, installation and maintenance of service lines up to and including 650 V.
IS: 3043	-	Code of practice for earthing.
IS: 1490	-	Recommendation for minimum performance requirements of mains-operated public address amplifiers.
IS: 1819	-	Recommendation for general requirements of public address amplifiers.
IS: 1031	-	Methods of measurements of loudspeakers and loudspeaker systems.
IS:1554 (Part1)	-	PVC insulated (heavy duty) electric cables for working voltages up to and including 1100 V.
IS: 694	-	PVC insulated cables for working voltage up to and including 1100 volts.
BS: 2004	-	Electric cables for working voltage up to and including 1100 volts.

2.2 The design and operational features of all the equipments offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 **System Details**

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATIONAL REQUIREMENTS

The public address system and their associated accessories shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variation indicated in Design Philosophy-Electrical without exceeding temperature rise limits as per relevant standards and without detrimental effect on any part.

5.0 TECHNICAL REQUIREMENTS

5.1 The public address system shall be microprocessor based, non-EPABX distributed amplifier type. It should be designed for communication between various process units and office areas of an industrial plant and various control room(s).

5.1.1 The band width of the communication system shall not be less than 9 KHz for intelligible speech reproduction required for industrial environment.

5.1.2 The system shall comprise of:

i) Microprocessor based central exchange
ii) Master control station(s)
iii) Field stations and junction boxes, if any
iv) Power supply unit
v) Cables
vi) Loudspeaker

5.1.3 All other items not specifically mentioned, but required for the completeness of the system shall be supplied.

5.2 **Microprocessor based central exchange**

5.2.1 The exchange shall be rack mounted microprocessor controlled. It should be designed such that future extensions or modification can be easily carried out.

5.2.2 The actual control of communication shall be from the exchange. From the exchange, various system information and data shall be acquired, processed and communication links between stations shall be established as per user requirement through master control station.

5.2.3 The exchange shall be 100% redundant in hot standby mode. The exchange shall have facility for hooking up with the existing EPABX system. It shall have two independent lines of communication viz. page & party.

5.3 **Master control stations (MCS)**

5.3.1 The MCS shall be desk mounted type and shall comprise of a keyboard with LEDs, a built-in loudspeaker and a built-in dynamic noise cancelling goose neck microphone. It should have facility for duplex mode of communication.

5.3.2 The MCS shall have a key to initiate an EPABX call and should have facility to receive EPABX call.

5.3.3 The MCS shall have features to initiate the following type of call:

i) All call

ii) Alarm call
iii) Conferencing
iv) Inter MCS call
v) Call from MCS to field station & vice-versa
vi) Global call
vii) Call from field station of one MCS to field station another MCS

5.3.4 The MCS shall have drop out facility i.e. after connecting two field stations, the MCS, if required, may drop out of the ongoing conversation. Priorities shall be assigned to the various calls (Alarm & Global) shall have higher priority than other calls.

5.4 **Field Station**

5.4.1 It shall be of cast aluminium (LM-6) enclosure and shall consist of adequate capacity amplifiers for page channel, telephone type handset (but made of unbreakable material and of different size to make it pilfer proof), cradle switch and all other necessary control switches & push buttons required for satisfactory operation of the system.

5.4.2 Handsets shall be completely factory wired up to terminal blocks and shall be provided with cable termination accessories for connecting external cables.

5.4.3 The field stations shall be suitable for hazardous area classification defined as zone I/II, gas group IIA/IIB/IIC & temperature class T3. All master control station shall be suitable for outdoor installation with IP-65 protection.

5.5 **Loudspeaker (LS)**

5.5.1 Loudspeaker shall be highly efficient, high power driver unit designed for non-ringing to deliver clear reproduction. The driver unit shall be lockable type to avoid pilferage.

5.5.2 Loudspeaker shall be provided with impedance matching transformer. Transformer shall have the minimum “frequency characteristic” required for public address system.

5.5.3 Loudspeaker for indoor mounting shall be direct radiator, permanent magnet moving coil type rated for 15W. However, loudspeaker for outdoor mounting and in areas with high ambient noise level shall be pressure unit operated, projector or horn type, weatherproof, rugged die-cast aluminium construction rated for 15W.

6.0 POWER SUPPLY

6.1 Power supply single phase, 240 V, 50 Hz shall be made available at one point only by owner. Further distribution, if required, shall be arranged by the vendor.

6.1.1 DC supply, if required, shall be arranged by the vendor from the dedicated power supply unit working on single phase 240 V, 50 Hz supply. DC supply shall have redundancy. Additional SMPS shall be provided.

6.1.2 The system shall be provided with a transistorised type UPS of one hour back-up and the battery used shall be Nickel-Cadmium type.

7.0 CABLES

7.1 Signal and loudspeaker cables shall have annealed tinned copper, twin twisted & colour coded, PVC sheathed, GI round wire armoured and PVC overall sheathed. Loudspeaker cables shall be of 24 / 0.2 mm copper and signal cable shall be of 16 / 0.2 mm copper.

7.1.1 For power cables, 3 core 2.5 sq. mm annealed tinned copper, PVC insulated armoured cables are required.

7.1.2 The bidder shall indicate the details & quantity of cables required in tabular form.

8.0 CABLING

The contractor shall supply, lay & connect at both ends all the cables with accessories. The cables shall be accommodated in the existing overhead cable racks / structures as far as possible; where racks are not available, the cables shall be laid underground by using GI protection pipes.

9.0 JUNCTION BOXES

The junction boxes shall be of die cast aluminium powder coated. These shall be complete with inspection cover, conduit glands and terminal stripes. The cover shall be gasketted to make it dust & vermin proof and IP-55 protection. Holes for screwing the covers shall have stainless steel inserts.

10.0 EARTHING

All the equipment and their associated accessories of public address system shall be provided with earthing terminals and shall be connected to the owner's ground mat by vendor as per relevant Indian Standard.

11.0 ERECTION & COMMISSIONING

The bidder shall quote for complete, testing & commissioning along with fittings & accessories. Good engineering practice in conformity with latest Indian Standard & code of practice shall be followed for erection & commissioning of all the accessories of public address system.

12.0 DRAWINGS AND DOCUMENTS

12.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

12.2 All drawings and documents shall have the following description written boldly.

i) Name of client
ii) Name of consultant
iii) Enquiry / order number with plant / project name
iv) Equipment Code no. and Description

13.0 SPARES

13.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments.

13.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

13.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

13.4 All spare parts shall be identical to the parts used in the equipments.

14.0 PACKING

The public address system shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

15.0 DEVIATIONS

15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR PUBLIC ADDRESS SYSTEM

Sl. No.	Documentation	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Guaranteed technical particulars	Y	Y	Y
2.	Outline drawing showing dimensions and other details.	Y	Y	Y
3.	Complete assembly drawings of equipments showing plan, elevation and cross section.	Y	Y	Y
4.	Schematic of field stations of each type.	Y	Y	Y
5.	Cable schedule with complete layout drawings	N	Y	Y
6.	Illustrative and descriptive catalogues	Y	N	Y
7.	Installation, operation & maintenance manual	N	N	Y
8.	Quality assurance program	Y	N	N
9.	Type test certificate for			
	i) Hose proof items	Y	N	Y
	ii) Flame proof items	Y	N	Y
10.	Test certificates	N	N	Y
11.	Guarantee certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

UNINTERRUPTED POWER SUPPLY

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	AMBIENT CONDITIONS & ELECTRICAL SYSTEM CHARACTRISTICS
4.0	DESIGN AND OPERATIONAL REQUIREMENTS
5.0	CONSTRUCTIONAL DETAILS
6.0	COMPONENT DETAILS
7.0	OPTIONAL ITEMS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY
ANNEXURE - II	METERING INDICATIONS AND ALARM SCHEDULE
ANNEXURE - III	LIST OF SPARES

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION
BD: 8040	BLOCK DIAGRAM FOR PARALLEL RUNNING REDUNDANT UPS SYSTEM

1.0 SCOPE

1.1 The specification covers the design, manufacture, testing at works and despatch in well packed condition of Uninterrupted Power Supply System required to supply AC power for non linear loads (i.e. instrumentation loads).

1.2 This standard shall be read in conjunction block diagram & UPS distribution diagram.

1.3 The scope shall include the following:

i) Full wave controlled rectifier

ii) Inverter

iii) Static switches

iv) Storage battery

v) Static voltage stabilizer for bypass supply

vi) Manual bypass switches

vii) Isolation / output transformer to achieve desired output voltage

viii) UPS Distribution Boards

ix) Interconnecting cabling between various units of UPS

x) All other items required, but not specified for safe and reliable operation of UPS system.

2.0 STANDARDS TO BE FOLLOWED

2.1 The equipment shall conform to the latest issue of the following and relevant Indian Standard specifications Equipment complying with equivalent IEC standards shall also be acceptable.

IS-13314	-	Solid state inverters run from storage batteries
IS-11260	-	Stabilized power supplies AC output
IEC-146	-	Solid state inverters

2.2 The equipment shall also conform to the provision of Indian Electricity Rules, Indian Supply Act and any other statutory regulations in force from time to time.

3.0 AMBIENT CONDITIONS & ELECTRICAL SYSTEM CHARACTERISTICS

These shall be as specified in the Design Philosophy-Electrical.

4.0 DESIGN AND OPERATIONAL REQUIREMENTS

4.1 The UPS unit and its associated equipments shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions indicated in Design Philosophy-Electrical without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.

4.2 The UPS system shall be based on latest generation of IGBT based, pulse width modulated (PWM) design with proven performance. The basic scheme required for UPS system shall be as indicated in Block diagram in this specification.

4.3 The UPS shall have Redundant Scheme with Bypass. Under normal operating conditions, both inverter units should run in parallel sharing 50% load in synchronism with by-pass power and supply uninterrupted A.C. power to load. On failure of one of these inverters, the faulty inverter should get automatically disconnected from the load and healthy inverter should supply 100% load in synchronism with by pass supply. In the event of second inverter also developing a fault, a no-break load transfer to standby power supply should take place through static switch.

4.4 Output frequency of the inverters must remain synchronised to one another which in turn shall be synchronised to the standby power supply frequency provided the latter does not vary by more than +3% to -5%. It should be possible to change the setting of frequency range of synchronism between above limits by frequency selector switch. Outside these limits inverter should desynchronise with the bypass and run at its own frequency. When running at its own frequency, frequency variation shall be maintained less than ±1.0%. Resynchronisation with bypass power supply must take place automatically with some time delay when frequency comes back to +3% to -5% range. Change-over from inverter to bypass or bypass to inverter shall also be possible in desynchronised mode of operation. Change-over time in both synchronised and desynchronised mode operation shall be indicated.

4.5 The UPS unit shall be suitable for 0.7 lagging to unity power factor. The overall power factor may be taken as 0.8 lagging.

4.6 The maximum waveform distortion of the output voltage shall not exceed 5% r.m.s. for linear loads and 10% r.m.s for non-linear loads. The UPS unit shall be suitable for operation for non-linear loads having crest factor of 3.

4.7 The inverter steady state output voltage and frequency (free running) variation shall not exceed ±1% for specified input power supply condition and no-load to full load condition.

4.8 Voltage dip / rise on sudden application / throw of 100% load or on changeover from inverter to bypass or vice versa shall not exceed 15% and shall be recovered within 100 m. sec. to rated voltage.

4.9 UPS shall be designed for overload of 125% for 10 min. and 150% for 10 sec. after which drooping characteristic shall come into operation.

4.10 On failure of the main supply, inverter unit shall continue to supply rated load from the battery bank for one hour duration.

4.11 Charger shall simultaneously supply entire power necessary for inverter and to keep the battery of required capacity in fully charged condition. Provision for automatic charging in both float and boost shall be made.

4.12 Battery shall be Nickel-Cadmium or Lead Acid Plate tubular positive plate or VRLA type as indicated in Design Philosophy-Electrical. The battery capacity shall be decided considering load power factor as 0.8, derating factor for ageing 0.8 and derating for minimum ambient temperature as applicable.

4.13 The ventilation fans, if provided shall be fully redundant and connected to the output from the inverter and an audio-visual alarm shall be provided on its failure. It shall be possible to operate inverter for about half an hour even after the failure of the fan without temperature rise inside the inverter cubicle exceeding the safe operating temperature limits.

4.14 In case of inverter failure due to any reason or overload, affected unit shall be isolated and changeover to other inverter or to bypass shall take place automatically.

4.15 Noise level at a distance or 1m from UPS panels shall not exceed 60 dB.

4.16 UPS system shall be provided with necessary control, protection, metering, indication, alarm & annunciation for reliable and safe operation of the system. The suggestive list is indicated in Annexure-II.

4.17 All semi-conducting devices shall be protected by fast acting semi-conducting fuses. These fuses shall be co-ordinated with load side HRC fuses.

4.18 The battery may be taken out of service for maintenance during which period it shall be possible for the inverter to continue operation taking power from the rectifier. The input filter of the inverter shall be suitably designed to take care of this operational requirement.

4.19 It shall be possible to vary the output voltage steplessly within ±5% of the specified output voltage. This adjustment shall be possible to be made when UPS is in operation.

4.20 UPS system shall be suitable for both floating output and earthing of one leg in case of single phase system / star-point in case of three phase system.

4.21 The UPS system shall have very high system of reliability having minimum MTBF of 50,000 hrs. Vendor shall furnish the value of MTBF, MTTR & availability factor.

5.0 CONSTRUCTIONAL DETAILS

5.1 The equipment shall preferably be supplied in enclosed, dust & vermin proof, floor mounted, sheet steel enclosure. In case, it is necessary to provide opening for ventilation, this should be closed by fine mesh. Minimum degree of protection for enclosure shall be IP-43 as per IS-13947.

5.2 Enclosure shall be fabricated with cold rolled sheet annealed steel of minimum thickness 2.0 mm.

5.3 The door hinges shall be concealed type. The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets without any discontinuities. Gaskets shall be held in position in groove in shaped sheet steel work or these shall be of U type.

5.4 All external hardware shall be zinc passivated steel. Hardware for fixing the removable parts shall be provided with retaining devices.

5.5 Panels shall be liberally designed. All components shall be so mounted that they are easily accessible for inspection and maintenance.

5.6 UPS unit shall preferably have separate panels for each rectifier inverter units, bypass supply, distribution boards etc. Various panels of UPS except distribution boards shall be mounted side-by-side & bolted together to form compact assembly.

5.7 Distribution boards shall be of fixed type single front execution in fully compartmentalised design and divided into distinct panels each comprising of bus-bar chambers, individual feeder modules and vertical cable alley.

5.8 Mounting height of components requiring operation and observations shall not be lower than 300 mm and higher than 1800 mm.

5.9 All the live parts which are accessible after opening the front cover / back cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Bus bars of distribution boards shall be PVC sleeved.

5.10 Nameplate consisting of black Perspex with white engraving shall be provided for each panel and for each equipment mounted on the front of the panel. Suitable label identification for each component mounted inside the panel shall also be provided.

5.11 All the wirings shall be properly laid and ferruled at both ends. PVC channels may be used for wiring. For control wiring, minimum 1.5 sq. mm copper conductor shall be used.

5.12 The power connections shall be made by PVC insulated flexible copper cables or taped copper / aluminium strip.

5.13 All power & control cables shall enter from the bottom.

5.14 Removable bolted aluminium gland plate, heavy duty compression type rolled aluminium cable glands, crimping type aluminium cable lugs for Al. cables and copper cable lugs for Cu. cables, pressure clamp / bolted type terminals etc. shall be provided for each incoming and outgoing cable.

5.15 Terminal blocks shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.16 A suitably sized earth bus shall be provided at the bottom of panel with provision for earth connection at both ends to purchaser's earth grid.

5.17 All panels shall be of same height so as to form a bank which shall give good aesthetic appearance.

6.0 COMPONENT DETAILS

6.1 All components shall conform to relevant IS / IEC standards and shall be of reputed make. Makes of all components shall be subject to purchaser's / consultant's approval.

6.2 Thyristors, diodes and transistors

The thyristors, diodes and transistors shall have adequate safety margins to withstand specified operating conditions. A factor of safety of minimum 4 shall be taken against voltage surges.

6.3 PCBs

All electronic control & monitoring printed circuit cards shall preferably be modular plug in type. Monitoring points shall be provided in each of the PCB, PCBs shall be firmly clamped in position so that vibration or long usage does not result in loose contacts. Failure of each PCB shall be indicated by visual alarm and indication. The visual fault diagnostic shall preferably indicate fault into various sections of the card.

6.4 **Transformers and Chokes**

All transformers and chokes shall be of dry type and air cooled. This shall be class 'H' insulated, vacuum impregnated. Class B insulated cast resin transformers and chokes shall be also acceptable.

6.5 **Electrolytic Capacitors**

These shall be polarised aluminium type I, suitable for long life and category I, as per IS-4317 or equivalent IEC. The capacitor shall preferably be self healing type. These shall be so located in inverter panels that the operating temperature does not exceed 65ºC maximum.

6.6 **Instruments**

Ammeters & voltmeters shall be moving coil type of class 1.5 accuracy as per IS-1248. These shall be flush mounting type of minimum size of 96 mm x 96 mm and shall have taut band scale of 240º. Frequency meter shall be of reed type having range of 45 Hz to 55 Hz.

6.7 **Static Switches**

Static switches shall be naturally commutated type with parallel inverse connected thyristors. These shall be rated for continuous duty for 100% load. Short time rated static switches are not acceptable.

6.8 **Voltage Stabilizer**

Voltage stabilizer shall be static type and shall satisfy the following requirements:

i) Maximum output voltage variation under steady state condition shall be ±3%.

ii) Maximum harmonic distortion shall be less than 5%.

iii) The output voltage shall be restored within ±2% of nominal value in less than 2 secs.

6.9 **Battery**

Battery along with accessories shall conform to Technical Specification TS-8142.

6.10 **Indication Lamps**

All indication lamps shall be of LED type suitable for the specified control voltage, having minimum illumination of 40 milli candela. The colour of the LEDs shall be as follows:

ON	:	Red
OFF	:	Green
FAULT	:	Yellow

6.11 **Moulded Case Circuit Breakers**

For isolating devices of various equipment, moulded case circuit breakers shall be used. These shall be provided with overload and short circuit protective devices and shall conform to IS 2516.

7.0 OTHER ITEMS

7.1 Monitoring System

7.1.1 Microprocessor based monitoring system for UPS to supervise the UPS operation and to print out the following data at a preset time automatically by using its own printer shall be provided.

i) Output voltage of UPS (Common)
ii) Output current of UPS (Common)
iii) Input DC voltage of each inverter
iv) Input voltage of each rectifier (Ph to Ph)
v) Input current of each rectifier
vi) Output current of each inverter
vii) Output voltage of each inverter
viii) Room temperature
ix) Input frequency of each inverter
x) Output frequency of each inverter

7.1.2 In addition to print out once in a preset time, above data shall also be automatically printed for the following conditions:

i) Power source change over from mains to battery and vice-versa.
ii) Change over of load from UPS to bypass supply and vice versa.
iii) On failure of UPS
iv) On failure of either inverter
v) Also facility for on demand print out of above data shall be provided.

7.1.3 On failure of UPS, the printer shall print out the waveform of the following:

i) Output voltage of UPS
ii) Output current of UPS
iii) Output voltage of each UPS
iv) Output current of each UPS

7.2 Insulation monitoring & automatic earth fault finding system

Insulation monitoring and automatic earth fault finding system shall be provided to detect earth fault in unearthed system. The system shall preferably be of the type which injects a low frequency alternating voltage between the earth and the network which is used for determining the insulation resistance and to detect and locate earth faults. There shall be fixed detectors located in incoming feeders of main distribution boards and portable detector for location of fault within a feeder. The fixed detector shall be connected to a central unit which can display a faulty feeder.

7.3 Potential free contact shall be brought to outgoing terminal for remote monitoring system for the following:

i) UPS-1 fault
ii) UPS-2 fault
iii) Load on inverter

iv) Load on bypass

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.3 The finishing shade shall be RAL 7035.

8.4 Electrostatic powder paint shall be preferred.

9.0 TESTS AND INSPECTION

9.1 The UPS units shall be subjected to tests as per relevant standards. The tests shall include, but not limited to the following:-

i) Rectifier & inverter soft starting
ii) Regulation test
iii) Heat run test for 8 hours
iv) Overload test
v) Test for changeover time in synchronised and desynchronised mode.
vi) Test for dynamic response and transient performance
vii) Sequence & transfer test
viii) Noise level measurement
ix) Test to check the selectivity of protective devices
x) Alarm test (simulation of various fault conditions)
xi) Measurement of harmonic distortion
xii) Ventilation test (operation without fan)
xiii) Insulation test
xiv) Current division in parallel UPS

9.2 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.3 These inspections, shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.

- Name of client
- Name of consultant
- Enquiry / order number with plant / project name

- Equipment Code no. & Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-III.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	Block Diagram	Y	Y	Y
4.	General Arrangement drawings and foundation plan	Y	Y	Y
5.	Calculation for battery sizing	Y	N	N
6.	Feeder Details for Distribution Boards	Y	Y	Y
7.	Descriptive literature and catalogues	Y	N	Y
8.	Bill of materials	N	Y	Y
9.	Schematic & Wiring Diagram	N	Y	Y
10.	Installation, operation & maintenance manual	N	N	Y
11.	Spare parts list with identification	Y	N	Y
12.	Test Certificates	N	N	Y
13.	Guarantee certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N – No

ANNEXURE – II

METERING INDICATIONS AND ALARM SCHEDULE

A. METERING

1. Incoming Voltmeter with selector switches for each incomer
2. Ammeter with selector switches for each incomer
3. Ammeter & Voltmeter at each inverter output and bypass output.
4. Frequency meter & power factor meter at one common point of output
5. Ammeter & Voltmeter at incoming of each UPS distribution boards
6. Ammeter at each rectifier output
7. Battery charge / discharge meter

B. LED INDICATION

1. A.C. Mains 'ON'
2. Rectifier output 'ON'
3. Load on inverter
4. Load on bypass
5. Inverter synchronised to mains
6. Battery on float
7. Battery on boost
8. Fault (one lamp for all types of fault)

C. AUDIO-VISUAL ALARM (with Accept, Reset & Test facilities)

1. Mains failure
2. Rectifier failure
3. Inverter output over voltage
4. Inverter output under voltage
5. Inverter fuse failure
6. Rectifier fuse failure
7. Fan failure
8. Inverter temperature high
9. Static switch failure
10. Bypass input failure
11. Inverter desynchronised

ANNEXURE – III

LIST OF SPARES

The following spare parts shall be quoted with recommended quantity along with the offer.

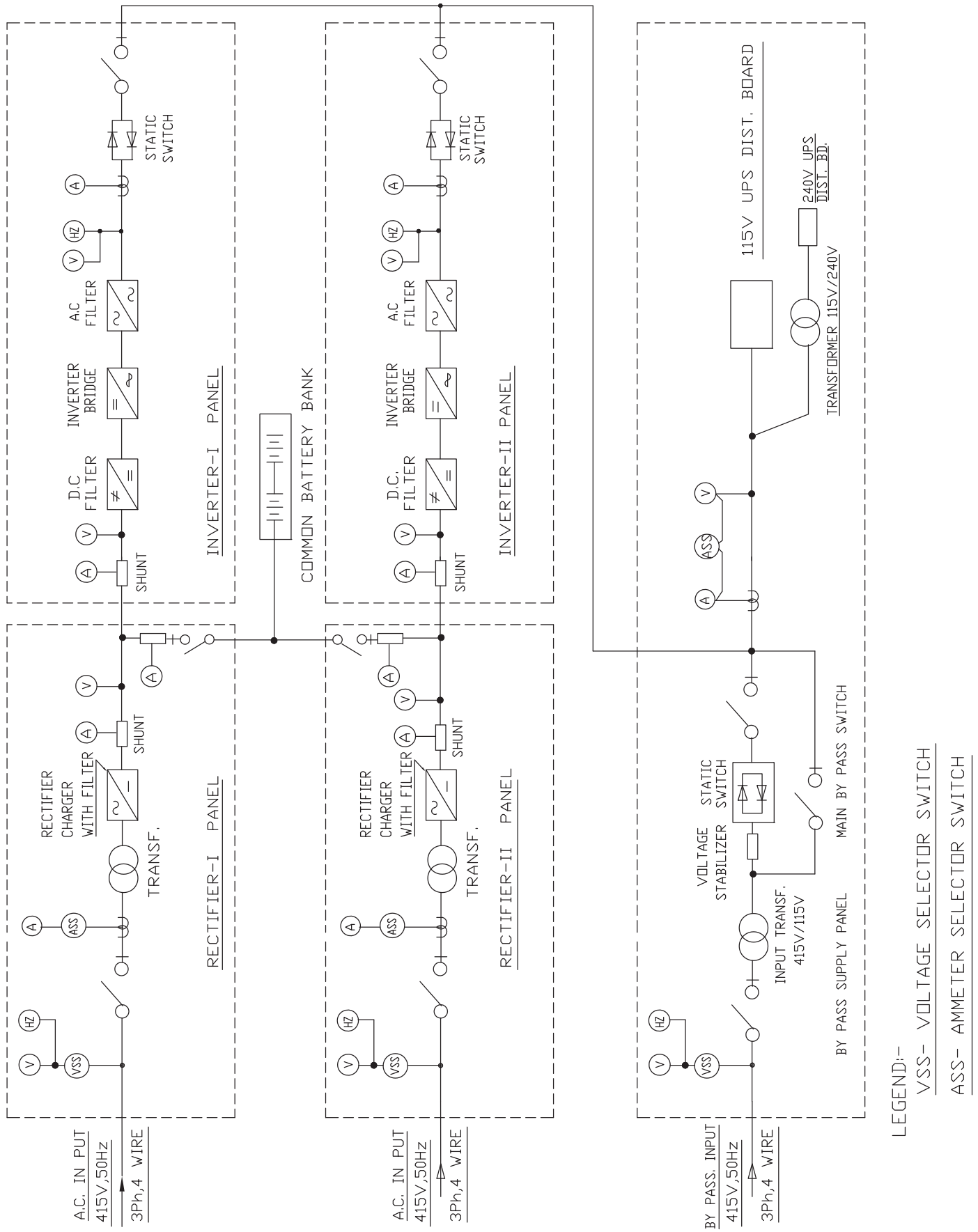
A. OPERATIONAL & MAINTENANCE SPARES

1. Ventilation fan
2. One of each type of PCBs
3. One of each type of thyristors, diodes & transistors (Min. 20%)
4. One of each type of capacitors, resistors & chokes (Min. 20%)
5. Semiconductor fuses & HRC fuse links of each rating 50%
6. MCCB & control switches one of each rating
7. Signal lamps 50%
8. Battery cells 2 nos. (Min. 5%)
9. Electrolyte 10%
10. Any other item not indicated but considered necessary

B. COMMISSIONING SPARES

Recommended commissioning spares shall be quoted.

पी डी आई एल PDIL	BLOCK DIAGRAM FOR PARALLEL RUNNING REDUNDANT UPS SYSTEM	BD : 8040	0
		DOCUMENT NO.	REV
		SHEET 1 OF 1	



TECHNICAL SPECIFICATION

POWER TRANSFORMERS

CONTENTS

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ANNEXURE - III	DOCUMENTATION FOR POWER TRANSFORMERS

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well-packed condition of Power Transformers.

1.2 This standard shall be applicable for 3 phase, core type, separate winding power transformers of rating 315 KVA and above.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS 2026, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The transformer shall be suitable for operating at the rated capacity continuously at any of the taps, under the ambient conditions and with the voltage and frequency variations indicated in Design Philosophy-Electrical without exceeding the permissible temperature rise and without any detrimental effect on any part.

4.2 The transformer shall also be capable of delivering rated current at a voltage equal to 105 % of the rated voltage.

4.3 The transformer shall be capable of allowing at least three consecutive starts of the largest Squirrel Cage Induction Motor, while delivering 85% of its rated power without any harmful effect on its insulation. It shall be possible to repeat the starting cycle once in eight hours.

4.4 The transformer shall be designed to be loaded as per IS 6600.

4.5 The transformer shall be so designed as to operate in parallel satisfactorily with similar transformers.

5.0 GENERAL DESIGN FEATURES

5.1 The design of the transformers shall be in accordance with the latest practice.

5.2 **Rated Voltage, Frequency and Phase Connection**

These shall be as indicated in Specification Sheet.

5.3 **Tap Changing Gear**

5.3.1 Each transformer shall be provided with on-load/ off-circuit tap changing equipment on the high voltage winding with taps, as specified in Specification Sheet. It shall be mounted on one side, in an easily accessible position.

5.3.2 The range of tap changer shall be as indicated in Specification Sheet and arranged in steps of 2.5% unless specified otherwise in Specification Sheet.

5.3.3 The off-circuit tap changing shall be affected by an externally operated handle capable of being padlocked in any position and provided with tap position indicator and mechanical stops at the extreme positions.

5.3.4 For transformer specified with on-load tap changer, tap changing gear shall be complete with tap position indicator, limit switch, lock and key and necessary control panel. Provision shall be made for auto-manual operation. The manual operation shall be possible both from the panel as well as from field. In case the tap changer is located in a separate housing, the housing shall be connected with the conservator for oil connection. A separate buchholz relay shall be provided in such a case. Emergency mechanical manual device shall also be provided. A minimum of 2 lakh trouble-free operations shall be guaranteed.

5.4 **Impedance Voltage**

The impedance voltage of the transformer at $75^{O}C$ shall be as indicated in Specification Sheet. This shall be guaranteed within limits specified in Specification Sheet at principal tap position.

5.5 **Losses**

The losses under the full load condition, at the rated voltage and frequency shall be indicated by the vendor at $75^{O}C$. These shall be guaranteed within the tolerable limits specified in IS: 2026 at principal tap position. The purchaser has the right to impose penalty charges or reject the transformer in case of any difference in the test and guaranteed values.

5.6 **Temperature Rise**

The temperature rise of the winding, oil and core shall not exceed the values specified in IS: 2026 when the transformer is delivering its rated output continuously under the service conditions as indicated in Specification Sheet.

5.7 **Insulation Level**

All windings up to maximum system voltage of 72 KV shall have uniform insulation to earth. For windings having higher maximum system voltage, graded insulation is acceptable.

5.8 **Terminal Arrangements**

The HV and LV side terminal arrangement shall be provided as specified in Specification Sheet. Disconnecting link chambers shall be provided on the transformer primary side in all cases as well as on secondary side, except where the termination is through bus duct. The disconnecting chambers shall be oil filled, preferably connected with the main tank through an isolating valve and also provided with a drain valve. However for system not exceeding 11 KV, air filled disconnecting chamber may be accepted. Suitable cable end box complete with cable glands and lugs shall be provided for termination of cables. Gland plate for single core cables shall be non-magnetic.

5.9 The transformer shall be able to withstand the electro-dynamic and thermal stresses due to terminal short circuit of the secondary, assuming the primary side fed from an infinite bus. All leads and windings in cores shall be properly supported, clamped and tightened after vacuum drying to ensure the short circuit withstand capacity. The short circuit withstand duration shall be 3 Secs.

5.10 The short circuit test results for similar transformers (same or higher rating) shall be furnished.

5.11 The transformer shall be so designed as to minimise any undue noise and vibration.

5.12 Due attention shall be given in the design for the suppression of harmonics.

5.13 **Cooling System**

5.13.1 The cooling system shall be as indicated in Specification Sheet. In case the transformer is designed for two types of cooling, the output rating for each type shall be indicated in the offer. The minimum acceptable output shall be 70% of rated output when forced type of cooling system is not in operation.

5.13.2 Wherever ONAF Cooling is specified, the cooling fans shall be adequately rated and shall be suitable for auto/manual and local/remote operation. Auto operation shall be through winding temperature indicator contact. Cooling fan motors may be group controlled and shall be suitable for DOL starting. Individual DOL circuit shall be provided with bi-metallic thermal overload relay, back up fuse, contactor etc.

6.0 CONSTRUCTIONAL FEATURES

6.1 **Core**

6.1.1 The transformer core shall be of high grade, non-ageing, electrical silicon cold rolled magnetic sheet steel of low hysterisis loss and high permeability. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall not exceed 1.7 Tesla. The core structure shall be securely grounded to prevent electrostatic potential. Lifting eyes and lugs shall be provided on the limbs and coils assembly. Preferably no bolt shall be used in the cores. Clamping shall be done external to the limb. Bolts passing through the yoke, if any, shall be insulated for 2 KV for transformers rated up to 33 KV and 5 KV for higher voltage ratings.

6.1.2 The temperature of the core shall not exceed that permitted in IS.

6.2 **Tank**

6.2.1 The tank shall preferably be made of mild steel plate of adequate thickness capable of withstanding stress not less than 0.40 kg/cm^2, properly welded and gusseted to ensure a rigid construction. It shall also be able to withstand normal transportation shocks without any deformation and shall be capable of withstanding following vacuum.

Highest System Voltage	MVA Rating	Vacuum in mm of Hg
Up to 72 KV	Up to 1.6	250
	Above 1.6 to 20	500
	Above 20	760
Above 72 KV	For all Ratings	760

6.2.2 For outdoor transformer, the top of the tank, the marshalling box and the headers of radiators, shall be of such a construction so as to prevent accumulation of water.

6.2.3 Guides shall be provided to facilitate tanking and untanking of the core with the coil assembly. The details of anchoring of core and coil assembly of the tank shall be furnished.

6.2.4 Radiators, where necessary, shall be provided on the tank to facilitate cooling. These shall be detachable type and shall be provided with isolating valves at ends, drain plug and air release plug. The radiators shall be fabricated out of minimum 1.25 mm thick seamless steel tubing or pressed sheet steel. For sizes up to 500 KVA, cooling tubes shall be acceptable.

6.2.5 Means for lifting and jacking of the transformer shall be provided.

6.3 **Windings**

6.3.1 Each coil shall be made out of paper insulated electrolytic grade copper conductor. Similar coils shall be interchangeable. Successive coils of a winding shall be connected by accessible joints and shall be brazed and finished smooth to prevent abrasive damage to insulation. There shall be no sharp bends in the connecting leads to prevent corona discharge. Aluminium foil wound transformer will also be acceptable.

6.3.2 The winding assembly shall be dried and impregnated in the vacuum with tested insulating oil. The insulation resistance and polarization index of the winding measured after impregnation shall be furnished in the test certificate.

6.3.3 For transformers rated 20 MVA and above vapour phase drying shall be adopted.

6.3.4 The magnitude of impulse surges transferred from HV to the LV winding by inductive and capacitive coupling shall be limited to a value below the rated impulse strength of the LV winding. The impulse voltage test results and surge distribution on windings for similar transformer shall be furnished.

6.4 **Insulation Materials**

6.4.1 Class ‘A’ insulating materials specified in IS 1271 shall be used. Paper insulation shall be new and free from punctures. Wood insulation, where used, shall be well seasoned and treated.

6.4.2 The mineral oil shall comply with IS: 335. 10% extra oil shall be supplied along with the transformer in non-returnable drums.

6.4.3 For the transformers required to be filled up with inert gas for transport purpose, the required amount of oil including 10% extra shall be supplied in non-returnable drums.

6.5 **Bushing**

The bushing insulator shall be rated for the maximum system voltage and shall comply with the requirements laid down in IS. The minimum current rating shall be 400 Amps. in case of overhead line connected transformers, the bushings shall be outdoor type having required creepage distances to suit the atmospheric condition and complete with arcing horns. In case of transformers connected with bus duct or cable, the bushings shall be enclosed in the terminal box. In either case, they shall be detachable from outside of the tank. The hardware shall be of tinned copper or nickel plated brass suitable to receive the conductor sizes as specified. Separate neutral bushings shall be provided for earthing the neutral, if indicated in Specification Sheet. All bushings shall be marked with the symbols corresponding to the connection diagram indicated in the diagram plate and in accordance with IS.

7.0 FITTINGS

7.1 Fittings as listed in Annexure - I shall be provided. Any other fittings which may be necessary for the satisfactory operation of the transformer shall also be provided on each transformer.

7.2 All fittings shall conform to relevant Indian Standard Specifications.

7.3 Fittings such as conservator and associated pipes, explosion vent pipe etc. shall be designed to withstand vacuum as specified in Clause 6.2.1 against atmospheric pressure.

7.4 Fittings such as rating plate, dehydrating breather, off-circuit tapping switch, dial type thermometer etc. which need to be observed/ operated, shall be mounted at convenient heights of not more than 1.5 M from the base of the transformer and located so as to be clearly visible from the front.

7.5 All opening shall be provided with gasketted metallic covers for protection during transportation.

7.6 All valves shall be of globe/butterfly type provided with blanking plates. The valve body shall be made of either Carbon Steel with trim of 13 Cr. steel or gun metal.

7.7 The rating plate, the terminal diagram and terminal marking plates shall be made of Aluminium and shall contain relevant details as per IS 2026. The Code No. of equipment shall be marked on a separate plate.

7.8 All terminals shall be anti loosening type and complete with connectors of required size. The earthing terminals shall have identification marks.

7.9 **Winding Temperature Indicator**

Winding temperature indicator for measuring hot spot temperature of the winding shall comprise of current transformer image coil, temperature sensing element, capillary tube jacketed with PVC sleeve, 150 mm dia. local indicating instrument with two pairs of contacts one for alarm and other for trip and maximum point indicator capable of being reset by hand without tools.

7.10 **Oil Temperature Indicator**

Oil temperature indicator for measuring top oil temperature shall comprise of 150 mm dial type thermometer, thermometer pocket and capillary tube jacketed with PVC sleeve. Thermometer shall have two pairs of contacts, one for alarm and other for trip and maximum point indicator capable of being reset by hand without tools.

7.11 **Buchholz Relay**

The buchholz relay as per IS 3637 shall be of double float type, provided with, two pairs of contacts, one for alarm and other for trip, facility for testing by injection of air by hand pump and with a cock for draining and venting of air. The relay shall be provided with shutoff valves on the conservator side as well as on the tank side.

7.12 The alarm and trip contacts of all protective devices shall be potential free and rated for 1 Amp at 110 V / 220 V D.C. as specified in Specification Sheet.

7.13 **Marshalling Box**

7.13.1 A marshalling box shall be provided to accommodate all auxiliary devices except those which are to be located directly on transformer or housed in a separate panel.

7.13.2 The marshalling box shall be dust, weather and vermin proof type made of sheet steel of not less than 2 mm thick. The box shall be rectangular in shape having sufficient space for easy termination of cables. The terminal block shall be pressure clamp type. 10% spare terminals shall be provided.

7.13.3 Suitable heavy duty double compression type rolled Aluminium cable glands for all incoming and outgoing cables shall be provided.

7.14 **Current Transformers**

The current transformers, if specified in Specification Sheet, shall be provided and shall comply with IS 2705. The C.T. terminals shall be accessible through a weatherproof removable cover for the purpose of testing etc. CT polarity shall be clearly marked. The C.T. for standby earth fault protection shall be 15 VA, 5P10. The C.T's for differential and restricted earth fault protection shall be of Class PS accuracy. The values of V_k and Imag for these CTs shall be furnished at the order stage.

7.15 **Wiring**

All controls, indication and protective devices provided on the transformer shall be wired upto the terminal block inside the marshalling box, by means of stranded copper heat resistant PVC insulated armoured cable of 1.1 KV grade and size not less than 2.5 sq. mm. Wiring shall be properly fixed on cable tray with at least 100 mm clearance from the transformer body. Suitable identification mark shall be provided on all wires.

7.16 All bought out items shall be of reputed make to be approved by Consultant/ Purchaser.

8.0 PAINTING

8.1 The surface to be painted shall be shot or sand blasted to remove all dust, scale and foreign adhering matter. All traces of oil and greases should be removed by suitable treatment.

8.2 All steel surfaces in contact with insulating oil shall be painted with heat resistant oil insoluble insulating varnish.

8.3 All steel surfaces exposed to outside shall be painted with suitable anti-rust and anticorrosive paints. Epoxy paints shall be used.

8.4 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.5 Unless otherwise specified, the finishing shade shall be light grey Shade No. 631 as per IS 5.

8.6 1 litre of paint per transformer shall be supplied for touch up at Site.

9.0 TESTS AND INSPECTION

9.1 All transformers shall be routine tested as per IS 2026. Transformer oil shall be tested as per IS 335.

9.2 Additional tests, wherever specified, shall be carried out on one transformer of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of Purchaser's representative. In addition, the transformers shall be subject to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the Vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 The drawings and documents as per Annexure-III shall be furnished, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly:

-- Name of Client
-- Name of Consultant
-- Enquiry / order number with plant / project name
-- Equipment Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipment as specified in Annexure-II.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The transformer shall be suitably packed to avoid damage in transit and shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil. Bushing shall be wrapped in straw ropes or similar material and complete transformer shall be packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 All loose pieces shall be separately wrapped in moisture resistant paper and marked with identification mark of the corresponding transformer.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

LIST OF FITTINGS

I. The fittings as given below shall be provided for all the ratings of transformers.

1. Oil Sampling Valve.
2. Filter valves with plug.
3. Radiator shutoff valves on top and bottom for each unit.
4. Buchholz relay shutoff valves.
5. Winding temperature indicator for 1000 KVA and above.
6. Oil temperature indicator.
7. Oil level indicator with minimum marking.
8. Oil conservator complete with drain plug and oil filling hole with cover.
9. Buchholz relay with air release device and alarm and trip contacts.
10. Silica gel breather with oil seal and connecting pipe.
11. Explosion vent.
12. Bi-directional rollers.
13. Inspection holes with cover.
14. Marshalling Box.
15. Rating Plate.
16. Diagram and Terminal marking plate.
17. Lifting lugs.
18. Jacking pad.
19. Earthing Terminals.
20. Air release device.
21. Neutral bushing for earthing.

II. The additional fittings as given below shall be provided.

1. Magnetic oil level gauge with low oil level alarm contact.
2. Hauling lugs for extra high voltage transformers.
3. Protective CTs for
   a) Stand-by earth fault.
   b) Restricted earth fault.
   c) Differential protection.
4. Bi-directional wheels if already bi-directional rollers not considered.
5. Skids.

ANNEXURE - II

LIST OF SPARES

The spare parts as given below shall be quoted for all the ratings of the transformers:

1. Bushings with accessories for all voltage grades.
2. Complete set of gaskets.
3. Explosion vent diaphragm.
4. Oil Level Gauge.
5. Complete charge of Silicagel.
6. Gland packing /O-rings for every valve.
7. Buchholz Relay.
8. Dial Type Thermometer.
9. One set of fixed and movable contacts for OLTC.
10. One set of fan and it's motor.
11. One set of pump and it's motor.
12. One set of switches, fuses and lamps etc. for Cooler Control Panel and OLTC panel.

Note:

1. Item 9 to 12 shall be quoted only where applicable.
2. All spare parts shall be identical to the parts used in the transformer.

ANNEXURE - III

DOCUMENTATION FOR POWER TRANSFORMERS

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2	Technical Particulars, duly filled-in	Y	Y	Y
3	Dimensional drawing for complete Transformer, Marshalling Box, disconnecting chamber, terminal chambers etc.	Y	Y	Y
4.	Schematic and Wiring Diagram	N	Y	Y
5.	Terminal arrangement drawing	N	Y	Y
6.	Installation, operation and maintenance manual	N	N	Y
7.	Catalogues and test certificates for bought out accessories	Y	N	Y
8.	Type test certificates of similar transformer	Y	N	Y
9.	Test Certificates	N	N	Y
10.	Guarantee Certificates	N	N	Y
11.	Spare parts list with identification marks	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

NEUTRAL EARTHING RESISTOR

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	ACCESSORIES
7.0	PAINTING
8.0	TESTS AND INSPECTION
9.0	DRAWINGS AND DOCUMENTS
10.0	SPARES
11.0	PACKING
12.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of Neutral Earthing Resistor for earthing the neutral of power transformers / generators for limiting the line to ground fault current.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS 3043, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The neutral earthing resistor shall be suitable for carrying the rated current for duration of 30 seconds under the specified ambient conditions and voltage and frequency variations without the temperature exceeding 350ºC.

4.2 The resistor shall be designed to carry continuously 20% of the rated short time current without any harmful effect.

4.3 The housing shall be sized such that temperature rise of the metal parts through which current is not required to pass, when rated current is passed for the specified period, shall not exceed 40ºC.

5.0 GENERAL DESIGN AND CONTRUCTIONAL FEATURES

5.1 Resistors

5.1.1 The total resistance of the bank at ambient temperature shall be as indicated in specification sheet.

5.1.2 The resistance bank shall be of heavy duty non-inductive type having high specific resistance and low temperature co-efficient.

5.1.3 The resistor elements shall be made of joint-less, non-corroding, sturdy and oxidation resistant AISI 304 / AISI 406 stainless steel of punched / formed construction.

5.1.4 The contact between elements shall be made by individually bolting the terminals of two adjacent elements and connecting them in series, parallel or combination of both to achieve the specified resistance. The interconnecting link shall be zinc plated copper of uniform cross section throughout.

5.1.5 The resistance grid shall be properly supported so that damage due to vibration and thermal or mechanical stresses is avoided.

5.1.6 Porcelain / Epoxy insulators rated for the highest system voltage shall be used to insulate the resistor elements from the body of the housing.

5.1.7 Insulation level for resistor bank shall be as follows:

Highest system voltage	Power frequency withstand voltage	Impulse withstand Voltage
Up to 3.6 KV peak	10 KV RMS	40 KV
7.2 KV peak	20 KV RMS	60 KV

5.2 **Metal clad housing**

5.2.1 The housing shall be fabricated out of 3 mm thick sheet steel fitted on a 6 mm thick mild steel frame work. This shall be floor mounting type and rectangular in shape.

5.2.2 It shall be suitable for outdoor installation and shall have minimum degree of protection IP: 43 as per IS 2147. Ventilating louvers, if provided, shall be covered by fine wire mesh from inside and shall be such that the above degree of protection for the enclosure is not altered. Top cover of the housing shall be slopping construction to prevent accumulation of water.

5.2.3 All external hardware below 8 mm size shall be of stainless steel and those of higher size of mild steel zinc passivated.

5.3 **Isolation Arrangement**

5.3.1 An isolator shall be provided on the incoming side to isolate the resistors from the main equipment. Where indicated in specification sheet a bolted link may be provided in lieu of the isolator.

5.3.2 The isolating switch shall be single pole knife type having a rating of 1.5 times the rated current of the resistor. The switch shall have four sets of potential free auxiliary contacts, 2 NO and 2 NC for remote indication, wired to a terminal block. An external handle, suitably insulated and lockable both in the ON and OFF positions, shall be provided for the switch. The handle shall preferably be mounted at a height of 1.5 meters from the base of the housing.

5.4 **Current Transformers**

Epoxy moulded current transformer shall be provided if specified in specification sheet of accuracy 5P for stand by earth fault protection and PS for restricted earth fault protection. The CT connections shall be brought to separate terminal box with shorting arrangement.

5.5 **Terminal Arrangement**

5.5.1 For incoming connection, either bushing or cable box arrangement, as indicated in specification sheet shall be provided. In case of bushing connection, the bushing shall

be provided on top of the housing. In case of cable box connection, the same shall be mounted on the side of the housing.

5.5.2 For the outgoing connection, cable box arrangement is to be considered in all cases. The cable box shall be mounted on the side of the housing.

5.5.3 Heavy duty double compression type rolled Aluminium cable glands shall be provided for all the incoming and outgoing cables.

5.5.4 The equipment terminals shall be anti loosening type and complete with tinned copper cable lugs suitable for cables of specified size. For bushing connections, suitable tinned copper conductor shall be provided as per conductor size specified.

6.0 ACCESSORIES

6.1 The equipment shall be complete with cable glands, cable lugs, drain plug, lifting hook, name plate, foundation bolts and all other accessories required to make the equipment complete in all respects.

6.2 Name Plate

6.2.1 Name plate shall be of stainless steel with letters embossed on them.

6.2.2 The name plate shall contain all the required details and shall include at least the following:

i) Make
ii) Description of code no. of equipment
iii) Short time rating
  a) Current
  b) Duration
iv) Rated voltage
v) Maximum temperature rise over ambient
vi) Total resistance at ambient temp.
vii) Materials of resistors
viii) Degree of protection of enclosure

7.0 PAINTING

7.1 The enclosure, after suitable pre-treatment shall be painted with two coats of antirust paint followed by two coats of anti-corrosive paints.

7.2 Epoxy based paints shall be used.

7.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

7.4 The finishing paint shall be light grey shade no. 631 as per IS 5.

8.0 TESTS AND INSPECTION

8.1 Following tests shall be carried out on the neutral earthing resistors:

8.1.1 Routine Tests

i) Resistance value measurement at room temperature.

ii) Power frequency high voltage test for one minute.

iii) Insulation resistance test.

8.1.2 Type test

i) Heat run test.

8.2 The above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and inspection at site for final acceptance.

8.3 The purchaser's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

9.0 DRAWINGS AND DOCUMENTS

9.1 The drawings and documents as per Annexure-I shall be furnished unless otherwise specified.

9.2 All drawings and documents shall have following descriptions written boldly.

- Name of the client
- Name of consultant
- Enquiry / order number with plant / project name
- Equipment code no. and Description.

10.0 SPARES

10.1 Spares for operation and maintenance

Item wise unit prices of following spare parts shall be quoted along with main equipment with recommended quantity.

i) Bushing with accessories

ii) Support insulators

iii) Resistor element

10.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

10.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

10.4 All spare parts shall be identical to the parts used in the equipment.

11.0 PACKING

11.1 The neutral earthing resistor shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

11.2 A sign to indicate the upright position of the panel for placing during transport and storage shall be clearly marked.

11.3 Packing box shall include one copy of the installation operation and maintenance manual

12.0 DEVIATIONS

12.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	General arrangement drawings	Y	Y	Y
4.	Illustrative and descriptive catalogues	Y	N	Y
5.	Installation, Operation and maintenance manual	N	N	Y
6.	Test Certificates	N	N	Y
7.	Guarantee Certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

CAPACITOR BANK & ASSOCIATED EQUIPMENT

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN FEATURES
6.0	PROTECTIVE SCHEME (PROVIDED BY PURCHASER)
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR CAPACITOR BANK & ASSOCIATED EQUIPMENT
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in packed condition of "Shunt Capacitor Bank & Associated Equipment" required for system power factor improvement.

1.2 The capacitor bank and associated equipment shall generally consist of the following.

i) Basic capacitor unit with built in fuse
ii) Discharge resistor
iii) Series reactor
iv) Residual V. T. for mounting voltage unbalance
v) Set of PVC sleeved copper bus bars interconnecting the basic units
vi) Set of supporting insulators
vii) Steel racks / cabinets of mounting capacitor units
viii) Door limit switch
ix) Control panel for automatic operation
x) Any other equipment not specified, but required for safe & proper operation of the system

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture & testing of the equipment covered by this specification shall comply with the latest issues of following Indian standards, unless otherwise specified.

IS: 2834	--	Shunt Capacitor for power system
IS: 5553	--	Series reactors
IS: 3156	--	Voltage Transformers
IS: 3123	--	Switch gear and control-gear for voltage up to & including 1000V & 1200V DC
IS: 4237	--	General requirements for switchgear and control-gear for voltage not exceeding 1000V & 1200V DC

2.2 The design & operation features of equipment shall also comply with provision of the latest issue of the Indian Electricity Rules & other relevant statutory acts & regulation. The supplier shall, wherever, necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever, any requirement laid down in this standard differs, from that in Indian standard specification, the requirement specified herein shall prevail. Equipment complying with equivalent IEC standards shall also be acceptable.

3.0 SERVICE CODITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 **System Details**

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIRMENTS

4.1 The capacitor bank and associated equipment shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variation under the ambient condition indicated in Design Philosophy-Electrical without exceeding the permissible temperature rise and without any detrimental effect on any part of equipment.

4.2 The capacitor bank and associated equipment shall be suitable for parallel switching and withstand the thermal and dynamic stresses caused by transient during switching operations.

5.0 GENERAL DESIGN FEATURES

5.1 **Capacitor Unit**

5.1.1 The capacitor bank / sub bank shall comprise of appropriate number of basic single phase units & which shall be connected in star formation to obtain rated KVAR at rated voltage.

5.1.2 Each unit shall have required number of capacitor elements housed in hermetically sealed, leak proof, sheet steel container. The container shall be provided with suitable brackets, supporting insulators, terminal & bushing for external connections.

5.1.3 Each element of basic units has its own built in fuse which shall isolate the faulty element automatically without affecting the healthy elements.

5.1.4 Capacitor shall be preferably self healing polypropylene type.

5.2 **Discharge Device**

5.2.1 A suitable discharge resistor of adequate rating shall be permanently connected across the terminals inside the container to discharge the residual voltage to 50V or less within 1 minute for capacitor rated upto 650V and within 5 minute for capacitor rated above 650V.

5.3 **Series Reactor**

5.3.1 A suitable series reactor conforming to IS: 5553 to limit the inrush current and suppress the harmonics shall also be provided whenever required.

5.3.2 The reactor shall be copper wound, non-magnetically shielded, oil immersed, natural cooled, sealed type and shall be provided with following fittings.

i) Oil sampling cum drain valves.
ii) Filter valves with plugs.
iii) Buchholz relay with shut off valves, air release device & alarm and trip contact.
iv) Oil temperature indicator with minimum marking.
v) Oil level indicator with minimum marking.
vi) Oil conservator complete with drain plugs and oil filling hole with cover.

vii) Silica gel breather with oil seal & connecting pipes.
viii) Explosion vent.
ix) Bi-directional rollers.
x) Thermometer pocket.
xi) Radiator with isolating valves.
xii) Marshalling box.
xiii) Rating plate, wiring diagram plate & terminal marking plate.
xiv) Lifting lugs.
xv) Earthing terminals.
xvi) Air release device.
xvii) Cable termination arrangement for incoming & outgoing device.

5.3.3 Dry type reactor shall only be offered if mentioned in specification sheet. Such reactors shall be class F/H insulated.

5.3.4 The reactor shall have linear volt ampere characteristics upto 150% of rated capacitor current.

5.4 **Residual voltage transformer**

5.4.1 3 phase dry type residual voltage transformer of adequate capacity to facilitate neutral unbalance protection and rapid discharging of capacitor shall be provided.

5.4.2 The primary winding of voltage transformer shall be star connected while the secondary winding shall be in open delta for connection to neutral phase displacement relay.

5.4.3 The accuracy class shall be 3P for protection & 1 for metering.

5.5 **Door limit switch**

5.5.1 A door limit switch suitable for mounting on the door frame of the capacitor room shall be provided for each bank. This door limit switch shall l be used to trip the power supply to capacitors with initiation of opening action of the door of the capacitor room.

5.5.2 A door limit switch shall be totally enclosed in the aluminium / cast iron housing, fully oil, water & dust tight and shall conform to utilization category AC11 / DC11 as per IS: 6875. This shall be fast actuation type provided with 6 sets of 1 NO & 1 NC contacts rated for 5 amps at 415V AC and 1A at 220V DC.

5.6 **Capacitor control panel**

5.6.1 Capacitor control panel for control, protection and automatic switching operation of MV capacitor bank shall be provided, if specified in specification sheet.

5.6.2 Capacitor control panel shall be of dust, damp & vermin proof construction having enclosure class IP-51 as per IS: 13947 Part-1.

5.6.3 The enclosure shall be fabricated out of the cold rolled sheet steel having minimum thickness of 2 mm. the doors shall have concealed hinges & provided with neoprene gaskets.

5.6.4 The panel shall be liberally designed. All the components shall be accessible from the front. It shall be possible to attend any component without the necessary removing adjacent ones. All the relays, meters, push buttons including lamps etc. shall be flush

mounted. The mounting height of components requiring operation & observation shall not be lower than 300 mm & higher than 1800 mm.

5.6.5 The capacitor control panel shall control the capacitor bank which in turn shall have a number of sub banks for easy of control & to maintain the desired power factor under varying load conditions.

The owner shall arrange C.T supply to sense the power factor. Necessary C.T., selector switch, power factor meter and power factor correction relay shall be provided in the control panel. In addition, the control panel shall have Photo manual selector switch and P.F. raise lower push buttons for manual operation. These common features shall be located near the incoming unit.

5.6.6 Each control shall be provided with TPN switch, voltmeter with selector switch, Ammeter with selector switch and other auxiliaries, as required to receive the incoming power.

5.6.7 No. of out going feeders for the control panel shall be decided as per the no. of sub banks to be controlled by it. Each feeder shall be provided with TP switch, fuses, contacts, “ON”& “OFF” indication lamps and other auxiliaries as required.

5.6.8 Required no. and size of heavy duty double compression type Aluminium cable glands suitable for incoming and out going power and control cables shall be mounted on removal gland plate provided at a minimum height of 75 mm from the bottom of the panel. Crimping type Aluminium and copper lugs for aluminium and for copper cable respectively shall be provided for termination of cables.

5.6.9 The control panel shall be complete with its base channels, foundation bolt etc.

5.6.10 A continuous earth bus of aluminium, running along the entire length of the lower part of the control panel shall be provided with lugs at two ends for connection with external earth grid. The minimum size of earth bus shall be 150 sq. mm.

5.6.11 Components Details

5.6.11.1 The switches shall be of capacitor duty type rated for 1.5 times the rated capacitor current with a minimum rating of 25 A and shall conform to IS: 13947.

5.6.11.2 The fuses shall be of non-deteriorating HRC link type and suitably rated for capacitor switching. These shall conform to IS: 13703.

5.6.11.3 All contactors shall be of capacitor duty type rated for 50% higher than rated capacitor current & shall conform to IS: 2959. Control supply voltage shall be 240V single phase AC unless otherwise stated. One set of NO & NC potential free contacts shall be made available as spare.

5.6.11.4 Ammeter, Voltmeter & power factor meter shall be of accuracy class 1.5 as per IS: 1248 of minimum 96 sq.mm size & shall have $0\text{-}240^0$ scale.

5.6.11.5 The push buttons & selector switches shall conform to utilisation category AC11/ DC11 as per IS: 6875. Contacts shall be rated for 5A at 415V AC and 1A at 220V DC. The push button shall be of momentary contact spring loaded type with a set of 1 NO & 1 NC contacts. The selector switches shall be stay put type and provided with oval shaped handless.

5.6.11.6 The signal lamps shall be LED type. Colour of lamp shall be “Red” for “ON” & “Green” for “OFF” signals.

5.6.11.7 Terminal blocks shall be pressure clamp type up to 35 sq. mm. cable and bolted lugs type for higher sizes of cables. The minimum current rating of terminal block shall be16A. 20% extra terminals shall be provided in the terminal block.

5.7 **External cable termination**

5.7.1 Each capacitor bank / sub bank shall be provided with proper termination arrangement where terminal connection from all the three phases shall be brought for connection with external cable. The termination arrangement shall include cable glands, cable lugs, termination kits, supporting arrangements etc. complete in all respect.

5.8 **Interlocks**

All necessary interlocks to ensure correct & safe operation of capacitor banks shall also be provided.

5.9 **Earthing**

Each basic capacitor unit shall be connected to the earth strip provided on the steel racks which in turn shall be connected to the main earth grid through two nos. suitable earth terminals provided on the racks.

6.0 PROTECTIVE SCHEME (PROVIDED BY PURCHASER)

6.1 The vendor shall confirm the adequacy of the protective devices and also suggest the setting and any other additional protective devices required.

7.0 ACCESSORIES

The supply shall include the following accessories.

7.1 **Control panel space heater**

The control panel shall be provided with a thermostatically controlled space heater, rated for 240V, 50Hz & controlled through double pole miniature circuit breaker.

7.2 **Name plate**

7.2.1 All the equipment shall be provided with name plates containing all the information's as per relevant standard.

7.2.2 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.2.3 Name plate of capacitor control panel shall be of black prespex with white engraving and of minimum 3 mm thickness while those on other equipment shall be of stainless steel.

7.3 **Steel racks**

7.3.1 Sheet steel racks shall be provided to house the capacitor units, residual P. T. etc. in tier formation.

7.3.2 The racks shall be suitable for assembly at site. The racks & hardware used for assembly shall be hot dip galvanized.

7.3.3 Any other accessories required but not specified, shall be supplied to make the capacitor installation complete in all respect and ensure safe & proper operation.

8.0 PAINTING

8.1 The sheet steel enclosure after degreasing, pickling in acid, cold rinsing, phosphatising passivating etc. shall be painted with two coat of anti-rust paints followed by two coats anti corrosive paints.

8.2 Epoxy based paint shall be used.

8.3 All paint shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handing.

8.4 Unless otherwise specified, the finishing shade shall be light gray shade no. 631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 All capacitor banks and control panel shall be subjected to routine tests as per IS: 2834 and its associated equipment as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works & site inspection.

9.4 These inspections shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have following description written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-II.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 All the equipment shall be properly packed before despatch to avoid damage during transport, storage & handling.

12.2 The packing box shall contain a copy of the installation, operation & maintenance manual.

12.3 A sign to indicate the upright position on the position of the package to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR CAPACITOR BANK & ASSOCIATED EQUIPMENT

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	General Arrangement Drgs. with Overall dimensions of the following equipment. - Capacitor bank - Reactor - Control panel	Y	Y	Y
4.	Foundation plan indicating certified dimensions floor opening, weight, clearance etc. - Capacitor bank - Reactor - Control panel	Y	Y	Y
5.	Schematic & wiring diagram	N	N	Y
6.	Descriptive literature of Various equipment	Y	N	Y
7.	Installation, operation & maintenance manual	N	N	Y
8.	Guarantee certificate	N	N	Y
9.	Test certificate	N	N	Y
10.	Spare parts list with identification marks	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - II

LIST OF SPARES

The following spare parts shall be offered along with the main equipment.

1. **For Capacitor Bank**

   i) Basic capacitor unit complete with built in fuse / and discharge device

   ii) Supporting insulators

   iii) Fuses

   iv) Set of gaskets

2. **For Control Panel**

   i) Single lamps

   ii) Relays of each type

   iii) Contactors of each rating

TECHNICAL SPECIFICATION

AUXILIARY SERVICE TRANSFORMER

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN FEATURES
6.0	CONSTRUCTIONAL FEATURES
7.0	FITTINGS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR AUXILIARY SERVICE TRANSFORMERS

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of auxiliary service transformers.

1.2 This standard shall be applicable for 3 phase / single phase, separate winding transformers of rating below 315 KVA used for Auxiliary services such as lighting, control, Instrument supply etc.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 1180 Part - 1 & 2	--	Outdoor type 3 phase distribution transformers up to and including 100 KVA, 11 KV
IS: 2026	--	Power transformers
IS: 11171	--	Dry type power transformers

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The transformer shall be suitable for operating at the rated capacity continuously at any of the taps, under the ambient conditions and with the voltage and frequency variations as indicated in Design Philosophy-Electrical without exceeding the permissible temperature and without any detrimental effect on any part.

5.0 GENERAL DESIGN FEATURES

5.1 Rated voltage and frequency

These shall be as indicated in Design Philosophy-Electrical.

5.2 **Phase connections**

5.2.1 Three phase transformer

The primary winding shall be connected in delta and secondary winding in star with neutral point earthed (Vector group Dyn-11)

5.2.2 Single phase transformer

Primary winding shall be connected between two phases of a 3 phase system or to the three phases in open delta execution as specified in specification sheet and secondary single phase winding shall have one terminal earthed with the tank through link inside the secondary terminal box.

5.3 **Tapping**

5.3.1 The transformers shall be provided with off circuit tap changer with tapping of ± 2.5% and ± 5%.

5.3.2 For transformers having primary 3.3 KV and above, tap changing shall be effected with an externally operated handle, capable of being padlocked in any position on the primary side.

5.3.3 For transformers having primary 415V and below, tap changing shall be effected by means of links in the terminal chamber on the primary side.

5.4 **Impedance voltage**

The impedance voltage of the transformer at 75ºC shall be 4% unless indicated otherwise in specification sheet.

5.4.1 **Losses**

The losses shall be indicated by the vendor and shall be guaranteed, within tolerable limits specified in IS: 2026 at rated voltage and frequency.

5.4.2 **Terminal Arrangement**

The primary and secondary side terminals shall be brought outside the tank through porcelain bushing in dust and weather proof terminal boxes, with links for tap changing where required and suitable heavy duty double compression type rolled aluminium cable glands and cable lugs for receiving cables. The neutral point of the secondary winding shall be brought out separately and earthed to the transformer body through test link. Terminal board for the primary and the secondary winding shall be amply sized and made of SRBP/ FRP materials.

5.4.3 **Resistance to short circuit**

The transformers shall be able to with stand electrodynamic stresses due to terminal short circuit of the secondary assuming primary side fed from the infinite bus.

5.4.4 **Cooling System**

Transformers rated up to 50 KVA shall be natural air cooled type and above 50 KVA shall be natural oil cooled / natural air cooled type as indicated in specification sheet.

6.0 CONSTRUCTIONAL FEATURES

6.1 **Core**

The transformer core shall be of high grade non ageing electrical silicon cold rolled magnetic sheet steel of low hysteresis loss and high permeability. The maximum flux density in any part of the core and yoke at rated voltage and frequency shall not exceed 1.7 Tesla for oil cooled transformers and 1.3 Tesla for air cooled transformers.

6.1.1 The tank for oil cooled transformer shall be made of mild steel plate of adequate thickness. Cooling tubes, where necessary, shall be provided.

6.1.2 Air cooled transformer shall be sheet steel enclosed having minimum thickness of 2.0 mm and shall be provided with suitable reinforcement as required. The minimum degree of protection for the enclosure shall be IP: 31. Ventilating louvers, if provided, shall be covered by fine wire mesh.

6.1.3 All external hardware shall be zinc passivated steel.

6.2 **Windings**

6.2.1 Coil shall be made out of electrolytic grade copper conductor.

6.2.2 Class-F / class-H insulating material shall be used for air cooled transformers.

6.2.3 For oil cooled transformer class-A insulating material shall be used. Mineral oil shall comply with IS: 325. 10% extra oil shall be supplied along with transformer in non-returnable drums.

6.2.4 Winding assembly shall be dried and impregnated in vacuum with tested insulating oil / varnish.

6.3 **Bushing**

The bushing insulators shall be rated for the maximum system voltage and shall comply with the requirement laid down in IS: 2099 / IS: 7421. The minimum current rating shall be 250A.

7.0 FITTINGS

7.1 Following fittings shall be provided for air cooled transformers.

i) Rating and diagram plate
ii) Lifting lug
iii) Primary and secondary cable boxes with heavy duty double compression type aluminium cable glands and lugs.
iv) Earthing terminals
v) Rollers (for 25 KVA and above)

7.2 In addition to the above following fittings shall be provided for oil cooled transformer.

i) Oil conservator complete with drain plug, oil filling hole with cover and oil level indicator with minimum marking.
ii) Silica gel breather
iii) Dial type thermometer
iv) Oil sampling cum drain valve
v) Explosion vent
vi) Air release plug

7.3 Any other fittings which may be necessary for satisfactory operation of the transformer shall also be provided.

7.4 All fittings shall conform to relevant Indian Standards.

8.0 PAINTING

8.1 The surface shall be painted after removing all dust, scale and foreign adhering matter. All traces of oil and greases should be removed by suitable treatment.

8.2 All steel surfaces in contact with insulating oil shall be painted with heat resistant oil insoluble insulating varnish.

8.3 All steel surfaces exposed to outside shall be painted with suitable anti rust and anti corrosive paints. Epoxy paints shall be used.

8.4 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.5 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

8.6 1 litre paint per air / oil cooled transformer shall be supplied for touch up at site.

9.0 TESTS AND INSPECTION

9.1 All transformers shall be routine tested as per IS: 2026.

9.2 Additional tests, wherever specified, shall be carried out on one transformer of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the transformer shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 The drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of Consultant
- Enquiry / Order No. with plant / project name
- Equipment Code no. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of following items as applicable shall be offered along with the main equipment with recommended quantity.

i) Bushing with accessories for all voltage grades

ii) Complete set of gaskets

iii) Oil level gauge (for oil cooled transformer only)

iv) Complete charge of silica gel with glass container (for oil cooled transformer only)

v) Gland packing / O-ring for every valve (for oil cooled transformer only)

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The transformers shall be suitably packed in wooden crates to avoid damage in transit. Oil cooled transformers shall be properly sealed so as to completely exclude oxygen and moisture from coming in contact with oil.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE – I

DOCUMENTATION FOR AUXILIARY SERVICE TRANSFORMERS

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	Dimensional drawing with terminal arrangement details	Y	Y	Y
4.	Illustrative and descriptive literature	Y	N	Y
5.	Installation, Operation and maintenance manual	N	N	Y
6.	Test Certificates	N	N	Y
7.	Guarantee certificate	N	N	Y
8.	Spare parts list with identification marks	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

MEDIUM VOLTAGE SWITCH BOARDS

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DESIGN AND CONSTRUCTIONAL FEATURES
6.0	COMPONENT DETAILS
7.0	ACCESSORIES
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR MEDIUM VOLTAGE SWITCH BOARDS
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Medium Voltage Switchboards.

1.2 This standard shall be applicable for the Power Control Centres, Power cum Motor Control Centres and Motor Control Centres.

1.3 This standard shall be read in conjunction with relevant Specification Sheets, Feeder details & Schematic diagrams etc.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise Specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS 8623	-	Specification for low voltage switchgear and control gear assemblies
IS/IEC 60947	-	Low-voltage switchgear and control gear (General Rules)
IS 5578	-	Guide for marking of insulated conductors
IS 10118	-	Code of practice for selection, installation and maintenance of switchgear and control gear
IS 11353	-	Guide for uniform system of marking and identification of conductors and apparatus terminals

Various components housed in the switchboards shall conform to the Indian Standard specifications as mentioned against the component details or IEC specifications.

2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations, as applicable. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification / IEC Specification, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The Medium Voltage Switchboards shall be suitable for operating at the specified rating continuously, with the specified voltage and frequency variations under the ambient

conditions indicated in Design Philosophy-Electrical, without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 The switchboards shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type sheet steel panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.

5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS/IEC 60947.

5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of sheet steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheets. Suitable reinforcement, wherever necessary, shall be provided.

5.1.4 The door hinges shall be concealed type.

5.1.5 All external hardwares shall be zinc passivated steel. The hardwares for fixing the removable parts shall be provided with retaining devices.

5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove, in shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.

5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones.

5.1.8 The layout of the component inside the module shall be liberal to facilitate maintenance and interconnecting wiring between the components shall not be subjected to any undue stresses at the bends.

5.1.9 Mounting height of components requiring operations and observation shall not be lower than 300 mm and higher than 1800 mm.

5.1.10 Inter panel barriers shall be provided.

5.1.11 All the live parts which are accessible after opening of front cover/cable alley cover/back cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Removal facility shall be provided for all such parts.

5.1.12 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

5.2 Panel Arrangement

The Switchboards shall be in drawout, single front/double front execution, fully compartmentalised type and divided into distinct panels, each comprising of:

i) A completely metal enclosed bus-bars compartment running horizontally the top.
ii) Individual feeder modules.
iii) Enclosed vertical bus-bars serving all modules, in case of multi-tier panels.
iv) A vertical cable alley.
v) Separate horizontal enclosure for all auxiliary power and control buses.

5.3 Circuit Breaker Controlled Feeders

5.3.1 The panels housing circuit breaker feeders shall be in single front draw out execution. The incoming and bus coupler circuit breaker feeders shall be in single tier formation while the outgoing circuit breaker feeders may be in double tier formation.

5.3.2 A suitable barrier shall be provided between the circuit breaker and the associated control, protective and indication devices including instrument transformers.

5.3.3 All the protective relays and meters shall be flush mounted type. The relays and meters pertaining to a particular circuit breaker shall be mounted on the same panel. Where it is not possible to accommodate all the relays and meters in the same panel, one metering panel shall be provided adjacent to the circuit breaker panel exclusively for that feeder. Location of these in the adjacent panel of other feeders shall not be acceptable.

5.3.4 A spacious cable chamber suitable for accommodation, support and termination of required number of power cables shall be provided at the back. No bare bus-bars or live connection shall intrude into the cabling space.

5.3.5 The switchboard shall be provided with following inter locks and safety features:

i) It shall not be possible to open the compartment door unless the breaker is drawn to isolated position.

ii) The withdrawn and engagement of a circuit breaker shall not be possible unless it is in open position.

iii) The operation of a circuit breaker shall not be possible unless it is in fully service, test or isolated position.

iv) It shall not be possible to close the circuit breaker in service position unless all auxiliary and control circuits are connected.

v) A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.

vi) Insertion of the manual mechanism shall render the motorised mechanism in operation.

vii) Circuit breaker ‘ON’, ‘OFF’ indication shall be provided at the back of each panel. Alternatively, alarm shall be provided in case panel back door is opened with breaker “ON”.

viii) Caution nameplate shall be provided at the back of incomer’s panels where terminals are likely to remain live and isolation is possible only from remote end.

ix) Automatic safety shutter, with Padlocking facility for locking in closed position, to completely cover the spouts for the bus-bars and cable connection when the breaker is withdrawn.

5.4 Switch/MCCB Controlled Feeders

5.4.1 The panels housing motor starter or other feeders shall be draw out type in single front or double front execution.

5.4.2 All components of one feeder shall be mounted on a rigid sheet steel chassis.

5.4.3 Each panel shall be divided into a number of modules in tier formation placed one above the other. These modules shall be closed on all sides.

5.4.4 The modules shall be so placed that largest one is placed at the bottom of the panel. Type modules shall be at least 300 mm from the base channel.

5.4.5 The number of modules shall be so decided that the cables in the cable alley are not over crowded. However the number of module in any panel shall not exceed six.

5.4.6 The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders respectively.

5.4.7 The minimum clear width of cable alley shall be 250 mm.

5.4.8 For MCC rated above 630 Amp. The incomer and bus coupler modules shall be located in individual single panel. For MCC rated for 630 Amp. and below the incomer and bus coupler modules shall be half the panel size.

5.4.9 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position and close the door unless the module is fully plugged in. Defeat interlock facility shall be provided.

5.5 Special Features of Draw out Modules

5.5.1 The module shall be fully draw out type with sheet steel chassis moving freely on the guides. Chassis of the same size shall be fully interchangeable.

5.5.2 The module shall have the following distinct mechanical positions:

i) Service -- In which both power and control contacts shall be made.

ii) Test -- In which power contacts shall be isolated but control contacts shall be made.

iii) Isolated -- In which both power and control contacts shall be Isolated.

Maintenance position shall be preferred.

5.5.3 Each position shall be clearly marked. Padlocking facility shall be provided to padlock the chassis in any of the position.

5.5.4 The movement of the chassis from one position to the other shall be controlled by using an appropriate racking mechanism. Stopper shall be provided to prevent over travel of the chassis beyond the isolated position.

5.5.5 The guiding system shall permit smooth movement of the module and the power and control contacts shall be self-aligning type so that accurate alignment of the contacts is ensured.

5.5.6 No wiring shall be taken to the door. Only the actuators of the push buttons and switches, lenses for the indicating lamps and Perspex cover for meters shall be mounted on the door.

5.5.7 The power contacts shall be of plug-in/stab-in type made of silver plated copper, spring loaded and of adequate current carrying capacity. The contacts shall be so designed that contact pressure is maintained both under normal and short circuit conditions.

5.5.8 The parting contacts, both on bus-bar side and outgoing cable side, shall always be copper to copper and both sides silver plated. A bimetallic strip shall be used where two dissimilar materials are in contact.

5.5.9 The drawout type mechanism shall be screw racking in and out mechanism with handle to be provided for the same and not pull and push rack in rack out arrangement.

5.6 Bus-Bars and Connections

5.6.1 The bus-bars shall be for three phase and neutral. The main bus-bars and connections shall be made of high conductivity Aluminium alloy conforming to grade E 91 E of IS 5082 / electrolytic grade copper of rectangular cross-section. Auxiliary bus-bars for control supply, space heater supply etc. shall be made of electrolytic copper.

5.6.2 The horizontal bus-bars shall be insulated with heat shrinkable PVC sleeves of reputed make to protect against approach to live parts. The vertical bus-bars shall be sleeved or shrouded by barriers. Removable type insulating shrouds shall be provided for all joints of horizontal bus-bars.

5.6.3 The bus-bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding temperature limits specified in IS: 8084. The thermal rating of the bus-bars shall be designed to withstand the system fault current for 1 second without exceeding the limiting temperature of 200ºC for bare Aluminium/Copper. Calculation for bus-bars sizing shall be furnished along with the offer.

5.6.4 Horizontal bus-bars shall be of the same cross-section through out. Stepped bus-bars shall not be acceptable.

5.6.5 The bus-bars shall be arranged and colour coded according to IS: 5578 / IS: 11353.

5.6.6 The bus-bar chamber shall be sufficiently spacious and shall have separate screwed covers for maintenance purpose.

5.6.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built-in anti-tracking barriers. The support materials shall be of DMC or fibreglass reinforced thermosetting plastic.

5.6.8 Bus-bar joints shall be between the two transporting sections only.

5.6.9 A minimum of two bolts shall be used in bus-bar joints. Only high tensile electric galvanized bolts, nuts and washers shall be used.

5.6.10 In case of Aluminium bus-bars, all joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion.

5.7 Earth Bus

A continuous earth bus of Aluminium, running along the entire length of the lower part of the switchboard shall be provided with lugs at two ends for external connections. The minimum size of earth bus shall be suitable for carrying three phase fault current for 1 sec.

5.8 Bus Duct

5.8.1 Suitable extension of bus-bars in proper phase sequence on the top or bottom as specified in Specification Sheet, with the connecting bolts shall be provided where connection of transformer to switchboard is specified to be through bus duct.

5.8.2 Bus duct between two halves of a switchboard, if required, shall be supplied by the switchboard manufacturer. The bus-bars of interconnecting bust duct shall be similar to the main bus-bars of the switchboard and as specified above.

5.8.3 Bust duct between transformer and incoming breaker panel, if included in Vendor's scope, shall conform to TS-8062.

5.9 Clearances and Creepage Distances

5.9.1 The clearances and creepage distances shall not be lower than the values specified below:

i) Minimum clearance between two live conductors -- 20 mm

ii) Minimum clearance between live parts and accidentally dangerous part -- 20 mm

iii) Minimum creepage distance -- 28 mm

5.9.2 The clearances and creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulation, separators or barriers shall not be considered to reduce the clearance from the values specified above.

5.9.3 At the termination points in the equipment e.g. switches, contactors, thermal relays etc. It is realized that above clearances may not always be possible to be maintained. All such points, where above clearances and creepage distances are not possible to be maintained, shall be insulated or taped.

5.10 **Insulation**

5.10.1 The insulation used shall be non-hygroscopic and may be of porcelain, epoxy resins or fibreglass moulded with plastic. It shall be of adequate electrical, mechanical and thermal strength to give trouble free service during normal operation and short circuit conditions.

5.10.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

5.11 **Power Wiring**

5.11.1 The connections from bus-bar to individual functional unit on the modules shall be of PVC insulated flexible copper cables or taped Copper/Aluminium strip.

5.11.2 The power wiring size shall be decided based on rating of the switch/breaker after using a rating factor of not more than 50% over the current rating in free air.

5.11.3 Power wiring size selected for breaker controlled module shall also be able to withstand full short circuit current for duration of 0.25 sec.

5.11.4 In any case minimum size of power wiring shall not be less than 4 sq. mm copper.

5.11.5 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus-coupler shall not be less than the size adopted for horizontal bus-bar.

5.12 **Control Wiring**

5.12.1 The switchboard shall be completely factory wired and ready for external connections.

5.12.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:

C.T. Circuit -- 2.5 sq. mm

V.T. and Control Circuits -- 1.5 sq. mm

5.12.3 All wiring shall be provided with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

5.12.4 Control wiring circuits, fed from a supply common to a number of panels, shall be so protected that failure of a circuit in one panel does not effect the operation of the other panels.

5.12.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and so supported that on opening of the door there is no undue strain on wire leads.

5.12.6 The control cables shall be neatly arranged and property supported.

5.13 **External Cable Termination**

5.13.1 All power and control cables shall enter the switchboard from the bottom. Sufficient space shall be provided for ease of connection and termination of cables.

5.13.2 The type, number and sizes of cables shall be as indicated in Feeder details.

5.13.3 Double Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.

5.13.4 The cable glands shall be of rolled Aluminium or nickel plated brass heavy duty double compression type and shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two number spare knockouts of size 20 mm shall also be provided on the gland plates for future use. Gland for termination of single core cables shall be nonmagnetic type.

5.13.5 For all power cables, crimped type Aluminium lugs for Aluminium cables and tinned Copper lugs for Copper cables shall be provided.

5.13.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable sizes and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.

5.13.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.

5.13.8 Suitable clamps to support the vertical run of cables shall be provided.

5.13.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.13.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.14 **Feeder Details**

5.14.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagrams.

5.14.2 Interlocks shall be provided between incomers and bus section panels. The interlocks shall be either electrical or mechanical type. In addition, arrangement for defeating the interlock shall also be provided to facilitate manual changeover.

5.14.3 Auto changeover scheme, wherever specified, shall be provided.

5.15 **Dummy Panels**

Dummy panels complete with bus-bar system in 400 mm width may be required for which unit price shall be indicated.

5.16 **Control Power Supply**

5.16.1 D.C. Power required for closing, tripping and indication of circuit breaker feeders shall be supplied at the bus coupler panel through two completely separate circuits by owner, one for tripping and other for closing and indication.

5.16.2 For receiving each external control supply, a double pole miniature circuit breaker shall be provided. This power shall be distributed inside the switchboard for each circuit breaker feeder having its MCB unit.

5.16.3 Reference schematic diagram for A.C. control supply through control transformer for switchboards with buscoupler (PDS E: 412) shall be suitably modified such that control bus shall have option to switch to other bus control supply for redundancy in case of failure of auxiliary transformer and isolation of auxiliary transformer to be from incoming and outgoing to be made possible by suitably rating MCB.

5.16.4 Control supply for all motor feeders shall be fed by MCB and not fuses.

5.17 **Space Heater Power Supply**

5.17.1 Panel space heater shall be fed from a separate bus common for the whole board. This bus shall be fed from owner's supply for which a double pole MCB shall be provided in bus section panel.

5.17.2 Power supply for space heaters of motors shall be tapped from this bus by means of a MCB located in the motor feeder compartment. These MCBs shall be of triple pole and rated for 15 Amp.

6.0 COMPONENT DETAILS

Components of the switchgear shall ensure type of coordination 'C' as per IS:60947 (Part 4/ Section 1). The make of the components shall be as specified elsewhere in the NIT.

6.1 **Circuit Breaker**

6.1.1 The circuit breakers shall comply with the requirement of IS/IEC 60947.

6.1.2 All circuit breakers shall be of P2 (0-3 min - CO - 3 min - CO) category, capable of carrying the specified current at the site conditions and making/breaking of the system fault current.

6.1.3 Type test certificates from an independent testing authority shall be furnished along with the offer for each circuit breaker rating and type.

6.1.4 The circuit breakers controlling motors shall be suitable for DOL starting and stopping of induction motor a number of times.

6.1.5 The circuit breakers controlling capacitors shall be suitable for energizing and de-energizing the rated capacitor bank.

6.1.6 Incomer & Bus coupler circuit breakers shall be of the 3 phase, 4 pole horizontal draw out, horizontal isolation, air break type whereas motor feeder breaker shall be of the 3 phase, 3 pole horizontal draw out, horizontal isolation, air break type.

6.1.7 The circuit breaker shall be suitable for electrical or manual closing as specified. Manual operated breakers shall have independent manual spring closing mechanism. In case of electrically operated breaker, it shall have motor wound spring mechanism. In all cases tripping shall be by means of shunt trip coil.

6.1.8 All circuit breaker units of the same rating shall be physically and electrically interchangeable.

6.1.9 The circuit breakers shall be electrically and mechanically trip free and provided with anti-pumping feature.

6.1.10 Provision shall be made for slow closing for maintenance purposes. A suitable handle shall be provided one for each board for this purpose.

6.1.11 The circuit breakers shall have three positions i.e. service, test and isolated with the cubicle door closed. Necessary stoppers shall be provided to prevent the excessive movement of the breaker cradle than desired for the position. Service and test positions of the breaker shall have monitoring switch having 1NO+1NC contacts.

6.1.12 The circuit breaker shall be provided with emergency manual trip device, mechanical 'ON', 'OFF' and 'ISOLATED' position indicators and operation counter.

6.1.13 A maintenance truck/device for raising, lowering and withdrawal of the circuit breaker shall be supplied for each switch board.

6.1.14 The arc interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits, without requiring excessive maintenance of the contacts. The arc shall be restricted within the interrupting chamber and no emission of flame shall be allowed which may cause electrical breakdown or damage to insulation on the apparatus.

6.1.15 The main contacts shall be self aligning, adjustable and replaceable type.

6.1.16 The arcing contacts shall be easily accessible for maintenance and inspection and shall be easily replaceable type. They shall be provided with, contact face of special arc-resisting and non-pitting metal.

6.1.17 Mechanical safety interlock shall be provided for safe operation and movement of the breaker.

6.1.18 The circuit breakers shall be provided with minimum of four normally open and four normally closed auxiliary switch contacts, over and above those required for its own control scheme, for Owner's use. The contacts shall be wired separately to the terminal board.

6.2 Moulded Case Circuit Breakers

6.2.1 The circuit breaker shall conform to IS/IEC 60947 and shall be of P2 category having rupturing capacity as specified in Specification Sheet and mounted on a draw out chassis.

6.2.2 The circuit breaker shall be provided with spring assisted quick make quick break type manually operated trip free mechanism, mechanical 'ON', 'OFF' position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB Chassis shall be provided with service, test and isolated position and automatic safety shutter.

6.2.3 The thermal and short circuit tripping devices shall be adjustable type.

6.2.4 When used for motor circuits, shunt trip device shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.

6.2.5 In addition, under voltage trip shall be provided.

6.3 Switches

6.3.1 The switches shall be motor duty type AC 23 Category and shall comply with the requirements laid down in IS/IEC 60947. Switches up to 63 Amps shall be rotary type and those of 100 Amps. & above, link type.

6.3.2 'ON' and 'OFF' position of the switches shall be indicated on the module. Provision shall be made to lock the switch in the 'OFF' position.

6.3.3 The fixed contacts shall be shrouded type. All contacts shall be silver plated.

6.4 **Fuses**

6.4.1 The fuses shall be of non-deteriorating HRC cartridge link type and shall conform to IS: 13703. They shall be suitable for the load and service required in the circuit.

6.4.2 One fuse puller shall be supplied along with each board.

6.5 **Air Break Contactors**

6.5.1 The Air Break Contactors shall be of Category AC3/AC4, unless otherwise specified, conforming to IS: 60947 and flapper type.

6.5.2 The dropout voltage shall not exceed 65% of rated voltage.

6.5.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages. The spare auxiliary contacts shall also be wired up to the terminal blocks.

6.6 **Bimetal Thermal Overload Relays**

6.6.1 The contactor shall be provided with three pole bimetal thermal overload relays, unless other-wise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with changeover contact. Thermal relays having long time/current characteristics, operated through saturated C.T.s shall be supplied, wherever required.

6.6.2 Bimetal thermal relays shall conform to IS: 3231 and IS/IEC 60947 and shall have built-in single phasing preventor.

6.6.3 The bimetal relays shall be provided with a manual resetting device resetable after opening module door. Auto reset thermal relays are not acceptable.

6.7 **Current Transformers**

6.7.1 The current transformers shall conform to IS: 2705.

6.7.2 C.T.s shall be Class F insulated and vacuum impregnated or resin cast. The C.T.s shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.7.3 The short time thermal withstand ratings of C.T.s shall be same as the thermal withstand rating of the breakers.

6.7.4 The C.T.s output shall be minimum 15VA for breaker feeders and 7.5 VA for the other feeders per phase and in any case, the output shall be adequate for the protection and metering duties involved with sufficient margin. The C.T.s shall have the following accuracies for the various applications:

	Application	**Class of accuracy as per IS: 2705**
i)	For metering service	- 1
ii)	For use with protective relays	- 5P

iii) For use with restricted earth fault and differential relays - PS

6.7.5 The C.T. cores for metering and protection shall be separate.

6.7.6 The ratio of C.T.s shall be as specified in Feeder details.

6.7.7 All the C.T.s shall be provided with terminals and shorting links. One of the terminals of the C.T. shall be earthed. The polarity of the C.T.s shall be clearly marked.

6.7.8 Provision of Interposing C.T.s is not acceptable.

6.7.9 The C.T.s shall be capable of withstanding momentary open circuit on the secondary side without injurious effects.

6.8 **Voltage Transformers**

6.8.1 The V.T.s shall be Class F insulated and vacuum impregnated or resin cast conforming to IS: 3156.

6.8.2 The primary nominal voltage shall be equal to the system nominal voltage. The secondary terminal voltage shall be 110 V.

6.8.3 The primary and secondary winding shall be protected by HRC fuses in each phase except in the ground phase of the secondary side.

6.8.4 The V.T.s shall be mounted on separate withdrawable carriage. The accuracy Class of V.T.s shall be 1.

6.8.5 The rated output of each V.T. shall be adequate for the relays, meters and associated wiring connected to it and shall not be less than 50 VA per phase.

6.9 **Control Transformers**

These shall be air cooled Class F insulated and vacuum impregnated. The rating of control transformer shall be twice the hold on VA of all contactor/relays or 2.5 KVA whichever is high. It shall be free from hum and rigidly mounted. Epoxy cast transformers shall be preferred.

6.10 **Transformers for Kondorffer Starting**

These shall be three phase core type, Class F insulated and vacuum impregnated. Tapping at 90%, 80%, 70% & 60% shall be provided and terminals shall be brought out for easy change of tapping at site. The operating temperature shall not exceed 80ºC. The transformers shall be suitable for taking 7.5 times the specified full load current of the motor continuously for 120 secs.

6.11 **Relays**

6.11.1 All protective relays shall be of latest version, microprocessor based numerical type with communication port and interlinked with online energy management system. 100% redundancy shall be provided for communication.

6.11.2 Motor above 45KW shall be provided with electronic/numerical/microprocessor based relay in additional to thermal overload and fuse.

6.12 **Timers**

6.12.1 The timers shall be electronic pneumatic or synchronous type with manual/auto reset features as per the functional requirements. The time delay shall be 'ON' delay or 'OFF' delay type as specified. The repeat accuracy shall be 0.5% or better.

6.12.2 All contactor fed motor feeder shall be provided with off delay timer to avoid tripping of motor in power dip situation.

6.13 **Single Phasing Preventor**

6.13.1 Single phasing preventor relay shall be of the current operated type, suitable for the system voltage. The relay shall not operate for normal system voltage but operate positively in the event of unbalanced voltage more than the normal. The relay shall not operate in case of total interruption of power.

6.13.2 The relay shall be fail safe, self reset type and provided with flag indication. The relay operation shall be independent of the motor rating, loading and speed.

6.14 **Instruments and Meters**

6.14.1 All instruments shall be flush mounting type with square face of 96 mm x 96 mm. They shall be tropicalized and dust tight.

6.14.2 Meters shall be digital multifunctional meters with communication port for energy management at remote location.

6.14.3 All ammeters and voltmeters, to be provided separately, shall have 0-90º scale and shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248. The scale range of the ammeters and voltmeters shall be as indicated in the Feeder details.

6.14.4 In case of motor feeders, the ammeters shall be graduated uniformly upto C.T. primary current and with compressed end scale upto 6 times C.T. primary current. Red pointer shall be provided, which shall be adjusted at site for indicating full load current of the motor.

6.15 **Push Buttons and Control Switches**

6.15.1 The switches and push buttons shall conform to utilization category AC11/DC11 as per IS: 60947. The contact shall be rated to make, break and carry inductive current of 5 Amp at 415 V AC and 1 Amp at 220 V DC.

6.15.2 The control switches shall be spring return rotary type, unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.

6.15.3 The selector switches shall be stay put rotary type and provided with oval shape handles.

6.15.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for 'Start' shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.

6.15.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.16 **Miniature Circuit Breakers**

6.16.1 The miniature circuit breakers shall conform to IS: 8828 and shall be of duty category M-9.

6.16.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.

6.16.3 A certificate for short circuit rating and Current-Time tripping curve shall be furnished along with the offer.

6.17 **Signal Lamps**

6.17.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows :

Red	--	Circuit breaker/switch/contactor closed.
Green	--	Circuit breaker/switch/contactor open.
White	--	Trip circuit healthy.
Amber	--	Alarm and auto trip.
Blue	--	Non-Trip

6.17.2 All lamps shall be of LED type with lumen output of 200 mili candela in axial direction.

6.17.3 Universal LED lamp with operating voltage of 24-240V AC/DC shall be supplied for ease of replacement and spare maintenance.

7.0 ACCESSORIES

7.1 The supply shall include the following accessories:

-- Maintenance truck/device for raising, lowering and withdrawal of circuit breaker, if required.
-- Fuse puller.
-- Test plug for relays.
-- Test plug for kWh meters.

7.2 **Space Heater**

7.2.1 Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

7.2.2 Ammeter and indication lamp for panel and motor space heater ON shall be provided on the panel.

7.3 **Name Plates**

7.3.1 The switchboard shall have large name plate on the top indicating its Name, Designation and Code No.

7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate indicating panel number both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black Perspex with white engraving and of minimum 3mm thick.

7.4 Any other accessories required, but not specified, shall also be supplied to make the switchboard complete in all respects and ensure safe and proper operation.

8.0 PAINTING

8.1 The enclosure, after degreasing, pickling in acid, cold rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 The finishing shade shall be RAL 7035.

8.5 One litre of paint shall be supplied along with each board for touch up at site.

9.0 TESTS AND INSPECTION

9.1 All the switchboards shall be subjected to routine test as per IS: 8623 and their components as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of Purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspections shall however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly:

-- Name of Client
-- Name of Consultant
-- Enquiry / Order Number with Project / Plant Name
-- Code No. & Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the main equipment as listed in Annexure-II.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the switch boards.

12.0 PACKING

12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR MEDIUM VOLTAGE SWITCHBOARDS

Sl.No.	Documentation Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheets, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled in	Y	Y	Y
3.	Feeder Details	Y	Y	Y
4.	General arrangement and Foundation Drgs.	N	Y	Y
5.	Schematic and Wiring Diagrams	N	Y	Y
6.	Calculation for Bus-bar sizing	Y	Y	N
7.	Terminal Arrangement Drgs.	N	Y	Y
8.	Illustrative and Descriptive Literature	Y	N	Y
9.	Catalogues for bought out accessories.	Y	N	Y
10.	Installation, Operation and maintenance manual.	N	N	Y
11.	Test Certificates			
	i) Type -- Switchboard	Y	N	N
	-- Circuit Breaker	Y	N	N
	-- MCCB's	Y	N	N
	ii) Routine	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	Spare Parts List	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - II

LIST OF SPARES

The following spare parts shall be quoted along with the offer:

A. Panels with Bus-bars.

B. Modules of various motor ratings and types of outlets.

C. BREAKERS (OF EACH RATING)

i) Fixed Arcing Contact Assembly
ii) Moving Arcing Contact Assembly
iii) Mechanism Reset Spring
iv) Trip bar spring and any other spring used in the circuit breaker mechanism
v) Cluster Contacts
vi) Arc Chute Assembly
vii) Shunt trip Coil
viii) Closing Coil
ix) Motors for MWS operated breakers
x) Secondary Isolating Contact Blocks
xi) Release Devices, if any
xii) Shutter Assembly

D. SWITCHES (OF EACH RATING)

i) Assembled Switch in Open Execution
ii) Single Pole moving Blade Assembly
iii) Single Pole Base Assembly

E. FUSES (OF EACH RATING)

i) Fuse Link
ii) Fuse Fittings

F. CONTROL SWITCHES

i) Trip-Neutral-Close Control Switch
ii) Local-Remote Selector Switch
iii) Thermostat
iv) Ammeter Selector Switch
v) Voltmeter Selector Switch
vi) Push Button Element

vii) Push Button actuator of each type

G. CONTACTOR (OF EACH RATING)

i) Contactor with Auxiliary Contacts

ii) Operating Coil

iii) Auxiliary Contact Block

H. RELAYS

i) Relays of each type

ii) Glass cover of each case.

I. INDICATION LAMPS

i) Indicating Lamp Globes of each colour.

ii) Indication Lamp Fittings

iii) Indicating Lamp Bulbs

J. METERS

i) Ammeter

ii) Voltmeter

K. TRANSFORMERS

i) Current Transformer of each rating.

ii) Potential Transformers

L. MCB (OF EACH RATING)

M. MISCELLANEOUS

i) Alarm Bell

ii) Alarm Buzzer

TECHNICAL SPECIFICATION

HIGH VOLTAGE SWITCH BOARDS

CONTENTS

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ANNEXURE - I	DOCUMENTATION FOR HIGH VOLTAGE SWITCHBOARDS
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of High Voltage Switch Boards.

1.2 This standard shall be read in conjunction with relevant Specification Sheets, Feeder details & Schematic diagrams etc.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment shall comply with the latest issues of the following standard, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 3427 A.C. Metal enclosed switchgear and control gear for rated voltages above 1 kV up to and including 52 kV.

IS: 13118 Specification for high voltage alternating current circuit breakers.

IS: 5578 Guide for marking of insulated conductors.

IS: 11353 Guide for uniform system of marking and identification of conductors and apparatus terminals.

IS: 10118 Code of Practice for selection, installation and maintenance of switchgear and control gear.

Various components housed in the switchboards shall conform to the Indian Standards Specification as mentioned against the component details or IEC Specifications.

2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications / IEC Specification, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The switchboards shall be suitable for operating at the specified rating continuously, with the specified voltage and frequency variations under the ambient conditions indicated in Design Philosophy-Electrical, without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 The switchboards shall consist of an assembly of a series of floor mounting, identical, metal clad, cubicle type panels placed side by side to form a compact assembly and shall be extensible on either side.

5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP4X as per IS: 3427. However, in case some ventilation openings are to be provided, these may be permitted for equipment located indoors and such openings shall be covered by fine wire mesh ensuring minimum IP3X protection.

5.1.3 The framework of the cubicles shall be bolted / welded construction. The minimum thickness of sheet steel shall be 3 mm for base channel and 2 mm for other members. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.

5.1.4 The switchboard shall be mounted on the channel which shall be included in the vendor's scope.

5.1.5 Each cubicle shall be provided with front access door with handle lock and key for breaker compartment and a removable back cover. The door hinges shall be concealed type. Front doors of the panels shall mechanically stop in full open position to facilitate removal of breakers and for ease of maintenance.

5.1.6 All external hardwares shall be zinc passivated steel. The hardwares for fixing removable parts shall be provided with retaining devices.

5.1.7 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove, in shaped sheet steel work or these shall be U-type.

5.1.8 Each cubicle shall have separate compartment within the cubicle for circuit breaker, bus-bars, instrument transformers, metering and relaying devices and cable termination.

5.1.9 Inter-panel and inter-compartment fire resistant barrier shall be provided. Cast resin seal off bushing shall be provided in the bus compartment, through which connections to breaker compartment/cable compartment/bus compartment of adjacent panel shall be taken. Failure of one of the equipment shall not effect the equipment in the adjacent compartment.

5.1.10 All the components shall be accessible for inspection and maintenance without the necessity of removing the adjacent ones. Their mounting shall be accessible and ensure the necessary degree of safety.

5.1.11 The layout of the components inside the cubicle shall be liberal to facilitate maintenance and the interconnecting wiring between components shall not be subjected to undue stresses at the bends.

5.1.12 Mounting height of components requiring operation and maintenance shall not be lower than 300 mm and higher than 1800 mm.

5.1.13 All live parts which are accessible after opening of front and back door/cover shall be properly insulated or provided with insulating barrier to prevent accidental contact. Phase insulating barriers shall be provided between the breaker poles. Removal facility shall be provided for all such barriers.

5.1.14 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

5.1.15 The switchboard shall be provided with following interlocks and safety features:

i) The withdrawal and engagement of a circuit breaker shall not be possible unless it is in open position.

ii) The operation of a circuit breaker shall not be possible unless it is in fully service,

test or isolated position.

iii) It shall not be possible to close the circuit breaker in service position unless all auxiliary and control circuits are connected.

iv) A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.

v) Insertion of the manual mechanism shall render the motorized mechanism inoperable.

vi) Circuit breaker “ON”, “OFF” indication shall be provided at the back of each panel.

vii) Caution name plate shall be provided at the back of incomer panels where terminals are likely to remain live and isolation is possible only from remote end.

viii) Automatic safety shutter, with padlocking facility for locking in closed position, to completely cover the spouts for bus-bars and cable connection when the breaker is withdrawn.

5.1.16 3.3kV/11kV individual panel width shall not be less than 800mm.

5.2 Bus-Bars and Connections

5.2.1 The bus-bars shall be for three phases. The bus-bars and connection shall be made of high conductivity aluminium alloy of rectangular cross-section.

5.2.2 Bus-bars and connections shall be sleeved to protect against approach to live parts and to eliminate potential arcing points. Sleeving material shall have adequate electrical, thermal and mechanical properties to withstand impulse level, temperature rise during normal and short circuit condition and allow easy bending of bus bars.

5.2.3 The bus-bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the limits specified in IS: 8084. The thermal rating of the bus-bars shall be designed to withstand the system fault current for 3 seconds without exceeding the limiting temperature of 250ºC for bare copper. Calculation for bus-bar sizing shall be furnished along with the offer.

5.2.4 Horizontal bus-bars shall run in a separate compartment through the entire length of the board and shall be of same cross-section throughout. Stepped bus-bars shall not be acceptable.

5.2.5 The bus-bars shall be arranged and colour coded according to IS: 5578 & IS: 11353.

5.2.6 The bus-bars chamber shall be sufficiently spacious and shall have separate screwed covers for maintenance purpose. It shall be adequately ventilated and shall allow the escape of the hot gases.

5.2.7 The bus-bars shall be rigidly supported at equal intervals to withstand the stresses due to full short circuit and also to take care of thermal expansion.

5.2.8 A minimum of two bolts shall be used per bus-bar joint. Only high tensile electro galvanized cadmium plated bolts, nuts and washers shall be used. The washers shall be spring and plain type. The bus-bar supports shall be of molded construction with built-in anti-tracking barriers. The support materials shall be of DMC or fiber glass reinforced thermosetting plastic.

5.2.9 The bus-bars, both horizontal and vertical, shall be PVC sleeved. Insulating shrouds shall be provided for all joints of insulated bus-bars.

5.3 Earth Bus

A continuous earth bus of Aluminium running along the lower part of the switchboard

shall be provided with two end terminals with lugs for external connection. The earth bus shall be rated to carry three phase fault current for a period of 3 sec.

5.4 **Bus Duct**

5.4.1 Suitable extension of bus-bars in proper phase sequence on the top or bottom, as specified in Specification Sheet, with connecting bolts shall be provided where connections between transformer and switchboard or between two halves of the switchboard is specified to be through bus duct.

5.4.2 Bus duct between two halves of the switchboard, if required, shall be supplied by the switchboard manufacturer. The bus-bars of interconnecting bus duct shall be similar to the main bus-bars of switchboard as specified above and shall conform to IS: 8084.

5.4.3 Bus duct between transformer and switchboard, if included in vendor's scope shall conform to IS: 8084.

5.5 **Clearances and Creepage Distance**

The clearance and creepage distance shall be adequate to meet the BIL of the equipment.

5.6 **Insulation**

5.6.1 The insulation used shall be non-hygroscopic and shall be of porcelain, epoxy resins or fiber glass molded with plastic. It shall be of adequate electrical, mechanical and thermal strength to give trouble free service during normal operation and short circuit conditions.

5.6.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

5.7 **Control Wiring**

5.7.1 The switchboard shall be completely factory wired and ready for external connections.

5.7.2 The wiring shall be complete in all respect so as to ensure proper functioning of control, interlocking, protection, metering, indications and annunciations.

5.7.3 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The minimum size of wires shall be as follows:

C.T. Circuit	--	2.5 Sq. mm
V.T. and Control Circuits	--	1.5 Sq. mm

5.7.4 All wiring shall be provided with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminal outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

5.7.5 Control wiring circuits, fed from a supply common to a number of panels, shall be so protected that failure of a circuit in one panel does not affect the operation of other panels.

5.7.6 The wiring to the equipment mounted on the doors shall be carried out with flexible multi-strand copper conductor cable and so supported that on opening of the door, there is no undue strain on wire leads.

5.7.7 The control cables shall be neatly arranged and properly supported.

5.8 External Cable Termination

5.8.1 All power and control cables shall enter the switchboard from the bottom on the back of the panel. Sufficient space shall be provided for ease of connection and termination of cables.

5.8.2 All power cables and control cables shall be of type, number and size as indicated in Feeder Details.

5.8.3 The termination arrangement for single core cables shall be such that so as to minimize flow of eddy current and heating due to eddy currents.

5.8.4 Heavy duty double compression type rolled Aluminium cable glands along with the cable lugs, as required shall be provided for termination of control cables and auxiliary power supply cables.

5.8.5 The cable glands shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two number spare knockouts of size 20 mm shall also be provided on the gland plate for future use.

5.8.6 Terminal blocks shall be provided at suitable locations inside the panels for termination of control and auxiliary power supply wiring. These terminal blocks shall be pressure clamp type up to 35 sq. mm cables and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volt service. The minimum current rating of the terminal block shall be 16 Amp.

5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.

5.8.8 The terminal block shall be grouped according to circuit functions and numbered suitably. 20% extra terminals shall be provided in the terminal block.

5.8.9 Suitable clamps to support the vertical run of cables shall be provided.

5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.8.11 For additional safety, booting shall be provided for all the cable termination along with the barrier.

5.9 Feeder Details

5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagrams.

5.9.2 Non-paralleling interlocks shall be provided between incomers and bus section panels. However, momentary paralleling of the system shall be possible for changeover without supply interruption. The interlocks shall be either electrical or mechanical type. Arrangement for defeating the interlock shall also be provided. Bypass arrangement for synchro check shall be provided in 3.3kV & 11kV panels.

5.9.3 Auto changeover scheme, wherever specified, shall be provided.

5.10 Dummy Panels

Dummy panels complete with bus-bar system in 400 mm width shall be required for which unit price shall be indicated.

5.11 **Control Power Supply**

5.11.1 D.C. power required for closing, tripping and indication shall be supplied at the bus coupler panel through two completely separate circuits by the owner, one for tripping and another for closing and indication for the whole board.

5.11.2 For receiving each external control power supply, a double pole miniature circuit breaker shall be provided. This power shall be distributed inside the switchboard for each feeder having its MCB unit.

5.11.3 Reference schematic diagram for A.C. control supply through control transformer for switchboards with buscoupler (PDS E: 412) shall be suitably modified such that control bus shall have option to switch to other bus control supply for redundancy in case of failure of auxiliary transformer and isolation of auxiliary transformer to be from incoming and outgoing to be made possible by suitably rating MCB.

5.11.4 Control supply for all motor feeders shall be fed by MCB and not fuses.

5.12 **Space Heater Power Supply**

5.12.1 Panel space heaters shall be fed from a separate bus, common for the whole board. This bus shall be fed from owner's supply for which a double pole MCB shall be provided in bus section panel.

5.12.2 Power supply for space heaters of motors shall be tapped from this bus by means of miniature circuit breakers located in the motor feeder panels. These MCB's shall be of triple pole and rated for 15 Amp.

6.0 COMPONENT DETAILS

The make of the components shall be as specified elsewhere in the NIT.

6.1 **Circuit Breakers**

6.1.1 The circuit breakers shall comply with the requirements of IS: 13118.

6.1.2 All circuit breakers shall be of 0-0.3 sec-CO-3 min-CO rated operating sequence capable of carrying the specified current at the site conditions and making/breaking of the system fault current.

6.1.3 Type test certificates from an independent testing authority shall be furnished along with the offer for each circuit breaker rating and type.

6.1.4 The circuit breakers controlling motors shall be suitable for DOL starting and stopping induction motor a number of times and shall have provision to limit over voltage to the value safe for motor insulation. Unless otherwise specified this value shall be taken as 2.5 times the rated voltage. The magnitude of the voltage surge produced by the breaker when switching off the smallest motor shall be indicated.

6.1.5 The circuit breakers controlling capacitors shall be suitable for energizing and de-energizing the rated capacitor bank.

6.1.6 The circuit breakers shall be of the 3 phase, single break, horizontal draw-out, vertical/horizontal isolation type. The medium of arc quenching shall be minimum vacuum only or SF6 with approval of M/s RCF.

6.1.7 The circuit breakers shall be suitable for electrical/manual closing as specified in Feeder details. Electrically operated circuit breakers shall preferably have motor wound spring

closing mechanism with provision for manual closing arrangement. Manually operated circuit breakers shall have independent manual spring closing mechanism. In all cases tripping shall be by means of shunt trip coil.

6.1.8 All circuit breaker units of the same rating shall be physically and electrically interchangeable.

6.1.9 The circuit breakers shall be electrically and mechanically trip free and provided with anti-pumping feature.

6.1.10 The circuit breakers shall have three positions, i.e. service, test and isolated with the cubicle door closed. Necessary stoppers shall be provided to prevent the excessive movement of the breaker cradle than desired for the position. Service and test positions of the breaker shall have monitoring switch having 1NO+1NC contacts.

6.1.11 The circuit breakers shall be provided with emergency manual trip device, mechanical 'ON', 'OFF', 'ISOLATED' position and spring 'CHARGED', 'DISCHARGED' indicators and operation counter.

6.1.12 A maintenance truck/device, if required, for raising, lowering and withdrawals of the circuit breaker shall be supplied for each switchboard.

6.1.13 The arc interrupting devices shall be capable of interrupting satisfactorily current from zero to the rated interrupting current when used on predominantly capacitive or inductive circuits, without requiring excessive maintenance of the contacts. The arc shall be restricted within the interrupting chamber and no emission of flame shall be allowed which may cause electrical breakdown or damage to insulation on the apparatus.

6.1.14 Mechanical safety interlock shall be provided for safe operating and movement of the breaker.

6.1.15 The circuit breakers shall be provided with minimum of four normally open and four normally closed auxiliary switch contacts, over and above those required for its own control scheme, for owner's use. These contacts shall be wired separately to the terminal board.

6.1.16 The closing coil and other associated auxiliary relays shall operate satisfactorily at all voltages between 85% and 110% of the rated control voltage. The tripping coil and other associated relays shall operate satisfactorily at all voltages between 70% and 110% of the rated control voltage.

6.1.17 Cable earthing facility shall be provided in the circuit breaker for discharging of power cable through the circuit breaker contact with circuit breaker in drawn-out position. An integral earthing arrangement shall be preferred. In case the integral earthing arrangement is not feasible due to circuit breaker design, a separate earthing truck, which shall be inserted in place of circuit breaker, shall be provided per board.

6.1.18 Positive earthing of circuit breaker frame shall be maintained at every position of circuit breaker. The earthing contact shall be line/scrapping type and not of point type.

6.2 Current Transformers

6.2.1 The current transformers shall conform to IS: 2705.

6.2.2 C.T.s shall be class F insulated and vacuum impregnated or resin cast type. The C.T.s shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.2.3 The short time thermal withstand ratings of the C.T.s shall be same as the thermal withstand ratings of the breakers.

6.2.4 The C.T.s output shall be minimum 15 VA per phase and in any case, the output shall be adequate for the protection and metering duties involved with sufficient margin. The C.T.s shall have the following accuracies for the various applications:

	Application	Class of Accuracy as per IS: 2705
i)	For metering service	1
ii)	For use with protective relays	5 P
iii)	For use with restricted earth fault and differential relays	PS

6.2.5 The C.T. cores for metering and protection shall be separate.

6.2.6 The ratios of the current transformers shall be as indicated in Feeder details.

6.2.7 All the C.T.s shall be provided with terminals and shorting links. One of the terminals of the C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.

6.2.8 Provision of interposing C.T. is not acceptable.

6.2.9 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

6.3 Voltage Transformers

6.3.1 The V.T.s shall be class F insulated and vacuum impregnated or resin cast type conforming to IS: 3156.

6.3.2 The primary nominal voltage shall be equal to the system nominal voltage. The secondary terminal voltage shall be 110 / $\sqrt{3}$ V.

6.3.3 The rated output of each VT shall be adequate for the relays, meters and associated wiring connected to it with sufficient margin and shall not be less than 200 VA per phase.

6.3.4 The accuracy class of V.T.s shall be 1 as per IS: 3156.

6.3.5 The primary and secondary winding shall be protected by HRC fuses in each phase except in the grounded phase of the secondary side.

6.3.6 The V.T. shall be mounted on a with-drawable carriage. Shutters with padlocking facility, provided on high voltage sides, shall be so arranged that the live orifices are automatically closed when the V.T. is withdrawn.

6.3.7 Mechanical interlocking arrangement shall be provided so that the access to the high voltage fuse is possible only when the V.T. is fully withdrawn.

6.4 Relays

6.4.1 All protective relays shall be of latest version, microprocessor based numerical type with communication port and interlinked with online energy management system. 100% redundancy shall be provided for communication.

6.5 Timers

6.5.1 The timers shall be electronic, pneumatic or synchronous type with manual/ auto reset features as per the functional requirements. The timers shall be ‘ON’ delay or ‘OFF’ delay type as specified. The repeat accuracy shall be 0.5% or better.

6.6 **Instruments and Meters**

6.6.1 All instruments shall be flush mounting type with square face of 96 mm x 96 mm. They shall be tropicalized and dust tight.

6.6.2 Meters shall be digital multifunctional meters with communication port for energy management at remote location.

6.6.3 All ammeters and voltmeters, to be provided separately, shall have 0-90º scale and shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248. The scale range of the ammeters and voltmeters shall be as indicated in the Feeder details.

6.6.4 In case of motor feeders, the ammeters shall be graduated uniformly upto C.T. primary current and with compressed end scale upto 6 times C.T. primary current. Red pointer shall be provided, which shall be adjusted at site for indicating full load current of the motor.

6.7 **Push Buttons and Control Switches**

6.7.1 The switches and push buttons shall conform to utilization category AC11/DC11 as per IS: 13947. The contact shall be rated to make, break and carry inductive current of 5 Amps. at 415 V AC and 1 Amp. at 220 V DC.

6.7.2 The control switches shall be spring return rotary type, unless otherwise specified and provided with Pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices, if required.

6.7.3 The selector switches shall be stay put rotary type and provided with oval shape handles.

6.7.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The start push button shall be shrouded type and coloured green. The stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type and coloured black. The fixing ring shall be metallic white.

6.7.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.8 **Control Fuses**

6.8.1 The fuses shall be non-deteriorating HRC cartridge link type and shall conform to IS: 13703. They shall be suitable for load and service required in the circuit.

6.8.2 One fuse puller shall be supplied along with each board.

6.9 **Miniature Circuit Breakers**

6.9.1 The miniature circuit breakers shall conform to IS: 8828 and shall be of duty category M-9.

6.9.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.

6.9.3 Type test certificate for short circuit rating and current time tripping curve shall be furnished along with the offer.

6.10 **Signal Lamps**

6.10.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follow:

Red	-	Circuit breaker 'ON'
Green	-	Circuit breaker 'OFF'
White	-	Trip circuit healthy
Amber	-	Alarm and auto trip
Blue	-	Non-Trip

6.10.2 The lamps shall LED type with lumen output of 200 millicandella in axial direction.

7.0 ACCESSORIES

7.1 The supply shall include the following accessories.

- Maintenance truck/device for raising, lowering and withdrawal of circuit breaker, if required.
- Earthing truck, in case the integral earthing arrangement is not feasible in the circuit breaker.
- Fuse puller.
- Test plug for relays.
- Test plug for kWh meters.
- Special tools and tackles, as required.

7.2 Space Heater

7.2.1 Each panel shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker. Ammeter and indication lamp for space heater ON shall be provided on the panel.

7.3 Name Plates

7.3.1 The switchboard shall have large name plate on the top to indicate its name and designation.

7.3.2 Each panel shall be provided with name plate both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black Perspex with white engraving and of minimum 3 mm thick.

7.4 Any other accessories required, but not specified, shall also be supplied to make the switchboard complete in all respects and ensure safe and proper operation.

8.0 PAINTING

8.1 The enclosure, after degreasing, pickling in acid, cold rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coals of anti-corrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 The finishing shade shall be RAL 7035.

8.5 One litre of paint shall be supplied along with each board for touch up at site.

9.0 TESTS AND INSPECTION

9.1 All the switchboards shall be subjected to routine test as per IS: 3427 and their components as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspection shall, however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments.

11.2 Commissioning Spares

Commissioning Spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The switchboard shall be properly packed before dispatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and

storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR HIGH VOLTAGE SWITCHBOARDS

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheets, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	Feeder Details	Y	Y	Y
4.	General arrangement and Foundation Drawings	Y	Y	Y
5.	Schematic/Wiring Diagrams	N	Y	Y
6.	Calculation for Bus-bar sizing	Y	Y	N
7.	Terminal Arrangement Drawings	N	Y	Y
8.	Illustrative and Descriptive Literature	Y	N	Y
9.	Catalogues for bought out accessories	Y	N	Y
10.	Installation, Operation and maintenance manual	N	N	Y
11.	Test Certificates			
	i) Type - Switchboard	Y	N	N
	- Circuit Breaker	Y	N	N
	- MCB	Y	N	N
	ii) Routine	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	Spare Parts List	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - II

LIST OF SPARES

The following spare parts shall be quoted along with the offer:

A. **BREAKERS (OF EACH RATING)**

i) Trip bar spring and any other spring used in the circuit breaker mechanism
ii) Shunt trip coil
iii) Closing coil
iv) Diodes, if used
v) Secondary Isolating contact blocks
vi) Release devices, if any
vii) Any other spares recommended for VACCUM/SF6 circuit breakers

B. **CONTROL SWITCHES**

i) Trip-Neutral-Close Control Switch
ii) Local-Remote Selector Switch
iii) Thermostat
iv) Ammeter Selector Switch
v) Voltmeter Selector Switch
vi) Push Button Element
vii) Push Button Actuator of each type

C. **MINIATURE CIRCUIT BREAKER (OF EACH RATING)**

D. **RELAYS**

i) Relays of each type

E. **METERS**

i) Ammeter
ii) Voltmeter
iii) KWh Meter

F. **INSTRUMENT TRANSFORMERS**

G. **FUSES (OF EACH RATING)**

i) Fuse link
ii) Fuse fittings

H. **MISCELLANEOUS**

i) Alarm bell
ii) Alarm buzzer

TECHNICAL SPECIFICATION

MEDIUM VOLTAGE BUS DUCT

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
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9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
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ANNEXURE - I	DOCUMENTATION FOR MEDIUM VOLTAGE BUS DUCT

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture testing at works and despatch in well packed condition of medium voltage bus duct.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of following Indian Standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 8084	-	Interconnecting bus-bars for A.C. Voltage above 1 KV up to and including 36 KV.
IS: 8623	-	Specification for low voltage switchgear and control gear assemblies.
IS: 5578	-	Guide for marking of insulated conductors.
IS: 11353	-	Guide for uniform system of marking and identification of conductors and apparatus terminals.

2.2 The design and operational features of all the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard differs from those in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The bus duct shall be suitable for operating at the rated capacity continuously under the ambient conditions and with the voltage and frequency variations indicated in Design Philosophy-Electrical without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 Enclosures

5.1.1 The sheet steel enclosure for enclosing and supporting the bus-bars shall be made out of 14 SWG sheet steel, bolted on the angle iron frame work.

5.1.2 The enclosure shall completely enclose the bus bars from all sides. It shall have degree of protection IP: 52 for indoor installation and IP: 55 with rain protection canopy for

outdoor installation as per IS: 13947. Where part of the bus duct is required for indoor installation and part for outdoor installation, the complete section shall be suitable for outdoor installation. Ventilation louvers, if necessary, shall be provided with fine wire mesh from inside, in that case the degree of protection shall be IP: 42. Neoprene gasket shall be provided on covers at joints.

5.1.3 Whether bus duct (with louvers) is installed outdoor or indoor, suitably rated space heater with thermostat control shall be provided at different locations inside the bus duct to avoid moisture condensation.

5.1.4 All external hardwares of diameter less than 8 mm shall be stainless steel and those of diameter 8 mm and above shall be mild steel zinc passivated.

5.2 Bus Bars and Connections

5.2.1 The bus-bars shall be of three phase and neutral, non-segregated and air insulated type.

5.2.2 The bus bars shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature limits specified in IS: 8084. The bus bars shall be designed to withstand the system fault current for one second without exceeding the total temperature of 200ºC. Type test certificate of similar bus duct shall be furnished.

5.2.3 The bus-bars material shall be high conductivity Aluminium alloy conforming to grade E91E of IS: 5082/electrolytic grade copper.

5.2.4 The bus-bars shall be rectangular in shape and cross-sectional area of neutral bus-bars shall be half of phase bus-bars.

5.2.5 The sizes of bus-bars selected shall be subjected to approval by PDIL. The vendor shall furnish supporting calculations for bus-bars and enclosure sizes both under normal load and short circuit conditions as well as that of temperature rise along with the offer.

5.2.6 All the bus-bars shall be bare and without any painting. The bus-bars shall be arranged and provided with proper phase identification as per IS: 5578/11353.

5.3 Joints and Bends

5.3.1 Only lap joints shall be used for jointing the bus bars. The over lap shall be equal to the width of the bus bars.

5.3.2 The contact surfaces of the overlapping bus-bars shall be thoroughly cleaned followed by application of good quality electrical grease and bolted immediately. In case of Aluminium to copper joints, copper bus-bars in addition shall be preferably tinned.

5.3.3 The bolting schedule adopted shall ensure proper contact pressure. A minimum of two bolts shall be used per joint.

5.3.4 The contact pressure shall be 100-140 kg/cm^2. Only high tensile, zinc passivated or galvanized steel bolts shall be used along with large diameter flat washers of adequate thickness.

5.3.5 At the bends, the bus-bars shall bend at a radius of 2t where the ‘t’ is the thickness of the bus-bars and the radius is measured to the inside of bus-bars.

5.4 Flexible Joints

Flexible joints and connections shall consist of tinned laminated copper strips or Aluminium strips of required cross sectional area. Precautions as mentioned under

5.3.2 shall also be observed while marking joints with laminated copper plates. Filler plates of Aluminium as required shall be used.

5.5 **Expansion Joints**

Expansion joints, where necessary, to allow for longitudinal expansion and contraction of bus-bars and bus enclosures caused by temperature variation shall be provided.

5.6 **Bus Bar Supports**

5.6.1 The bus-bars shall be rigidly supported at equal intervals. The bus-bars supports shall be such that they withstand stresses to which they may be subjected under normal and short circuit conditions.

5.6.2 The supports shall be of moulded construction of fibre glass reinforced with thermosetting plastics or superior materials. The supports, where necessary, shall either have built-in anti-tracking barriers or painted with anti-tracking varnishes.

5.7 **Clearances and Creepage Distance**

5.7.1 The clearances and creepage distance shall not be lower than the values specified below for any part of the bus duct.

i)	Minimum clearance between two live parts	-	25 mm
ii)	Minimum clearance between a live part and accidentally dangerous part	-	25 mm
iii)	Creepage distance	-	30 mm

5.7.2 The clearances and creepage distance, as specified above, shall definitely be maintained throughout the bus bars system. Provision of bus-bar separators or barriers shall not be considered to reduce the clearances from the values specified above.

5.8 **Terminal Chambers at Switchgear and Transformer End**

5.8.1 The bus duct shall be suitable for bolting to the flanges provided at the transformer and switchgear end. The exact dimensions and details of these terminal chambers shall be made available at the time of execution.

5.8.2 Phase changeover arrangement wherever required shall be provided in one of the terminal chambers to connect the bus-bars between same phase terminals at switchgear and transformer ends.

6.0 ACCESSORIES

6.1 **Earthing**

Two continuous earth strips of Aluminium having minimum 300 sq. mm size shall be provided throughout the length of bus duct or shall be suitable for full short circuit fault current for 1 sec. whichever is more.

6.2 **Drain Plug**

Bus duct shall be provided with drain plug to remove condensed moisture when required.

6.3 **Fire Barriers**

Two sets of epoxy moulded fire barriers shall be provided on switchgear end as well as transformer end.

6.4 **Name Plates**

6.4.1 Each bus duct shall be provided with a name plate of stainless steel with letter embossed on them and located at convenient location.

6.4.2 The name plate shall contain all details as per IS: 8084.

6.5 **Hardware**

Required number of hardwares like bolts, nuts, plain washers, spring washers etc. shall be provided for jointing the bus duct with transformer as well as switchgears.

7.0 LAYOUT

7.1 The proposed bus duct routing between transformer and associated switchgear shall be as shown in the drawing enclosed with NIT. Where no layout drawing is enclosed, the schedule of quantities shall be followed for bidding. However, the exact routing and details of switchgear and transformer end chambers shall be supplied at the time of order or drawing approval.

7.2 The successful vendor shall prepare final layout drawing for each bus duct with bill of materials and submit the same for PDIL/Purchaser's approval.

8.0 PAINTING

8.1 The enclosure after degreasing, pickling in acid, rinsing, phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey having shade no. 631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 The bus duct shall be subjected to routine tests as per relevant standard.

9.2 Wherever specified, temperature rise tests shall be carried out on a minimum 5 metre length bus duct of each rating.

9.3 The test shall be carried out in manufacturer's works in presence of purchaser's representative. In addition, the bus ducts shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from his responsibility of making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure - I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of following spare parts shall be quoted along with main equipment with recommended quantity.

i) Set of bus bar supports
ii) Set of gaskets
iii) Set of special tools, if necessary, for dismantling and maintenance

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The bus duct shall be properly packed before despatch to avoid damage during transport, storage and handling. It shall be wrapped in polythene bags to make it waterproof. An additional wrapping with bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 COORDINATION WITH OTHER SUPPLIERS

The successful vendor shall coordinate fully with the purchaser's transformer and switchgear suppliers and shall freely exchange all the technical information with them to ensure a well matched bus duct between transformer and switchgear. The vendor shall also forward to the purchaser the copies of all correspondence and drawings so exchanged.

14.0 DEVIATIONS

14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR MEDIUM VOLTAGE BUS DUCT

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	General arrangement for each bus duct showing the complete layout.	Y	Y	Y
2.	Design calculations a) Bus bars sizing b) Flexible sizing c) Temperature Rise d) Support Span	Y	Y	N
3.	Filled-in specification sheet & Technical Particulars	Y	Y	Y
4.	Switchgear end termination details for each rating of bus duct.	N	Y	Y
5.	Transformer end termination details for each rating of bus duct.	N	Y	Y
6.	Assembly drawing of rigid bends.	N	Y	Y
7.	Assembly drawing of bends with flexible	N	Y	Y
8.	Assembly drawing of straight run	N	Y	Y
9.	Transposition chamber details	N	Y	Y
10.	Installation, operation & maintenance manual	N	Y	Y
11.	Test Certificates			
	i) Type	Y	N	N
	ii) Routine & others	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	List of spare parts	Y	N	N

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

SHEET STEEL DISTRIBUTION BOARDS

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DESIGN AND CONSTRUCTIONAL FEATURES
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8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Sheet Steel Distribution Boards.

1.2 This standard shall be read in conjunction with relevant Specification Sheets and Feeder details.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment shall comply with the latest issue of the following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 8623	-	Specification for low voltage switchgear and control gear assemblies.
IS: 13947	-	Specification for Low-voltage Switchgear and Control gear
IS: 5578	-	Guide for marking of insulated conductors.
IS: 11353	-	Guide for uniform system of marking and identification of conductors and apparatus terminals.
IS: 10118	-	Code of practice for selection, installation and maintenance of switchgear and control gear.

Various components housed in the distribution board shall conform to the Indian Standard Specification as mentioned against the component details.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The distribution board shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions indicated in Design Philosophy-Electrical, without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 DESIGN AND CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 The distribution board shall consist of an assembly of a series of floor mounting, identical, metal clad, dead front type panels of unitized design. The panels shall be placed side by side to form a compact assembly and shall be extensible on either side.

5.1.2 The complete assembly shall be dust, damp and vermin proof having minimum degree of protection equivalent to IP-52 as per IS: 13947.

5.1.3 The frame work of the cubicles shall be of bolted/welded construction. The minimum thickness of steel shall be 2 mm for load bearing members, 1.6 mm for non-load bearing members and 3 mm for base channel. The doors and covers shall be fabricated from cold rolled sheet steel. Suitable reinforcement, wherever necessary, shall be provided.

5.1.4 The door hinges shall be concealed type.

5.1.5 All external hardware shall be zinc passivated. The hardware for fixing the removable parts shall be provided with retaining devices.

5.1.6 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove of shaped sheet steel work or these shall be of U type. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.

5.1.7 All the components shall be accessible for inspection and maintenance without the necessity for removal of the adjacent ones. In case of single front design all components shall be accessible from the front for maintenance and back opening doors/ openable covers for maintenance shall not be acceptable.

5.1.8 The layout of the components inside a module shall be liberal to facilitate maintenance and the interconnection of wiring between the components shall not be subjected to any undue stress at the bends.

5.1.9 Mounting height of components requiring operation and observation shall not be lower than 300 mm and higher than 1800 mm.

5.1.10 Inter panel barriers shall be provided.

5.1.11 Adequate arrangement for earthing shall be provided to safeguard the operator or other personnel from electric hazards under all conditions of operation.

5.2 Panel Arrangement

5.2.1 The distribution board shall be drawout / non-drawout type in single front/double front configuration.

5.2.2 Each Panel shall have its horizontal bus-bar chamber running on the top with multi-tier module units in the centre and having vertical bus-bar chamber and cable alley on either side.

5.2.3 The modules shall be enclosed on all sides and shall be so arranged that larger ones are placed at the bottom portion of the panel. Fixed type modules shall be at least 300 mm from the base channel.

5.2.4 The number of modules in the panel shall not exceed six for motor starter feeders and eight for switch fuse/MCB/MCCB feeders. The minimum size of module shall be 300 mm and 200 mm for starter and switch fuse feeders. The incomer and bus coupler module sizes for ratings up to 400 A shall be half the panel size. For higher ratings they shall be housed in single panel.

5.2.5 The module door shall be so interlocked that it shall not be possible to open the door with switch in closed position. Defeat interlock facility shall be provided.

5.2.6 The relay, meters, switches and lamps shall be flush mounted. All components of one module shall be mounted on the same module on a rigid sheet steel chassis. A 20 mm dia. rotating knob on the door shall be provided for closing and opening.

5.3 **Bus Bars and Connections**

5.3.1 The bus-bar shall be suitable for the supply system specified in the Specification Sheet. The bus-bar and connections shall be made of electrolytic copper or high conductivity aluminium alloy conforming to Grade E91E of IS: 5082.

5.3.2 The bus-bar shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the temperature of 90ºC. The bus-bars shall also be designed to withstand the system fault current for 1 second without exceeding the temperature of 200ºC for bare aluminium and 250ºC for bare copper. The minimum acceptable size of bus-bars shall be 250 sq. mm (Al). Calculation for the bus-bar sizing shall be furnished along with the offer.

5.3.3 In case of double front arrangement of distribution boards, different sets of vertical bus-bars shall be provided. The vertical bus-bars shall be PVC sleeved or shrouded by insulating barriers which shall have cut-outs to permit entry of power wires. It shall be possible to remove the shroud for inspection and maintenance. Neutral-bars shall be provided in this chamber.

5.3.4 Horizontal bus-bars shall be of same cross-section through out. Stepped bus-bars shall not be acceptable.

5.3.5 All bus-bars shall be arranged and colours coded according to IS: 5578/11353.

5.3.6 The horizontal bus-bar shall run in a separate bus chamber located at the top shall have separate screwed cover for inspection purpose.

5.3.7 The bus-bars shall be rigidly supported at equal intervals to withstand maximum short circuit stresses. The supports shall be of moulded construction with built in anti tracking barriers. The support material shall be of fibre glass reinforced thermosetting plastic.

5.3.8 All joints shall be suitably treated to avoid oxidation of contact surfaces and bimetallic corrosion. A minimum of two bolts with spring washers shall be used for horizontal bus-bar joints.

5.3.9 Horizontal bus bars shall be insulated with heat shrinkable PVC sleeves of reputed makes. Insulating shrouds shall be provided for all joints of insulated bus-bars.

5.4 **Clearance and Creepage Distances**

5.4.1 The clearance and creepage distances shall not be lower than the values specified below :

i)	Minimum clearance between two live conductors	--	20 mm
ii)	Minimum clearance between live part and accidentally dangerous part	--	20 mm
iii)	Minimum creepage distance	--	28 mm

5.4.2 The clearances and the creepage, as specified above, shall definitely be maintained in the bus-bar system. Provision of bus-bar insulations, separator or barriers shall not be considered to reduce the clearance from the values specified above.

5.4.3 At the termination points in the equipment, e.g. switches, contactors, thermal relays, etc. it is realized that above clearance shall not always be possible to be maintained. All such points where above clearance are not possible to be maintained shall, therefore, be insulated or taped.

5.5 **Insulation**

5.5.1 The insulation used shall be non-hygroscopic and shall be of porcelain, Epoxy- resins or fibre glass moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.

5.5.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution.

5.6 **Power Wiring**

5.6.1 The connections from bus-bar including neutral to individual units on the modules shall consist of PVC insulated flexible copper cable or tapped copper strip.

5.6.2 The power wiring size shall be decided based on the rating of the switch, after using a rating factor of not more than 50% over the current rating in free air. In any case the minimum size of power wiring shall not be less than 4 sq. mm copper.

5.6.3 The size of connection from incomer to horizontal bus-bar and from horizontal bus-bar to bus coupler shall not be less than the size adopted for horizontal bus-bar.

5.7 **Control Wiring**

5.7.1 The switch board shall be completely factory wired and ready for external connections.

5.7.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 Volt grade. The size of wires shall be as follows:

C.T. Circuit -- 2.5 sq. mm

V.T. and Control Circuits -- 1.5 sq. mm

5.7.3 All wiring shall be provided with dependent both end marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

5.7.4 Control wiring circuits, fed from a supply common to a number of feeders, shall be so protected that failure of a circuit in one feeder does not affect the operation of the other feeders.

5.7.5 The wiring to the equipment mounted on the doors shall be carried out with flexible multi strand copper conductor cable and supported so that opening of the door, there is no undue strain on wire leads.

5.7.6 The control cables shall be neatly arranged and properly supported.

5.8 **External Cable Termination**

5.8.1 All power and control cables shall enter the distribution board from the bottom. Sufficient space shall be provided for ease of connection and termination of cables.

5.8.2 All cables shall be of 1.1 KV grade PVC insulated armoured and PVC sheathed except for single core cable which shall be unarmoured. The number and sizes of cable shall be as indicated in Feeder details.

5.8.3 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.

5.8.4 The cable glands shall be of rolled Aluminium or Nickel plated brass heavy duty double compression type and shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the distribution board. Two numbers spare knockouts of size 20 mm shall also be provided on the gland plates for future use.

5.8.5 For all power cables crimped type aluminium lugs for aluminium cables and tinned copper lugs for copper cables shall be provided.

5.8.6 The terminal blocks shall be pressure clamp type up to 35 sq. mm cable and bolted lug type for higher sizes of cables. These shall be protected type and rated for 1100 Volts service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearance and creepage distance are available.

5.8.7 Where more than two cables in parallel are required to be terminated, a system of bus links shall be provided with adequate clearance and spacing.

5.8.8 Suitable clamps to support the vertical run of cables shall be provided.

5.8.9 The terminal block shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.8.10 For power connections, suitable marking on the terminals shall be provided to identify the phases.

5.9 Feeder Details

5.9.1 The requirements of incomer, bus coupler and outgoing feeders shall be as indicated in the single line diagram, feeder details and corresponding schematic diagram.

5.9.2 The bus coupler shall be so located that it is possible to maintain half of the bus-bars while the other half is still alive. Complete segregation of bus-bar connections to bus coupler shall be provided.

5.9.3 Castle key type mechanical interlocks shall be provided between incomers and bus section modules to avoid paralleling of incomers. In addition padlocking facilities shall be provided in OFF position.

5.9.4 Single phase loads shall be distributed as far as possible on all the three phases.

6.0 COMPONENT DETAILS

6.1 The make of the components shall be as specified elsewhere in the NIT and shall conform to type of co-ordination C as per IS: 13947.

6.2 Moulded Case Circuit Breakers

6.2.1 The circuit breaker shall conform to IS: 13947 (Part 2) and shall be of P2 category having rupturing capacity as specified in Specification Sheet.

6.2.2 The circuit breaker shall be provided with spring assisted quick make quick break type manually operated trip free mechanism, mechanical ON/OFF position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB cubicle shall be provided with service, test and isolated position and automatic safety shutter.

6.2.3 The thermal and short circuit tripping device shall be adjustable type.

6.2.4 When used for motor circuit shunt trip devices shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.

6.2.5 In addition, under voltage trip shall be provided, if specified.

6.3 **Switches**

6.3.1 The switches shall be Motor duty type AC23 category and shall comply with the requirements laid down in IS: 13947 (Part 3). Switches up to 63 Amps shall be rotary type and those of 100 Amp and above shall be link type.

6.3.2 'ON' and 'OFF' positions of the switches shall be indicated on the panel. Provision shall be made to lock the switch in the 'OFF' position.

6.3.3 The fixed contacts shall be shrouded and the contacts shall be silver plated.

6.3.4 Two Pole switches shall also isolate the neutral circuit along with phase circuit.
4 Pole / 2 Pole switches shall be used for 3 Phase/1 Phase circuits respectively.

6.4 **Fuses**

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 13703. They shall be suitable for the load and the service required in the circuit.

6.5 **Air Break Contactors**

6.5.1 The Air Break Contactor shall be of AC3 category unless otherwise specified, conforming to IS: 13947 (Part-4) and flapper type. Gravity operated contactors are not acceptable.

6.5.2 The dropout voltage shall not exceed 65% of rated voltage.

6.5.3 Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps. AC or 1 Amp DC at the specified control voltages. The spare auxiliary contacts shall also be wired terminal block.

6.6 **Bimetal Thermal Overload Relays**

6.6.1 The contactor shall be provided with three pole bimetal thermal overload relays unless otherwise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with changeover contact.

6.6.2 Bimetal relays shall conform to IS: 3231 and shall have built in single phasing preventor.

6.6.3 The bimetal relays shall be provided with a manual reset device resetable after opening the cubicle door. Auto reset thermal relays are not acceptable.

6.7 **Current Transformers**

6.7.1 The current transformers shall conform to IS: 2705.

6.7.2 Current Transformers shall be Class-F insulated and vacuum impregnated. The Current Transformers shall be rigidly mounted and shall be easily accessible for maintenance and testing.

6.7.3 The Current Transformers shall be of 7.5 VA output. The output shall be adequate for the instrument and metering duties involved with sufficient margin. The Current Transformers shall have the accuracy Class-1 for the metering duty.

6.7.4 All the Current Transformers shall be provided with terminals and shorting links. One of the terminals of C.T. shall be earthed. The polarity of the C.T. shall be clearly marked.

6.7.5 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

6.8 Instruments and Meters

6.8.1 All instruments shall be flush mounting type with square face and shall be tropicalized and dust tight.

6.8.2 The size of the instruments shall be 96 mm x 96 mm for full and half size modules and 72 mm x 72 mm for lower size modules.

6.8.3 Dials shall be parallax free with scale marked in black on white background and shall be suitable for direct reading.

6.8.4 Zero adjusters shall be provided for operation from the front of the cases.

6.8.5 All ammeters and voltmeters shall have 0 - 240º scale moving iron spring controlled type and of Class 1.5 accuracy as per IS: 1248. The scale range of the ammeter and voltmeter shall be as indicated in the feeder details.

6.8.6 In case of motor feeders, the ammeter shall be graduated uniformly upto C.T. primary current and with a compressed end scale upto 6 times the C.T. primary current. Red pointer shall be provided, which can be adjusted at site for indicating full load current.

6.8.7 KWH meter shall be 3 phase 4 wire type. These shall conform to the requirements of relevant IS and shall be C.T. operated. The current coil shall be rated for 5 Amp.

6.8.8 All kWh meters shall be provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.

6.9 Push Button and Control Switches

6.9.1 The switches and push buttons shall conform to utilization category AC 11/DC 11 as per IS: 13947 (Part-5). The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp at 220 V DC.

6.9.2 The control switches shall be spring return rotary type unless otherwise specified and provided with pistol grip type handle. The control switches for circuit breakers shall be additionally fitted with lost motion devices and sequencing devices.

6.9.3 The selector switches shall be stay-put rotary type and provided with oval shape handles.

6.9.4 The push buttons shall be of momentary contact spring loaded type with a set of normally close and open contacts. The push button for ‘Start’ shall be shrouded type and coloured green, stop push button shall be un-shrouded type and coloured red and other push buttons shall be un-shrouded type coloured black. The fixing ring shall be metallic white.

6.9.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

6.10 Miniature Circuit Breakers

6.10.1 The miniature circuit breakers shall conform to IS: 13032 and shall be of duty category M-9.

6.10.2 It shall be provided with overload and short circuit protective devices in a heat resistant housing.

6.10.3 A certificate of short circuit rating and current time tripping curve shall be furnished alongwith the offer.

6.11 **Signal Lamps**

6.11.1 Signal lamps shall be provided to indicate the various circuit conditions as shown in scheme drawings. The colour of the lamps for various functions shall be as follows:

Red	--	Switch/Contactor closed.
Green	--	Switch/Contactor open.

6.11.2 The lamps shall be LED type having lumen output 200 milli candela in axial direction.

6.11.3 It shall be possible to remove the globe from outside for replacement of lamps.

7.0 ACCESSORIES

7.1 The supplier shall include the following accessories.

-- Fuse Puller.
-- Test plug for kWh meters.

7.2 **Space Heater**

Each vertical section shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker.

7.3 **Name Plates**

7.3.1 The distribution board shall have large name plate on the top to indicate its name and designation.

7.3.2 Each feeder shall be provided with name plate. Each single front panel shall have name plate both in front and back.

7.3.3 All control switches, push buttons, lamps etc. shall have functional identification labels.

7.3.4 Name plate shall be of black perspex with white engraving and of minimum 3 mm thick.

7.3.5 Any other accessories required, but not specified shall also be supplied to make the distribution board complete in all respects to ensure safe and proper operation.

8.0 PAINTING

8.1 The enclosure after degreasing, pickling in acid, cold rinsing phosphatising, passivating etc. shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be light grey Shade No.631 as per IS: 5.

8.5 One litre of paint shall be supplied along with each board for touch up at site.

9.0 TESTS AND INSPECTION

9.1 The distribution boards shall be subjected to routine test as per IS: 8623.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defect which shall be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly:

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in the Annexure-II.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The distribution board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS

Sl.No.	Documents	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	Feeder Details	Y	Y	Y
4.	General Arrangement and Foundation Drawings	Y	Y	Y
5.	Schematic Diagrams with Terminal arrangement drawings	N	Y	Y
6.	Calculation for Bus-bar sizing	Y	Y	N
7.	Illustrative and Descriptive literature	Y	N	Y
8.	Catalogues for bought out accessories	Y	N	Y
9.	Installation, Operation and Maintenance Manual	N	N	Y
10.	Test Certificates			
	-- Type (for MCCB & MCB)	Y	N	N
	-- Routine	N	N	Y
11.	Guarantee Certificates	N	N	Y
12.	Spare Parts List	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - II

LIST OF SPARES

The following spare parts shall be quoted along with the offer.

A **MOULDED CASE CIRCUIT BREAKER** (OF EACH RATING)
- i) Complete Breaker Assembly
- ii) Complete Breaker Assembly.

B **SWITCHES** (OF EACH RATING)
- i) Assembled switch in open execution
- ii) Single pole moving blade assembly
- iii) Single pole base assembly

C **FUSES** (OF EACH RATING)
- i) Assembled switch in open execution
- ii) Single pole moving blade assembly
- iii) Single pole base assembly

D **CONTROL SWITCHES**
- i) Trip-Neutral-Close Control Switch
- ii) Local-Remote Selector Switch
- iii) Heater Switch
- iv) Thermostat
- v) Ammeter Selector Switch
- vi) Voltmeter Selector Switch
- vii) Push Button
- viii) Push Button Element
- ix) Push Button Actuator of each type

E **CONTACTOR** (OF EACH RATING)
- i) Contactor with Auxiliary Contacts
- ii) Operating Coil
- iii) Auxiliary Contact Block

F **INDICATING LAMPS**
- i) Indicating lamps globes of each colour
- ii) Indicating lamp fittings
- iii) Indicating lamp bulbs

G **METERS**
- i) Ammeter
- ii) Voltmeter

H **PROTECTIVE RELAYS**
- i) Relays
- ii) Thermal overload relay of each type

NOTE: 1. All spare parts shall be identical to the parts used in the distribution boards.

TECHNICAL SPECIFICATION

LIGHTING SUB DISTRIBUTION BOARDS

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION
SD: 8083	TYPICAL WIRING DIAGRAM FOR LIGHTING SUB-DISTRIBUTION BOARDS

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of lighting sub distribution boards.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable

IS: 13947	-	Low voltage switchgear and control gear
IS: 8623	-	Specification for low voltage switchgear and control gear assemblies

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant statutory acts and regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The lighting sub-distribution boards shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variations indicated in Design Philosophy-Electrical, without exceeding the specified temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The lighting sub distribution boards shall be fabricated out of 2.5 mm thick cold rolled sheet steel and shall be suitable for mounting on wall/structure. These shall have dust and vermin proof construction conforming to IP-54 as per IS: 13947. For outdoor installation, the enclosure shall conform to IPW-55, suitable canopy made out of 2 mm thick Aluminium sheet shall be supplied along with the board.

5.2 The miniature circuit breakers shall be so mounted inside the enclosure that their operating knobs project outside for easy operation. The cut-out for the knobs on the enclosure shall be lined with gasket for dust proofness. For further protection against ingress of dust, the portion where the knobs have protruded out, shall be provided with another external front cover, internally hinged at the top, gravity operated and with a knurled knob at the bottom. The external cover shall be flushed with the main cover.

Continuous neoprene gasket shall be provided to make the board completely dust and weather proof.

5.3 All external hard ware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel zinc passivated.

5.4 The sub-distribution boards to be located indoors shall have top entry arrangement for outgoing cables and bottom entry for incoming cable. However for outdoor locations, all cable entries shall be from the bottom only.

5.5 Three phase and neutral bus bar system of adequate size shall be provided to which all outgoing and incoming MCB's shall be connected.

5.6 The internal wiring shall be carried out by means of single core PVC insulated 2.5 sq. mm stranded copper conductor cables.

5.7 Two earthing terminals outside the board shall be provided.

5.8 Suitable label inscription consisting of black perspex with engraving for the board and circuit nos. of all outgoing feeders shall be provided. The label inscription of the board shall contain description and code no.. The circuit nos. of outgoing feeders shall be serially indicated as 1L, 2L.....17L, 18L.

5.9 The board shall be complete with terminal block, cable glands, cable lugs and other accessories as specified.

6.0 SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS

6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.

6.2 The enclosure group and temperature class shall be as indicated in specification sheet.

6.3 The enclosure shall be of cast iron/cast Aluminium alloy (4600 as per IS: 617).

6.4 Cables shall enter the terminal chamber through flame proof compression type cable glands. From terminal chamber to the main enclosure connection shall be made through bushings. Direct entry of external cables into the main enclosure shall not be accepted.

6.5 The sub-distribution board shall be of 6 way type.

6.6 Individual earth terminals shall be provided for the earth conductor of the outgoing cables beside the phase and neutral terminals.

6.7 The sub-distribution board must be certified by Central Mining Research Institute, Dhanbad or other statutory authority for use in specified hazardous area.

7.0 COMPONENT DETAILS

7.1 The lighting sub-distribution board shall be wired and have components as per SD-8083 (copy attached).

7.2 **Miniature Circuit Breaker (MCB)**

7.2.1 The MCB shall be of duty category M-9 and shall conform to IS-8828. It shall be provided with overload and short circuit protective devices.

7.2.2 The incoming MCB's or switches shall be of triple pole and switched neutral type and outgoing MCB's of single pole and switched neutral type, single phase earth leakage protection in each phase of the incomer shall be provided.

7.3 **Terminal Block**

Pressure clamp type terminal blocks shall be provided both for incoming and outgoing cables. The rating of the terminal block shall be at least 1.5 times the rating of the MCB.

7.4 **Cable Glands**

Heavy duty double compression type Aluminium cable glands suitable for XLPE insulated, armoured and PVC sheathed 1.1 KV grade incoming and outgoing cables shall be provided.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti rust paint followed by two coats or anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 The finishing shade shall be light grey shade no.631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 All the lighting sub-distribution boards shall be subjected to routine tests as per IS: 8623.

9.2 Additional tests, wherever specified, shall be carried out on one lighting sub-distribution board of each type.

9.3 The above mentioned tests shall be carried out in the manufacturer's works in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 The purchaser's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly.

- Name of client
- Name of consultant

- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices for the following items, along with recommended quantity for the period, shall be quoted along with the main equipment.

i) MCB
ii) Terminal blocks
iii) Terminal bushings

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The equipment shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS

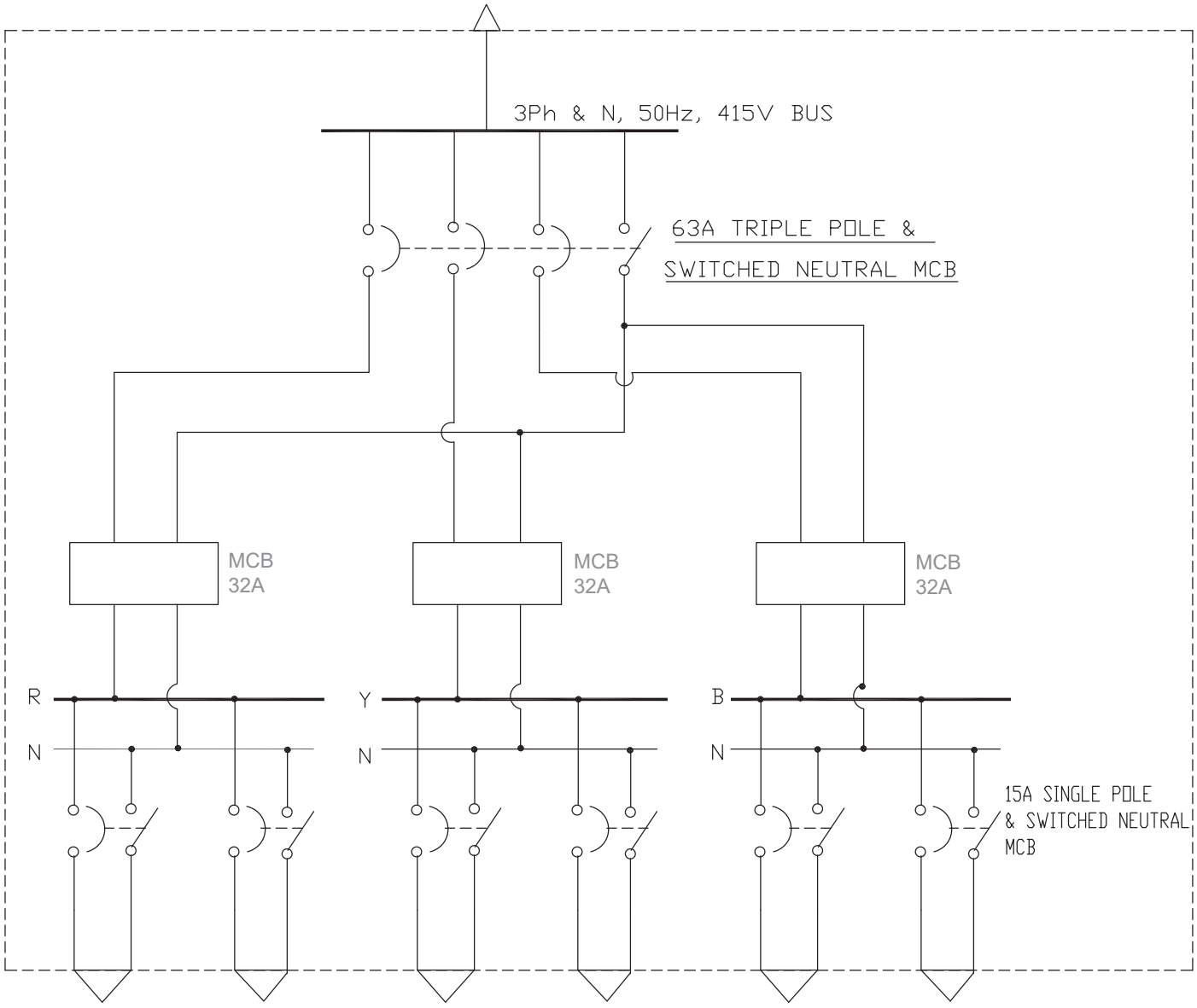
SL. NO.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical particulars, duly filled-in	Y	Y	Y
3.	General arrangement Drgs.	Y	Y	Y
4.	Certificate for flameproofness from statutory testing authority wherever applicable	Y	N	Y
5.	Schematic diagram	N	Y	Y
6.	Descriptive literature of Various equipment	Y	N	Y
7.	Guarantee certificate	N	N	Y
8.	Test certificate	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

पी डी आई एल PDIL	TYPICAL WIRING DIAGRAM FOR LIGHTING SUB–DISTRIBUTION BOARDS	SD : 8083	1
		DOCUMENT NO.	REV
		SHEET 1 OF 1	



SL. NO.	LIGHTING SUB-DIST. BOARD TYPE	NOS. OF OUTGOING FEEDERS
1.	A	6
2.	B	9
3.	C	12
4.	D	15
5.	E	18

TECHNICAL SPECIFICATION

INDUCTION MOTOR

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN FEATURES
5.0	PERFORMANCE
6.0	COUPLING DETAILS
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10.0	PAINTING
11.0	TESTS AND INSPECTION
12.0	PACKING
13.0	DRAWINGS AND DOCUMENTS
14.0	SPARES
15.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR INDUCTION MOTORS

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of medium voltage and high voltage induction motors.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-325 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.

2.3 Flame proof motors shall, in addition, comply with the requirements laid down in IS: 2148.

2.4 Increased safety motors shall, in addition, comply with the requirements laid down in IS: 6381.

2.5 Motors with type of protection “n” shall, in addition, comply with the requirements laid down in IS: 9628.

2.6 Wherever any requirement laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

The ambient conditions shall be as indicated in the Design Philosophy-Electrical.

3.2 System Details

3.2.1 The details of power system to which the motors will be connected shall be as indicated in the Design Philosophy-Electrical.

3.2.2 The motors shall be suitable for connection to a power system where transient disturbances are very likely to occur. During the transient disturbances, voltage of the system may completely disappear and return in a short time with the motors still running and connected. Under this condition, the return of voltage may occur at such an instant that the induced e.m.f. in the motor is in phase with the applied voltage giving rise to current surges which may reach a value equal to 1.6 times the starting current and also cause transient torques of large magnitudes.

4.0 GENERAL DESIGN FEATURES

4.1 Enclosure

4.1.1 The enclosure of motors for indoor and outdoor services shall be IPW-55 as per IS: 4691.

4.1.2 Motors for outdoor service shall be provided with special seals for the enclosure, joints, bearing housing, terminal boxes etc. so that no extra protective covering for ingress of water shall be required.

4.1.3 Vertical motors for outdoor installation shall be provided with a rain protective hood.

4.1.4 All external hardwares shall be zinc passivated.

4.1.5 The enclosure shall be provided with threaded metallic plug to permit drainage of condensed water from the inside.

4.2 **Cooling**

4.2.1 All motors shall be totally enclosed fan cooled conforming to IC-0141 as per IS: 6362 unless otherwise specified.

4.2.2 In case of CACA construction, the same shall conform to IC-0161 as per IS: 6362.

4.2.3 In case of CACW construction, the same shall conform to ICW 37A 91 as per IS: 6362.

4.2.4 Wherever service conditions indicated in the specification sheet are such that corrosive agents are present in the surroundings, the following materials of construction for cooling tubes shall be adopted, unless otherwise specified.

For CACA motor - Aluminium tubes having minimum thickness of 1.6 mm

For CACW motor - Low carbon alloy steel

4.2.5 In case of CACW motors, the cooling tubes and flanges shall also be suitable for the cooling water analysis. Trays shall be provided for collection of leaking water with arrangement for its drainage.

4.2.6 The cooling fans shall be suitable for bidirectional rotation of motors. These shall be fastened to the motor shaft by means of compensating rings or will be balanced independent of the motor. Guide key or reference points shall be supplied to prevent wrong assembly. The cooling air shall be sucked from the non-driving end.

4.2.7 The cooling fans shall be made of non-sparking materials such as cast Aluminium (LM-6 alloy) / cast iron.

4.3 **Direction of Rotation**

4.3.1 Motors shall be suitable for both directions of rotation. In case of any design limitation, the same shall be indicated in the offer.

4.3.2 In either case, a plate showing the direction of rotation corresponding to the phase terminal markings shall be fitted at the driving end shield of the motors.

4.4 **Stator**

4.4.1 The stator laminations shall be made from suitable magnetic sheet iron varnished on both sides. Where ventilation is required, these shall be arranged in suitable packs, each pack being separated by spacers to form ventilating ducts for circulation of air.

4.4.2 The slot shall be open type with coils so arranged that the coils can be easily removed for inspection and repair.

4.5 **Rotor**

4.5.1 The rotor shall be of squirrel cage construction, unless otherwise specified.

4.5.2 For small motors, the squirrel cage shall preferably be of pressure die-cast construction. For large motors, the rotor bars and the end rings shall be of copper or copper alloy. The bars shall be firmly placed in slots to prevent vibration during start up / locked rotor condition. Conductor ends shall be securely fixed to the end rings using the latest brazing techniques. Retaining rings shall be provided for high speed machines for the end rings. The rotor cage shall be designed for the required starting and duty cycles.

4.5.3 Wherever wound rotor is specified, the windings shall have the same features as detailed for the stator windings. The rotor voltage shall not exceed the stator voltage.

4.5.4 The rotor shall be dynamically balanced and shall rotate perfectly with no preferential stop points. The rotor shall be constructed such as to allow the removal or addition of material for balancing.

4.5.5 The rotor shaft shall be electrically and magnetically so balanced that the induced shaft voltage does not exceed 200 millivolt. Otherwise the bearing housing at non-driving end shall be insulated for 2 KV.

4.6 **Windings and Insulation**

4.6.1 The motor coils shall be made out of insulated electrolytic grade copper conductor. Successive coils shall be connected by accessible joints, well brazed and finished smooth to prevent damage to insulation.

4.6.2 The motors shall be insulated assuming the power system neutral as isolated.

4.6.3 All motors shall be insulated with class B or F insulation with tropical and fungicidal treatments.

4.6.4 Wherever class F insulation is specified, the windings shall be easily replaceable type and the temperature rise shall not exceed that of class B insulation.

4.6.5 The winding coils shall be dried, properly impregnated with suitable varnishes to withstand the site conditions and properly baked. At least two additional impregnations and baking shall be applied to the assembled stator coil, making a total of three impregnations and baking. Finally the windings shall be painted with special anti-acid and anti-alkali paints to withstand the site conditions.

4.6.6 The windings shall be well brazed and capable of withstanding thermally and mechanically the transient disturbances specified under clause 3.2.2.

4.6.7 Lead-in wire between the windings and the outside terminals shall be made through bushings in H.V. motors. For M.V. motors, heat resistant insulated conductors shall be used as lead-in wire.

4.6.8 The windings shall be star connected for high voltage motors and delta connected for medium voltage motors.

4.7 **Slip Rings and Brushes**

4.7.1 Slip rings shall be located in the non-driving side. The material of construction shall be copper alloy. The slip rings and the brush gear shall be cooled by the motor cooling fan.

4.7.2 For explosion proof motors, the slip rings and brush gear shall be housed in a flameproof housing. In case this is not possible, the housing shall be pressurised type with flameproof pressure switch for interlocking with the motor. In either case, glass covers shall be provided for inspection.

4.7.3 The starting rheostats shall be designed for intermittent duty and rated for 10 minutes. Where speed regulation is required, the rheostats and the controllers shall be suitable for such duty and be continuously rated. Auxiliary contacts shall be provided on the controllers for connections to the motor supply controls to prevent wrong operations during starting.

4.8 **Bearings**

4.8.1 All motors shall be provided with bearings suitable for the application. The bearings must be guaranteed to ensure a smooth operation and a life not shorter than 30,000 hrs.

4.8.2 Where external thrusts are specified, the motors shall be fitted with special roller thrust bearings capable of withstanding the specified thrust. In such cases, the guaranteed life of the bearings shall not be less than 20,000 hours.

4.8.3 The bearing housing shall be effectively sealed against ingress of dust and water and creep age of lubricants along the shaft.

4.8.4 The bearing shall be suitable for both directions of rotation of the motor.

4.8.5 All motors shall be provided with on-line grease lubrication arrangement for both DE and NDE side bearings except for motors of frame size 112 and less and flange mounted M.V. motors. The arrangement shall be complete with grease nipple and drain plug located at convenient locations.

4.8.6 All oil lubricated bearings shall be fitted with oil level indicator and resistance temperature detector/dial type thermometer with alarm and trip contacts.

4.8.7 Self cooled bearing system shall be preferred.

4.8.8 The manufacturer shall specify the type of lubricant and the time interval of lubrication for the bearings of each motor.

4.8.9 The bearing temperature shall not exceed 90ºC for grease lubricated bearings and 70ºC for oil lubricated bearings.

4.8.10 Wherever shaft end-play has been specified, the bearings shall be capable of providing the specified end-play.

4.8.11 Bearings shall be of SKF/FAG make only. List of bearings shall be provided with supply of motor.

4.9 **Terminal Box**

4.9.1 All the terminal boxes shall have identical degree of protection as that of the motor.

4.9.2 The power terminal box shall be mounted on the right hand side of the motor as viewed from the coupling end. Terminal box shall be rotatable through 360° in steps of 90°. The motor shall be symmetrical about its axis so that stator can be rotated through 180° to suit cable entry.

4.9.3 The power terminal boxes shall be as follows:

a) For H.V. motors - Phase segregated type capable of with standing the system fault level for 0.2 Sec. or more.

b) For M.V. motors - Manufacturer's standard box with epoxy or SRBF moulded terminal board.

4.9.4 The mounting arrangement of power and neutral side terminal boxes for HV motors shall be identical so that it shall be possible to interchange the boxes at site.

4.9.5 In case of H.V. motors, all the six leads of the motors shall be taken out, three on one side and three on the other side to separate terminal boxes. However, neutral shorting link shall be provided on the neutral box for star connection.

4.9.6 In case of M.V. motors, all the six leads of the motors shall be taken out to a common terminal box. Shorting links for delta connections shall be provided in the terminal box for motors 112 frame and above.

4.9.7 For increased safety motors and for motors with type of protection "n", the terminals shall be provided with positive locking device so that they do not become loose during normal operation.

4.9.8 The power terminal boxes shall have adequate clearances in between the terminals and also between the terminals and cable gland for proper termination of cables. Where more than one cable is required to be terminated in parallel, the spacing in the box shall be adequate for easy termination.

4.9.9 Separate terminal boxes shall be provided for connection of power, control and space heater cables.

4.9.10 All terminal boxes shall be complete with heavy duty double compression type cable glands and lugs/connectors to receive the external cables.

4.9.11 Where cross linked polyethylene cables are specified, the terminal box shall be suitably designed for proper termination of such cables.

4.9.12 The cable lugs shall be of tinned copper and suitable for crimping.

4.10 **Geared Motors**

Where geared motors are specified, the gears shall be oil lubricated, heavy duty as per AGMA class III and capable of transmitting the rated motor power continuously. They shall be capable of withstanding moderate shock loads having a service factor of 2 and the starting duties. They shall be silent and smooth in operation. Inspection glass shall be provided to indicate the oil level in the gear box.

5.0 PERFORMANCE

5.1 Starting

5.1.1 The motors shall be capable of being started direct-on-line, unless otherwise specified.

5.1.2 The starting torque of each motor shall be higher than the initial resisting torque of the driven load through out the starting period even at a feeding voltage of 85% of the rated voltage for normal purpose motor and 80% of the rated voltage for special purpose motor.

5.1.3 The starting current shall not be greater than 6 times the rated current when the motors are started at full voltage including tolerances, unless otherwise specified.

5.1.4 The motors shall be suitable for the following starting cycle:

a) With the motor at ambient temperature - 2 successive starts and 3rd start after 5 minutes.

b) With the motor at steady state load temperature - 1 immediate start and 2nd start after 5 minutes. This sequence shall be repeated in the next hour.

5.1.5 Speed switch shall be provided, wherever required, to fulfil the starting conditions.

5.2 Locked Rotor Condition

5.2.1 The locked rotor withstand time (t_E), under hot condition at 110% of rated voltage shall be more than the starting time of the motor coupled to the load even at the lowest stipulated starting voltage by 2 secs. for motors, having starting time up to 10 secs. and by 5 secs. for motors, having starting time more than 10 secs.

5.2.2 For increased safety motors, t_E under hot condition shall not be less than 10 secs. The value of t_E shall be determined in the presence of purchaser's representative unless test certificate from an independent testing authority is submitted for similar motors. The time t_E and the locked rotor current shall be stamped on the name plate as well as indicated in the test certificates.

5.2.3 For deciding the time t_E in all cases, the temperature of the insulated stator and rotor shall not exceed the value stipulated under clause no. 5.4.3.

5.3 Running

5.3.1 All motors shall be continuous maximum rated (S1 duty as per IS: 325), unless otherwise specified.

5.3.2 The motors shall be capable of delivering the rated output without exceeding the specified temperature rise under the system voltage and frequency variation conditions as specified in the Design Philosophy-Electrical.

5.3.3 The motors shall be suitable for running at the rated load for 5 minutes duration at 80% voltage and for 1 Sec. duration at 70% voltage, without exceeding the specified temperature rise.

5.4 **Temperature Rise**

5.4.1 The total temperature of the stator winding under full load running condition shall not exceed the values permissible for the specified insulation class. For increased safety motors, the total temperature shall be 10ºC less than for normal motors.

5.4.2 For explosion proof motors, the maximum surface temperature shall not exceed the values applicable for temperature class of the hazardous gases / vapours present in the surrounding area. However for type 'n' motors, the maximum allowable temperature shall not exceed 200ºC.

5.4.3 In case of starting and locked rotor conditions stipulated under clause nos. 5.1.4 and 5.2.1 respectively, the maximum temperature in the rotor shall not exceed the following values:

For squirrel cage rotor	-	300ºC
For wound rotor	-	As applicable to the insulation class
For explosion proof motor	-	As per temperature class of the hazardous gases / vapours, without exceeding the above temperature as applicable

6.0 COUPLING DETAILS

6.1 Unless otherwise specified, all motors shall be coupled to the driven equipment through flexible coupling.

6.2 Normally the coupling half for the motor shaft shall be supplied by the driven equipment supplier. The coupling half shall be keyed on the shaft with a tapered joint or shrunk with a straight joint. For this purpose, the motor manufacturer shall coordinate all details of the coupling system with the driven equipment manufacturer, wherever required.

6.3 Where rigid coupling is specified, the motor shaft shall have the desired class of accuracy.

6.4 For all vertical flange mounted motors, the limitations on shaft extension, run out, perpendicularity and eccentricity, as required by the driven machine supplier shall be complied with by the motor supplier.

6.5 i) If the motor is to be coupled to a reciprocating pump or compressor requiring fluctuating torque, the motor supplier shall ensure that the inertia of the driving and driven machine assembly shall be such that the variation in the armature current shall not exceed ±66% of the rated current while delivering full load.

ii) The measurement of armature current shall be done with the oscillograph.

iii) The additional fly wheel, if any, shall be assembled at such a distance from the motor so as to allow easy inspection of the windings.

iv) All necessary coordination with driven equipment manufacturer shall be carried out by the motor manufacturer.

6.6 i) Wherever belt drive is specified, the motor supplier shall ensure that the shaft extension and the bearings are suitable for the duty specified.

ii) Unless otherwise specified, the slide rails for all belt driven motors shall be supplied by the motor manufacturer.

6.7 Spacer coupling shall be provided for all motor/pump to ease out the DOR checking/Maintenance without carrying out the shifting or removal of motor/pump.

7.0 ACCESSORIES

The motors shall be complete with the accessories.

7.1 Space Heaters

7.1.1 Space heaters rated for 240 V A.C. shall be provided to keep the winding dry for all high and medium voltage motors, except for motors rated below 30 KW which shall be suitable for space heating by connecting 24 V A.C to any of the two motor winding terminals. Provision for the same shall be made in the MCC/PMCC panel.

7.1.2 The location of the space heaters shall be such as to allow easy access for inspection, maintenance and replacement.

7.2 Name Plates

7.2.1 The name plates shall be of stainless steel with letters embossed on them.

7.2.2 The name plate shall contain all the relevant details as per IS: 325 and in addition shall indicate the following:

i) The description and code no. of motor

ii) Degree of protection of enclosure

iii) Temperature rise of windings under running condition

iv) Designation of bearings

v) Recommended type of lubricant and interval of lubrication

vi) Direction of rotation

vii) Mounting Arrangement

7.2.3 Flameproof motors shall have additional name plate containing relevant particulars as per IS: 2148.

7.2.4 Increased safety motors shall have additional name plate containing relevant particulars as per IS: 6381.

7.2.5 Motors with type of protection “n” shall have additional name plate containing relevant particulars as per IS: 9628.

7.3 Embedded Temperature Detectors

7.3.1 All high voltage motors shall be provided with 6 nos. of evenly distributed embedded resistance temperature detectors for measurement of winding temperature. These shall be located in positions at which the highest temperatures are likely to occur.

7.3.2 In addition, the high voltage motors shall be provided with

i) 1 no. RTD for hot air temperature measurement

ii) 2 nos. RTDs (1 on each side) for bearing temperature measurement of oil lubricated bearings. For grease lubricated bearings, RTD shall be provided only where specified

7.3.3 These RTDs shall be of platinum having 100 ohm resistance at 0ºC and temperature coefficient as 3.850×10^{-3}.

7.3.4 The RTDs shall be 3 lead type having power frequency insulation level of 2KV.

7.3.5 The RTDs shall comply with the requirements laid down in IS: 2848.

7.4 **Dial Type Thermometers**

7.4.1 In high voltage motors, the measurement of hot air and bearing temperature (of oil lubricated bearings) by dial type thermometers shall be provided wherever specified.

7.4.2 The arrangement shall consist of a dial type of mercury-in-steel thermometer so mounted that its stem shall be located in the maximum temperature region.

7.4.3 The thermometer shall have two potential free contacts for alarm and trip.

7.4.4 All contacts shall be rated for 2 Amps. at 110 V D.C.

7.4.5 For bearing temperature measurement, separate thermometers shall be provided for each bearing.

7.4.6 For grease lubricated bearings, temperature measurement arrangement shall be provided only where specified.

7.5 **Oil Supply System**

7.5.1 For large sized motors, where forced oil lubrication system is considered, a common oil supply system for the motor and the driven equipment shall be provided by the driven equipment manufacturer.

7.5.2 However, the motor supplier shall quote separate price for the complete oil system of the motor.

7.5.3 The system shall be suitable for location near the motor.

7.5.4 The oil supply system for each motor shall include:

i) 2 Nos. 100% rated motor driven pumps with motors

ii) 1 No. oil tank complete with oil level gauge and thermometer

iii) 1 No. oil cooler

iv) 1 No. oil filter

v) 1 No. differential pressure switch for filter

vi) 2 Nos. pressure switches

vii) Necessary piping

viii) Necessary control and interlocks

8.0 VIBRATIONS

The motor vibrations measured at the bearings must not exceed the limits specified in IS: 12075.

9.0 NOISE LEVEL

The motor noise level shall not exceed 85 dB measured at a distance of 1 metre from the motor.

10.0 PAINTING

10.1 Enclosures of the motor and its accessories shall be painted with two coats of anti-rust paint and two coats of anti-corrosive paint after suitable pre-treatment.

10.2 Epoxy paint, wherever specified, shall be used.

10.3 Unless otherwise specified, the finishing shade shall be light grey having shade No. 631 as per IS: 5.

11.0 TESTS AND INSPECTION

11.1 All motors shall be routine tested as per relevant standards.

11.2 Additional tests, wherever specified, shall be carried out on one motor of each rating.

11.3 For high voltage motors of each rating, polarization index test shall also be carried out.

11.4 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the motor shall be subject to stage inspection at works and inspection at site for final acceptance.

11.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defects which may be noticed subsequently.

12.0 PACKING

12.1 The motors shall be properly packed to safeguard against weather conditions and handling during transit.

12.2 The shaft shall be properly clamped / supported.

12.3 Rust inhibiting agents shall be applied to fittings and sliding surfaces.

12.4 All flanges shall be closed with blanking plates to avoid entry of foreign materials.

12.5 The loose pieces of the motor / spare parts / Instruments shall be separately wrapped in moisture resistant paper and marked with identification marks and name plate of the corresponding motors.

12.6 The packing box / crate shall include a copy of installation, operation and maintenance manual.

13.0 DRAWINGS AND DOCUMENTS

13.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

13.2 All drawings and documents shall have the following descriptions written boldly:

- Name of client
- Name of consultant
- Enquiry / order number with plant / project name
- Motor Code No. and Description

14.0 SPARES

14.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the motors.

14.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

14.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

14.4 All spare parts shall be identical to the parts used in the motors.

15.0 DEVIATIONS

15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR INDUCTION MOTORS

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet and Technical Particulars completely filled-in	Y	Y	Y
2.	Dimensional Drawings	Y	Y	Y
3.	Drawings and data for air / water heat exchangers, if necessary	N	Y	Y
4.	Drawings and data for oil system, if necessary	N	Y	Y
5.	Characteristic curves			
	a) Thermal withstand curve	N	Y	Y
	b) Load Vs FL current	N	Y	Y
	c) Load Vs Efficiency	N	Y	Y
	d) Load Vs Power factor	N	Y	Y
	e) Load Vs Speed	N	Y	Y
	f) Voltage Vs Thermal Withstand time	N	Y	Y
	g) Starting current Vs Time	N	Y	Y
6.	Connection diagram for RTDs, thermometer etc.	N	Y	Y
7.	Terminal Box drawings	Y	Y	Y
8.	Illustrative and Descriptive catalogues	Y	N	Y
9.	Catalogues of bought out accessories	Y	N	Y
10.	Spare parts list	Y	N	Y
11.	Installation, Operation and Maintenance manual	N	N	Y
12.	Test certificates			
	a) Routine	N	N	Y
	b) Type	N	N	Y
	c) For enclosure	Y	N	Y
13.	Guarantee Certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

INTERLOCKING SWITCH SOCKET AND PLUG

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR INTERLOCKING SWITCH SOCKET AND PLUG

1.0 SCOPE

1.1 The standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of interlocking switch socket and plug.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS-4160/ IEC-309 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of Indian Electricity Rules and other statutory acts and regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The equipment shall be suitable for operating at the rated capacity continuously, under the ambient condition indicated in Design Philosophy-Electrical, without exceeding the specified temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The switch socket shall be heavy duty industrial type. The interlocking arrangement shall be such that it is not possible to insert or withdraw the plug with the switch in 'ON' position.

5.2 The switch sockets shall have dust, hose and weather proof construction conforming to IPW55 as per IS: 13947 and shall be suitable for outdoor use without any extra protection. All jointing surfaces shall be smoothly machined and of sufficient width to prevent ingress or dust. Further the covers shall be provided with continuous gaskets made of neoprene to prevent ingress of dust and moisture.

5.3 The enclosure of switch sockets and plugs shall be of cast aluminium alloy 4600 and suitable for fixing on wall / structure.

5.4 The enclosure shall be largely dimensioned in order to avoid temperature rise inside it which may damage the insulating materials and gaskets employed therein.

5.5 The insulating materials used shall be non-hygroscopic, mould proof and treated with suitable varnish to withstand the ambient conditions.

5.6 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm or above shall be of mild steel zinc passivated.

5.7 Suitable arrangement for looping of cables from one switch socket to the other shall be provided. For switch sockets rated above 63A, looping shall be done from busbars and for switch sockets rated 63A and below, looping may be done from terminal block. Necessary terminals, cable glands and lugs for looping shall be provided. Also one no. The readed plug for each switch socket shall be supplied loose.

5.8 All the relevant information shall be provided on engraved name plate made of aluminium.

5.9 The enclosure shall be provided with two earthing terminals outside the body.

6.0 SPECIAL FEATURES FOR FLAME PROOF SWITCH SOCKET AND PLUGS

6.1 The enclosure shall be in addition of flame proof execution as per IS: 2148.

6.2 The enclosure group and temperature class shall be as indicated in specification sheet.

6.3 Cable shall enter the terminal chamber through flame proof compression type cable glands. From the terminal to the main enclosure, the connection shall be made through proper bushings. Direct entry of external cables into the main enclosure shall not be accepted.

6.4 An additional earthing terminal inside the terminal chamber shall be provided.

6.5 Switch socket, plug and cable glands must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

6.6 Further interlocking shall be provided so that the contacts cannot be energised when the plug and socket are separated.

7.0 COMPONENT DETAILS

7.1 The rating of the components shall be as indicated in specification sheet.

7.2 Air Break Switches

7.2.1 The switches shall be quick make, quick break rotary type and of utilisation category AC-23 as per IS: 13947.

7.2.2 Switches shall be hand operated from outside the cover. The switch handle shall remain fixed to the front cover while removing the front cover.

7.3 H.R.C. Fuses

7.3.1 The sockets shall be provided with link type HRC fuses.

7.3.2 The fuses shall be capable of withstanding a short circuit current of 50 KA and shall be delayed action type conforming to IS: 13703. These shall be mounted on a shrouded base.

7.4 **Socket Outlets**

7.4.1 The socket outlet shall be located in the lower part of the enclosure and shall be provided with a threaded aluminium cover attached to the body with G.I. chain, to protect the socket after extraction of the plug. Spring loaded automatic shutter shall not be acceptable.

7.4.2 The socket contacts shall maintain satisfactory spring pressure and contact with the corresponding plug under normal service conditions.

7.4.3 The socket contacts shall be sunk well below the surface of the socket- outlets so as to make it impossible to be touched unintentionally.

7.4.4 An earthing contact shall be provided in the socket outlet which shall ensure making and breaking respectively of its contact with the earthing pin of the plug before and after making and breaking of the corresponding current carrying contacts.

7.5 **Plugs**

7.5.1 The plugs shall be so constructed so that these can be easily fitted in to the socket outlets.

7.5.2 These shall be provided with knurled knob arrangement for screwing on the body of the socket so that it can be securely fixed on the top.

7.5.3 The plug base and cover shall be firmly secured to each other and shall be sufficiently robust in construction to withstand normal usage.

7.5.4 The plug pins shall preferably be of single part. The earthing pin shall be slotted with a single slot and shall be larger in dimension than other pins.

7.5.5 The plug and socket contacts shall be self aligning type with best electrical continuity.

7.5.6 The plug shall be provided with dust proof cable entry suitable for receiving TRS flexible heavy duty copper conductor cable of specified size. The arrangement shall be such that the conductors are relieved from strain including twisting where they are connected to the terminals and that the outer surface of the cable at the place of entry is not damaged.

7.5.7 Insulating barriers forming an integral part of the plug shall ensure separation of metals and bare flexible conductors at different potentials.

7.6 **Cable Termination**

7.6.1 Switch socket shall have cable termination arrangement on the upper part of the housing and shall be provided with side entries, one on either side, through heavy duty double compression type rolled aluminium cable glands suitable for 1.1 KV grade XLPE insulated armoured and PVC sheathed cables.

7.6.2 The terminal blocks shall be pressure clamp type for switch socket rated up to 63A and bolted lug type for higher ratings. The terminals shall be rated for at least 1.5 times the switch rating.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 The finishing shade shall be light grey shade no.631 as per IS: 5, unless specified otherwise.

9.0 TESTS AND INSPECTION

9.1 The switch sockets and plugs shall be subjected to routine tests as per IS-4160 and other relevant standards.

9.2 Wherever specified, additional tests shall be carried out on one switch socket and plug of each rating.

9.3 The tests shall be carried out in the manufacturer's works in the presence of purchaser's representative. In addition to the above tests, the equipment shall be subject to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts for the following items as applicable shall be offered along with the main equipment with recommended quantity.

i) Switch

ii) Fuse base

iii) Fuse

iv) Terminal blocks

v) Terminal bushings

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The switch socket and plug shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE – I

DOCUMENTATION FOR INTERLOCKING SWITCH SOCKET AND PLUG

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	Y	Y	Y
2.	Technical Particulars	Y	Y	Y
3.	General arrangement and foundation drawing	Y	Y	Y
4.	Schematic / wiring diagram	N	Y	Y
5.	Illustrative and descriptive literature	Y	N	Y
6.	Catalogue for bought out accessories	Y	N	Y
7.	Installation operation and maintenance manual	N	N	Y
8.	Test Certificates			
	a) Type	N	N	Y
	b) Routine	N	N	Y
9.	Guarantee Certificate	N	N	Y
10.	Certificate of flameproofness from statutory testing authority wherever applicable.	Y	N	Y
11.	Spare parts list with identification marks	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

LIGHTING FIXTURES AND ACCESSORIES

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATIONAL REQUIREMENTS
5.0	GENERAL CONSTRUCTIONAL REQUIREMENTS FOR FIXTURES
6.0	TYPE OF FIXTURES
7.0	ACCESSORIES
8.0	TESTS AND INSPECTION
9.0	DRAWINGS AND DOCUMENTS
10.0	SPARES
11.0	PACKING
12.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR LIGHTING FIXTURES AND ACCESSORIES
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works, and despatch in well packed condition of lighting fixtures and their accessories.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the lighting fixtures and their accessories covered by this standard shall comply with the latest issue of the following and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS:1913(Part 1)	--	General and safety requirements for Luminaries Part-1: Tubular fluorescent lamps
IS:6665	--	Code of practice for Industrial lighting.
IS:1777	--	Industrial luminaries with metal reflectors.
IS:5077	--	Decorative lighting outfits.
IS:10322	--	Luminaries.
IS:4012	--	Dust proof electric lighting fittings
IS:3528	--	Waterproof electric lighting fittings.
IS:13947 (Part-1)	--	Specification for Low-voltage Switchgear and Control gear – Part-1 : General Rules
IS:2148	--	Electrical Apparatus for Explosive Gas Atmospheres - Flameproof Enclosures “d”
IS:2206 (Part 1)	--	Flameproof electric lighting fittings Part-1: Well glass and bulk head types.
IS:2206 (Part 2)	--	Flameproof electric lighting fittings Part-2: Fittings using glass tubes
IS:8224	--	Electric lighting fittings for division-2 areas.
IS:1534 (Part 1)	--	Ballasts for fluorescent lamps: for switch start circuits.
IS:6616	--	Ballasts for high pressure mercury vapour lamps.
IS:1569	--	Capacitors for use in tubular fluorescent high pressure mercury and low pressure sodium vapour discharge lamp circuit.
IS:2215	--	Starters for fluorescent lamps.
IS:3323	--	Bi-pin lamp holders for tubular fluorescent lamps.
IS:1258	--	Bayonet lamp holders.
IS:10276	--	Edison screw lamp holders.
IS:3324	--	Holders for starters for tubular fluorescent lamps.

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATIONAL REQUIREMENTS

The fixtures and their associated accessories shall be suitable for operating continuously under the ambient conditions and with the voltage and frequency variations indicated in Design Philosophy-Electrical without exceeding temperature rise limits as per relevant standards and without detrimental effect on any part.

5.0 GENERAL CONSTRUCTIONAL REQUIREMENTS FOR FIXTURES

5.1 The fixtures shall be complete with all accessories including the control gear box but excluding the lamp.

5.2 The control gear box for fluorescent lamp fixtures shall consist of starter, ballast and capacitor for power factor improvement and for correction of stroboscopic effect.

5.3 The control gear box for mercury vapour fixtures shall consist of ballast and capacitor for power factor improvement. The control gear box for sodium vapour fixtures shall comprise ballast, capacitor and an electronic ignitor.

5.4 The fixture housing control gear box shall be made of CRCA sheet steel, aluminium sheet or cast aluminium.

5.5 The fixtures shall be provided with cable glands wherever specified and a terminal block suitable for termination of copper conductor up to 2.5 sq. mm size. Looping facility shall be provided wherever indicated.

5.6 The control gear box shall normally be mounted separate / integrally. Where the control gear box is to be mounted separately, the same shall be housed in as enclosure made of CRCA sheet steel / cast aluminium. The control gear box shall additionally contain HRC fuse (except for FLP fittings), suitable terminals with lugs, three numbers cable glands and a spare threaded plug.

5.7 The control gear box shall be suitable for location in the same area as the fixture and shall have the same degree of protection.

5.8 All external hardware such as bolts and nuts of below 8 mm size, toggle lever, hinge pins etc. shall be of stainless steel and bolts and nuts of higher sizes shall be zinc passivated with sufficient thick layer capable of withstanding the operating conditions.

5.9 Neoprene gaskets shall be provided where necessary to prevent ingress of dust, moisture and insects inside the fixture and to make the fixture suitable for outdoor installation.

5.10 The fixture / control gear box shall have minimum degree of protection equivalent to IP-55 for outdoor installation and IP-43 for indoor installation as per IS-13947 (Part-1).

5.11 The fixture shall be so designed that it shall be possible to maintain or replace the different accessories without difficulty, including the replacement of the lamp.

5.12 The insulation of wiring conductor for fixture and control gear box (where provided separately) shall be selected considering the maximum temperature due to the heat generation by ballast, lamp, etc. under normal operating condition and its proximity with the same. Wherever necessary, heat resistant type insulated conductor shall be used for the wiring of the fixture and control gear box.

5.13 The wiring between different components of the fixture and control gear box shall be properly secured to avoid loosening of the connection due to vibration.

5.14 The fixture / control gear box shall be provided with an internal earthing terminal.

5.15 The fixture shall be designed to maximise the downward throw of luminous flux.

5.16 The fixture / control gear box shall be suitable for type, number and wattage of lamp.

5.17 Where integral control gear box is not provided, maximum rating and type of the lamp which can be used with the fixture shall be indicated on the name plate.

5.18 **Painting**

5.18.1 All metal surfaces shall be made completely free from any scale and rust by suitable processes of degreasing and pickling. The thoroughly cleaned surface shall be pre-treated by phosphatising and passivating.

5.18.2 Aluminium surfaces shall be pre-treated by anodisation.

5.18.3 Two coats of zinc chromate primers shall be applied on all metal surfaces before application of two coats of finishing paint as specified for different types of fixtures. Where epoxy paint is specified, epoxy based primers.

5.19 **Supporting Arrangement**

5.19.1 Fixture shall be suitable for mounting on the ceiling / structure as required. A mounting bracket shall be supplied, where necessary.

5.19.2 Sketch showing the mounting arrangement and dimension for each type of fixture shall be furnished.

6.0 TYPE OF FIXTURES

6.1 **Commercial Decorative Type**

6.1.1 <u>Channel / Rail Mounting Fluorescent Fixtures</u>

6.1.1.1 The fixtures shall be provided with CRCA sheet steel enclosure housing all electrical accessories, mounting channel, good quality clear acrylic cover/ opal diffuser / louver of

non-yellowing type and high impact polystyrene black end plates. The mounting channel shall be provided with a reflector plate to hold the cover / diffuser / louver, so that the same shall not come out when the end plates are removed.

6.1.1.2 Where continuous mounting is specified, instead of end plates at the two consecutive ends of the fixtures, one 25 mm wide aluminium strip painted with black epoxy paint with proper fixing arrangement shall be provided to cover the gap between the two fixtures. The strip shall be so shaped that it can be easily fitted or removed without difficulty.

6.1.1.3 The channel housing and the reflector plate shall be epoxy stove enamelled.

6.1.1.4 The fixtures shall be suitable for 2x36 W fluorescent tube / 15W compact fluorescent (CFL) lamps.

6.2 Recess Mounting Fluorescent Fixture

6.2.1 The fixtures shall be suitable for recess mounting on false ceiling. The fixtures shall have CRCA sheet steel enclosure housing all electrical accessories, reflector plate and good quality non-yellowing type clear acrylic cover / opal diffuser / louver.

6.2.2 The fixtures shall be suitable for 2x36W fluorescent tube / 15W compact fluorescent (CFL) lamps.

6.2.3 The housing and the reflector plate shall be stove enamelled white.

6.2.4 Mirror optics fixtures shall be suitable for recess mounting on false ceiling. The fixtures shall have CRCA sheet housing, stove enamelled, white and containing all electrical accessories.

6.2.5 Mirror optics fixture where specified shall have high purity anodised aluminium reflector for high photometric performance and specially designed V-shaped parabolic cross louvers for better glare control.

6.2.6 Mirror optics fixtures shall be suitable for 2x36W fluorescent tube / 15W compact fluorescent (CFL) lamps.

6.3 Industrial Type

6.3.1 Channel / Rail Mounting Fluorescent Fixtures

6.3.1.1 The fixtures shall be provided with CRCA sheet steel mounting channel containing all the accessories, suitably covered with CRCA sheet steel and epoxy stove enamelled.

6.3.1.2 The fixture without reflector shall be with epoxy stove enamel finish. Where reflector is specified the same shall be CRCA sheet of minimum 20 SWG thickness and vitreous enamelled white inside and grey outside.

6.4 Hose Proof Fluorescent Fixtures

6.4.1 The fixtures shall be totally enclosed type, suitable for outdoor installation having enclosure equivalent to IP-55 as per IS-2147. Test certificate in respect of the IP-55 enclosure shall be submitted.

6.4.2 The fixtures shall have aluminium housing having control gear tray containing all electrical accessories wired up to terminal block.

6.4.3 The Fixtures shall have clear acrylic front cover, properly sealed in the metallic door frame which shall have hinges at one side and arrangement on the opposite side for proper fixing of the front cover by application of sufficient pressure on the frame cover

gasket. The gasket shall be of such quality that it shall not deteriorate during opening and closing of the front door, for replacement of lamps or maintenance of the fixtures.

6.4.4 The fixtures shall have epoxy stove enamel finish, white inside and grey outside.

6.5 **Corrosion Proof Fluorescent Fixtures**

6.5.1 The fixtures shall be suitable for installation in an area laden with corrosive chemical dusts and vapours.

6.5.2 The ballast, capacitor and terminal block shall be housed in a cast aluminium enclosure which shall be made dust and vapour proof with the use of neoprene rubber gaskets. The internal connecting wires shall run inside 2 nos. seamless aluminium pipes properly screwed and sealed on either side of the control gear housing. The end boxes shall be made of cast aluminium fixed at the ends of the seamless pipes which shall contain the starter holder, starter and the lamp holders.

6.5.3 The lamp holders shall be so designed that when the lamps are fitted, ingress of corrosive dust and vapour inside the lamp holders is prevented to protect lamp pins.

6.5.4 The fixtures shall be epoxy stove enamelled.

6.6 **Bulk head Type Incandescent / Mercury Vapour Fixtures**

6.6.1 The fixtures shall be made of cast aluminium alloy in weather proof execution finished in epoxy stove enamel grey outside and white inside, provided with prismatic heat resistant glass cover and 3 mm G.I. wire guard.

6.6.2 For use with H.P.M.V. lamp, separate control gear box shall be supplied.

6.7 **Well Glass Type Incandescent / Mercury / Sodium Vapour fixtures.**

6.7.1 The fixture housing shall be made of cast aluminium alloy in dust, vapour and weather proof execution finished in epoxy stove enamel, grey outside and white inside, provided with clear heat resistant glass which shall be fitted with neoprene gasket and 3 mm G.I. wire guard.

6.7.2 Where top entry is specified for suspension, the fixture shall be suitable for 19 mm NB G.I. pipe.

6.7.3 Where additional dispersive reflectors are specified to be supplied with the fixtures, the same shall be of CRCA sheet steel vitreous enamelled.

6.8 **High Bay Type Mercury / Sodium Vapour Fixtures**

6.8.1 The fixtures shall be in dust and vapour proof execution with a reflector and heat resistant glass cover and shall be provided with separate / integral control gear.

6.8.2 The control gear and lamp holder housings shall be of cast aluminium so designed as to achieve better heat dissipation and proper cooling of the unit.

6.8.3 The reflector shall be made of anodised aluminium epoxy enamelled outside and electrochemically brightened inside.

6.8.4 The canopy shall be of cast aluminium having terminal block for external connection and provided with suspension hook.

6.8.5 The canopy, control gear and lamp holder housings shall be epoxy stove enamelled.

6.9 **Street Lighting Fixtures**

6.9.1 The fixtures shall be suitable for fluorescent / mercury vapour / sodium vapour lamp as specified and shall be made of cast /sheet aluminium epoxy enamelled housing, anodised aluminium reflector and non-yellowing type acrylic cover.

6.9.2 The fixture shall be totally enclosed type suitable for outdoor installation having enclosure equivalent to IP-43 as per IS-13947 (Part-1).

6.9.3 The fixtures shall have light distribution same as that of semi-cut off type as specified.

6.9.4 The fixtures shall be provided with side entry for the supporting pipe. The cable shall be taken inside through the supporting pipe of 25 mm dia.

6.9.5 The clamping arrangement for the supporting pipe shall be designed to suit the weight of the fixture and wind load for mounting height upto 16 M as specified in the relevant Indian Standard Specification. The clamping arrangement shall provide wide range flexibility in the use of supporting pipe by the purchaser.

6.9.6 Unless otherwise specified, fixture for use with mercury / sodium vapour lamp shall be provided with arrangement of adjusting the position of lamp holder to have a cut off or semi-cut off light distribution.

6.10 Flood Lighting Fixtures

6.10.1 The fixtures shall be in weatherproof execution suitable for high pressure mercury / sodium vapour lamp and shall comprise of epoxy stove enamelled, cast aluminium alloy body, a clear heat resistant flat toughened glass, an anodised mirror polished aluminium reflector and a focussing device.

6.10.2 The fixtures shall be having an arrangement for rotation on both horizontal and vertical planes and locking in any desired position.

6.10.3 The complete unit shall be mounted on a heavy base of cast iron for fixing the fixture on a structural platform.

6.10.4 All cast iron and M.S. structural provided in the fixture shall be epoxy painted.

6.10.5 A separate control gear box suitable for the rating of the lamp specified shall be supplied along with the fixture.

6.11 Post Top Lantern Type Fixture

6.11.1 The fixtures shall be suitable for mercury / sodium vapour lamps having cast aluminium spigot, circular opal non-yellowing type acrylic diffuser and cast aluminium pole mounting base with integral control gear.

6.11.2 The fixtures shall be suitable for outdoor installation.

6.11.3 The canopy and the mounting base shall be epoxy stove enamelled.

6.12 Air Obstruction Lighting Fixtures

6.12.1 The fixtures shall be suitable for neon cold cathode helix and shall be complete with neon lamp, transformer, red glass dome, necessary terminal box and other accessories.

6.12.2 The fixtures shall have body of corrosion resistant aluminium alloy casting and shall be suitable for outdoor use and mounting on 40 mm NB G.I. pipe. Necessary electrical threading shall be tapped in the fixture for mounting.

6.12.3 The optical system of the glass should give a symmetrical light distribution with intensity not less than 10 candles. The intensity shall be uniform between 10º and 90º above horizontal.

6.13 **Fixtures for use in Hazardous Area**

6.13.1 The fixtures for use in hazardous area shall be in cast aluminium (alloy 4600) / cast iron enclosure which shall be epoxy stove enamelled.

6.13.2 The fixtures shall have general constructional features as per clause 5.0 and type conforming to clause nos. 6.4 to 6.12 unless indicated otherwise and shall also comply with relevant Indian standard for the type of fixtures specified viz. flameproof / increase safety fittings for division 2 areas.

6.13.3 The fixtures shall be suitable for hazardous area for enclosure group and temperature class.

6.13.4 Flameproof fixture / control gear box shall be provided with flameproof cable glands.

6.13.5 Lighting fixture / control gear box for division-2 area shall be provided with increased safety cable glands.

6.13.6 One internal earthing terminal shall be provided.

6.13.7 The vendor shall confirm that the fixture and control gearbox, where supplied separately, have been tested and certified by relevant statutory authorities for use in the hazardous area as offered by them and shall submit the relevant documents along with the offer.

7.0 ACCESSORIES

7.1 **Ballast**

The ballast shall be highly inductive silicon steel laminated, copper wire wound polyester filled heavy duty type.

7.2 **Capacitors**

7.2.1 The capacitors shall be constant value type hermetically sealed in metal enclosure to ensure long trouble free service.

7.2.2 The value of capacitors for power factor improvement shall be so selected that the corresponding lamp circuit power factor does not fall below 0.95 lag.

7.3 **Starter**

The starter shall be suitable for igniting fluorescent lamp having bi-metal electrodes and radio interference suppression capacitor in an enclosure of high mechanical strength.

7.4 **Lamp Holder**

7.4.1 The lamp holders shall ensure proper contact with the lamp during continuous operation, preventing extinguishing of the lamp due to small vibration.

7.4.2 The material of the lamp holder shall be suitable to withstand the operating temperature without any deterioration.

7.4.3 The lamp holder for fluorescent lamp shall be spring loaded rotor type, suitable for bi-pin lamp, so designed to prevent contact with live parts of the lamp holder after the lamp has been taken out or during insertion / removal of the lamp.

7.4.4 The lamp holder for mercury / sodium vapour and incandescent lamp shall be Edison screw type, excepting for incandescent lamps rated up to 100 watt, which may be bayonet type.

7.5 **Starter Holder**

The starter holders used for fluorescent lamp shall ensure good electrical contact with the starter pin with strong spring action for trouble free operation. It shall be possible to insert or remove the starter with ease.

7.6 **Cable Glands**

Cable glands shall be of rolled aluminium, double compression type suitable for XLPE insulated armoured and PVC sheathed 1.1 KV grade cables.

8.0 TESTS AND INSPECTION

8.1 The following tests shall be carried out on the lighting fixtures and their accessories as per relevant IS.

8.1.1	Routine tests	-	On each lighting fixture and its accessories.
8.1.2	Acceptance tests	-	On one sample of each type.
8.1.3	Type tests	-	Wherever specified on one lighting fixture of each type and its accessories.

8.2 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the fixtures shall be subjected to stage inspection at works and inspection at site for final acceptance.

8.3 These tests and inspection shall however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

9.2 All drawings and documents shall have the following description written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

10.0 SPARES

10.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments.

10.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

10.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

10.4 All spare parts shall be identical to the parts used in the equipments.

11.0 PACKING

11.1 The lighting fixtures shall be properly packed to safeguard against weather conditions and handling. It shall be wrapped in polythene bag with an additional wrapping of bitumen paper to make it completely waterproof before the equipment is packed in wooden crates.

11.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

12.0 DEVIATIONS

12.1 Deviation, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR LIGHTING FIXTURES AND ACCESSORIES

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheets, duly completed	Y	Y	Y
2.	Technical particulars, duly filled-in	Y	Y	Y
3.	Illustrative and descriptive catalogues indicating general arrangement, light distribution, light absorption and utilisation factors, full load currents, power factors and power requirement for each type of fixture including control gear losses.	N	Y	Y
4.	Sketch showing mounting arrangement with dimensions.	Y	Y	Y
5.	Type Test Certificates for			
	(a) Hose proof fixtures (b) Flame proof fixtures (c) Division-2 area fixtures	Y	N	Y
6.	Spare parts list	Y	N	Y
7.	Test certificates	N	N	Y
8.	Guarantee certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - II

LIST OF SPARES

1. Reflector of each type.
2. Lamp holder of each type
3. Starter for fluorescent tubes
4. Starter holder for fluorescent tubes
5. Capacitor for each type
6. Ballast of each type
7. Fuse of each type
8. Acrylic cover / Diffuser / Louvre of each type
9. Terminal block of each type
10. Transformer for air obstruction light fittings
11. Neon lamp of each type
12. Electric Ignitor for sodium vapour lamps
13. Heat resistant toughened glass cover of each type
14. Cable glands of each type
15. Allen keys of different sizes as applicable

TECHNICAL SPECIFICATION

BATTERY CHARGER

CONTENTS

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ANNEXURE - I	REQUIREMENT OF PROTECTIONS, METERING, CONTROL AND INDICATIONS / ANNUNCIATIONS FOR BATTERY CHARGER
ANNEXURE - II	DOCUMENTATION FOR BATTERY CHARGER
ANNEXURE - III	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well packed condition of Battery Charger Units.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this specification shall comply with the latest issue of IS: 8623 Specification for low voltage switchgear and control gear assemblies and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment shall also comply with provisions of the latest issue of the Indian electricity Rules and other relevant Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 DESIGN AND OPERATIONAL REQUIREMENTS

4.1 The Battery Charger Unit and its components shall be suitable for operating at the specified rating continuously with the specified voltage and frequency variations under the ambient conditions indicated in Design Philosophy-Electrical, without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.

4.2 The battery charger shall be microprocessor based and the battery charger configuration shall be 2FC+1FCBC to supply continuous load and keep the battery in state in float mode. In Boost mode, for initial charging of Battery and after power restoration subsequent to failure, to recharge the battery while simultaneously supplying load current.

4.3 The rated voltage of the float charger for lead acid battery shall be 2.2 Volt / Cell and final charging voltage of the boost charger shall be 2.75 Volt / Cell. The rated output voltage of the charger under 4.2 (a) above shall be adjustable by ± 5% of the rated value manually.

4.4 Charging unit stated under 4.2 (a) above shall be fully automatic using silicon controlled rectifiers (SCR) common for Float and Boost service. Charger D.C. output voltage shall be maintained within ± 2% irrespective of the input supply variations as indicated in Design Philosophy-Electrical and load variation of 0 to 100% by closed loop voltage feed back control system. The charger shall be provided with current limit feature.

4.5 The output voltage of the float charger shall be monitored and in case voltage falls below 90% of the rated voltage the stand by charger shall be automatically switched 'ON' with audio-visual alarm and annunciation. Time delay features shall be incorporated to avoid spurious changeover.

4.6 Boost charging shall be achieved through the same silicon controlled rectifier (SCR) which shall regulate the charger output automatically by current control closed loop system. Provision for manual adjustment of charger output shall also be made. Charger shall maintain its output current constant at starting rate/ finishing rate of battery charging current irrespective of variation in input supply and battery condition.

4.7 Transfer from float charging to boost charging and vice versa shall be automatic as per the battery charge condition.

4.8 During boost charging operation, arrangement shall be made so that DC power to load is not interrupted even if AC power fails during this operation. During Boost charge period, battery backup to load shall be arranged by a tapping from suitable point of the battery.

4.9 Suitable dropper diodes shall be provided to reduce the voltage across the load to 105% of the rated voltage at rated load current. When power supply to the charger fails, the dropper diodes shall be by-passed automatically through contactor so that full battery output voltage is available to the load.

4.10 Provision of suitable filters shall be made so that the ripple in output voltage shall not exceed 3% and 10% for float and boost charger respectively.

4.11 It shall be ensured that during boost charging, no over/under charging of cells takes place.

4.12 All the automatic features specified above shall also have provision of manual arrangement for control of charging rates and transfer from one charger to others.

4.13 Charger unit shall be provided with all required indication, metering, protection, control and alarm annunciation devices for safe and reliable operation and shall include at least as indicated in Annexure-I.

5.0 CONSTRUCTIONAL FEATURES

5.1 Each of the charger units shall be housed in separate metal clad cubicles of identical size suitable for floor mounting and arranged to form a compact switchboard.

5.2 The complete assembly shall be dust, damp and vermin proof type equivalent to IP-43 as per IS/IEC 60947. In case it is necessary to provide openings for ventilation, these shall be closed from inside by fine wire mesh. Forced ventilated panel shall not be acceptable.

5.3 The frame work of cubicles shall be of bolted/welded construction, fabricated out of cold rolled sheet steel of not less than 2 mm thickness. The thickness of base channel shall not be less than 3 mm, suitable reinforcement, wherever necessary, shall be provided.

5.4 Hinged doors shall be provided on both the front and back side for easy access. The door hinges shall be concealed type.

5.5 The doors and the removable covers shall be provided with non-deteriorating neoprene gaskets. Gaskets without any discontinuity shall be preferred. Gaskets shall be held in position in groove in shaped steel work or these shall be 'U' type. Only one joint per gasket shall be permitted. Adhesive cement, if used, shall be of good quality so that the gaskets do not come off during service.

5.6 The mounting of the components shall be such that these are accessible for checking and replacement without the necessity of removing the adjacent ones, at the same time ensuring necessary degree of safety.

5.7 It shall be possible to carry out maintenance of one charger when the other is in operation.

5.8 The meters, switches and lamps shall be flush mounted type. All components of one unit shall be mounted on the same unit.

5.9 All the live parts shall be insulated. Parts which can not be insulated shall be provided with insulating barriers. These barriers shall provide shielding of all live parts to prevent accidental contact when the door is open. However, for the parts requiring handling normally, such as fuses/lamps etc., separate barriers shall be provided. The barriers in all cases shall cover the cable lug portions and shall be firmly secured, stable and durable. It shall, however, be possible to remove such barriers, if required.

5.10 At the equipment termination points, insulated phase barriers, PVC bolt caps, PVC hoses or insulating ribs shall be provided.

5.11 The outgoing terminal blocks shall be shrouded type or provided with insulating barriers.

5.12 Adequate arrangement for earthing shall be provided to safeguard the Operator or other personnel from electric hazards under all conditions of operation.

5.13 **Clearances and Creepage**

The clearances and creepage distances shall not be lower than the values specified below:

i)	Minimum clearance between two live parts	:	20 mm
ii)	Minimum clearance between a live part & earth	:	20 mm
iii)	Minimum creepage distance	:	28 mm

5.14 **Insulation**

5.14.1 The insulation used shall be non-hygroscopic and may be of porcelain, epoxy resin or glass fibre moulded with plastic. It shall be of adequate electrical and mechanical strength to give trouble free service during normal operation and short circuit conditions.

5.14.2 The insulation shall be treated suitably to withstand the tropical conditions and atmospheric pollution as specified.

5.15 **Wiring**

5.15.1 The switch board shall be completely factory wired and ready for external connections.

5.15.2 The wiring shall be complete in all respect so as to ensure proper functioning of control, protection, interlocking and measurement.

5.15.3 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables of 1100 V grade of minimum 1.5 Sq.mm size.

5.15.4 All wiring shall be marked with dependent both ends marking as per IS: 5578. Numbered ferrules, reading from the terminals outwards, shall be provided at both ends for easy identification. These shall be interlocking type plastic ferrules.

5.15.5 The control cables shall be neatly arranged and properly supported on PVC wiring channel.

5.16 **Cable Termination**

5.16.1 The boards shall be designed for bottom entry of the power and control cables. Sufficient space shall be provided for ease of connection and termination of cable.

5.16.2 Provision for receiving one 415 V, 3 phase 4 wire incoming supply lines, one for each charger shall be made. However, DC output for battery and load shall be looped inside the panel and only one outgoing supply each for battery and load shall be provided.

5.16.3 The termination of cables shall be done through cable glands which shall be suitable for the cables.

5.16.4 Heavy duty double compression type rolled Aluminium or nickel plated brass cable glands shall be provided. The cable glands shall be mounted on a removable gland plate, provided at a minimum height of 75 mm from the bottom of the switchboard. Two spare knockouts of size 20 mm shall also be provided on the gland plate for future addition of control cables.

5.16.5 For all power cables, crimped type cable lugs of same material as of conductor shall be provided.

5.16.6 The internal power wiring shall be terminated in the terminal blocks for connection to the outgoing cables, These terminal blocks shall be pressure clamp type up to 35 Sq.mm, cable and bolted lug type for higher sizes of cables, These shall be protected type and rated for 1100 V service. The minimum current rating of terminal block shall be 16 Amp. The construction shall be such that after the connection of cables by means of lugs, necessary clearances and creepage distances are available.

5.16.7 Not more than two wires shall be connected to any terminal. If necessary a number of terminals shall be jumpered together to provide wiring points.

5.16.8 Wherever necessary, suitable clamps to support the vertical run of cables shall be provided.

5.16.9 The terminal blocks shall be grouped according to circuit functions and suitably numbered. 20% extra terminals shall be provided in the terminal block.

5.16.10 For power connection, suitable marking on the terminals shall be provided to identify the phases.

5.17 **Earth Bus**

5.17.1 A continuous earth bus of Aluminium of suitable size minimum 32 x 6 mm shall be run all over the length in the lower part of the board with two ends connected to the external earth terminals of the board.

6.0 COMPONENT DETAILS

6.1 **Rectifier Transformer**

This shall be double wound, air cooled, 3 phase type. Class 'F' insulating materials shall be used, with temperature rise limited to Class 'B'. The windings shall be vacuum impregnated.

6.2 **Thyristors and Diodes**

The thyristors and diodes shall be properly selected to have adequate safety margin. A factor of safety of minimum 4 shall be taken for voltage surges and 2 for current ratings. The thyristors and diodes shall be mounted on their respective heat sinks which shall preferably be made of extruded Aluminium properly machined and providing intimate contact with the stud for heat dissipation. Each thyristor/ diode shall be protected with properly designed snubber circuit.

6.3 **Air Break Switches**

The switches shall be heavy duty quick make, quick break type conforming to IS/IEC 60947. Switches shall be snap action rotary type. 'ON'-'OFF' position of the switch shall be boldly indicated. The handle of switches shall remain fastened to the door even when the door is opened after turning the switch 'OFF'. The AC input switch shall not be directly mounted on the door.

6.4 **Fuses**

For protection of thyristors/ diodes, semi-conductor fuses shall be provided. All other fuses shall be HRC cartridge link type. They shall be suitable for the load and service required.

6.5 **Contactors**

The contactor shall be air break type of category AC-3/ DC-1 as per IS/IEC 60947. DC contactor shall be provided with arc chutes and magnetic blow out coil. The contactors shall not drop out even when the coil voltage drops to 65% of rated voltage.

6.6 **Thermal Overload Relays**

Adjustable bimetal thermal overload relays shall be provided. The bimetal relays shall be ambient temperature compensated. The thermal relays shall be provided with a manual resetting device on the door.

6.7 All ammeters and voltmeters shall be class 1.5 as per IS 1248 and shall be flush mounted type of minimum size 96 x 96 mm. Ammeters and Voltmeters for A.C. service shall be of moving iron type and that for D.C. service shall be moving iron or moving coil type. Zero adjuster shall be provided for operation from the front of the cases.

6.8 **Printed Circuit Boards (PCBs)**

The PCBs shall conform to IS 7405. These shall be of fibre or epoxy glass moulded of minimum thickness 1.5 mm and shall have gold plated contacts and silver or nickel plated tracks. All PCBs shall be of plug-in type contained in a dust proof box. PCBs shall be self diagnostic type and shall be provided with status indication. Metering points shall be provided on each PCB and the PCBs shall be clamped in position so that vibration or long usage does not result in loose contacts.

6.9 **Timers**

The timers shall be electronic, pneumatic or synchronous type conforming to IS: 5834 with manual/auto reset features as per the functional requirements. The repeat accuracy shall be within 5%.

6.10 **Control and Selector Switches**

6.10.1 All the control and selector switches shall be of rotary type with thermal utilization category of AC 11 or DC 11 as per IS 6875.

6.10.2 The control switches shall be spring return type and provided with pistol grip type handles.

6.10.3 The selector switches shall be stay-put type and provided with oval handle.

6.11 **Signal Lamps**

6.11.1 Signal lamps shall be provided to indicate the various circuit conditions and these shall be placed at a suitable height. The colour of the lamps for various functions shall be as follows:

Red	--	Circuit 'ON'
Green	--	Circuit 'OFF'
Amber	--	Alarm and auto trip.

6.11.2 The lamps shall be LED type having lumen output of 200 millicandella in axial direction.

6.12 **Audio Visual Alarm Annunciation**

6.12.1 A solid state audio-visual alarm annunciation system shall be provided for the board. Audible annunciation shall be provided by means of hooter with provision of remote alarm and acknowledgment. Visual annunciation shall be provided by flashing of the respective facia window. The facia window shall have translucent glass or plastic cover with inscription in black letters. Each facia window shall be provided with two lamps connected in parallel. The cover plate of the facia window shall be flush with the panel and shall be capable of easy removal to facilitate replacement of lamps.

6.12.2 The following operating sequence shall be adopted for audio visual alarm and indication:

System Condition	Visual Signal	Audible Signal
Normal	OFF	OFF
Abnormal	Flashing	ON
Acknowledge	Steady ON	OFF
Return to normal	OFF	OFF
Test	Steady ON	ON

6.13 Battery charger ON/OFF indication to be provided on DCS with alarm.

7.0 ACCESSORIES

7.1 The supply shall include the following accessories:

7.1.1 Space Heater

Each cubicle of the board shall be provided with a thermostatically controlled space heater, rated for 240 V, 50 Hz and controlled through double pole miniature circuit breaker. The space heater supply shall be tapped from incomer power supply.

7.1.2 Name Plates

7.1.2.1 The board shall have a large name plate on the top to indicate its name and designation.

7.1.2.2 Each cubicle shall be provided with a name plate.

7.1.2.3 All control switches, push buttons, lamps etc. shall have function identification labels.

7.1.2.4 Name plate shall be of black perspex with white engraving of minimum 3 mm thickness.

7.1.3 Fuse Puller

7.2 Any other accessories required but not specified shall also be supplied to make the board complete in all respects and ensure its safe and proper operation.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anti-corrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified the finishing shade shall be light grey having Shade No. 631 as per IS 5.

9.0 TESTS AND INSPECTION

9.1 The board shall be subjected to routine tests as per IS 8623 and other relevant standards. Heat run test, if specified, in specification sheet shall be carried out.

9.2 Additional tests, wherever specified shall be carried out on one board of each rating.

9.3 All the above tests shall be carried out in presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

9.4 These inspections shall however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-II shall be supplied unless otherwise specified.

10.2 All drawings and documents shall have the following description written boldly:

- Name of client

- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-III.

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipments.

12.0 PACKING

12.1 The board shall be properly packed before despatch to avoid damage during transport, storage and handling.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual along with one set of drawings.

12.3 A sign to indicate the upright position of the panels to be placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

REQUIREMENT OF PROTECTIONS, METERING, CONTROL AND INDICATIONS / ANNUNCIATIONS FOR BATTERY CHARGER

Sl. No.	Description	To be mounted on		
		Float cum Load Charger	Standby Float cum Load Charger	Boost Charger
1	2	3	4	5
1.	**A.C. Input Side**			
	i) ON/OFF Switch	Yes	Yes	Yes
	ii) HRC Fuses	Yes	Yes	Yes
	iii) Contactor	Yes	Yes	Yes
	iv) Thermal O/L Relay	Yes	Yes	Yes
	v) Single phasing and Phase Reversal	Yes	Yes	Yes
	vi) Voltmeter with SS	Yes	Yes	Yes
	vii) Ammeter with SS	Yes	Yes	Yes
	viii) Signal Lamp (ON/OFF)	Yes	Yes	Yes
2.	**Rectifiers**			
	i) Semiconductor fuses	Yes	Yes	Yes
	ii) Filters with fuses	Yes	Yes	Yes
	iii) Surge Suppressors	Yes	Yes	Yes
3.	**DC Output Side**			
	i) ON/OFF Switch	Yes	Yes	Yes
	ii) HRC Fuses	Yes	Yes	Yes
	iii) Blocking Diodes	Yes	Yes	Yes
	iv) Voltmeter	Yes	Yes	Yes
	v) Ammeter	Yes	Yes	Yes
	vi) Signal Lamp (ON/OFF)	Yes	Yes	Yes
	viii) Charging Ammeter (on demand type)	Yes	Yes	Yes

Sl. No.	Description	To be mounted on		
		Float cum Load Charger	Standby Float cum Load Charger	Boost Charger
1	2	3	4	5
4.	**Common Items**			
	i) Droper Diodes	Yes		
	ii) Solid State facia annunciator for :	Yes	Yes	Yes
	-- Automatic changeover from one charger to another			
	-- Rectifier fuse failure in float/standby float/boost			
	-- Incoming supply failure float/standby float/boost			
	-- DC output under voltage			
	-- Earth fault			
	-- Single phasing and phase reversal			
	-- Filter fuse failure float/ standby float/boost			
	iii) Battery isolating switch and HRC fuses			Yes
	iv) Battery under voltage relay			Yes
	v) Battery earth fault relay			Yes
	vi) DC Contactor			Yes

NOTE: Any other components as required for satisfactory operation of the battery charger shall be provided.

ANNEXURE - II

DOCUMENTATION FOR BATTERY CHARGER

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	General arrangement drawings showing overall dimensions of the charger board and mounting details of various equipment inside the charger panel	Y	Y	Y
4.	Foundation plan indicating certified dimensions, floor openings, weight, clearance etc.	N	Y	Y
5.	Schematic and Wiring Diagrams	N	Y	Y
6.	Descriptive literature of the charger and various components mounted in the panel.	Y	N	Y
7.	Characteristics curves for the charger and all other static and control devices, relays etc.	N	N	Y
8.	Installation, Operation and Maintenance manual	N	N	Y
9.	Guarantee Certificates	N	N	Y
10.	Test Certificates	N	N	Y
11.	Spare parts list with identification marks	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - III

LIST OF SPARES

The following spare parts shall be quoted along with the offer:

			Float	Boost
i)	Fuse links and fuse bases of each type & rating			
	a) AC Input HRC fuses	--	3 Nos.	3 Nos.
	b) Semiconductor fuse	--	6 Nos.	6 Nos.
	c) Filter condenser fuse	--	1 No.	1 No.
	d) DC Output HRC fuse	--	2 Nos.	2 Nos.
	e) Control fuse	--	5 Nos.	--
ii)	Contactor coils of each type & rating			
	a) AC Input mains contactor coils	--	1 No	1 No
	b) Aux. Contactor coils	--	1 No	1 No
	c) DC Contactor coil	--	1 No.	--
iii)	Control Switches of each type			
	a) AC Voltmeter switch	--	1 No	
	b) AC Ammeter switch	--	1 No	
	c) AC Input switch	--	1 No	
	d) DC Output switch	--	1 No	
	e) Triple pole switch common for all chargers	--	1 No	
iv)	Push button element with actuator	--	1 No	
v)	Indicating lamps			
	a) AC Input lamp	--	3 Nos.	3 Nos.
	b) DC Output lamp	--	1 No	1 No
vi)	Globes of Indication lamps			
	(1 No. of each colour)	--	3 Nos.	
vii)	PCB's of each type -- (1Set)			
	a) DC U/V	--	1 No.	1 No.
	b) DC O/V	--	1 No.	1 No.
	c) Battery earth fault	--	1 No	
	d) HV/Phase fail/Reversal	--	1 No.	1 No.
	e) SCR Controller card	--	1 No.	1 No.
viii)	SCR of each type	--	3 Nos.	3 Nos.
ix)	Diode of each type	--	3 Nos.	3 Nos.
x)	Tap Diode	--	1 No	

NOTE: - All spare parts shall be identical to those used in the equipment offered.

TECHNICAL SPECIFICATION

BATTERY

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	ACCESSORIES
7.0	TESTS AND INSPECTION
8.0	DRAWINGS AND DOCUMENTS
9.0	SPARES
10.0	PACKING
11.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR BATTERY

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and despatch in well packed condition of batteries and accessories.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the battery shall conform to the latest issue of the following standards:

IS: 1651	--	Stationary cells & batteries, lead-acid type (with tubular positive plate)
IS: 1652	--	Stationary cells & batteries, lead-acid type with plante positive plates.
IS: 10918	--	Vented type nickel cadmium batteries

All accessories shall also conform to the relevant Indian Standard. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The battery shall be able to deliver rated ampere hours when discharged at the 10 hours rate of discharge to a final voltage of 1.85 V per cell for Lead Acid and at the 5 hours rate of discharge to a final voltage of 1.1 V per cell for Ni-Cd battery under the ambient conditions indicated in Design Philosophy-Electrical.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The battery shall be of Ni-Cd and rated for 110V DC. Each battery bank shall consist of 110 number of cells.

5.2 Each cell shall be contained in a closed top container preferably transparent and unbreakable and shall incorporate positive plates, negative plates and separators of adequate dimensions. Lead acid battery shall be of plante plate type (positive plate).

5.3 The battery bank shall be complete with all necessary components such as lids, plugs, separators and buffers, inter-cell connectors, lead coated bolts and nuts, cell insulators etc.

5.4 The required quantity of electrolyte plus 10% extra quantity shall be supplied in suitable non-returnable containers along with the battery.

6.0 ACCESSORIES

The following accessories shall be supplied with each battery bank:-

(a)	1 Set	--	Battery Stand constructed out of teak wood without the use of any metal fastenings and coated with 3 coats of anti-acid paint. The stand shall be properly designed so that each cell shall be easily accessible for inspection, topping up etc. However, for Ni-Cd battery mild steel stand with alkali resistant paint may also be accepted
(b)	1 Set	--	Inter-row, inter-tier and inter-stand connectors and takeoffs. These shall be sized suitably to have adequate current carrying capacity and mechanical strength
(c)	1 Set	--	Cell Insulators
(d)	1 Set	--	Stand Insulators
(e)	1 No.	--	Centre zero cell testing voltmeter scaled 3-0-3 volts
(f)	2 Nos.	--	Syringe type Hydrometers for measuring the specific gravity of the electrolyte
(g)	2 Nos.	--	Gravity correction thermometers, mercury-in-glass type
(h)	1 Set	--	Connecting bolt wrenches
(i)	1 No.	--	Rubber syringe for tapping cells
(j)	1 No.	--	Wall mounting type teak wood holder for Hydrometer and Thermometer.
(k)	1 No.	--	Acid/Alkali resisting funnel.
(l)	1 No.	--	Acid/Alkali resisting jug.
(m)	1 Pair	--	Rubber gloves.
(n)	1 No.	--	Rubber Apron.

All other accessories, not specified above, but required for satisfactory operation and maintenance shall also be supplied.

7.0 TESTS AND INSPECTION

7.1 Type tests shall be carried out as per relevant standards on two cells in the presence of Purchaser's representative.

7.2 Acceptance tests, if specified in Specification Sheet, shall be carried out as per relevant standards on each cell after installation at site.

7.3 In addition, the battery shall be subjected to stage inspection at works and inspection at site for final acceptance.

7.4 These inspections shall, however, not absolve the vendor from his responsibilities for making good any defect which may be noticed subsequently.

8.0 DRAWINGS AND DOCUMENTS

8.1 Drawings and documents as per Annexure-I shall be furnished by the Vendor unless otherwise specified.

8.2 All drawings and documents shall have following description written boldly:

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

9.0 SPARES

9.1 Item wise unit prices for the following items with recommended quantity shall be quoted along with the main equipment.

i) Vent Plugs
ii) Float Guide
iii) Float
iv) Cell lid.
v) Cell Box
vi) Inter-cell connections
vii) Fasteners
viii) Complete Cell

9.2 Any other spare parts required, but not specified, shall also be quoted.

10.0 PACKING

The battery cells and accessories shall be properly packed to safeguard against weather conditions and rough handling. It shall be wrapped in polythene bags with an additional wrapping bitumen paper to make it completely water proof before it is packed in crates. The packing box shall contain a copy of the installation operation and maintenance manual.

11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE – I
DOCUMENTATION FOR BATTERY

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	Y	Y	Y
2.	Technical Particulars	Y	Y	Y
3.	Dimensional drawings showing the cell arrangement on stand (Plan, front and side elevation) for each type of battery.	Y	Y	Y
4.	Illustrative and descriptive literature giving the complete details of construction of battery	Y	N	Y
5.	Operation and maintenance instructions	N	N	Y
6.	Test Certificates			
	-- Type	Y	N	N
	-- Acceptance	N	N	Y
7.	Guarantee Certificates	N	N	Y
8.	Spare Parts lists	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

CABLES

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL PURPOSE CABLES
7.0	CABLE DRUM
8.0	TESTS AND INSPECTION
9.0	DRAWINGS AND DOCUMENTS
10.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR CABLES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and dispatch in well packed condition of power and control cables.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of cables covered by this standard shall comply with the latest issue of following Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

IS: 1554 Part (I)	--	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100 volts.
IS: 1554 Part (II)	--	PVC insulated (heavy duty) electric cables for working voltages from 3.3 KV upto and including 11 KV.
IS: 7098 Part (I)	--	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100 volts.
IS: 7098 Part (II)	--	Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 KV upto and including 33 KV
IS: 694	--	PVC insulated cables for working voltages upto and including 1100 volts
IS: 5831	--	PVC insulation and sheath of electric cables

2.2 The design and operational features of the cables offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the cables to comply with the above mentioned rules.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

The cables shall be suitable for operating continuously at the rated capacity as specified in relevant I.S. under the ambient conditions in Design Philosophy-Electrical without exceeding the permissible temperature rise and without any detrimental effect on any part.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The design, manufacture and workmanship of cables shall be in accordance with the latest practice.

5.2 All materials to be used shall be new, unused and of the best quality.

5.3 **Conductors**

The power cables shall be of stranded Aluminium / copper round or shaped conductors and control cables shall be of annealed high conductivity stranded copper round conductors. The conductors shall comply with the requirements of IS: 8130.

5.4 **Insulation**

The conductor insulation shall be type A/C and shall comply with relevant IS.

5.5 **Fillers**

The cables shall have suitable fillers wherever required, laid up with conductors to provide substantially circular cross section before the inner sheath is applied.

5.6 **Inner Sheath**

Inner sheath, wherever applicable shall be ST1/ ST2 type compound applied by extrusion process except for paper cables for which it shall be of lead or lead alloy.

5.7 **Armouring**

All power and control cables shall be armoured. The single core cables shall be armoured with hard drawn Aluminium taps / wires or any other suitable nonmagnetic material. All other cables shall have galvanized steel wire / strip armouring.

5.8 **Outer Sheath**

The outer sheath shall be ST1/ ST2 type compound applied by extrusion process and suitable to withstand atmospheric pollution, resistance to termites, fire retardant and coloured black.

5.9 **Screening**

Screening over conductor and insulation shall be provided as per relevant standard unless specified otherwise. The screening for control cables if specified shall be of aluminium, mylor or equivalent and provided with tinned drain wire which shall be continuous and permanently connected to the screen.

5.10 **Identification**

The individual cores of cables shall be coloured as per relevant IS. Where it is not possible to distinguish the cores by colour, coloured strip shall be applied on the cores or core nos. shall be marked on each core at regular intervals. All cables shall carry the manufacturer's name or trade mark, the cable size, voltage rating and year of manufacture at intervals not exceeding 100 meters. Running meter markings shall also be provided throughout the length of the cable.

5.11 **Dimension**

The overall dia. and dia. under armour of the cables shall be indicated by the vendor in the technical particulars. These shall be guaranteed with a tolerance of ± 5% but not exceeding 2 mm.

5.12 The cut ends of the cables shall be sealed by means of non-hygroscopic materials.

6.0 SPECIAL PURPOSE CABLES

6.1 Flame Retardant Low Smoke Cables

Flame retardant low smoke cables shall have outer sheath of PVC having following values.

- Minimum oxygen index - 29%
- Minimum temperature index - 250ºC
- Maximum acid gas generation - 20%
- Maximum smoke density rating - 60%

6.2 Heat Resistant Cables

Heat resistant cables, where specified in specification sheet, shall be of silicon rubber insulated laid circular with asbestos worming and overall glass fibre braided and varnished. Silicon rubber insulating compound shall conform to IS: 6380 and the constructional features shall conform generally to IS: 9968.

7.0 CABLE DRUM

7.1 The cables shall be supplied in non-returnable wooden drums (or steel drums if specified) of heavy construction. The wood used for construction of the drums shall be properly seasoned, sound and free from defects.

7.2 Cables shall be supplied in specified drum lengths. Where no such indication is given, standard drum lengths may be offered.

7.3 The tolerance on each drum of cable shall not exceed ± 2.5%. However, no negative tolerance on HV cables is acceptable.

7.4 All cable drums shall have stencilled data as per relevant IS as well as the purchaser's order no., item no. & drum no.

8.0 TESTS AND INSPECTION

8.1 The following tests shall be carried out on the cables as per relevant IS.

i) Routine Tests - On all cables
ii) Acceptance tests - On representative length of each size
iii) Type tests - Wherever specified on one cable drum of each size

8.2 In addition, the following tests shall be carried out on all fire retardant low smoke cables as per IS or as per the following standards:

i) Oxygen and temperature index test as per ASTM-D-2863

ii) Acid gas emission test as per IEC-754 Part-I

iii) Smoke density test as per ASTM-D-2843

iv) Flammability test as per IEC-332 Part-I or IS-10810

8.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the cables shall be subjected to stage inspection at works and inspection at site for final acceptance.

8.4 These tests and inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

9.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

10.0 DEVIATIONS

10.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR CABLES

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	Illustrative and Descriptive catalogues	Y	N	Y
4.	Installation, Termination and Jointing Instructions	N	N	Y
5.	Test certificates			
	a) Routine	N	N	Y
	b) Type	Y	N	Y
6.	Guarantee Certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

LOCAL CONTROL STATION

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATIONAL REQUIREMENTS
5.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAMEPROOF LOCAL CONTROL STATION
7.0	COMPONENT DETAILS
8.0	PAINTING
9.0	TESTS AND INSPECTION
10.0	DRAWINGS AND DOCUMENTS
11.0	SPARES
12.0	PACKING
13.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR LOCAL CONTROL STATIONS

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in well-packed condition of Local Control Stations.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of IS: 13947 and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity rules and other relevant statutory Acts and Regulations. The supplier shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATIONAL REQUIREMENTS

This equipment and associated components shall be suitable for operating satisfactorily under the specified ambient and system conditions.

5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

5.1 The Control Stations shall be suitable for control voltage not exceeding 500V, 50 Hz AC or 220V D.C.

5.2 The enclosure shall be of die cast Aluminium alloy LM-6. As an alternative to cast Aluminium, fibre glass enclosure is also acceptable.

5.3 The equipment shall have dust, hose and weather proof construction equivalent to IPW-55 as per IS: 13947. These shall be suitable for outdoor location without any additional protection or cover.

5.4 A rain-hood shall be offered as an additional item. It shall be made of 14 gauge Aluminium sheet bent to shape. In case of fibre glass enclosure, these can be made of fibre glass.

5.5 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.

5.6 The control station shall preferably be with bolted cover. The bolts for retaining the cover in position shall be provided with 10 mm dia. stainless steel and these shall be so arranged that they do not pierce into the door gasket.

5.7 All the components shall be mounted on a base plate inside the enclosure. Necessary actuating system for control switch, push button, non yellowing acrylic/ glass cover for ammeter and indication lamps shall be provided on the front cover. No wiring shall be carried out on the front cover.

5.8 The layout of components in the control station shall be liberal and standardised.

5.9 All mating surfaces shall be smoothly machined and shall be of sufficient width of at least 6 mm. The covers shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust and moisture. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.

5.10 The enclosure shall be suitable for mounting on wall or on steel structure. 4 Nos. holes suitable for 12 mm bolts shall be provided outside the enclosure for fixing the control stations.

5.11 The internal wiring shall be carried by means of single core PVC insulated 1.5 sq. mm stranded copper conductor cable. All termination shall be made with crimping type proper size lugs and shall be properly ferruled.

5.12 The control stations shall be completely factory wired and ready for external cable connection.

5.13 For easy identification, numbering ferrules shall be provided on all wiring at both ends i.e. equipment end and terminal block end. Terminals for external wiring shall be numbered

5.14 The enclosure shall be provided with two earthing terminals with studs of 8 mm. dia. projecting outside the enclosure for connection to earth. These terminals shall not pierce through the enclosure and shall be marked with earthing symbol.

5.15 Each control station shall be provided with minimum 2 mm thick stainless steel name plates or consisting of black Perspex with white engraving indicating the code number and description of the equipment controlled by it. Similar labels shall be provided for all indication lamps, push buttons and control switches. The name plate and label shall be fixed with screws only.

6.0 SPECIAL FEATURES FOR FLAME PROOF LOCAL CONTROL STATION

6.1 The enclosure shall be in addition, of flameproof execution as per IS: 2148.

6.2 The control stations shall be suitable for hazardous area of enclosure group and temperature class.

6.3 Cables shall enter the terminal box through flame proof cable gland. From the terminal chamber to the main enclosure, the connections shall be made through proper bushings. Direct entry of external cables into the main enclosure shall not be accepted. All entries shall be provided with stainless steel inserts.

6.4 An additional earthing terminal inside the terminal chamber shall be provided.

6.5 Local control stations and cable gland must be certified by the Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

7.0 COMPONENT DETAILS

7.1 Local control stations shall be provided with controlling and indicating elements.

7.2 **Trip-Neutral-Close Switch**

TRIP-NEUTRAL-CLOSE switch shall be double pole, 3 position, pistol grip, rotary type having self spring return feature to neutral position. The contacts shall be of phosphor bronze and shall be provided with two breaks in series. Mechanical sequence device to prevent two successive movements to the same position shall be fitted. The switch shall be capable of being padlocked in the 'TRIP' position.

7.3 **'Auto-Manual' Switch**

'Auto-Manual' switch shall be single pole stay put type having three positions "AUTO-OFF-MANUAL". Provision shall be made to padlock the switch in the "OFF" position.

7.4 **Selector Switch / Lock Service Switch**

These shall be single pole stay put type having two position with a pistol grip handle and capable of being padlocked in one of the position.

7.5 All the switches shall be rotary type with snap or wiping action contact and having a set of normally open and closed contacts in each position. All switches shall be provided with pistol grip handle.

7.6 **'Off-Auto-On' Switch**

7.6.1 'OFF-AUTO-ON' switch shall be in minimum three stack configuration, each stack having three positions with spring return from 'ON' to 'Auto' position and lockable in 'OFF' position by means of padlock.

7.6.2 The switch shall have sliding contact between 'AUTO' and 'ON' position. In 'OFF' position the contact shall be completely broken from 'AUTO' position.

7.7 **Push Buttons**

These shall be spring loaded, with a set of normally closed and open contacts. The push buttons for 'start' shall be shrouded type and coloured green while 'stop' push buttons shall be un-shrouded type and coloured red. Provision shall be made to padlock the 'stop' push button in 'OFF' position. The fixing ring shall be metallic white. An oil proof rubber cap shall preferably be provided.

7.8 The switches and push buttons shall conform to utilization category AC11/ DC11 as per IS: 13947. The contact shall be rated to make, break and carry inductive current of 5 Amp. at 415 V AC and 1 Amp of 220V DC. The contact arrangement shall be as shown in the terminal drawings. Built in locks instead of padlocking are not acceptable.

7.9 **Indication Lamps**

7.9.1 LED type indication lamps shall be provided to indicate the various circuit conditions as shown in the terminal drawings.

7.9.2 The LEDs shall provide good illumination through a viewing angle of 180º. The LEDs shall have lumen output of 200 milli Candella in the axial direction.

7.9.3 The colour of the LED indication for various functions shall be as follows:-

RED : For 'ON' Indication
GREEN : For 'OFF' Indication
WHITE : For "Ready for Service" Indication

7.10 **A.C. Ammeters**

The ammeter shall be flush mounting, moving iron spring controlled type, of accuracy class 1.5 as per IS:1248, with square face of minimum size 72 mm x 72 mm having scale range 0-240º. The ammeter shall be provided with uniform scale up to CT primary current and compressed end scale up to 6 times the CT primary current. Adjustable red pointer shall be provided to indicate the full load current of the motors. Zero adjusters shall be provided for operation from the front of the meter. All ammeters shall be operated through 1Amp. CTs only. The CT ratio and full load current shall be as indicated in specification sheet.

7.11 **D.C. Ammeters**

The D.C. ammeter shall be shunt operated. These shall be moving coil or moving iron type of accuracy class 1.5 as per IS: 1248.

7.12 **Terminal Blocks**

All control stations shall be provided with terminal blocks. Terminal blocks shall be located at a minimum distance of 50 mm from the bottom of the enclosure. The terminal blocks for the control station shall be suitable for conductor sizes of 2.5 mm^2. These shall be of pressure clamp type design mounted on the base channel. The minimum rating of terminal block shall be 16 Amp.

7.13 **Cable Glands**

The cables for the external connections, shall enter the terminal chamber through heavy duty double compression type rolled Aluminium cable glands suitable for 2.5 sq. mm PVC insulated, armoured, and PVC sheathed copper conductor 1.1 KV grade cables. The number and cores of control cables shall be as indicated in specification sheet. The cable gland shall be fitted in a threaded hole.

8.0 PAINTING

8.1 The enclosure after suitable pre-treatment shall be painted with two coats of anti-rust paint followed by two coats of anticorrosive paint.

8.2 Epoxy based paint shall be used.

8.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

8.4 Unless otherwise specified, the finishing shade shall be of light grey having shade no. 631 as per IS: 5.

9.0 TESTS AND INSPECTION

9.1 All equipment shall be routine tested as per relevant standards.

9.2 Additional tests, wherever specified, shall be carried out.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

9.4 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

10.0 DRAWINGS AND DOCUMENTS

10.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

10.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

11.0 SPARES

11.1 Spares for operation and maintenance

Item wise unit prices of spare parts for the following items as applicable shall be offered along with the main equipment with recommended quantity.

i) Trip-Neutral-Close switch
ii) Auto-Manual switch
iii) Selector switch
iv) OFF-Auto-ON switch
v) Ammeters of different ranges
vi) Push buttons of different types
vii) Indication lamps of different types
viii) Terminal blocks
ix) Terminal bushings

11.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

11.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

11.4 All spare parts shall be identical to the parts used in the equipment.

12.0 PACKING

12.1 The local control stations shall be properly packed to safeguard against weather conditions and handling during transit. It shall be wrapped in polythene bags and an additional wrapping of bitumen paper shall also be provided to make it completely water proof before the equipment is packed in wooden crates.

12.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

13.0 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR LOCAL CONTROL STATIONS

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	General Arrangement Drawings	Y	Y	Y
4.	Schematic Diagrams	N	Y	Y
5.	Illustrative and Descriptive catalogues	Y	N	Y
6.	Catalogues of bought out accessories	Y	N	Y
7.	Spare parts list	Y	N	Y
8.	Installation, Operation and Maintenance manual	N	N	Y
9.	Test certificates			
	a) Routine	N	N	Y
	b) Type (only for flameproof equipment)	N	N	Y
	c) For enclosure	Y	N	Y
10.	Guarantee Certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

JUNCTION BOX

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES
5.0	SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA
6.0	PAINTING
7.0	TESTS & INSPECTION
8.0	PACKING
9.0	DRAWINGS AND DOCUMENTS
10.0	SPARES
11.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR JUNCTION BOXES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing and inspection at works and delivery in well packed condition of junction boxes.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of relevant Indian standards unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 Flameproof & increased safety junction boxes shall in addition, comply with the requirement as laid down in IS: 2148 & IS: 6381 respectively.

2.3 The design and constructional features of the junction boxes offered shall also comply with the provision of latest issue of the Indian Electricity Rules and other relevant Statutory Rules & Regulations. The supplier shall, whenever necessary, make suitable modification in the equipment to comply with the above mentioned rules.

2.4 Wherever any requirement laid down in this standard differs from that in Indian Standard specifications, the requirement specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

The details of power supply system shall be as indicated in Design Philosophy-Electrical.

4.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES

4.1 The junction boxes shall be dust and weather proof and suitable for installation outdoors without extra protection. The degree of protection shall be IP-55 as per IS: 4691.

4.2 The junction boxes shall be of die cast aluminium alloy LM-6 with domed / suspension covers. As an alternative to cast aluminium, fibre glass enclosure is also acceptable if specified in specification sheet.

4.3 The casting of the junction boxes and their cover shall be pressure die cast. The casting shall be uniform and free from blow holes. All mechanical surfaces shall be free from burrs, dents and internal roughness.

4.4 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel zinc passivated. For fibre glass enclosure Nylon PVC bolts of diameter 8 mm may be used.

4.5 The clearances and creepage distances shall be maintained inside the junction boxes as per relevant Indian standard.

4.6 The junction boxes shall be suitable for wall / structure / ceiling mounting and necessary arrangement for mounting the same shall be provided.

4.7 The junction boxes shall be provided with continuous gasket made of neoprene or synthetic rubber to prevent ingress of dust. The gasket shall be held in position in groove provided in the enclosure and shall be pressed all around uniformly by suitably shaped projection of the door. Gaskets simply glued to the surface are not acceptable.

4.8 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass. Threaded terminals shall be made of brass (nickel plated or tinned) and provided with two tightening threaded nuts and four washers all made of brass (nickel plated or tinned). The terminals shall have two shorting links each horizontally placed connecting three terminals.

4.9 The terminal block shall be fitted with junction boxes base by means of 2 nos. 1/2” long nickel plated brass screws.

4.10 The junction boxes shall be provided with two nos. external earthing terminals and 1 no. internal earthing terminal.

4.11 All live parts inside the junction boxes shall be insulated and shall withstand a test voltage of 2.5 KV for 1 minute.

4.12 The junction boxes shall be provided with heavy duty double compression type rolled Al cable glands to suit the cable entries.

4.13 Threaded blanking plugs shall be provided for junction boxes to plug out the entries not in use as indicated in bill of quantities enclosed.

4.14 The junction boxes shall be provided with a blank stainless steel tag plate fastened to the junction box top cover with two stainless steel screws. The plate shall be at least 25 mm wide, 100 mm long and 1 mm thick.

4.15 For flameproof / increased safety junction boxes, the manufacturer shall submit copies of test certificates from statutory authorities clearly stating that the junction boxes as well as cable glands / blanking plugs are suitable for specified hazardous area.

4.16 **15 Amp. Junction Box**

4.16.1 The junction boxes shall be 4 way dome cover type.

4.16.2 The dimensions of the junction boxes with their cover and accessories shall be generally as per PDS: E-547.

4.16.3 The junction boxes housing terminal block shall be moulded type made of DMC / Fibre glass as per Drg. no. PDS: E-557.

4.17 **63 Amp. Junction Box**

4.17.1 The junction boxes shall be 3 / 4 way dome cover type.

4.17.2 The minimum internal diameter of the box shall be 240 mm.

5.0 SPECIAL FEATURES FOR JUNCTION BOXES FOR HAZARDOUS AREA

5.1 For increased safety junction boxes, the terminals shall be provided with positive locking device against loosening.

5.2 The enclosure shall be in addition, of increased safety execution, Exe, as per relevant standard and shall be suitable for installation.

5.3 The junction boxes shall be liberally dimensioned in order to avoid temperature rise inside the enclosure which may damage the insulating materials or gaskets employed therein.

5.4 Cables shall enter the terminal box through increased safety compression type cable glands. From the terminal chamber to the main enclosure, the connections shall be made through proper bushings.

5.5 An additional earthing terminal inside the terminal chamber shall be provided.

5.6 The junction boxes shall be provided with Brass-Nickel plated shorted links. The terminal block shall be made of non-hygroscopic compound. Bakelite / Hylam shall not acceptable.

5.7 All screws / bolts and nuts shall be of stainless steel.

5.8 Junction boxes and cable glands must be certified by Statutory Authorities for use in the specified hazardous area. Equipments certified by overseas authorities shall obtain certificate of compliance / letter of opinion from respective statutory authorities.

5.9 Duly wired prototype samples for junction boxes shall be submitted for scrutiny as and when called for.

5.10 Type Test certificates for increased safety type junction boxes and cable glands along with blanking plugs shall be supplied.

6.0 PAINTING

6.1 Epoxy based electrostatic powder coating paint shall be provided on exterior surface while the interior of junction boxes shall be painted with anti-condensate paint. The painting shall be able to withstand corrosive atmosphere.

6.2 Unless otherwise specified, the finishing shade shall be grey having shade no. 632 as per IS-5.

6.3 The terminal block of junction boxes shall be painted with Red, Yellow, Blue & Black colour for phase indication.

7.0 TESTS AND INSPECTION

7.1 The junction boxes shall be routine tested as per relevant standards.

7.2 Additional tests, wherever specified, shall be carried out on one unit of each rating.

7.3 The procedure & extent of the physical checks, routine & type test shall be governed by Quality Assurance Plan mutually agreed and approved by Inspection Authority.

7.4 All the above mentioned tests shall be carried out in the presence of purchaser's representative. In addition, the equipment shall be subjected to stage inspection at works and inspection at site for final acceptance.

7.5 These inspections shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

8.0 PACKING

Each junction box and cable gland shall be suitably packed and protected from damage due to transportation, loading and unloading. Threaded fittings shall have plastic caps to protect the threading.

9.0 DRAWINGS AND DOCUMENTS

9.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.

9.2 All drawings and documents shall have the following descriptions written boldly:

- Name of client
- Name of consultant
- Enquiry / order number with plant / project name
- Motor Code No. and Description

10.0 SPARES

10.1 Spares for operation and maintenance

Item wise unit prices of spare parts for the following items, as applicable, shall be offered along with the main equipment with recommended quantity.

i) Cable glands

ii) Threaded Plug

iii) Terminal blocks

iv) Terminal bushings

10.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

10.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

10.4 All spare parts shall be identical to the parts used in the equipment.

11.0 DEVIATIONS

11.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR JUNCTION BOXES

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	Y	Y
2.	Technical Particulars, duly filled-in	Y	Y	Y
3.	Certified dimensional drawing, including mounting details	Y	Y	Y
4.	Drawing showing constructional details	Y	Y	Y
5.	Illustrative and Descriptive catalogues	Y	N	Y
6.	Spare parts list	Y	N	Y
7.	FLP/Exe certificates for junction boxes and terminals conforming to IEC/ISS (CMRI, CCE, DGFASLI and BARC for terminals)	Y	N	Y
8.	Certificate for weather proof construction for junction boxes as per IPW-55	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

VENTILATION SYSTEM

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
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5.0	EQUIPMENT SPECIFICATION
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14.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR VENTILATION SYSTEM
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, testing at works, supply, packing, loading, transportation, unloading, storage of equipment at site, erection, site testing and commissioning of forced air ventilation system on turnkey basis.

1.1.1 The ventilation system shall consist of inlet air duct, air filters, centrifugal type fan, air distribution ducts, grills, damper etc.

1.1.2 Rain protection louvers with bird screen at the outlet of exhaust dampers shall be provided which shall be gravity operated.

1.1.3 All other items not specifically mentioned, but required for the completeness of the system shall be supplied.

1.1.4 In case of any fire, air supply shall be cut off. To fulfil this requirement contractor shall take the input from the nearby Fire Alarm System.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment and their standard shall comply with the latest issue of relevant Indian Standard Specification.

2.2 The design and operational features of the equipment and their installation shall also comply with the provisions of the latest issue of the Indian Electricity Rules and other Statutory Acts and Regulations. The vendor shall, wherever necessary, make suitable modifications in the equipment to comply with the above.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified herein shall prevail. Equipment complying with equivalent IEC standards shall also be acceptable.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 DESIGN AND OPERATIONAL REQUIREMENTS

4.1 The ventilation system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.

4.2 All the equipment shall be suitable for operating at their rated capacity continuously, under the ambient conditions and voltage and frequency

variations indicated without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on it.

4.3 All the equipment shall have adequate and standardised ratings.

4.4 The system design and selection of equipment ratings as well as their installation shall ensure adequate fresh air throughout the ventilated plant area for personnel comfort and proper functioning of the plant equipment.

4.5 For the main ventilation equipment, a room has been shown in the attached duct layout. The supplier shall confirm the adequacy of the room size.

4.6 The requirement of blowers where indicated is tentative. The vendor may alternatively offer ventilation schemes considered by him superior than specified.

4.7 The ventilation equipment offered shall be designed to affect the required number of air changes per hour and supply fresh air to the areas.

4.8 Two numbers of blower shall be provided and each rated for 100%. The discharge of each blower shall be connected to a common duct and an isolation valve shall be provided on discharge side of each blower.

4.9 A positive pressure of 5 mm of water gauge shall be maintained with in the area to be ventilated.

4.10 The concentration of the dust in the area is expected to be in milligrams and the size of dust particles will be 25 microns.

4.11 Discharge velocity of the air should be within comfortable limits and uniform distribution of air shall be achieved.

4.12 Every precautions shall be taken to reduce the sound level from the blowers to a minimum of 90 dB (A) at 1 metre distance. If required, silencers may be fitted to bring down the sound level.

4.13 Vendor shall indicate the thickness and height up to which acoustic insulation is considered in the offer.

4.14 Vibration pads shall be used so that no vibration is transmitted to the buildings.

4.15 All safety regulations must be taken into consideration in the design and equipment layout. All moving and rotating parts shall be suitably guarded against accidental contacts by working personnel.

5.0 EQUIPMENT SPECIFICATION

5.1 Air Filters

5.1.1 The dry type air filters shall be provided at the air intake side for filtering dust particles of the air.

5.1.2 The filter shall be capable of removing dust particles of about 10 micron and above, the efficiency of the filter shall not be less than 99%. If considered necessary, double filter may be provided.

5.1.3 The velocity of air inside the filter shall not exceed 3 m/s.

5.1.4 The air filter shall be of robust construction fabricated out of 14 gauge sheet metal work.

5.1.5 The filters shall be capable of reuse after cleaning. Each filter shall be mounted in such a way that the removal and re-fixing after cleaning and maintenance is easier.

5.1.6 The filter shall be made of high efficiency particulate air filtration (HEPA).

5.1.7 Where filters are supplied in dismantled condition, assembly drawing shall be furnished by manufacturer.

5.2 Air supply blower

5.2.1 The blowers shall be in conformity with IS: 4894.

5.2.2 Blowers shall be centrifugal type and shall either be single width single inlet or double width double inlet type as per the volume and head of the air to be handled. The blowers shall have non overloading type characteristics.

5.2.3 The blowers shall be heavy duty type suitable for uninterrupted and trouble free service.

5.2.4 The blowers shall have end suction and upward / downward / inclined discharge as per requirement.

5.2.5 The blowers shall be coupled to the motors by pulley and V-belt arrangement.

5.2.6 The blowers shall be designed to operate within 9% and 25% of system throttling line.

5.2.7 The first critical speed of the rotating assembly shall be at least 25% above the operating speed.

5.2.8 The blowers shall be complete with all required accessories.

5.2.9 The casing shall be of welded construction and complete with inlet and outlet flanges, inspection holes, mounting legs and fittings lugs.

5.3 Ducting

5.3.1 Ducts for distribution of air shall either be of galvanised sheet steel having galvanising thickness of 150 microns or aluminium sheet conforming to IS: 1285, designation 52,000. The thickness of GI sheet / aluminium sheet shall be as follows:

- GI sheet - 1.2 mm
- Aluminium sheet - 1.6 mm

5.3.2 The following principles shall be adopted in the selection of duct sizing.

- Velocity of air shall not exceed 1.2 m/s in any section throughout the entire run.
- While changing the cross sections, the air velocity should not change abruptly.
- Bends shall be minimum wherever required, the bending radius should be more than 1.5 times the width of the ducts.
- Right angle bends shall have deflectors to reduce the pressure loss.
- The cross section of the ducts shall be preferably of square type.
- Interior shall be smooth and free from obstruction.
- The duct section shall be cross broken type.

5.3.3 Flexible bellows shall be provided for connecting the duct and the blowers to isolate the vibrations.

5.3.4 All longitudinal joints of the various sections of the ducts shall be either riveted by slip joints or bolted by angle ring joints. The centre distance of rivets / bolts shall not exceed 150 mm for sheets and 75 mm for structural steels.

5.3.5 All joints shall be properly sealed to prevent leakage of air by suitable sealing compounds.

5.3.6 The ducts shall be provided with continuous transverse bracing by angle irons. Longitudinal seams shall be provided for reinforcement, wherever required.

5.3.7 Along the main ducts, access doors shall be provided. Such doors shall be provided with sponge rubber gaskets for leak proofness.

5.4 Hanger and supports

5.4.1 The duct work shall be either hanged from the ceiling or supported on the sides of the column as the case may be. They shall be fixed to the ceiling / column by anchor bolts or welding.

5.4.2 The hangers / supports shall be adequate in number and size to prevent sagging, buckling or vibration. All hangers shall be of trapezoid type constructed out of 40 x 40 x 6 mm angle iron and suspended from two steel rods of 10 mm dia.

5.4.3 While crossing the floors, the ducts shall be supported by suitable collars fabricated out of angle iron. The opening left out after the erection of ducts and collars shall be filled up with bitumen compound of superior quality.

5.4.4 The fixing and support intervals shall not be more than 3 metres.

5.4.5 The complete supporting arrangement shall be subject to the approval of the purchaser before their installation.

5.5 Grills / Dampers

5.5.1 The air ducts shall be provided with grills having air turning devices, manually adjustable multilouvre dampers of contrarotating type for discharge of fresh air.

5.5.2 The controlling device for the dampers shall have provision to keep the damper in one position.

5.5.3 Thick wire netting guards shall be provided in the grills.

5.5.4 The mouth of the grills shall be downward having an angle of inclination of 30°.

5.5.5 The numbers, size and material of construction of discharge nozzles to be provided shall be subject to purchaser's approval.

5.6 **Motors**

5.6.1 The motors shall be of squirrel cage induction, totally enclosed, fan cooled having IPW-55 degree of protection complying with IS-325.

5.6.2 The insulation of the motors shall be class B/F. For class 'F' insulated motors, the temperature rise shall be limited to that of class B.

5.6.3 The rating and frame sizes of the motors shall be as per IS.

5.6.4 The motors shall be suitable for 3 successive starts from cold and 2 successive starts from hot when coupled to the driven equipment. The temperature of the rotor shall not exceed 300°C.

5.6.5 The motors shall be suitable for D.O.L starting even at a terminal voltage of 80%. The starting current shall not exceed 6 times when full voltage is applied.

5.6.6 All the six leads shall be brought out to the terminal box where suitable connection shall be made through shorting links.

5.6.7 The terminal box shall be amply sized and provided with terminal block of non cracking, non inflammable, non-hygroscopic and mould proof material.

5.6.8 All motors shall preferably be coupled to the driven equipment through flexible coupling.

5.6.9 In place of geared motors, motors with separate gear boxes between the motor and the driven equipment shall be preferred.

5.6.10 All motors shall be complete with on-line greasing facility and complete with required accessories such as name plate, lifting eye bolt, drain plug, earthing terminals, cable glands, slide rails etc.

5.6.11 All motors rated 30 KW and above shall be provided with space heater along with separate terminal box.

5.6.12 Rating of the motor shall be 15% higher than the driven load requirement and duty cycle shall match the requirement of driven machine.

5.6.13 Local control stations with ammeter shall be provided near each motor.

1.1 **Cable laying and terminations**

1.1.1 Power, control cables (supplied by owner) shall be laid from owner's PMCC/ MCC to the blower motors and local control stations. This shall include, installation of cable racks and its supports, laying fixing, jointing, terminating, testing and commissioning of cables with in the ventilation room.

1.1.2 The installation of cables shall be carried out as per the best practices and shall be in line with guidelines contained in IS: 1255.

1.1.3 Normally, plate inserts for fixing cable supports shall be provided by owner's civil contractor. However, if any extra inserts are required the same shall be fixed by the vendor.

1.1.4 All cables shall be laid in single layer. Control and power cables shall preferably be laid on separate trays. Cables shall be clamped at a maximum distance of 1500 mm of straight runs and at each end of bend.

1.1.5 Identification tags made of Aluminium with numbers punched on it shall be attached to each end of cable by means of G.I. binding wire. Tags shall additionally be put at an interval of 30 M on straight runs of cables.

1.1.6 Individual cores of control cables shall be provided with plastic interlocked type identification ferrules at both ends.

1.1.7 All cable termination shall be solderless crimping type.

2.0 EARTHING

2.1 Complete earthing installation shall be done as per IS: 3043.

2.2 The owner shall provide required number of earth buses from their earthing grid with in the ventilation room. Vendor shall earth all the equipments under his scope of supply by using 1.1 KV, single core, PVC aluminium conductor cable from these earth buses.

3.0 PAINTING

3.1 The surfaces to be painted shall be pretreated to remove all dust, scale and foreign adhering matter by suitable treatment.

3.2 All steel surfaces shall be painted with suitable anti-rust and anti-corrosive paints. Epoxy paints shall be used.

3.3 All paints shall be carefully selected to withstand tropical heat and extremes of weather. The paint shall not scale off, crinkle or be removed by abrasion due to normal handling.

3.4 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

4.0 CO-ORDINATION WITH OTHER CONTRACTORS

4.1 The successful vendor shall co-ordinate with owner's other vendors and shall freely exchange all technical information required for this purpose.

4.2 The successful vendor shall ensure that the variation in estimated quantities for ducting and acoustic insulation during quotation stage and quantities of actual execution at site shall be maximum ± 10%. Beyond this limit, their extra claim at any stage of the contractual period, if any, shall not be entertained.

5.0 TESTS AND INSPECTION

5.1 All equipment shall be routine tested as per relevant Indian Standard Specification.

5.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

5.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative.

5.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

6.0 ERECTION, TESTING AND COMMISSIONING

6.1 The vendor shall undertake installation of all equipment in accordance with code of practices in conformity with statutory regulations and to the entire satisfaction of the owner.

6.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials.

6.3 The vendor shall obtain the necessary clearance from the electrical inspector for equipment and installation. All necessary drawings and test certificates as required by the inspector shall be furnished. Any modification / rectification as required by him shall be carried out.

6.4 Package vendor shall demonstrate the guaranteed performance data, like discharge capacity, outlet velocity, static pressure developed and noise level inside the room before handing over ventilation system.

6.5 Following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.

1. Insulation test.
2. Continuity test.
3. High voltage test.
4. Simulation test.

7.0 DRAWINGS AND DOCUMENTS

7.1 The drawings and documents as per Annexure-I shall be furnished unless otherwise specified.

7.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name

- Code No. and Description

7.3 At the time of handing over the installation, the vendor shall supply as built drgs. Taking into consideration the actual execution carried out at site.

7.4 The vendor shall furnish a Bill of Material covered in his offer. However, this shall be treated for information only and shall not absolve him from his obligation to supply the required items and quantities for making the plant complete.

8.0 SPARES

8.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-II.

8.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

8.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

8.4 All spare parts shall be identical to the parts used in the equipments.

9.0 MAKE OF EQUIPMENT

The make of all the electrical equipment shall be as indicated elsewhere in the NIT.

10.0 DEVIATIONS

10.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTATION FOR VENTILATION SYSTEM

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For approval	Final
1.	Equipment Layout Drgs.	Y	Y	Y
2.	Civil Scope Drgs. (good for construction)	N	Y	Y
3.	Duct Layout Drg.	Y	Y	Y
4.	Filled in specification sheet	Y	Y	Y
5.	Technical Particulars	Y	Y	Y
6.	Bill of Material	Y	Y	Y
7.	Catalogues of Bought out items	Y	N	Y
8.	I.O.M. Material	N	N	Y
9.	Spare Parts List	Y	N	Y
10.	Test certificates	N	N	Y
11.	Guarantee Certificate	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE - II

LIST OF SPARES

The spares listed below shall be offered:

MOTORS

1. Set of bearings
2. Cooling fans
3. Grease nipple and plug

BLOWER

1. Set of Blower Bearings
2. V-Belts

FILTER

1. Pre-filter
2. Fine Filter

TECHNICAL SPECIFICATION

PASSENGER CUM GOODS LIFT

CONTENTS

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2.0	STANDARDS TO BE FOLLOWED
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6.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES
7.0	GENERAL DESIGN & CONSTRUCTIONAL FEATURES OF MECHANICAL EQUIPMENT
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ANNEXURE - I	LIST OF SPARE PARTS
ANNEXURE - II	DOCUMENTATION FOR PASSENGER CUM GOODS LIFT

1.0 SCOPE

1.1 This standard covers the technical requirements of design, manufacture, supply, erection, testing and commissioning of general purpose Passenger cum Goods Lift.

1.2 The scope of work shall include, but not limited to the following items :

i) Haulage mechanism
ii) Counter weights
iii) Guides
iv) Car with frame
v) Landing gates
vi) Door frames
vii) Control Panel
viii) Brakes
ix) Indication
x) Car lighting arrangement
xi) Car telephone
xii) Car Ventilation
xiii) Earthing
xiv) Gas Mask
xv) All other items not specified, but required for safe and proper operation of the lift.

1.3 The supplier shall include the isolation switch and all distribution equipment, cabling and wiring required for power, control and car lighting, telephones for the safe and proper operation of the lift. General lighting of the machine room and the landings are excluded.

1.4 Civil and structural work required for lift well, lift pit and machine room shall be provided by the owner in accordance with the requirement indicated by the supplier. However, necessary scaffolding in the hoistway, minor civil work, pit ladder, hoistway wiring, all steel material required for supports, lift shaft, bearing plates, buffer support channel, separator channel, sill support angle etc. are included in the scope of work.

1.5 The manufacturer shall be responsible for obtaining statutory approval for all equipment in lift installation from the factory inspector/electrical inspector of the state where the same is installed.

1.6 The vendor shall indicate the power requirement, loads and other details for structural design within 6 weeks from the date of L.O.I. to enable the owner to provide the above mentioned services.

2.0 STANDARDS TO BE FOLLOWED

2.1 The equipment and installation shall conform to the latest issues of the following relevant Indian Standards. Equipment complying with equivalent IEC standards shall also be acceptable.

IS:1860	--	Code of practice for installation, operation & maintenance of Electric passenger and goods lifts
IS: 2365	--	Steel wire suspension ropes for lifts, elevators and hoists.
IS: 3534	--	Outline dimensions of electric lift.
IS: 4666	--	Electric Passenger and goods lifts.
IS: 8151	--	Single speed three phase induction motors for driving lifts.

2.2 The design, installation and operational features of the equipment shall also comply with the provisions of the latest version of the following Acts and Statutory Regulations.

a) The Factory Act.

b) Lift Act

c) The Indian Electricity Rules

d) Fire Insurance Regulations

2.3 The supplier shall make suitable modification, addition/ alterations in the equipment, wherever necessary to comply with the above mentioned Act/ Rules/ Regulations.

2.4 Wherever any requirement laid down in this standard differs from that in Indian Standards, the requirements specified herein shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATIONAL REQUIREMENTS

4.1 All electrical equipment shall be Flameproof/ Increased Safety/ hose proof type design for successful use in the extreme conditions of voltage and frequency variations without exceeding the maximum specified temperature.

4.2 For control and safety features, 115 Volts A.C. single phase, 50 Hz supply shall be used. This shall be arranged by the supplier by suitable double wound stepdown transformers with one pole earthed. Where D.C. supply is required, necessary rectifiers etc. shall be included in the offer. 110 V/ 220 V D.C. supply will be provided by the owner for operating the emergency alarm bell and Emergency light in case of power failure.

4.3 Capacity & Duty

These shall be as indicated in Specification Sheet.

4.4 Method of Power Control

4.4.1 The operation of the lift shall be automatic without the need for any car attendant.

4.4.2 Operating Devices

i) In the Car

Flush type attractively finished metal panel housing push-buttons one for each landing, an emergency stop push button, light switch, fan switch and an alarm switch shall be installed in the car.

ii) In each landing

a) Flush type attractively finished metal housing shall be installed at each landing with a single push button for calling the lift. The call button shall not be provided at emergency landings. However, door at all emergency landings shall be provided.

b) Dust protective (car door open) lights shall be provided at each landing in a separate metal housing installed on the wall.

c) All normal & emergency landing doors shall be manually operable having single leaf spring closing feature.

4.4.3 Normal Operation

The car cannot be started unless the car gate is in the closed position and all hoist-way doors are in the closed position. Momentary pressure on a car button shall move the car to the landing selected where the car shall stop automatically. Uninterrupted movement of the car shall be ensured until the desired landing is reached.

A time relay shall be provided to make the car inoperative for a few seconds after the desired landing is reached or whenever a stop command is given. This interval shall be adjustable but sufficient to permit a passenger to enter the car or leave the car including the close/open operations of the car gate and hoist-way door. The closing and opening of the car gate shall be done manually on entering the car.

4.4.4 Emergency Operations

In case of power failure, suitable provision shall be made for manual hoisting or lowering of the lift to the nearest landing. It shall be possible to open the car gate and landing doors manually at which the car is at rest in the event of failure of power.

5.0 MACHINE ROOM

The machine room shall be located at ground floor above 0.5 m from finished floor level. Machine room shall be freely ventilated through openings fitted with fixed louvers and exhaust fan. Access to this machine room shall be provided through an adequately sized aluminium door for an easier removal of the equipment installed therein. The supplier shall indicate the details of machine room viz. size etc. Any other arrangement required for the safe operation of the equipment shall have to be provided by the lift vendor.

6.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES

The design of the lift and the associated equipment as well as their installations shall be in accordance with the latest engineering practice.

7.0 GENERAL DESIGN & CONSTRUCTIONAL FEATURES OF MECHANICAL EQUIPMENT

7.1 **Loading and Stresses**

7.1.1 All mechanical equipment shall be efficient in design for ease of erection, installation & maintenance.

7.1.2 The factor of safety for any part of the lift must not be less than 5 but higher factor shall be adopted for the parts specified in the relevant IS/ IEC.

7.1.3 Loads and their combination thereof and maximum permissible stresses shall be as per relevant IS / IEC specifications.

7.2 **Material of Construction**

7.2.1 All materials of construction used for the lift shall conform to the relevant IS Standards and codes of practices or equivalent IEC.

7.2.2 All equipment enclosures shall preferably be of cast aluminium.

7.2.3 All external bolts and nuts including stay bolts up to 8 mm dia shall be of stainless steel and for sizes above shall be of M.S. zinc passivated.

7.2.4 Name plates on equipment shall be made of stainless steel with the letters embossed on them.

7.2.5 All pulleys shall be anti-spark type.

7.2.6 Exposed copper & copper alloys are not permitted to be used.

7.3 **Lift Machine**

The machine shall be of the single wrap traction type and shall include the driving motor, electromechanical brake, steel worm, bronze gear, steel sheave shaft and sheaves etc. mounted on a single base plate. The worm shaft shall be provided with ball bearings to take the end thrust. Roller bearings shall be provided for sheave shaft to ensure alignment and long bearing life. The driving sheave shall be helically grooved to ensure proper traction and minimize rope wear. Adequate arrangement for lubrication shall be provided for all bearings from single application point and oil filled worm gear.

7.4 **Guides and Fixtures**

Rigid guides of steel construction of sufficient strength, round section or ‘T’ section type with machined working surface shall be used for guiding lift car and counter-weight throughout their travel.

Guides of ‘T’ section shall be held rigidly to their fastenings by through bolts or by clips to restrict torsion. These shall be so jointed and fixed to their brackets that the guides shall not deflect by more than 3 mm laterally under normal operation. Guides and their fixing shall withstand application of safety gear when stopping a fully-loaded car or counterweight. Guide bracket shall be fixed to walls, plate inserts or stair stringer by bolts or bolted to the building or structural steel work.

7.5 **Buffers**

Buffers shall be installed under the lift car and top of the car and counterweight in accordance with requirement of IS: 4666 or as per relevant IEC. These shall be complete with steel mounting members.

7.6 **Lift Frame**

The car shall be carried in steel car frame sufficiently rigid to withstand the operation of the safety gear without permanent deformation to the car frame. The deflection of the cross head members and the members carrying the platform shall not exceed 1/1000 of the span under static conditions with the contact load evenly distributed over the platform. At least 4 sets of roller guides shall be provided, two at the top and two at the bottom of the car frame. Necessary Facia Cover Plates for supporting the door frames on various landings shall be provided. Necessary safety devices shall be mounted underneath the car platform.

7.7 **Lift Car**

7.7.1 The car shall be of rigid construction for use in a chemical plant. The fittings inside the car should be properly protected against damage by tools or pipes, etc. carried by Workmen and by the corrosive action of chemical dusts and vapours.

7.7.2 Lift car shall be provided with roof, gates and car enclosure and the dimensions shall be as per IS: 4666 or as per relevant IEC.

7.7.3 Lift car shall have a 20 Watts fluorescent fixture suitable for hazardous area classification.

7.8 **Car Enclosure**

The enclosure and door shall be of Stainless Steel 2.0 mm thick. Doors shall be able to withstand thrust of 35 Kg. applied normally at any point without any permanent deformation. Car enclosure shall be rigidly secured to the car floor & car frame.

7.9 **Car Platform**

Car platform shall be of steel construction suitable for specified contract load. The flooring shall be of 5 mm thick aluminium chequered plate bolted to the platform members. Car platform should have an apron of sufficient depth so as to prevent any object being trapped between car platform and lift landing.

7.10 **Emergency Exit**

A hinged cover not less than 600 mm x 450 mm opening upwards shall be provided in the car roof to serve as an emergency exit. The emergency exit shall be provided with an electrical interlock which will prevent the lift from being operated when the emergency exit is left open.

7.11 **Load Plate**

A plate showing the lift capacity shall be fitted inside the car. The load-plate shall indicate in a tabular form various combinations for number of passengers and goods loads permissible for safe operation in compliance with the applicable lift act.

7.12 **Car Gate**

The car gate shall be collapsible door and steel painted with anticorrosive paint. The gate shall be hung on an aluminium track by Nylon rollers and guided in a finished groove sill on the car platform. The hangers and tracks for doors together with their fixtures shall be of adequate strength and rigidity. Means shall be provided to prevent

the collapsible door from jumping the tracks or jamming. Suitable stops shall be provided to prevent the hanger carriage from leaving the end of the track. The distance between the collapsible car door & landing door shall be Min. 145 mm.

7.13 Hoist way Doors

The supplier shall furnish and install at each landing, steel swing doors with 2 mm thick & secured to give a clear opening of 900 mm width x 2000 mm height complete with door frames, hinges, handles, vision panels and door closures. The door shall be spring closing type.

7.14 Car Safety and Governor

Car safety device shall be provided to stop the car in case of excessive descending speed. The safety devices shall be operated by a centrifugal speed governor located at the top of the hoistway and connected to the governor through a continuous steel rope. The tension frame of the governor part at the bottom of the hoistway shall have stainless steel shaft. Suitable means shall be provided to cut-off power to the motor and apply the brake on application of the safety device. The rollers of the safety devices shall be of stainless steel.

7.15 Counterweight

The counter weight shall be provided for smooth operation. This shall be constructed of multiple sections of cast iron weighted with lead discs and two tie rods passing through holes in all sections. Two tie rods shall be provided for safety reasons. The counterweights shall withstand the effect of buffer impact. Renewable guide shoes shall be provided at the top and bottom of the weight. Screen protection for the counter weights shall also be provided.

7.16 Sheaves and Beams

Car and counter weight sheaves shall be provided as required. The sheaves shall be of cast iron grooved for the hoist ropes, sheaves shall have grease lubricated bearings.

7.17 Suspension Ropes

Hoisting ropes and compensating ropes of sufficient length made of galvanised traction steel shall be provided in the lift. They shall have PVC sleeving. Two ropes, independent of one another shall be used for suspension. Suspension ropes shall be in accordance with IS: 2365.

7.18 Cat Ladder

A cat ladder shall be provided throughout the length of the lift shaft for facilitating the escape of person trapped inside the lift car. The cat ladder shall be made of either stainless steel or suitable aluminium alloy. It shall be fixed to the lift well plate inserts or structure.

8.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES OF ELECTRICAL EQUIPMENT

8.1 **Main Switch**

One No. heavy duty switch fuse unit rated for 415 V, 63 A shall be provided by the lift supplier in the Control Panel/Sub-control Panel to receive the incoming supply.

8.2 **Lift Motor**

Motor for use in the lift shall be as per IS: 8151 and suitable for lift duty. It shall be of squirrel cage design, class F insulated (temp. rise limited to that of Class B), totally enclosed fan cooled type, having an enclosure of IP55 as per IS: 4691. The temperature rise of the motor through-out the working range shall not exceed the value specified in IS: 325. The terminal box and cable glands for motor shall be suitable for area classification.

8.3 **Brake**

A Solenoid Operated brake having at least two brake shoes shall be provided. The brake shall be spring applied and electrically released type. This shall be capable of bringing the lift car to smooth stops under variable loads.

Earth fault, short circuit or residual magnetism shall not prevent the brake from being applied when the power supply to the lift motor is interrupted. Means of releasing the brake in emergency case shall be provided.

8.4 **Controller**

A floor mounting cubicle type control panel shall be supplied to control the operation of the lift. The controller shall house the devices for starting, stopping, speed control of the lift motor and automatic application of the brake after the desired operation, operation of the safety devices on power failure. Necessary protective equipment for each electrical equipment and circuits shall be provided. The components as well as their layout shall conform to the relevant ISS/IEC. The controller panel shall be fabricated out of CRCA steel having thickness of 2 mm or more. The doors shall be internally hinged type. The design shall be totally enclosed, dust tight and vermin proof. For dustproof-features neoprene gaskets properly held in positions shall be provided at all jointing surfaces. The panel shall be of adequate size (not less than 1000 mm width x 600 mm depth x 2200 mm height) so that the operating temperature in the panel is within the permissible limits. The controller shall be housed in the machine room without having any ventilation facilities. The entire panel shall be painted with 2 coats of epoxy based paints after suitable chemical treatments.

The main and auxiliary contactors and relays shall be liberally spaced inside the controller. They shall be marked with the designation. The wiring shall be carried out with 2.5 sq.mm solid copper PVC insulated conductors, neatly laid and bunched with PVC bands. They shall be numbered as per IS: 375.

A reverse phase relay shall be provided on the controller to protect the lift against phase reversal and phase failure.

A lockable maintenance/service control switch shall be provided. In service position all safety interlocks shall be in circuit whereas in maintenance position safety interlocks shall be by passed so as to carry out maintenance.
For external connections all the power and control wires shall be terminated in the terminal block. For power cable, crimped type Cu lugs shall be supplied. For control

cable, pressure clamp type terminal blocks shall be provided. Ferrules shall be provided on all the wires.

8.5 **Car Operating Panel and Hall Stations**

Both shall have heavily zinc plated sheet steel bore with aluminium cover fitted by means of stainless steel screws. A continuous neoprene rubber gasket shall be provided to make the box dust proof. The push button units shall be of reputed make subject to Purchaser's approval.

8.6 **Car & Hoist way Junction Boxes**

The junction boxes shall be of 6 mm thick cast aluminium having neoprene rubber gasket for dust proofing. The size of the junction boxes shall be adequate for the termination of cables as required. The cover fixing arrangement shall be external and the fixing screws shall be of stainless steel.

8.7 **Terminal and Final Limit Switches**

The terminal switches shall be provided to slow down and stop the car automatically at the terminal landings.

The final limit switches shall be provided to automatically cut off the power and apply the brake in case of the car travelling beyond the terminal landings.

All the limit switches shall be of positive action type. The operating arms and rollers shall be of stainless steel. The moving pins shall be made of stainless steel supported on oil-less bronze bushings. The enclosure of the limit switches shall be of cast aluminium provided with neoprene gasket.

8.8 **Car Gate Interlock**

An electrical interlock shall be provided in the car gate to prevent the movement of the car away from a landing unless the car gate is in the closed position. Effective locking devices shall also be provided to prevent the opening of the gate unless the car is on a particular landing.

8.9 **Hoist way Door Interlock**

Each hoist way door shall be provided with an approved interlock to be operated by a retiring cam on the car to prevent the movement of the car away from the landing unless all the doors are closed and locked. The interlocks shall also prevent opening of the doors except at the landing where the car is stopping or has stopped. The retiring arm shall be provided with dust protective covers.

8.10 **Door Open Bell**

An industrial bell shall be installed on the car to ring while a landing button is pressed and the car gate is open. The bell shall be for 110 V DC.

8.11 **Car Travelling Cable**

All electrical connections to the car shall be made by means of a multi-core hanging copper conductor flexible cable, one end of which is connected to terminal box fitted

above the car, the other to a terminal box fitted in the well at approximately the mid-position. These travelling cables shall conform to B.S.S. 977 having FRLS properties also. All car connections from the controller shall run to the well terminal box. The length of the flexible cable shall be approximately equal to half the lift total travel plus 5 meters so that the car may travel from end to end of the well without subjecting the cable to any strain.

8.12 **Wiring**

From the safety aspect, it is essential that all electric cabling and wiring be carried out in a sound and efficient manner and be in accordance with IS:732.

8.13 **Telephone**

An arrangement for installation of a telephone set inside the lift car shall be provided. This shall include an aluminium cabinet for telephone set having hinged door and flushed with the lift car with proper nameplate on the door.

Necessary leads shall be provided on the travelling cable for this purpose. The owner shall terminate the exchange cables in the machine room. Necessary arrangements shall be provided to receive this. The receiver shall be supplied and installed by the supplier. Necessary terminal block shall be provided in the cabinet for this purpose.

8.14 **D.C. Lighting**

One No. 60 W, 110 V DC lighting fixture shall be provided in lift car for lighting in case of power failure.

8.15 **Earthing**

The metal frame work of the motors, controllers/switchgear, electrical equipment in the car, car metal framework, guide rails & buffers and the electric conduit shall be effectively earthed in accordance with the latest issue of Indian Electricity Rules and IS:3043. The cross-sectional area of the earth conductor in the travelling cable shall be equal to that of the current carrying conductors. All equipment shall be earthed at least by two separate earth conductors.

9.0 PAINTING

9.1 All vendor equipment shall be painted with two coats of corrosion resistant epoxy based paint after suitable pretreatment.

9.2 The pre-treatment shall include treatments for removal of dust, scale and other foreign matters, epoxy based primer coating and final painting by spraying.

9.3 All fabricated items shall have shop coating of the primer only. Painting shall be carried out at site after their installation. The site painting shall have one coat of corrosion resistant epoxy based primer followed by two coat of epoxy based paint by spraying.

10.0 TESTS AND INSPECTION

10.1 All the items shall be routine tested as per relevant Indian Standards in the presence of Purchaser's representative. The supplier shall give a fortnight notice to the owner to enable its representative to be present for these tests.

10.2 In addition all the equipment shall be subject to stage inspection at works.

10.3 These inspections shall, however, not absolve the vendor free from his responsibility for making good any defects which may be noticed subsequently.

11.0 ERECTION, TESTING AND COMMISSIONING

11.1 The supplier shall undertake the erection of all equipment in accordance with established practices, in conformity with the statutory regulations and to the entire satisfaction of the owner.

11.2 The supplier shall arrange all the necessary erection, tools and tackles including the supply of erection materials. The manufacturer shall also supply bulk lead lighting fitting inside hoist way to be provided at every 20 metres interval suitable for area classification.

11.3 The supplier shall to obtain the necessary clearance from the statutory authorities for equipment supplies and installation. All necessary drawings and test certificates as required by the authorities shall be furnished. Any modification/ rectification, as required by the authorities shall be carried out.

11.4 Approved tests shall be performed on all equipment to the Owner's entire satisfaction. All the test results shall be recorded and submitted to the owner.

11.5 The entire installation shall be tested to prove the required performance in the presence of Purchaser's representative.

12.0 SPARES

12.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-I.

12.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

12.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

12.4 All spare parts shall be identical to the parts used in the equipments.

13.0 DRAWINGS AND DOCUMENTS

13.1 The drawings and documents as per Annexure-II shall be supplied unless otherwise specified.

13.2 All drawings and documents shall have the following descriptions written boldly:

i) Name of client
ii) Name of consultant
iii) Enquiry / order number with plant / project name
iv) Equipment Code No. and Description

13.3 At the time of handing over of the installation, the supplier shall supply as-built drawings taking into consideration the actual execution carried out.

14.0 DEVIATIONS

14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE – I

LIST OF SPARE PARTS

I. The spare parts as given below shall be quoted for recommended quantity with unit price.

Sl. No. Description

a) For Machine and Brake
- Brake Lining
- Brake Rivets
- Bushing
- Gaskets

b) For Controller
- Relay of each type
- Aux. Relay of each type
- Timer - OFF Delay
- Selector Switch of each type
- Pilot lamp of each type
- Push Button of each type
- Lamp of each type
- Rectifier
- Transformer of each type
- Condenser of each type
- Resistor of each type
- Fuse Element of each type

c) Limit Switch of each type

d) For Car and Hall Fixtures
- Guide Shoe for Cage
- Guide Shoe for Counter Weight
- Babbitt Metal
- Telephone Receiver

e) For Swing Door
- Guide
- Bushing
- Chain
- Door Closer

Sl. No. Description

f) For Steel Collapsible Sliding Car Gate

Chain

Gate Switch

Guide

g) For Retiring cam and Electromagnet

Magnet Coil

Cam

Bushing

Spring

h) For Gear Box

Bearing of each type

Oil Seal of each type

0' Ring

i) For Electric Motor

Bearings (DE/NDE)

j) Bearing For Deflector Sheave

k) Bearing For Overhead Sheave

II. The following erection/commissioning spare parts shall also be quoted for recommended quantity with unit price

a) Limit Switch

b) Fuse element of each rating

c) Pilot lamps

d) Bolts with tools box

e) Push buttons

f) Retiring cam Spring

g) Brake Shoe and Rivet

h) Lamp

NOTE : The Vendor shall indicate the type number and unit prices in the bid.

ANNEXURE – II

DOCUMENTATION FOR PASSENGER CUM GOODS LIFT

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	Y	N	Y
2.	Technical Particulars, duly filled in	Y	N	Y
3.	Drawings showing lift well machine room & pits with layout of equipment showing position of various landings	Y	Y	Y
4.	Technical & Illustrative literature of all equipment	Y	N	Y
5.	Quantity & exact position of all vertical load and horizontal thrust to the supporting structure	Y	Y	Y
6.	Details of inserts & openings to be provided in lift shaft, machine room & pits or any other civil detail required	Y	Y	Y
7.	Foundation drawing suitable for civil works calculation complete with static & dynamic loads, necessary anchorage & elevation	Y	Y	Y
8.	Electrical arrangement of equipment in hoist way	N	Y	Y
9.	Wiring Diagram	N	Y	Y
10.	Schematic Diagram	N	Y	Y
11.	Equipment Detail with make	N	Y	Y
12.	Detailed dimensional drawing of all equipment	N	Y	Y
13.	Type Test Certificates	N	N	Y
14.	Routine Test Certificates	N	N	Y
15.	Operation and maintenance manual	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

ELECTRICALS FOR OVERHEAD CRANES & HOISTS

CONTENTS

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ANNEXURE - I	DOCUMENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS
ANNEXURE - II	LIST OF SPARES

1.0 SCOPE

1.1 This standard covers the technical requirements of design, engineering, manufacture, testing at works, supply at site, erection, site testing and commissioning of the complete electrical equipment and accessories as required for the overhead travelling crane and hoists.

1.2 This standard shall be read in conjunction with relevant mechanical specifications, other relevant standards / specifications.

1.3 The scope of work shall include but not limited to the following items:

i) Drive motors
ii) Starting resistors (in case of slip ring motors)
iii) Power control panel
iv) Control stations
v) Limit switches
vi) Electromagnetic brakes
vii) Power and control cables with accessories
viii) Earthing of all equipment
ix) All other items, not specified but, required for safe and proper operation

1.4 The owner shall provide one no. medium voltage feeder for each crane / hoist and terminate the feeder cable in an isolator located at one end of the bay at a height of 1.5 m from the operating floor. The vendor shall indicate the exact power requirement (running and peak) to enable the owner to size and provide the power supply feeder.

1.5 Further distribution of power from this isolator onwards shall be in the vendor's scope.

1.6 Working platform shall be provided for checking and maintenance of the hoist.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture, testing and installation of the equipment shall comply with the latest issue of IS-6547, IS-807 and other relevant Indian Standard specifications and codes of practices. Equipment complying with equivalent IEC standards shall also be acceptable.

2.2 The equipment and installation shall also comply with the provisions of latest issue of Indian Electricity rules and other statutory acts and regulations.

2.3 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specification, the requirement specified here-in shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 **System Details**

These shall be as indicated in Design Philosophy-Electrical.

3.3 The owner shall provide only three phase power at the specified medium voltage. For lighting, control and plug supply the vendor shall provide necessary single phase step-down transformers.

3.4 All the electrical equipment shall be so designed that enable the crane / hoist to operate at its rated capacity and specified duly cycle with the system variation under the ambient conditions indicated in Design Philosophy-Electrical without exceeding the permissible temperature rise and without any detrimental effect on any part.

4.0 GENERAL DESIGN AND CONSTRUCTIONAL REQUIREMENTS

4.1 The electrical system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.

4.2 All equipment shall have adequate and standard ratings as per ISS.

4.3 All electrical equipment to be located in indoor plant area shall be enclosed in dust, damp and vermin proof enclosure equivalent to IP-54 as per IS: 13947 / IS: 4691.

4.4 Equipment to be located outdoor shall be weather proof and have IPW-55 protection as per IS: 13947 / IS: 4691 and shall also be provided with canopy as far as practicable.

4.5 The equipment to be located in hazardous area shall have additional protection as follows:

a) Zone – I All the equipment shall be in flameproof execution.

b) Zone – II The equipment producing sparks under normal operation shall be in flameproof execution and others shall be in increased safety execution.

The equipment shall be suitable for the enclosure group and temperature class as indicated in Design Philosophy-Electrical. The equipment selected shall conform to relevant Indian Standard Specification and must be certified by Central Mining Research Institute, Dhanbad or any other statutory authority for use in the specified hazardous area.

4.6 The pendant push button shall be light weight enclosure of aluminium/ polypropylene etc. In case of hazardous areas, the loop between the pendant push button and the crane control panel shall be made intrinsically safe by using suitable isolators. Alternatively certified flame proof components and increased safety terminals can be hosed in the hose proof aluminium / polypropylene enclosure.

4.7 Special care shall be taken to ensure that the parts to be opened for inspection and maintenance retain their dust tightness even after repeated opening and closing operations.

4.8 All mating surfaces shall be properly machined. Neoprene gaskets shall be used for dust and weather proofing. The gaskets shall be without any discontinuity.

4.9 Only non-hygroscopic materials shall be used for insulation. All insulation shall be specially impregnated to withstand ambient conditions and atmospheric pollution.

4.10 All live parts shall be adequately protected to prevent inadvertent or accidental contact.

4.11 The minimum clearance and creepage distance of M.V. equipment shall be 20 and 28 mm respectively and shall be positively maintained after connections.

4.12 All external hardware of diameter less than 8 mm shall be of stainless steel and those of diameter 8 mm and above shall be of mild steel zinc passivated.

4.13 Earthing terminals complete with sockets and identification marks shall be provided on the enclosure of all electrical equipment. The number of terminals shall be two for equipment rated above 240V and one for those rated 240V and below. Additional internal earthing arrangement shall be provided for flameproof equipment.

4.14 All equipment shall be provided with stainless steel name plates containing the particulars as per relevant IS along with the description and code nos. of equipment

4.15 All the electrical equipment shall be provided with separate terminal box, heavy duty double compression type rolled aluminium cable glands, proper crimping lugs and anti-vibration type terminals suitable for the cable sizes required.

4.16 Enclosure for limit switches, pendant push button, junction boxes and magnets etc. shall be of cast aluminium. Enclosure for control panel, transformer and resistors may be of sheet steel. The thickness of the sheet steel for the enclosure shall not be less than 2.5 mm. All enclosures shall be suitably painted to withstand atmospheric pollution.

4.17 The doors or inspection covers shall be provided with threaded knobs or butterfly nuts made of plated carbon steel. Copper or copper alloys shall not be used outside the enclosures.

4.18 To facilitate maintenance and testing of all electrical equipment:

a) Disconnecting links shall be provided where necessary.

b) All cable lugs and terminals shall be numbered in a permanent form corresponding to the wiring diagram.

c) Easy access and adequate working space shall be provided around all motors, panels, limit switches etc. safety railing shall be provided, where necessary.

5.0 EQUIPMENT SPECIFICATION

5.1 Power Connection

5.1.1 The main supply shall be obtained by flexible cable.

5.1.2 In case of overhead bare conductors, they shall be of copper and mounted on side of the crane bridge. Four number of gunmetal type current collector with renewable carbon inserts shall be used for power connection. One end of the bare conductor shall be connected to the owner's isolator by means of fixed cable.

5.1.3 In case of flexible cable arrangement, the cable shall be connected at one end of the crane and the other end to owner's isolator. The cable shall be hung at intervals by festooned type arrangement.

5.1.4 In either case the power fed to the trolley shall be by means of flexible cables fixed and supported by festooned arrangement.

5.1.5 The arrangement of fixing and supporting the flexible cables shall be such that the cable is not damaged due to repeated travelling of the crane and trolley. Supporting G.I. wire shall be provided, wherever required.

5.1.6 The collector rollers and shoes shall be designed to avoid sparking.

5.2 **Power Control Panel**

5.2.1 The panel shall house all the necessary electrical equipment for distribution of power and control of individual equipment / circuit.

5.2.2 The panel shall be totally enclosed, floor mounting, dead front, free standing type in cubicle construction.

5.2.3 The panel shall house the following:

i) For incoming supply

- Triple pole switch fuse units
- Supply 'ON' signal lamps (LED Type)

The above switch shall cut off all power driven and associated equipment on the crane except lighting and plug supply circuits.

ii) For motors

- Reversing type starter with necessary contactors and timers.
- Other controlling relays and devices.

iii) For lighting, control and plug supply

- Single phase transformers
- Isolating switch fuse units on primary and secondary sides.

5.2.4 All switches shall be motor duty type (AC 23) and rated for 1.5 times of the full load current of the circuit. The incoming switch shall be interlocked with the panel door.

5.2.5 All contactors shall be air break type and of AC4 utilization categories. The thermal rating of the contactor shall be 1.5 times the full load current of the circuit.

5.2.6 The power contactors shall be interlocked electrically and mechanically so that there shall be no possibility of simultaneous operation of two contactors for the same motor.

5.2.7 Electrical interlock shall be provided between main hoist and micro hoist motors.

5.2.8 All thermal overload relays shall have in-built single phasing feature and ambient compensated, separately mounting and hand reset type. The reset push bottom for thermal overload relays shall be provided on the cover of the control panel so that it is possible to reset the relay from outside without opening the cover of the panel. Also indication shall be provided for hoisting/travel motors tripping on overload.

5.2.9 The panel shall be installed on properly levelled base frame fabricated out of channels of suitable size.

5.3 **Motors**

5.3.1 The design and specification of all motors shall comply with requirements stated elsewhere in the specifications.

5.3.2 The power rating of the motors shall be 25% higher than the design requirement of the driven equipment, under the specified service and duty conditions.

5.3.3 All motors shall preferably be of squirrel cage type and so designed that smooth acceleration or deceleration of the load is possible without any jerks. Further a maximum displacement of 2 mm when starting and stopping the motor in quick succession shall be guaranteed.

5.3.4 The motors for main hoist and micro hoist shall be suitable for intermittent duty type S4 with 60% C.D.E. and 300 starts / stops per hour. The motors for long travel and cross travel shall be suitable for S2 duty for 60 minutes.

5.3.5 The motors shall be so located that all parts are accessible for inspection and maintenance without affecting normal ventilation.

5.4 Brakes

5.4.1 The brakes for each motor shall be suitable for duties as specified below:

a) Main / Micro hoist S4 duty

b) Long / cross travel S2 duty

5.4.2 The coil of the brake shall be wound with fibre glass covered annealed copper conductor suitable for class H application. An additional covering with glass taps shall be provided over the coil. The maximum temperature of the coil for continuous operation shall be limited to 140º C. The coil shall be vacuum impregnated.

5.4.3 For other design details refer mechanical engineering standard.

5.5 Limit Switches

5.5.1 Limit switches of both shunt and series type shall be used in control and power circuit.

5.5.2 These shall be heavy duty type and of sturdy construction in cast aluminium enclosure.

5.5.3 The mode of operation of these limit switches shall be positive and direct acting type.

5.5.4 The contacts shall be rated 50% more than the required current ratings.

5.5.5 The width of the roller of limit switches shall be sufficient to avoid slippage of contact with the striker.

5.5.6 The striker provided for operating these limit switches shall have rubber padding on surface which will make contact with roller to actuate it. The limit switches and its roller should be designed to withstand the frequent impact pressure.

5.5.7 Switches in which the contacts are operated by spring or gravity or both on the withdrawal of a chain or similar devices, shall not be used.

5.6 Transformers

5.6.1 These shall be of dry type, class H insulated, air cooled, double wound and mounted inside the panel.

5.6.2 The transformers shall be provided with switch fuse unit on their primary side of suitable rating. One side of secondary windings of the transformers shall be earthed and other shall be provided with fuse of suitable rating.

5.6.3 The rating of the transformers shall be at least 2.5 times the continuous load.

5.7 **Junction Box**

Junction boxes shall be of cast aluminium construction and adequately sized to enable easy termination of cables.

5.8 **Hand Lamps**

5.8.1 Provision shall be made in the crane for use of hand lamps by installing 2 nos. 24 volts, 2 pin metal clad switch sockets. One of the sockets shall be on the bridge (outside the panel) and the other on the trolley.

5.8.2 The transformer primary and secondary voltage shall be 250V and 25V respectively.

6.0 CABLES, CABLE TERMINATION AND CONNECTIONS

6.1 The cables used for fixed wiring shall be 1.1 KV grade XLPE insulated armoured and PVC sheathed overall, and shall conform to IS: 7098 Part-I.

6.2 The flexible cable used for power supply to crane and also for interconnection of equipment mounted on moving and fixed part of the crane shall be 1.1 KV grade heavy duty type.

6.3 All cables shall be properly laid and supported with adequately sized aluminium clamps at 500 mm interval.

6.4 Cable entry on all electrical equipment e.g. panels, motors, limit switches, brakes, junction boxes etc. shall be through double compression type rolled aluminium cable glands.

6.5 The internal power wiring of panels shall be carried out by PVC insulated stranded copper flexible cable.

6.6 The wiring shall be arranged in a neat fashion and supported on PVC channel or PVC stand of screw support.

6.7 For equipment mounted on the doors, the wiring shall be carried out with flexible stranded copper cables in such a way that no strain is put on the wires and equipment when the door is opened for inspection and maintenance.

6.8 External looping of wires shall be done through separate dust tight junction boxes.

6.9 The sizes of power cables to be used shall be subject to owner's approval. The minimum size of power and control cables shall be 16 sq. mm (Al) & 2.5 sq. mm (Cu) respectively.

7.0 EARTHING

7.1 The earthing of all electrical equipment shall be carried out in accordance with IS: 3043.

7.2 The enclosures of electrical equipment shall be connected to an aluminium earth ring on the crane which in turn shall have effective electrical connection with the bridge.

7.3 The crane bridge shall be earthed through the bridge travel runway rails on both sides which in turn shall be earthed to owner's earth ring located on the ground floor.

7.4 Further the power supply cable for the crane shall have an additional conductor for earth connection. Both sides of this conductor shall be earthed.

7.5 All earth conductors shall be of aluminium.

7.6 This size of earth conductor shall be equal to half the size of the power conductor subject to a minimum size of 10 sq. mm.

8.0 CONTROL DESK / CONTROL STATION

8.1 The crane shall be controlled either from the floor by means of a pendant control station or from bridge mounted control desk as indicated in the mechanical data sheet.

8.2 In either case, the units shall have the following control devices:

- Main off push button with padlocking arrangement.
- Indication lamps for supply 'ON'
- Control push buttons, as specified in the mechanical data sheet.
- All other devices required for safe and proper operation of the crane / hoist.

8.3 All push buttons shall be momentary contact type, coloured as per IS: 6875 and have 1 NO and 1 NC contacts.

8.4 The bridge mounted control desk, where specified, shall be of totally enclosed and dust tight construction. All controlling equipment shall be mounted on the top. It shall be located at most convenient location to allow movement of the operator. The installation shall be equipped with adjustable chair, fan, light and main isolating switch.

8.5 The pendant control station, where specified, shall be in a single enclosure and in totally enclosed dust light execution. The unit shall be suspended and supported from the bridge platform by flexible steel wire rope. The connection shall be made with a multi core flexible copper conductor cable and shall have 20% spare cores. One core shall be provided for earth connection of the circuit.

8.6 The control supply of the hoist shall be 24V for safety reasons. Hence the power contactor and other auxiliary shall be 24V AC.

9.0 PAINTING

Enclosures of all electrical equipment shall be painted with two coats of epoxy based primers after suitable pre-treatment. Two coats epoxy based paint of approved colour.

10.0 MAKE OF ELECTRICAL ITEMS

The make of the electrical items shall be as indicated elsewhere in the NIT.

11.0 TESTS AND INSPECTION

11.1 All equipment shall be routine tested as per relevant Indian Standard Specifications.

11.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

11.3 All the above mentioned tests shall be carried out in presence of owner's representative.

11.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

11.5 Despatch of materials shall be subject to written consent of owner or his representative.

12.0 INSTALLATION, TESTING AND COMMISSIONING

12.1 The vendor shall undertake installation of all electrical equipment in accordance with latest code of practices, in conformity with recommendation of the respective equipment manufacturer, drawings approved by the owner or owner's representative, direction of Engineer-in-charge, statutory regulations and to the entire satisfaction of the owner.

12.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials including structural steel.

12.3 Following tests shall be specifically conducted before commissioning in presence of owner's representative. All the test results shall be recorded and submitted to the owner.

i) Insulation test.

ii) Continuity test.

iii) High voltage test.

iv) Simulation test.

13.0 DRAWINGS AND DOCUMENTS

13.1 Drawings and documents as per Annexure-I shall be supplied unless otherwise specified.

13.2 All drawings and documents shall have the following description written boldly :

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

14.0 SPARES

14.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed in Annexure-II.

14.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

14.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

14.4 All spare parts shall be identical to the parts used in the equipments.

15.0 DEVIATIONS

15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE - I

DOCUMENTENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification sheet and technical particulars completely filled in	Y	Y	Y
2.	Composite schematic diagram	Y	Y	Y
3.	Dimensional drawing showing the mounting details and general arrangement for the following equipment			
	a) Motors	N	Y	Y
	b) Power control panel	N	Y	Y
	c) Control station	N	Y	Y
	d) Limit switches etc.	N	Y	Y
4.	Down shop lead and power supply arrangement with civil scope.	N	Y	Y
5.	Inter-connection with terminal diagram and cable details	N	Y	Y
6.	Operating and maintenance instruction manual	N	N	Y
7.	Catalogues of bought out items	Y	N	Y
8.	Test certificates	N	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

ANNEXURE-II

LIST OF SPARES

1) Bearings of each type & no.
2) Contactor coil of various ratings.
3) Complete set of contactor of each rating.
4) Moving & fixed contact blocks of contactors of each rating.
5) Limit switches of each type.
6) Push button elements.
7) Push button actuators.
8) Fuses of various ratings.
9) Fuse fittings of various ratings.
10) Indicating lamp fittings.
11) Indicating lamps.
12) Over load relays of various ranges.
13) Brake coils.
14) Set of carbon brushes in case of S.R. motors.
15) Set of resistors for S.R. motors.
16) Any special tools and tackles required for maintenance

NOTE :

i) All the spare parts shall be identical to original parts.

ii) The tenderer shall also quote for any other spares as deemed necessary to be kept in stock for stipulated time.

TECHNICAL SPECIFICATION

DIESEL GENERATOR SET

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	STANDARDS TO BE FOLLOWED
3.0	SERVICE CONDITIONS
4.0	OPERATING REQUIREMENTS
5.0	DIESEL ENGINE
6.0	GENERATOR
7.0	CONTROL PANEL BOARD
8.0	INSTRUMENTATION
9.0	ACCESSORIES
10.0	PAINTING
11.0	TESTS AND INSPECTION
12.0	SPARES
13.0	DRAWING AND DOCUMENTS
14.0	DEVIATIONS
15.0	PACKING
ANNEXURE - I	LIST OF SPARES
ANNEXURE - II	DOCUMENTATION FOR DIESEL GENERATOR SET

1.0 SCOPE

1.1 This standard covers the technical requirements of design, engineering, manufacture, assembly, testing at works and delivery in well packed condition, erection, testing and commissioning of diesel generator set (D.G. Set) complete with all required accessories and control equipment to supply continuous electrical power.

1.2 This standard is applicable for D.G. set having rating more than 500 KVA.

1.3 The scope of supply shall include, but not limited to the following:

a) Diesel engine, complete with all the required accessories and components.

b) Generator set, for operation with the above diesel engine, complete with all the required accessories and components.

c) Drive coupling between diesel engine and generator set complete with guard.

d) Engine flywheel, if required, with starter ring and guard.

e) Fuel oil system comprising of fuel oil tank, supply pump, filter, piping, valves, fittings etc.

f) Air intake system comprising of air blower, air filter, turbo charger etc.

g) Lubrication oil system comprising of lube oil pump, filter, cooler, piping, valves, fittings etc.

h) Jacket cooling system comprising of radiator, water circulation pump, necessary piping and fittings etc.

i) Starting system complete with battery, battery charger, starter motor, control system etc.

j) All inter connecting piping, valves and fittings up to the battery limits.

k) Torsional vibration damper at the free end of the crank shaft.

l) Speed regulation system.

m) Provision for hand barring of the engine along with the hand barring tool.

n) Platforms, walkways, stairs and hand racks, as required, for adequate access during operation and maintenance.

o) A common base frame suitable for assembly of engine, radiator and alternator with there accessories. Anti, vibration mounting and foundation bolts shall also be supplied. Base frame shall be designed for transportation of above items duly assembled on it.

p) Exhaust manifold complete with silencers, asbestos lagging, metallic expansion bellows and piping as per lay out of D.G. room.

q) All necessary instruments for monitoring and safe starting, running and stopping of the D.G. set their auxiliaries complete with tubing and cabling.

r) Control panel.

s) Cabling material between control panel and all equipment within the battery limit including cables, racks, earthing terminating materials etc.

t) All safety and protective devices.

u) All other items not specified here but, necessary for safe, satisfactory and uninterrupted operation of D.G. set.

v) Set of special tools and tackles required for installation and maintenance.

w) Spare parts for the specified duration.

x) All other services.

2.0 STANDARDS TO BE FOLLOWED

2.1 The design, manufacture and testing of the equipment covered by this standard shall comply with the latest issue of the following codes and other relevant Indian standard specifications. Equipment complying with equivalent IEC standards shall also be acceptable.

i) BS 649 - Diesel engines for general purpose.

ii) IS-10000 - Methods of test for internal combustion engine.

iii) ASME codes.

iv) IS 4722 - Rotating Electrical Machines - Specification.

v) Oil coolers as per TEMA class “C”

2.2 Equipment designed and manufactured to other national standards shall be acceptable provided they are in no way inferior to the above mentioned standards. The vendor shall supply English version of the relevant standard in such case.

2.3 The design and operational features of the equipment offered shall also comply with the provisions of latest issue of the Indian Electricity Rules and other statutory regulations. The vendor shall, wherever necessary, make suitable modification in the equipment to comply with the above.

2.4 Wherever any requirement, laid down in this standard, differs from that in Indian standard / IEC, the requirement specified here in shall prevail.

3.0 SERVICE CONDITIONS

3.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

3.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

4.0 OPERATING REQUIREMENTS

4.1 The D.G. set shall be suitable for “black start” operation. The equipment offered shall be suitable for operating at their rated capacity continuously under the ambient conditions and voltage & frequency variations indicated in Design Philosophy-Electrical, without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.

4.2 The D.G. set shall be designed for continuous operation at full load or partial load and have the capability to run at 110% of the MCR for one hour in every 12 hrs.

4.3 The D.G. set covered under this standard shall be meant to supply power in one of the following modes.

Type A - Emergency power i.e. to provide reliable power due to failure or outage of normal supply automatically within a specified time to critical devices and equipment of the installation.

Type B - Stand by power i.e. to provide reliable power due to failure or outage of the normal supply to all devices and equipment of the installation.

Type C - Backup power i.e. to provide reliable power due to restriction imposed by the supply authorities of the normal supply to some section of the installation.

The exact mode shall be as indicated elsewhere in the NIT.

4.4 The D.G. set meant to supply emergency power (Type A) should start automatically and quickly on receipt of starting impulse from owner's remote panel after prolonged idle period. Under such conditions, the auxiliary power and cooling water shall not be available. The starting and lubrication system shall be suitably designed to take care of these conditions and allow easy, safe and quick starting. The loading sequence and its duration are as specified by purchaser elsewhere.

4.5 The D.G. set meant to supply standby power (Type-B) shall be started automatically and conditions mentioned above shall also apply. However, the loading sequence is not automatic and hence need not be defined by purchaser.

4.6 The D.G. set meant to supply backup power (Type-C) shall be manually controlled and started manually. Idle period may not be long and the requirement of auxiliary power and cooling water can be ensured due to the availability of the normal supply.

5.0 DIESEL ENGINE

5.1 General Design Feature

5.1.1 The diesel engine shall be of multistroke, multicylinder with mechanical fuel injection arrangement and complete with all the required accessories.

5.1.2 The engine output shall be at least 15% greater than the power required for the loads (including internal consumption by D.G. set) and loading sequence.

5.1.3 The engine shall be suitable for trouble free operation with high speed diesel conforming to IS: 1460.

5.1.4 The unbalance force transmission to the foundation shall be minimum. Critical speed of the assembly shall be sufficiently higher than the rated speed of the engine.

5.1.5 The engine shall be provided with turbo charger, filter and silencer mounted suitably on the engine frame and complete with necessary ducts work for air intake.

5.1.6 The engine shall be provided with exhaust silencer, necessary ducts, minimum 2 nos. expansion bellows and supporting arrangement from ceiling for exhausting the gases to outside.

5.2 Fuel Oil System

5.2.1 The system shall comprise of gravity fed oil tank.

5.2.2 The gravity tank shall be complete with the provision of filling up by Hand pump from the standard drums. The Hand pump and associated hose pipe shall be provided by the vendor.

5.2.3 The gravity fed oil tank shall be located at a height from floor and near the wall of the engine room. Suitable brackets / structure shall be provided by the vendor for this purpose. The tank shall be fabricated out of M.S. plates in cylindrical construction. The capacity of the tank shall be adequate for 12 hours continuous running of the engine. It shall be complete with valves for filling & draining, vent connection, level gauge glasses, level switches for low level alarm.

5.3 **Jacket Cooling System**

5.3.1 The engine shall be provided with radiator type air cooling system.

5.3.2 All the necessary items for the system such as water pump, radiator, fan, piping and fittings shall be provided to make the system complete in all respects.

5.3.3 Head tanks, if required, shall be included in the scope of supply for make up water as well as taking care of the expansion of the jacket water.

5.4 **Lube Oil System**

5.4.1 Proper lube oil system shall be provided for all lubricating points of the engine. The system shall be automatic pressure feed type and provided with a gear type pump driven from the crank shaft. The system shall be complete with fine wire mesh duplex strainer, valves, tank, oil cooler, header and branch piping suitably mounted on bed plate. Necessary accessories like pressure gauge, temperature and pressure switches for alarm and controls shall be provided.

5.4.2 The cooler shall be shell and tube type and connected to the engine cooling water system.

5.5 **Starting System**

5.5.1 The Electrical starting system shall be provided up to 1000 KVA DG set. However, for more than 1000 KVA DG set electrical / pneumatic starting shall be provided.

5.5.2 Both manual and automatic starting scheme shall be provided. The manual starting system shall be local while automatic starting system shall be suitable for impulses from owner's remote panel.

5.5.3 The starting system shall be such that the D.G. set shall start & come up to rated speed and be ready to accept full load within the period.

5.5.4 The electric starting system shall comprise of starter motor, battery, battery charger, necessary cabling, required instruments and accessories.

5.5.5 The Ni-Cd battery shall be heavy duty type and suitable for 20 successive starting attempts of the engine without draining. The charger shall have both float / boost charging facilities. The battery shall be complete with suitable stand and other required accessories.

5.5.6 The pneumatic starting system may comprise of a camshaft driven rotary air distributor admitting air to a series of automatic air starting valves fitted on individual cylinder heads or an air cranking motor operating through a ring gear on the engine fly wheel. The pneumatic starting system shall consist of:

a) One 100% capacity A.C. motor driven air compressor, additional engine driven air compressor shall be provided.

b) One air receiver of adequate capacity to supply air for minimum six (6) starts of engine.

c) Solenoid operated valves.

d) Pressure switches for automatic starting and stopping of the compressor.

e) After-coolers for compressor, if required, suitable for raw cooling water.

5.5.7 The compressor for charging the starting air receiver shall be driven by an A.C. motor. The starting and stopping of this motor driven compressor shall be controlled automatically by suitable pressure switches so that the air receiver remains charged always.

5.5.8 Vendor shall provide all necessary devices including solenoid valves so that with an impulse for starting of the engine received from purchaser's emergency equipment or manual start push button, the entire operation of starting of the diesel set shall take place automatically.

5.6 Governing System

5.6.1 The speed governing system of the diesel engine shall satisfy the following requirements:

a) Steady state speed regulation shall be adjustable between 0 to 5% manually.

b) Steady state speed regulation once fixed, shall not vary beyond + 0.5%.

c) Transient speed regulation shall not exceed 4.5% of rated speed. Momentary under speed and over speed shall not exceed 2% and 8% respectively.

d) Recovery time shall be within 3 seconds.

5.6.2 The governor system shall be electronic type and provided with adequate scheme to control the speed in the event of failure of power to the governor.

5.6.3 A mechanical over speed trip device shall be provided to operate at 110% of rated speed.

5.6.4 An engine mounted emergency push button shall be provided to trip the engine in case of emergency.

5.6.5 Separate Tachometer shall be provided to indicate the speed of the engine locally.

6.0 GENERATOR

6.1 General Design Features

6.1.1 The generator shall be directly coupled to the engine.

6.1.2 The ingress protection class of the enclosure shall be IP44 as per IS: 4691.

6.1.3 The generator and its accessories shall be capable of withstanding electrical, mechanical and thermal stresses while meeting the performance requirements.

6.1.4 The generator shall be synchronous A.C. Generator; star connected and shall have C.M.R. of specified output at 0.8 lag p. f. at rated voltage and frequency.

6.2 **Winding and Insulation**

6.2.1 The stator and rotor coils shall be made out of electrolytic grade copper conductors. Successive coils shall be connected by accessible and well brazed joints.

6.2.2 The coils shall be class F insulated and treated with tropical and fungicidal treatments.

6.2.3 The windings shall be dried, properly impregnated with suitable varnish to withstand the site conditions and properly baked. At least two additional impregnations and baking shall be applied to the assembled coil making a total of three impregnations and baking. Finally the windings shall be painted with special anti-acid and anti-alkali paint to withstand the site condition.

6.2.4 The leading wire between the windings and the outside terminals shall be through bushings.

6.3 **Performance Requirement**

6.3.1 The generator and the diesel engine shall match properly to deliver the rated load under the specified ambient and system conditions.

6.3.2 The specified rating of the D.G. set indicated are net electrical power output required for owner's use and does not include the power required by the auxiliaries of the diesel set. The actual output rating of the generator to be offered by vendor shall take into account the power requirement of the auxiliaries, 15% extra margin.

6.3.3 The generator shall have an overload capacity of 10% for 1 hour in any consecutive period of 12 hours after having attained the thermal equilibrium corresponding to the rated load. The terminal voltage shall be equal to the rated value. At the time of switching 'ON' the emergency loads, restarting or reacceleration of squirrel cage motors shall be required, in addition to switching 'ON' of the lighting loads, which will be six times the rated load at power factor of 0.35 lagging. The generator and its accessories shall be capable of supplying this load at the above mentioned low power factor. Limitations, if any, shall be clearly indicated by the vendor.

6.3.4 The transient reactance shall be as low as possible to limit the voltage drop to 10% due to above loading conditions.

6.3.5 <u>Largest Motor Starting Requirement</u>

The D.G. set shall be designed such that it can start squirrel cage induction motor of specified rating by D.O.L. starting method when already loaded up to 80% of its rated load. The voltage dip at the generator terminal shall not exceed 10% of its rated voltage during the entire starting period which will not exceed 5 seconds.

Limitations of the engine size offered by the bidder, if any, shall be indicated clearly by the bidder.

Supporting calculation shall be supplied by the successful bidder for approval of the owner.

6.3.6 The short circuit ratio, of the generator at rated KVA and rated voltage shall not be less than 0.5.

6.3.7 The generator shall withstand 20% over speed for 2 minutes without any damage to any part.

6.3.8 The generator shall be capable of withstanding the three phase short circuit at its terminals while operating at its voltage without sustaining any damage.

6.3.9 The temperature rise of stator windings, exciter and other parts shall not exceed the limits specified in relevant IS.

6.4 Excitation System

6.4.1 The generator shall be provided with static brushless excitation system comprising of shaft driven rotor exciter, thyristor and other associated items.

6.4.2 The armature and field windings shall be class F insulated similar to that of generator.

6.4.3 The capacity of the system shall be adequate to meet the performance and largest motor starting requirement of the generator.

6.5 Voltage Regulator

6.5.1 The generator shall have static type voltage regulators to be mounted on the control panel. The regulator system shall be suitable to meet the following requirements:

a) Allow the generator to meet the performance requirements.
b) Both auto and manual control.
c) Prevent automatic rise of field voltage in the event of excitation supply failure.
d) Transfer to manual mode in the event of control circuit failure in auto mode.
e) Operated by the output current and voltage of the generator.

6.6 Space Heater

6.6.1 Space heaters rated for 240V A.C. shall be provided to keep the winding dry during idle conditions.

6.6.2 The location of the space heaters shall be such as to allow easy access for inspection, maintenance and replacement.

6.7 Embedded Temperature Detectors

6.7.1 The generators shall be provided with 6 nos. of embedded resistance temperature detectors for measurement of winding temperature. Three of these shall be provided between the coils, one in each phase and the other three at the base of the slots, one in each phase, placed 120° apart.

6.7.2 The ETD's shall be of platinum having 100 ohm resistance at 0°C and temperature coefficient as 3.85×10^{-5}.

6.7.3 The ETD's shall be 3 lead type having power frequency insulation level of 2 KV.

6.7.4 The temperature indicator with selector switches shall be provided in the control panel.

6.8 Terminal Boxes

6.8.1 All the terminal boxes shall have IP-54 degree of protection.

6.8.2 The power and control terminal boxes shall be separate. All the six leads of the generator stator shall be taken out, three to one side and three to the other side to separate power terminal boxes.

6.8.3 The power terminal box shall be spacious and have adequate clearance between the terminals and the cable gland for proper termination of required nos. of aluminium cables.

6.8.4 The power terminal boxes shall be provided with tinned copper sockets suitable for crimping.

6.8.5 The control terminal boxes shall be provided with pressure type terminal blocks.

6.8.6 All terminal boxes shall be complete with heavy duty double compression type aluminium cable glands suitable for the cable sizes required.

7.0 CONTROL PANEL BOARD

7.1 Requirements

7.1.1 The control panel board shall comprise of control & instrument section, power & protection section and distribution section for satisfactory and trouble free operation of the set. Each section shall be a complete panel.

7.1.2 The control and instrument panel shall house the following:

a) All the required controlling elements for the engine, generator and exciter control, for both manual and automatic operations.

b) Panel mounted instrument

c) The required protective devices for the engine.

d) The audiovisual annunciation system indicating abnormal operating conditions.

e) Control switches and indicating lamps.

f) Automatic voltage regulator.

g) All other items, as required.

7.1.3 The power and protection panel shall house the following:

a) Circuit breaker in draw out execution suitable for local/remote operation and provided with protective relays, C.T.s Ammeters, Voltmeters, KWH meters, Frequency meters, ON/OFF/Trip indicating lamps, control switches etc. for the control of generator.

b) M.W.S. operated A.C.B. in draw-out execution suitable for local remote operation and provided with protective relays, C.T.s, Ammeters, ON/OFF/Trip indicating lamps, control switches etc. for the control of outgoing power feeders, as indicated else where.

7.1.4 The distribution panel shall house the following:

a) Necessary feeder circuit outlets complete with switches, fuses, contactors, overload devices, ON/OFF/Trip indicating lamps, Ammeters etc. for the D.G. set auxiliaries, if required.

b) D.C. battery charging equipment required for the start up and control of the D.G. set. The charger shall be complete with float and boost charging arrangement both in auto and manual mode.

7.2 General Design Features

7.2.1 The panels shall be free standing, floor mounting, identical, metal clad cubicle type in construction and placed side by side to form a compact assembly in dust/ damp and vermin proof type equivalent to IP-54 as per IS-13947 Part-1.

7.2.2 The thickness of sheet steel members shall not be less than 2 mm for cold rolled steel. Suitable reinforcement, wherever necessary, shall be provided. The base channel shall be more than 3 mm thick.

7.2.3 The door hinge shall be concealed type. All threaded screws in the removable parts shall be provided with retaining rings.

7.2.4 All the components shall be accessible for checking and taking off without the necessity of removing the adjacent ones. Their mounting shall be accessible and ensure the necessary degree of safety.

7.2.5 The relays, meters, switches and lamps shall be flush mounted type. Their minimum mounting height shall be 900 mm from the base of the panel.

7.2.6 The bus bars shall be for three phase and neutral and made of electrolytic copper or aluminium of required cross section and PVC sleeved. These shall be amply sized to carry the rated continuous current under the specified ambient temperature without exceeding the total temperature of 90°C. The thermal rating of the bus bars shall be designed to withstand the system fault current for one second without exceeding the temperature of 250°C for bare copper.

7.2.7 The clearances and creepage distance shall not be lower the values specified below:

7.3 Control Wiring

7.3.1 The panel board shall be completely factory wired and ready for external connections.

i) Minimum clearance between two live conductors - 20 mm.

ii) Minimum clearance between live parts and accidentally dangerous part - 20 mm.

iii) Minimum creepage distance - 28 mm.

7.3.2 The wiring shall be carried out with flexible stranded PVC insulated copper conductor cables for 1100 volts grade.

The size of wires shall be as follows:

C.T. Circuit - 2.5 sq. mm copper

V.T. & Control circuits - 1.5 sq. mm copper

7.3.3 All wiring shall be marked in accordance with IS-375. Numbered Ferrules reading from the terminals outwards shall be provided at both ends of all wiring for easy identification. These shall be interlocking type plastic ferrules.

7.4 Circuit Breakers

7.4.1 The circuit breakers shall generally comply with the requirements of IS: 13947, having P2 category, capable of carrying the specified current at the site conditions and making/ breaking of the system fault current.

7.4.2 Type test certificates from an independent testing authority shall be furnished along with the offer, for each circuit breaker rating, which shall clearly prove the capability of circuit breakers and include the short circuit tests, temperature rise test, electrical overload tests and endurance test (both electrical and mechanical).

7.4.3 The circuit breakers shall be provided with motor wound spring closing mechanism and electrically and mechanically trip free and have anti pumping features.

7.4.4 The circuit breakers shall have three positions for service, test and isolated with the cubicle door closed, and position indicators provided to indicate the positions of the breaker. Stoppers shall be provided to prevent excessive movement of the breaker

cradle than desired, for each position. Each position of the breaker shall have monitoring switch having 1 NO + 1 NC contacts.

7.4.5 Provision shall be made for testing the circuit breaker in test position.

7.4.6 Automatic safety shutters shall be provided to screen the cable and the bus bars spouts when the circuit breaker is withdrawn from the cubicle.

7.4.7 The circuit breakers shall be provided with an emergency manual trip device, mechanical 'ON' 'OFF' and 'ISOLATED' position indicators and operation counter.

7.4.8 Mechanical safety interlock shall be provided for safe operation movement of the breaker.

7.4.9 The closing coil and other associated auxiliary relays shall operate satisfactorily at all voltages between 85 to 110% of the rated control voltage. The tripping coil and other associated relays shall operate satisfactorily at all voltages between 70 to 110% of the rated control voltage.

7.5 Control Fuses

The fuses shall be of non-deteriorating HRC cartridge link type and conform to IS: 2208. They shall be suitable for the load and the service required in the circuit.

7.6 Current Transformers

7.6.1 C.T's shall be cast resin emulated, accuracy class as per IS-2705, 1 for metering and SP/PS for protection.

7.6.2 All the C.T's shall be provided with terminals and shorting links. One of the terminals of the C.T.s shall be earthed. The polarity of the C.Ts shall be clearly marked.

7.7 Voltage Transformer

The V.T. shall be cast resin insulated having secondary terminal voltage of 110V unless specified otherwise and accuracy class of shall be 1 as per IS: 3155 and provided with primary / secondary fuses.

7.8 Relays

All protective relays shall be provided in drawout and dust proof cases and shall be flush mounted type. They shall be fully tropicalised. Relays shall be of make and type as approved.

The following protective relays shall be provided.

i) IDMTL over current and Residual earth fault.

ii) IDMTL standby earth fault.

iii) Over voltage or under voltage

iv) Reverse power

v) Hand reset tripping relay

vi) Over frequency and under frequency protection

7.9 **Instruments and Metering**

7.9.1 All instruments shall be flush mounting type with square face of 96 sq. mm. They shall be tropicalised and dust tight. Make and type of instruments shall be as approved.

7.9.2 Marking of the scale shall be black on white background and suitable for direct reading.

7.9.3 Zero adjusters shall be provided for operation from the front of the cases.

7.9.4 All indicating instruments shall be moving iron spring controlled type of class 1.5 accuracy as per IS: 1248.

7.9.5 The KWH meter shall be as per relevant IS and provided with test blocks for current and voltage coils for testing them at site without interrupting their recording while in service.

7.9.6 The following instruments shall be provided.

i) Voltmeter with selector switch
ii) Ammeter with selector switch
iii) Frequency meter
iv) KW meter
v) KWH meter

7.9.7 One MFM meter along with communication port shall be provided.

7.10 **Signal Lamps**

LED type signal lamps shall be provided to indicate the various circuit conditions and these shall be placed at suitable height. The colour of the lamps for various functions shall be as follows:

Red	-	Circuit breaker 'ON'
Green	-	Circuit breaker 'OFF'
White	-	Trip circuit healthy
Amber	-	Alarm and auto trip fault
Blue	-	Non trip fault

7.11 **Name Plate**

7.11.1 The panel board shall have a large name plate on the top to indicate its name and designation. Each feeder shall be provided with name plates. Each panel shall have name plates both in front and back.

7.11.2 All control switches, push buttons, lamps etc. shall have function identification labels.

7.12 **Cable Termination**

Necessary cable glands and lugs for power and control cables shall be provided.

8.0 INSTRUMENTATION

8.1 The instrumentation requirement shall include field / panel mounted instruments, push buttons, lamps, audio-visual alarm system and other accessories as required.

8.2 The provision required in the control panel board shall include the followings:

i. Multipoint electronic self balancing temperature indicator with selector switch for generator winding.

ii. Tachometer for engine speed.

iii. Fuel oil day tank level indicator.

iv. Audio-visual alarm system for:

a) Low lube oil pressure
b) Over speed of engine
c) High jacket water temperature
d) Low jacket water pressure
e) Winding temperature high
f) All shutdown condition
g) Other abnormal conditions, as required

v. Shutdown system for:

a) Maximum jacket water temperature
b) Engine over speed
c) Minimum lube oil pressure
d) High winding temperature
e) Generator faults
f) Faults in the excitation system
g) Failure of engine to start after a preset time
h) Other faults, as required

vi. Excitation control system complete with:

a) Rheostat for manual control
b) Automatic voltage regulator
c) Field discharge resistance
d) Diodes / Rectifiers
e) All other items, as required

vii. Engine control system complete with:

a) Auto / manual switch
b) Control equipment and circuitry for Auto Mains Failure starting other than for type ‘C’ sets.
c) Push buttons and other control equipment for manual start.
d) Equipment and circuitry for pre-start priming, if required.
e) Equipment and circuitry for repeated attempt to start.
f) Indicating lamps for fail to start.
g) Audio visual alarm as specified and required.
h) Instrumentation as specified and required
i) Operation hour counter
j) All other items, as required

8.3 The field mounted instruments shall include the followings:

a) Pressure gauge for lube oil
b) Dial type thermometer for jacket water and various bearings.
c) Tachometer for engine speed.
d) Fuel oil day tank level indicator.
e) Other items, as required.

8.4 The supply shall be complete with all instrument erection materials with 10% extra provision.

8.5 All instruments, shall be suitable for site maximum ambient temperature, All electrical and electronic instruments shall be tropicalised and fungus proof.

9.0 EARTHING

Double earthing shall be provided by laying earthing strip for the DG Set.

10.0 ACCESSORIES

The D.G. set shall be complete with all required accessories, whether indicated or not, to make the installation complete in all respects and to ensure its safe and proper operation.

11.0 PAINTING

The enclosures, after suitable pre-treatment, shall be painted with two coats of anti rust paint followed by two coats of anti-corrosive epoxy based paints.

12.0 TESTS AND INSPECTION

12.1 All routine tests as per relevant standards shall be carried out in the presence of purchaser's representative.

12.2 The D.G. set shall be tested for output, general performance, overloads and other tests sufficient to prove the correctness of the design both at works and at site.

12.3 In addition, the equipment shall be subjected to stage inspection during process of manufacture at works and site inspection.

12.4 These inspections shall, however, not absolve the vendor free from his responsibility for making good any defect which may be noticed subsequently.

13.0 SPARES

13.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments as listed Annexure-I.

13.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

13.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

13.4 All spare parts shall be identical to the parts used in the equipments.

14.0 PACKING

14.1 The equipment shall be properly packed before despatch to avoid damage during transport, storage and handling.

14.2 The equipment shall be wrapped in polythene to make it water proof. Bags of silica gel shall be kept inside to absorb moisture present during transport and storage. An additional wrapping with bitumen paper shall also be provided before the equipment is packed in wooden crates.

14.3 A sign indicating the position of the equipment placed during transport and storage shall be clearly marked. Also proper arrangement shall be provided to handle the equipment.

15.0 DRAWING AND DOCUMENTS

15.1 Drawings and documents as per Annexure-II shall be supplied unless otherwise specified.

15.2 All drawings and documents shall have the following descriptions written boldly.

- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

16.0 DEVIATIONS

16.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

ANNEXURE – I

LIST OF SPARES

I. The spare parts as listed below shall be quoted for the D.G. set along with the offer with itemwise unit prices:

1. Rings of various types and sizes.
2. Bearings of various types and sizes.
3. Gaskets of various sizes and types.
4. Lube oil filters.
5. Solenoids of various types and sizes.
6. Electrical actuator of various types and sizes.
7. Circuit breaker arcing and fixed contact assembly.
8. Excitation system diodes.
9. Fuses of all ratings.

II. Any other spare parts, not covered but, required shall also be quoted.

III. All spare parts shall be identical to the parts used in the D.G. Set.

ANNEXURE – II

DOCUMENTATION FOR DIESEL GENERATOR SET

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1	Specification Sheet, duly completed	Y	Y	Y
2	Technical Particulars, duly filled-in	Y	Y	Y
3	General arrangement and foundation drg. for all the equipment.	Y	Y	Y
4	Civil scope drawings	N	Y	Y
5	Earthing layout	N	Y	Y
6	Terminal arrangement drg. and Interconnection.	N	Y	Y
7	Sectional view of D.G. Set	N	N	Y
8	Illustrative and descriptive literature.	Y	N	Y
9	Catalogue for bought out accessories.	Y	N	Y
10	Installation operation & maintenance manual	N	N	Y
11	Type test certificates for engine, alternator and circuit breaker	Y	N	Y
12	Guarantee certificate	N	N	Y
13	Spare parts list with identification	N	N	Y
14	Calculations for justifying DG set size offered with respect to load and starting of largest load.	Y	N	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

Y - Yes, N - No

TECHNICAL SPECIFICATION

SOFT STARTER

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	GENERAL
2.0	GENERAL TECHNICAL REQUIREMENTS
3.0	EQUIPMENT SPECIFICATIONS
4.0	EARTHING
5.0	NAME PLATES AND RATING PLATES
6.0	ACCESSORIES
7.0	PAINTING
8.0	INSPECTION AND TESTS
9.0	INFORMATION REQUIRED BY PURCHASER FROM THE BIDDER
10.0	MISCELLANEOUS

1.0 GENERAL

1.1 Scope

This specification covers the general requirements for design, manufacture, assembly, inspection and testing at the vendor's works of high voltage indoor soft starters above 1100V grade.

1.2 Data sheet

Along with the offer, Bidder shall submit the data sheet.

1.3 Codes and standards

The design, manufacture, testing and performance of soft starter panel shall comply with all current statutes, regulations and safety codes in the locality where the equipment will be installed.

Unless otherwise specified, the soft starter shall confirm to the relevant Indian, IEC or British Standards. Nothing in this specification shall be construed to relieve the vendor of his responsibility. The relevant Standards are:

1.	IS: 2705 (1992)	Current Transformers. (Part - I to IV)
2.	IS: 3156 (1992)	Voltage Transformers. (Part - I to IV)
3.	IS: 1248 (1993)	Direct acting indicating analogue electrical measuring instruments and their accessories. (Part - I to IV)
4.	IS: 13703 (1993)	Low Voltage fuses for voltages not exceeding 1000V Ac. (Part - I and II)
5.	IS: 5578 (1985)	Guide for marking of insulated conductors.
6.	IS: 11353 (1985)	Guide for uniform system of marking and identification of conductors and apparatus terminals.
7.	IS: 694 (1990)	PVC insulated cables for working voltage upto and including 1100V.
8.	IS: 6875 (1973)	Control switches for voltages upto and including1000VAC and 1200V DC. (Part - I to IV)
9.	IS: 3700 (1972)	Essential ratings and characteristics of semi-conductor devices.
10.	IS: 4411 (1967)	Codes of designation of semi-conductor devices.
11.	IS: 5469 (1969)	Codes of practice for use of semi-conductor junction devices.
12.	IS: 10482 (1983)	Connectors for printed wiring board.
13.	IS: 12448 (1988)	Basic testing procedures and measuring methods for Electro-mechanical components for electronic equipment.
14.	IS:12970 (1990)	Semi-conductor devices – Integrated circuits.
15.	IS:13648 (1993)	Power electronic capacitors.
16.	IEC 297	Dimensions of panels and racks.
17.	IEC352	Solderless wrapped connections.
18.	IEC 446	Semi-conductor converters.
19.	IEEE 444	Protection standards for Thyristor converters.

2.0 GENERAL TECHNICAL REQUIREMENTS

2.1 **Design features**

(1) The thyristorised starter shall be used for starting of large induction motors.
(2) The soft starter shall give an excellent voltage control during soft starts, smooth steeples acceleration.
(3) The soft starter shall be used during starting for smooth and stepless acceleration only. Once motor gains its full speed bypass vacuum contactor shall be operated to bypass thyristors. The thyristor shall be short time rated (2 min.).
(4) The soft starter drive shall consist of the following.
- Isolation vacuum contactor.
- Bypass vacuum contactor.
- Thyristor unit.
- Motor protective devices.
- Indicating / Metering / Control circuits and accessories.
- Cooling / ventilation equipments / accessories.

(5) Soft starter shall have following minimum in built protection and alarm, but not limited to,
- Electronic over load.
- Line fault.
- Under voltage.
- Over voltage.
- Stall.
- Phase reversal.
- Open gate for thyristor.
- Over temperature for thyristor.
- Over load for thyristor.

(6) Soft starter panel shall be provided with following indicating, metering and control devices.
Motor starting / protection devices.
Selector switch – Auto / Manual.
Start / Stop push buttons for manual operation.
- Input voltmeter and ammeter.
- Meters to indicate power in MW.
- Current and potential transformers.
- Auxiliary relays.
- Audio-visual alarms / fault indicators.
- Alarm acknowledge / reset / test push buttons.
- Provision for wiring external sequential / process interlock / signals for starting / running / tripping.
- Terminals for remote control / indication.
- Space heater and ventilating fans / cooler, if required.

2.2 **Performance requirement**

Soft starter panel shall be designed for operation at design temperature of 46°C. Vendor shall provide the necessary arrangement within the panel for satisfactory operation of soft starter.

2.3 Construction

(1) Soft starter panel shall be industrial type (Non-hazardous), totally enclosed, dust and vermin proof, floor mounted, free standing cubicle type of construction confirming to the degree of protection as specified in data sheet.
(2) The panel cubicle shall comprise rigidly welded structural frame enclosed completely by sheet steel of minimum 14 SWG (cold rolled) thickness, smooth finished, leveled

and free from flaws. All doors and removable covers shall be provided with neoprene gasket all around to make the cubical dust and vermin proof.

(3) The panel shall be provided with bottom sheet steel plates of minimum 2mm thick. Panel shall be fitted with removable gland plates of sufficient thickness at the bottom of the panel for fixing cable glands for power and control cable termination. Sufficient space shall be provided for termination of power cable sizes, as specified in data sheet.

(4) Louvers shall be provided at front, rear, top and bottom of the panel to decipate heat developed inside.

(5) Degree of protection shall not be less than IP 4X.

(6) Panel shall be fitted with a label and serial number on the front and rear. In addition, panel shall be fitted with a label indicating panel designation and rating. All devices shall be provided with separate labels to indicate the function and also device numbers as marked in wiring diagrams.

(7) Main equipment of the panel shall be accessible for maintenance from the front and rear. All insulating material shall be flame resistant, non-hygroscopic and antitracking.

(8) All hardware's used inside the panel shall be zinc passivated.

3.0 EQUIPMENT SPECIFICATIONS

3.1 HT Fuses

(1) High voltage fuses shall be of HRC link type for the 6.6 KV voltage and shall comply with the requirements of relevant standards.

(2) The fuse link shall have a striker pin for indication and also for trip mechanism.

(3) It is vendor's responsibility to precisely co-ordinate these fuses with contactors and upstream protective devices in the same system and shall be adequately rated for short circuit capacity.

(4) The type of fuse chosen by vendor shall subject to approval by the purchaser. Vendor to furnish fuse prearcing time shall be furnished by along with the offer.

(5) Thyristor units shall be protected by fast acting semiconductor fuses

3.2 Vacuum contactors

(1) Vacuum contactors of adequate rating for the compressor motor starting at 6.6 kV Voltage to match the bypass & isolation application and shall conform to relevant India / IEC standards.

(2) Vacuum contactor shall be provided with properly designed and co-ordinated HRC fuses as mentioned in clause no. 3.1 above.

(3) AC or DC operating coil for the contactor shall be informed to vendor at later stage. This operating coil shall be rated to operate satisfactorily between 80% and 110 % of the rated voltage. The contactor shall not drop out, if the voltage drops to 70% of rated voltage shall make arrangements to derive the auxiliary power, using necessary control transformer, for operating the contactor.

(4) The vacuum contactors shall have exclusively for Purchaser's use minimum 1 NO & 1 NC auxiliary potential free contacts, rated for 10 amps, 240V AC and 0.5 Amp (inductive breaking) 220V DC or as specified and shall be wired upto the terminal blocks.

3.3 Instrument transformers

(1) The current transformers and Voltage transformers shall conform to the requirements stipulated in relevant standards. It shall vendor's responsibility to ensure adequate size of CT & VT

(2) The CTs & VTs shall be of cast resin type (insulation class "E" or better) and shall be

able to withstand the thermal and mechanical stress resulting from the maximum short circuit and momentary current ratings of the switchgear.

(3) CTs shall have polarity mrks on each transformer and at the associated terminal block Facility shall be provided for short-circuit and earthing the CT secondary at the terminal blocks.

(4) VTs shall be protected on the primary side by limiting fused and by MCBs on secondary side with 9kA interrupting ratings.

(5) The MCBs shall have min 1 NO + NC auxiliary potential free contacts, for annunication and interlocks.

(6) CTs shall withstand specified system fault current for 1 sec.

3.4 Measuring and recording instruments

(1) Microprocessor based measuring and recording instruments shall be provided. The unit shall have RS-485 port at the output for serial communication.

(2) These instruments shall be standalone type, shall be configurable and shall be compatible with higher level computer.

(3) The instrument shall be rectangular in shape and not greater than 150mm (W) x 150mm (H). The accuracy class shall be as per IS or international standards.

3.5 Control wiring and terminals

(1) Feeders for Control (DC) / Auxiliary supply shall be provided at one point of the panel and voltage level shall be as specified in data sheet. Terminals to receive AC/DC control and auxiliary power shall be provided in cubicle and the terminals shall adequately rated (min. 20A).

(2) Adequate rated 2 pole MCBs shall be provided for each of the AC/DC control circuits.

(3) Internal wiring shall be done with 650V grade PVC insulated, stranded copper conductor of minimum size 2.5mm2 size.

(4) Separate colour coding shall be used for AC / DC control and power circuits and earth wire.

(5) All incoming and outgoing and control wire connection shall be wired to adequately rated (min.20A), elmex type terminal blocks about 20% spare terminals shall be provided in cubicle. All terminals shall be easily accessible.

(6) All wire shall be bunched together and routed through wire ways inside cubicle.

(7) Separate schematics, wiring diagrams and termination schedule for external and internal cable/wire connections shall be furnished by the vendor. External connections shall include Purchaser's remote equipment, which will be furnished by Purchaser to the successful vendor.

(8) Low watt consumption LED type indicating lamps shall be provided.

(9) All wires, terminals and all other devices shall be provided with appropriate ferrules to correspond with wiring diagrams, for circuit identifications Termination lugs to be provided wherever necessary.

4.0 EARTHING

(1) An earth bus having cross section as specified in data sheet A shall be provided and extended through the length of the panel. All electrical equipment shall be connected to this earth bus.

(2) Suitable clamp type terminals with hardware at each end of the panel shall be provided to suit the size of the OWNER's earthing conductor of size 75 x 10 mm GI

(3) Hinged doors shall be earthed through flexible copper brand of adequate size paint at earthing points shall be removed for proper contact star washers for door earthing are not acceptable.

(4) Bolted joints, splices, taps. etc to the earth bus shall be with at least two bolts

5.0 NAME PLATES AND RATING PLATES

5.1 Name plate

(1) Nameplate with engraved letters shall be provided for both front and rear side of panel function of every instrument, relay fuse etc shall be indicated by labels fixed near each device.
(2) Non-corrosive name plates shall be manufactured in anodized aluminium sheet and the letters shall be engraved on black lettering on white background. The name plates/labels shall be held in position by self-tapping screws.
(3) All devices mounted inside the cubicle and instruments etc., shall be identified by marking the device numbers inside cubicle as per the wiring drawing.

5.2 Rating plates

(1) The panel shall have a rating plate fixed to the non-removable part of the enclosure.
(2) All electrical equipment like VTs, CTs, etc and all other electrical devices shall be provided with rating plate made of stainless steel which can be easily seen.
(3) The rating plates shall give all the relevant information as specified in relevant standards.
(4) Danger boards, caution boards, operating instruction plates, shall be fixed to panel as per the standard engineering practice and regulations.

6.0 ACCESSORIES

6.1 Heater

Soft starter panel shall be equipped with space heaters to prevent moisture condensation within the enclosure and shall be suitable for continuous operation on 240V, 1 phase, 50 Hz AC supply. The space heaters shall be controlled through thermostats. Supply for motor space heater shall be brought to separate terminals in respective cubicle.

6.2 Cooling

Soft starter panel shall be provided with necessary ventilation / cooling equipment's for smooth operation of soft starter at given design temperature.

6.3 Plug Point

A 240V, 1 phase, 50Hz AC plug point shall be provided in the interior of each cubicle with an on-off switch.

7.0 PAINTING

(1) Oil grease, dirt and rust from the sheet steelwork shall be thoroughly Cleaned and removed. Rust and scale shall be removes by picking process with dilute acid and alkaline solution. Phospating and thorough rinsing with clear water followed by final rinsing with dilute dichromate solution and oven drying shall follow this.
(2) The under surface shall he prepared by applying a coat of phosphate paint and coat of yellow zinc chromote primer. The under surface shall be made free from all imperfections before under taking the finishing coat.
(3) After application of Primer, two coats of finish epoxy paint shall be applied with each coat followed be stowing. The colour shade for the finish paint shall be shade 631

(Light Gray) as per IS 5, unless otherwise specified.

8.0 INSPECTION AND TESTS

(1) Routine tests shall be carried out at works in the presence of OWNER/PMC/ CONTRACTOR/Third party inspector as per relevant IS / IEC Standards.
(2) Vendor shall furnish type and routine test certificates for all bought out components for the panel, as per relevant standards.
(3) Test certificates for type test carried out on similar equipment of identical design, if available, shall be submitted along with the offer.

9.0 INFORMATION REQUIRED BY PURCHASER FROM THE BIDDER

The vendor shall submit with his offer following information: -
(1) Full technical description and performance details of the equipment accessories and components offered including heat losses for all components in kW.
(2) Overall dimensions and shipping dimensions and weight.
(3) Deviation taken by the vendor from the requirements of this specification.
(4) Guaranteed technical particulars.
(5) Man-day rates for commissioning supervision.

10.0 MISCELLANEOUS

Each panel shall be provided with the following
(1) Two sets of clearly identifiable key for all panel-locking devices.
(2) Complete set of special tools and equipment for installation maintenance and testing of each panel.

TECHNICAL SPECIFICATION

VARIABLE FREQUENCY AC DRIVE

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	GENERAL REQUIREMENTS
4.0	SITE CONDITIONS
5.0	TECHNICAL REQUIREMENTS
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	SPARES
8.0	DOCUMENTS
9.0	CERTIFICATE
10.0	PACKING AND DESPATCH

1.0 SCOPE

1.1 The scope of this specification is to define the minimum technical requirements for the design, manufacture, testing and supply of High Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor, Converter, Converter input transformer, drive output transformer, DC link reactor with associated auxiliaries, harmonic filters and field mounted local motor control panel.

1.2 The vendor shall be responsible for engineering and functioning of the complete system, meeting the intent and requirement of this specification. This shall include but not be limited to inverter sizing, transformer sizing, transformer impedance selection, vector group, input and output harmonic filter design and sizing, output dv/dt filter sizing, motor cable selection and motor sizing/selection.

1.3 This specification applies to drives connected to line voltage up to 1000 V AC for MV VFD.

1.4 This specification applies to drive systems having converter input voltage above 1000 V AC and up to and including 11000V AC for HV VFD.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS, unless otherwise specified:

IS: 325	Three-phase Induction Motors
IS: 3700	Essential Ratings and Characteristics of Semiconductor Devices
IS: 3715	Letter symbols for semi-conducting devices
IS: 4411	Code of designation of semi-conducting devices
IS: 5001	Guide for preparation of drawings of semiconductor devices and Integrated Circuits
IS: 5469	Code of practice for the use of semiconductor Junction Devices
IS: 14901	Semi-conductor devices- Discrete devices & Integrated Circuits
IS: 15880	Three Phase Cage Induction motors when fed from IGBT Converters Application Guide
IS: 8789	Values of Performance characteristics for Three Phase induction motor
IS: 12615	Energy Efficient Induction Motors - Three Phase Squirrel Cage
IS/IEC: 60947	Low Voltage Switchgear and Control gear
IS: 12729	Common specification for High-Voltage Switchgear and Control gear standards
IEC: 60 146-1-3	Semiconductor Convertors general requirements and line commutated convertors-Transformer & reactors
IEC: 61800	Adjustable speed electrical power drive systems
IEEE: 519	Recommended Practices and requirements for Harmonics Control in Electrical power system

2.2 In case of imported equipment, standards of the country of origin shall be applicable, if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC/BSNDE/IEEE/NEMA or equivalent agency shall be applicable.

2.5 In case of any contradiction between various referred standards/specifications and statutory regulations the following order of priority shall govern:

- Statutory regulations
- Specification
- Codes and standards

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply

3.3 Vendor shall give a notice of at least one year to the end user of equipment before phasing out the product/spares to enable the end user for placement of order for spares and services.

3.4 The vendor shall be responsible for design, engineering and manufacturing of the complete VFD system to fully meet the intent and requirements of this specification.

3.5 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection/sizing of offered variable frequency drive system.

3.6 The VFD drive shall consist of the following:-

(a) Incomer

(b) By pass

(b) Power module

(c) Transistorised Inverter Unit

(d) Motor protective devices

(e) Indicating/metering/control circuits and accessories

3.7 The VFD drive shall be provided as a complete package and shall be controlled from three different locations viz., (a) VFD panel (b) Local operator panel and (c) D.C.S.

A four position lockable selector switch shall be provided on the VFD panel for selecting operation from VFD panel/local operator panel/DCS/STOP position.

3.8 Local operator panel shall be suitable for outdoor installation with degree of protection for enclosure IP-55 and provided with the following:-

(a) START/STOP push buttons

(b) RAISE/LOWER push buttons/potentiometer for speed variation

(c) ON/OFF/TRIP indicating lamps

(d) Speed Indicator

(e) Ammeter

3.9 VFD panel shall be provided with the following:-

(a) Standard options (to be stated by vendor)

(b) Incomer

(c) By pass

(d) Power module

(e) Transistor inverter unit

(f) AC reactor

(g) Motor starting/protective devices

(h) Selector switch (4 position)

(i) START / STOP P.B.

(j) Speed controller

(k) Input voltmeter and ammeter

(l) Output KW meter/Ammeter and frequency meter

(m) Instrument, current, potential and control transformers

(n) Auxiliary relays

(o) Audio-visual alarms/fault indicators

(p) Alarm acknowledge/reset/test PBs.

(q) Provision for wiring external sequential/process interlocks/signals for

(r) starting/running/tripping.

(s) Terminals for remote control/indication

(t) Space heater and ventilating fans, if required.

3.10 Besides VFD panel shall include the following operating adjustments:-

(a) Acceleration and deceleration time-range in seconds.

(b) Current limit-range in percent of rated output current.

(c) Maximum and minimum frequency range in Hertz.

(d) Volts/Hertz ratio

(e) Voltage boost ratio in percentage.

(f) Starting torque setting adjustment.

(g) Starting current setting adjustment

3.11 Vendor shall propose setting ranges consistent with the operating conditions required.

3.12 Motor winding temperature detectors shall be monitored on VFD panel.

3.13 If multiple VFD are being supplied then instead of individual panel, a MCC comprising of VFD to be supplied with incomes and bus coupler arrangement and isolation of power to individual VFD for ease of replacement shall be considered.

4.0 SITE CONDITIONS

4.1 The AC drive system shall be designed to operate under specified site conditions. If not specifically mentioned therein, a design ambient temperature of 50°C. and an altitude not exceeding 1000 metres above mean sea level shall be considered.

4.2 The AC drive shall be installed indoors in a non-hazardous, air-conditioned room. Transformer installation (outdoor / indoor) shall be as indicated in design philosophy. Motor shall be installed outdoors in safe or hazardous area as specified.

4.3 All the equipment shall be designed for continuous duty as per nameplate rating under the specified ambient conditions.

5.0 DESIGN AND FABRICATION REQUIEMENTS

5.1 Performance Requirement

5.1.1 The unit shall be capable of proper operation for voltage variations of ±10%, frequency variations of ±5%, and combined variations of ±10%. Besides, the VFD unit shall be able to ride through voltage dips down to 80% of nominal, such as those experienced during motor starting. Also VFD shall be capable of riding through voltage outages of minimum 2 seconds duration.

5.1.2 Regulation of output voltage shall not be more than ±2% under steady state and ±8% under transient conditions.

5.1.3 Maximum drift in set frequency shall be ±0.1%. The unit should be able to hold a set speed, regardless of load torque variations.

5.1.4 The unit shall be suitable for 150% overload capacity for one minute.

5.1.5 The maximum noise level of the unit shall not exceed 85 dB(A) at a distance of 1 meter.

5.1.6 The unit shall have independently adjustable/automatic load dependent voltage boost at low end of frequency. There should not be any torque fluctuations at low speed.

5.1.7 The system shall be energy efficient, designed as standard product and shall provide very high reliability, high power factor, low harmonic distortion and low vibration/ wear / noise. It shall be easy to install in minimum time and expense and no special tools shall be required for routine maintenance.

5.1.8 The system shall be designed to deliver the motor input current and torque for the complete speed torque characteristics of the driven equipment, with input supply variation of ±10% and frequency variation of ±3%. The system shall be suitable for the load characteristics and the operational duty of the driven equipment. It shall be capable of withstanding the thermal and dynamic stresses and the transient mechanical torque, resulting from short-circuit.

5.1.9 The drive system shall be designed to operate in one or more of the following operating modes as to suit characteristics of the driven equipment:

a. Variable torque changing as a function of speed i.e. Speed squared
b. Constant torque over a specific speed range
c. Constant power over a specific speed range where the torque decreases when speed Increases
d. Any other as specified

5.1.10 The drive controller shall be equipped with microprocessor based digital regulator with programmable functions. The power control regulator logic shall provide for an acceleration/deceleration current limit curve and shall be capable of field adjustments without shutting the system down. Linear acceleration and deceleration shall be separately programmable from 0.1 to 20 seconds.

5.1.11 The MV VFD System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 with speed set accuracy of ±1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.12 The HV VFD System shall be suitable for single quadrant operation and the speed variation shall be with range 10-100 % with speed set accuracy of ±1% of rated maximum speed and steady state regulation of ±0.5% of rated speed.

5.1.13 The total harmonic distortion (THD) of the voltage and current at inverter output shall be as per IEC 61800 and same shall be considered in the design of the motor. The dv/dt limits & Vpeak shall also be as per IEC-61800-2.

5.1.14 Harmonics at the supply side of the drive system at primary of the main input transformer shall be restricted within the maximum allowable levels of current and voltage distortion as per recommendations in the latest edition of IEEE-519. The vendor shall perform design calculation for harmonic filter system considering VFD connected to the power system and including the supply of harmonic filters along with all accessories. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc. The studies shall highlight but not be limited to maximum load current, expected resonant frequencies, need of harmonic filters, sequence of switching of filters, voltage wave form, rating of equipments/ feeder for feeding filters etc.

5.1.15 Unless otherwise specified, the overload capacity of the controller shall be 150% of rated current of motor for one minute for constant torque applications, and 110% of rated current for one minute for variable torque applications at rated voltage. If the motor load exceeds the limit, the drive shall automatically reduce the frequency and voltage to the motor to guard against overload. If load demands exceed the current limit for more than 1 minute, the drive shall shutdown to prevent over heating of the motor and damage to the drive.

5.1.16 During operation, the system shall be capable of developing sufficient torque under all load conditions to respond to a 20% alteration in speed set point within a time limit upto 60 seconds.

5.1.17 The integrator action of the speed set point alteration shall be independently adjustable for both an upward and a downward alteration. The minimum time interval between set point adjustments by the distributed control system shall be considered as 10 seconds.

5.1.18 The drive shall trip in case the speed exceeds 105%of the maximum operational speed or reduces to 95% of the minimum operational speed for more than 10 seconds.

5.1.19 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.

5.1.20 Variable frequency drive shall be arranged so that it can be operated in an open circuit mode, disconnected from the motor for start up adjustments and troubleshooting/ maintenance.

5.1.21 Voltage at motor neutral shall be maintained at ground potential for the total operating condition.

5.2 **Control Requirement**

5.2.1 The system shall operate on constant V/f supply with required voltage boost capability in low frequency mode of operation.

5.2.2 Short time voltage dips up to 20% of nominal voltage (e.g. in case of a large motor start up connected to the same bus as VFD) shall not cause the control system to stop functioning and shall not trip the drive system.

5.2.3 The system shall also be equipped with a momentary powerloss ride through feature which will restart the system in case of voltage dip over 20% or power interruptions for less than 2 seconds, with recovery of the voltage to its nominal value .. The drive shall have the facility to block this feature, if required by the operator. Upon restart, the converter shall be capable of synchronizing onto a rotating motor and develop full acceleration torque within 10 seconds.

5.2.4 The system shall be suitable for number of starts as per attached specification for High/Medium Voltage Motors.

5.2.5 The power controller shall be controlled to always start the motor in the forward direction. Logic shall be provided to prevent the motor from being started in the reverse direction.

5.2.6 The drive motor shall be speed controlled corresponding to 4-20mA or 0-10 V reference input signal. Upon complete loss of the user's speed reference signal, the drive shall automatically run at constant speed as at 80-100% of the last speed reference available prior to the loss of signal.

5.2.7 It shall be possible to vary the speed of the drive in either manual or auto mode. Auto/Manual selection shall be from VFD panel unless otherwise specified.

a. With the selector switch in "manual" mode, the operator shall be able to set the speed through key pad (mounted on front of the drive panel) or from speed increase/decrease push buttons (from the field). Motor operated potentiometer shall be provided as a speed set point device.

b. With the selector switch in "auto" mode, speed of the motor shall be controlled from a 4-20 mA signal, from owner's PLC/DCS (Process Control) system. Necessary equipment required for interfacing with PLC/DCS shall also be provided in the VFD panel.

c. Local/Remote selector switch shall be provided in local control station (in Field). With the selector switch in "Local" mode, the operator shall be able to start and set the speed through local control station (in Field). With the selector switch in "Remote" mode, speed of the motor shall be controlled either from VFD panel or from Owner's PLC/DCS as explained in a) and b) above.

5.2.8 The required provision for the interface with remote PLC/DCS located at control room shall be either through hardwired connection (with potential free contacts and transducers as described elsewhere in this specification) or through serial communication link.

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system.

5.2.10 The closed loop control feedback for the drive system having output transformer shall be tapped from the secondary side of the output transformer.

5.3 **Panel Construction**

5.3.1 For MV VFD: The panel shall include suitable isolating device (i.e. Circuit breaker/MCCB/ Switch fuse) for main supply, contactors, semi conducting power devices (Diodes / IGBT) modules with protective devices, reactors, filters, output isolating device, control circuit, control accessories, indication and annunciation etc.

Main isolating device shall function as a manual disconnect and shall be an AC thermal magnetic circuit breaker or a fused switch with dual element fuse to trip automatically on fault currents. Devices shall be lockable in the open position and shall have a minimum interrupting capacity. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.

5.3.2 For HV VFD: The panel shall include suitable semi conducting power devices (Diodes/IGBT/IGCT/ IEGT/SGCT) modules with protective devices, reactors (if required), filters, control circuit, control accessories, indication and annunciation etc. The construction of the panel shall provide effective protection against electromagnetic emissions and shall meet the design requirement of relevant standards.

Upstream breaker 'ON/OFF/TRIP' indications and remote breaker closing and trip push buttons shall be provided on the front door.

5.3.3 Safety Interlock shall be provided so that power cabinet can't be opened unless the upstream breaker is disconnected, safety-grounding switch is closed and DC link capacitor is discharged. Power source breaker can only be closed once the earthing switch is open and panel door is closed with lock defeat facility.

5.3.4 The drive shall be suitably housed in sheet steel panels and shall be fabricated using cold rolled sheet steel. The sheet steel used for the panel shall be of minimum 2 mm CRCA. The panel shall be suitable for indoor installation, if not otherwise specified. The panel shall be free standing with degree of enclosure protection as IP-31. Maximum and minimum operating height shall be 1800 mm and 300 mm respectively.

5.3.5 Bolted un-drilled gland plate shall be provided at bottom. Clamp type terminals shall be used for connection of all wires up to 10 mm^2, and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300mm clear for MV & 600mm clear from HV from bottom of the cable gland plate.

5.3.6 Bus bars shall be of electrolytic copper/aluminium, sleeved, color coded separately for AC and DC system. All the live parts shall be sleeved / shrouded to ensure complete safety to personnel intending to carry out routine inspection by opening the panel doors. All the equipment inside the panel and on the doors shall be provided with suitable nameplate. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.7 All the power & control switches, component and accessories which are essential for normal and emergency operation shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, where provided, shall be switchboard type, back connected & of size 96x96mm. Scale shall have red mark indicating maximum permissible operating rating.

5.3.8 Each panel shall be provided with illuminating lamp/11 W CFL with switch and fuse. 5/15A, 240V power socket with switch and fuse shall be provided. Each panel shall have space heater with switch fuse and variable setting thermostat.

5.3.9 Copper earth bus of min. 30x6 sq.mm. upto short circuit withstand capacity of 31.5kA and 50x6 sq.mm. for a short circuit withstand capacity above 31.5kA shall be provided in the panel with provision for connection to plant earth grid. All the non-metallic components/parts shall be connected to the main earth bus bar. Separate earth bus bar and stud for electronic control system if required shall be provided.

5.3.10 All panels shall be of same height so as to form a uniform line-up, to give good aesthetic appearance.

5.3.11 All the control wiring shall be enclosed in plastic/ metal channel. Each wire shall be identified at both ends by self-sticking wire marker tapes or PVC ferrules. Power and control wiring inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm^2 size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm^2' size for control fuse rating above 16 A for electrical circuits and 0.5mm^2 for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

5.3.12 All electronic modules and components shall be accessible from front of panel only. Modular assemblies for both the system control electronic equipments and power electronic equipments shall be used.

5.3.13 Low voltage compartment and cabling shall be electrically and physically separated from the high voltage compartment.

5.3.14 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.

5.3.15 Suitable eyebolts/ lifting clamps/ strap & cradle arrangement shall be provided for lifting of the panel/shipping section. The bolts, when removed shall not leave any opening in the panel.

5.3.16 Acrylic type transparent insulating material shall be used for covering live components.

5.3.17 Drive keypad, operator control panel required for control, monitoring and measurements shall be supplied and installed outside the panel on the front door. It shall be accessible for operation without opening the front door and shall be non-removable type.

5.3.18 All equipment shall be complete with cable glands, lugs etc. and cable glands shall be single or double compression type for indoor and outdoor equipment respectively. Cable glands shall also be suitable for the hazardous area application.

5.4 **Cooling**

5.4.1 For MV Drive: Cooling system shall include well-dimensioned panel, adequate cooling airflow path, module cooling fan and if necessary, panel cooling fan. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+1) shall be provided. Necessary starters shall be provided within the VFD panels for these fans. In case redundant cooling fan is not possible to be mounted, same shall be supplied loose.

5.4.2 For HV Drive: The drive panel shall be naturally cooled or water cooled type as per manufacturer's standards. However, it is preferred to have natural air cooled system. If unavoidable, forced type-cooling system shall be provided. Cooling system shall include well-dimensioned panel, adequate cooling airflow path, modular cooling fan and if necessary, panel cooling fan or water-cooling system shall be considered. Vendor shall ensure that the panel dimensions and flow paths have been designed for continuous running at the specified ambient without overheating. For fan cooled drives, redundant ventilating fans (N+ 1) shall be provided. In case redundant cooling fan is not possible to be mounted in the panel, same shall be supplied loose.

For water-cooled drives, entire cooling system including but not limited to heat exchanger, flow and pressure meters and pumps shall be in vendor's scope. The system shall be provided with closed circuit water cooling system, requiring only make up water required for topping up. The cooling water pumps, in case provided, shall have 100% redundancy. Water quality/characteristics shall be as defined and selected cooling water system components/material shall be suitable for the same. Adequate safety measures shall be incorporated in water cooled drives such that no leakage is there which results in malfunctioning of electronic devices. Proper segregation between water cooling system and other equipment shall be provided. It is preferred that cooling cabinet panel shall be separated from the main panels.

Necessary starters shall be provided within the VFD panels for the Ventilation fans, Cooling Water circulation pumps, any other auxiliary motor etc. The system provided shall be interfaced with drive starting and shutdown so that safety interlocks such as start permit from cooling system to drive and trip signal from cooling system to drive in case of cooling system failure etc., are incorporated in the overall sequence logic.

5.4.3 MCB for motor space heater, auxiliary power supply if required for local panel, drive panel space heater etc. shall be included and mounted in easy accessible location.

5.5 **Equipment/ Component Specification**

5.5.1 Motor

The motor shall be designed, constructed and tested in accordance with the latest revision of Specification for Medium/High Voltage Induction Motor, in addition to the following requirements:

a. The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.

b. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.

c. The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed.

d. The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor.

e. The motors shall be provided with Class 'F' insulation with temperature rise limited to Class `B'.

f. Motors required to be transferred to DOL by-pass mode shall be rated for specified variations in system line voltage and frequency. Starting current of motor in DOL bypass mode shall be limited to value specified in motor specifications.

g. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.

h. The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-2 for MV / IEC-61800-4 for HV and necessary co-ordination between the VFD manufacturer & motor manufacturer w.r.t. incorporation of VFD output parameter in the design of motor shall be carried out.

i. The drive manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the drive.

j. MV Motors shall be provided with thermistor type temperature detector & HV Motors shall be provided with Resistance Temperature Detectors (RTDs).

k. Induced voltage at the shaft end of the motor at no load shall not exceed 250 mV rms for roller and ball bearings and 400 mV for sleeve bearings. The non driving end bearing shall be insulated from the motor frame to avoid circulating current. The insulated bearing end shield or pedestal shall bear a prominent warning.

5.5.2 Converter Transformer/ Output transformer

For MV System

The converter transformer shall be suitable for use with the variable frequency drive system. The impedances of transformers with two secondary windings for 12 pulse systems shall be selected to ensure equal load/current sharing between the two secondary windings, the converters and the motor windings under all operational conditions including starting and restarting. The transformer shall be provided with ± 5% off circuit taps in steps of ± 2.5%.

For HV System

a. The converter transformer shall be dry type or oil filled type. In case of the dry type transformer, it shall be mounted in the drive system panel. Offered transformer shall be as per enclosed Specifications.

b. The impedances of converter input transformers with more than one secondary windings for 12/18/24/36 pulse systems shall be selected to ensure equal load/current sharing between the secondary windings, the converters and the motor windings under all operational conditions including starting and restarting.

c. Drive out put transformer considered only for the purpose of meeting standard rated motor voltage i.e. 3300, 6600V, 11000V shall not be provided unless otherwise agreed between purchaser and the manufacturer.

5.5.3 Power Converter

a. The static power converter shall consist of a line side power converter for operation as a rectifier and a load side power converter for operation as a fully controlled inverter. Power converter shall be fast switching, most efficient and low loss type.

b. Normally, for all output short circuits, the inverter shall interrupt the current before any semi-conductor fuse blows. For internal short circuits, semi-conductor fuse protection shall be provided, and for faults upstream of semi-conductor fuses, the converter shall be able to withstand a three-phase short circuit current until interrupted by normal breaker operation. In case of fuseless design, the failure shall be limited to the particular device, without causing any damage to other parts of the power module. There must be clear annunciation of the failure of the device.

c. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.

d. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.

e. The current rating of the converter's semi-conductor components shall not be less than 120% of the nominal current flowing through the elements at full load of the VFD through the entire speed range.

f. All power diodes shall be of silicon type with minimum V_{BO} rating as 2.5 times the rated operating voltage.

g. The power converter circuit shall be designed so that motor can be powered at its full nameplate rating continuously without exceeding its rated temperature rise due to harmonic currents generated by the inverter operation.

h. The conversion devices and associated heat sinks shall be assembled such that individual devices can be replaced without requiring the use of any special precautions/tools.

i. The cooling system of the electronic components, if provided, shall be monitored and necessary alarms shall be provided to prevent any consequential damage to the power control devices.

j. Offered system shall also take into account the distance between Drive panel and motor and system shall include all material and accessories to make system suitable for a distance of 350m.

k. All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I^2t particulars of the power controller devices and the fuses shall be properly co-ordinated for the selection of fuses.

5.5.4 DC Link Reactor

a. Smoothing reactors for the DC link shall be designed to sufficiently decouple the rectifier and inverter portion of the converter and to limit fault currents in this circuit. AC line

reactors, if provided as per standard vendor design in MV system, shall be suitable for harmonic suppression and fault current limitation.

b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel. In case of fan cooled type, operation of fans shall be monitored.

c. Reactor shall be suitable for operation with the non-sinusoidal current wave shapes and DC components under all operational conditions of the system without exceeding its temperature limits.

5.5.5 Output Filter

VFD output current waveform should be inherently sinusoidal at all speeds, with harmonic limits as specified in this specification. Output filter shall be provided, if required. Output filter capacitors shall be provided with discharge circuits to ensure that all residual stored charge is reduced to less than 50 V DC within 60 seconds for MV system & 300 seconds for HV System after a loss of AC voltage. All capacitor shall be maintenance-free and self-healing type. The VFD system shall inherently protect motor from high voltage dv/dt stress, independent of cable length to motor. Output filter shall be an integral part of the VFD system and included within the VFD enclosure.

5.5.6 Bypass Feature

MV System:

5.5.6.1 Output contactor/Load Break Switch shall be provided for isolation between the output of the controller and the motor for VFD systems with Bypass feature.

5.5.6.2 Bypass feature shall be provided. Accordingly Bypass feature with Bypass starter shall meet the following requirements:-

Bypass starter shall comprise of switch-fuse, contactor, bimetal relay meeting the requirements of Type-2 coordination as per IS/IEC-60947. CBCT and ELR shall be provided for motors rated above 22kW & up to 55kW. Heavy duty starters shall be provided with saturable type current transformer operated overload relay only, which shall be suitable for motor starting time of 15-60 seconds. For motors rated above 55kW, MCCB and motor protection relay along with necessary metering shall be provided and for motors rated above 75kW and above, ACB and motor protection relay along with necessary metering shall be provided.

Bypass starter shall be in separate compartment and it shall be possible to isolate and maintain the VFD while drive motor runs in Bypass mode. Three contactors / breakers shall be used for this purpose, one contactor in the bypass and two contactors across the drive, such that in case of drive mal-operation, the motor could be taken on bypass control, while the drive could be attended by opening its contactors. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

HV System:

a. Bypass feature along with motor protection relay and output side breaker shall be provided. All necessary interlocks as required for safe and reliable operation of VFD system along with bypass feeder and output side breaker shall be provided in VFD system.

b. Bypass starter shall be in separate compartment and switching scheme shall be such that in case of drive mal-operation, the motor could be taken on bypass control manually, while the drive could be attended independently. Suitable interlock shall be provided such that bypass mode and VFD mode shall not operate simultaneously.

5.5.7 Local Motor Control Station

a. The local motor control station, to be installed in the field near the motor shall conform to the attached specifications. Components and accessories that are required in the local motor control station may be mounted on the local field mounted panel envisaged for the driven equipment.

b. Meters in the local control station shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current. Further, for drives with bypass facility, the meters shall be capable of reading bypass mode full load and starting currents as well as the VFD mode drive current.

5.6 **Protection, Control, Metering, Indication and Annunciation**

5.6.1 The system vendor shall provide all the necessary system control, protection, alarm and metering equipment for the entire drive system and its auxiliary equipment.

5.6.2 Automatic sequence control shall include start-up of cooling system, auxiliary system of the motor, interlock checking, automatic start and run-up of drive, planned and emergency shutdown. The same shall be processed through microprocessor-based system.

5.6.3 Operator Control Panel

a. Each drive shall be equipped with a front mounted operator control console consisting of a backlit alphanumeric display and a keypad with keys for parameterization and adjusting parameter which shall not be limited to Start/Stop, Local/Remote, Auto/Manual, Increase/Decrease, menu navigation and protection and measurement parameter selection, etc.

b. All parameter names, fault messages, warnings and other information shall be displayed in complete English words or standard English abbreviations to allow the user to understand the display without the use of a manual or cross-reference table. This shall also be used for the modification of all electrical values, configuration parameters, drive menu parameters, application and activity function access, faults, local control, adjustment storage, self test and diagnostics. Keypad shall be operable with password for changing the protection setting, safety interlock etc. However, the parameters such as measurements, setting, mode of drive etc. shall be allowed to be viewed without any password.

c. Operator console shall have facility/ port to connect external hardware such as Laptop etc. Console shall have facility to upload and download all parameter settings from one drive to another identical drive for start-up and operation.

d. Drive system control shall also have facility to receive tripping signal from upstream breaker for tripping and also provision for closing upstream breaker after all required process parameters are achieved.

e. User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

5.6.4 Protective Features

The system shall incorporate adequate protective features, properly coordinated for the drive control and for the motor but not limited to the following:

I. Incoming line surge protection
II. Under / Over voltage protection
III. Phase loss protection.
IV. Programmable over current protection and under load protection.
V. Inverter Fault.
VI. Over frequency/Over speed of motor
VII. Ventilation loss (In case same is not provided, drive shall generate an over temperature fault alarm and suitable sensors, as required for same, shall be provided).
VIII. Over temperature of equipment.
IX. Specific motor protection, including motor winding, bearing temperatures, over current, overload, negative phase sequence and earth fault protections etc.
X. System earth fault protection.
XI. Excitation system protection for synchronous motor
XII. Over and under frequency, rotor earth fault (if applicable), field failure protection for synchronous motor
XIII. Additional protection, if any for the drive system

5.6.5 Alarms

The system shall incorporate protection alarms, required for various fault conditions, for the Drive motor, Supply cables, Converter Transformer, DC Reactor and the Converter. Alarms shall also be included for the failure of various auxiliaries together with identification of the failing unit, loss of cooling system, various protection devices provided for converter transformer etc.

5.6.6 Control

The following controls shall be provided as a part of the Operator Control Panel or through separate switches.

I. Start/Stop
II. Speed control (Raise/Lower)
III. Forward/Reverse (if specified)
IV. Auto/Manual /Test mode
V. Local/Remote
VI. Emergency stop
VII. Start/Stop for bypass starter (where specified)
VIII. Trip-Remote Breaker
IX. Excitation control system for synchronous motors
X. Sequential switching of filters

5.6.7 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications.

I. Motor running
II. Motor stopped
III. VFD System Fault

IV. System ready to start
V. AC mains ON
VI. Motor over speed
VII. Rectifier output 'ON'
VIII. Motor zero speed
IX. Remote breaker trip
X. Excitation system healthy for synchronous motors

Above indications may be provided as a part of the operator control panel, i.e. door mounted keypad or through hardwired LEDs. LEDs provided for indication shall be cluster type with adequate brightness and minimum 2 nos. LEDs chips per light. LEDs shall be connected in parallel and each LED chip having diameter not less than 3mm.
Potential free contacts for items i to iv shall be wired separately for remote indications in DCS system.

5.6.8 Metering

Digital display of the following parameters shall be as a part of the Operator Control Panel, selectable by the operator.

I. Output voltage
II. Output current-VFD model Bypass mode
III. Output frequency
IV. Drive thermal state
V. Motor speed
VI. Motor energy meter
VII. Hour Run
VIII. Voltage and current meter for excitation system of synchronous motor
IX. KVAR, power factor meter for synchronous motors
X. Necessary transducer shall be provided with 4-20mA output for indicating motor
XI. speed and motor current in DCS unless otherwise specified for other parameters.

5.6.9 Annunciations

Potential free contacts shall be provided for following annunciations and shall be wired up to terminal block for owner's use for remote monitoring:

I. Rectifier fuse failure/Drive fault
II. Main AC failure
III. Inverter fuse failure/Drive fault
IV. Inverter overload
V. Inverter high temperature/Drive fault
VI. Failure of panel cooling system
VII. Motor failed to start/Drive fault

All drive internal faults will be annunciated as drive fault.

5.7 Fault Diagnostic

Fault diagnostic shall be built into the system to supervise the operation and failure of the system. The information regarding failure of any of the system including, shutdown of the system, shall be available for a period of minimum 4 days (96 hours) after a shutdown,

even though no supply would be available to the system. The system may be totally de-energized for maintenance or otherwise. It shall be possible to retrieve the record of events prior to tripping of the system or de-energisation. Auxiliary supply to the system components or to the electronics (firmware) for the diagnostics / display shall be taken care by the manufacturer for this purpose.

5.8 **External Power supply for auxiliary and Control Circuit**

Auxiliary power supply for devices external to VFD module, space heater supply for Motor, VFD panel space heater, auxiliary power supply for transformers, cubicle 11W CFL lamps, indicating lamps, digital meters (Ammeter, Speedometer) etc. shall operate on 240 volts single phase AC supply provided by purchaser.
All control circuit shall operate at maximum voltage of 240V AC or 220V DC. Vendor shall include supply of all control transformers, protective devices, associated accessories etc. and any other control supply voltage required for the system shall be derived by the vendor from the power supply made available by purchaser.

5.9 **Reliability Features**

The expected lifetime of the drive system shall be min. 20 years. The system including all individual components forming part of the system shall have an availability of minimum 0.997 and a minimum MTBF of 4 years.

The controller design shall incorporate the following reliability features:

- Pre-tested components with power components to be 100% tested under dynamic conditions.
- Printed circuit boards shall be computer tested and adjusted.
- Printed circuit boards shall be temperature cycled for a minimum of 40 hours.
- Printed circuit boards shall be treated for tropical, humid and corrosive environment.

5.10 **Maintenance features**

The controller design shall incorporate the following maintenance features:

Modular construction

All components shall be easily accessible.

Standard diagnostics to aid maintenance personnel. These shall include LED or alphanumeric displays, test or measurement points.

5.11 **Painting**

5.11.1 After preparation of the under surface, the panel shall be spray painted with two coats of epoxy based final paint or shall be powder coated. The colour shade of final paint shall be as RAL 7032, unless specified otherwise. Panel finish shall be free from imperfections like pinholes, orange peels, runoff paint, etc.

5.11.2 All metal surfaces shall be thoroughly cleaned and de-greased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under-surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The under-surface shall be made free from all imperfections before undertaking the finishing coat.

5.11.3 All unpainted steel parts shall be zinc passivated, cadmium plated or suitably treated to prevent rust and corrosion. If these parts are moving elements, then these shall be greased.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 During fabrication, the drive shall be subject to inspection by PDIL / Owner, or by an agency authorized by the Owner, to assess the progress of work, as well as to ascertain that only quality raw material is used.

6.2 All tests shall be carried out at the manufacturer's works under his care and expense. The tests shall be witnessed by an inspector of PDIL/Owner or of an agency authorized by the owner. Prior notice of minimum 4 weeks shall be given to the inspector for witnessing the tests.

6.3 All Routine & Type Tests shall be conducted as per the NIT for HV variable frequency drive 6-81-1050 as per IEC 61800-2.

6.4 Combined test for VFD and motor shall be carried at vendor's works.

6.5 String Test with driven equipment

If a string test with driven equipment is specified in the datasheet of the driven equipment, it shall be carried out with the job equipment.

7.0 SPARES

7.1 Commissioning Spares: Commissioning spares, as required, shall be supplied with the main equipment. Item-wise list of recommended commissioning spares shall be furnished for approval.

7.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

7.3 Recommend 2 years Operational Spares (other than mandatory spare) along with recommended quantity & item-wise unit price shall be furnished.

7.4 All spare parts shall be identical to the parts used in the equipment

8.0 DRAWINGS

8.1 Vendor shall submit to Purchaser, for approval, before completion of manufacturing and assembly of equipment following drawings and literature.

(i) Installation and maintenance manual including trouble-shooting chart.
(ii) Panel drawings and cable schedule
(iii) Block diagram and control logic.

4 hard copies & 1 soft copy of drs. & doc. shall be supplied with bid.

4 hard copies & 1 soft copy of drs. & doc. shall be supplied for approval after order within 4 weeks from the date of LOI.

8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

9.0 CERTIFICATION

The motors and associated Variable frequency drive system equipment shall have test certificates issued by recognized independent test house (CIMFRI BASEEFA/ LCIE/UL/FM or equivalent). All indigenous motors shall conform to Indian Standards and shall be certified by Indian testing agencies. All motors (indigenous and imported) shall also have valid statutory approvals as applicable for the specified hazardous location. All indigenous flameproof motors shall have valid BIS license and marking as required by statutory authorities.

Also the motor nameplate shall clearly indicate that the motor is suitable for operation with variable frequency drive along with VFD make and model number.

10.0 PACKING AND DESPATCH

All the equipment shall be divided in to several shipping sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. ship/rail or trailer. The equipment shall be wrapped in polyethylene sheets before being placed in wooden crates/cases to prevent damage to the finish. Crates/cases shall have skid bottoms for handling. Special notations such as 'Fragile', 'This side up', 'Weight', 'Owner's particulars', 'PO nos.' etc., shall be clearly marked on the package together with other details as per purchaser for scrutiny. The equipment may be stored outdoors for long periods before installation. The packing shall be completely suitable for outdoor storage, in areas with heavy rains/high ambient temperature.

TECHNICAL SPECIFICATION

CATHODIC PROTECTION FOR PLANT PIPING AND BURIED FACILITIES

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1.0 SCOPE OF WORK

1.1 The scope of work of CP contractor shall comprise of survey, design, detailed engineering, supply, installation, testing and commissioning of Impressed Current Cathodic Protection System for soil side corrosion prevention of all underground buried plant piping, u/g vessels and tank bottoms of above ground storage tanks.

1.1.1 **U/G Piping**: Long line linear MMO Titanium wire anode or polymeric anode pre-packed with coke breeze at anode manufacturer's factory and /or close distributed MMO Titanium tubular anode pre-packed with coke breeze at anode manufacturer's factory shall be considered as anodes for impressed current CP System for all underground piping.

For U/G piping in congested areas, long line linear anodes shall be used and for other area long line linear anodes or close distributed MMO tubular anodes shall be used. For close anode bed MMO tubular anode design, the MMO tubular anodes shall be distributed along the buried piping such that all sections of the buried piping are in within each anode's voltage gradient. This anode configuration causes the electrolyte around the structure to become positive to remote earth.

1.1.2 **Buried Vessels**: Long line linear MMO Titanium wire anode or polymeric anode pre-packed with coke breeze at anode manufacturer's factory and /or close distributed MMO Titanium tubular anode pre-packed with coke breeze at anode manufacturer's factory shall be considered as anodes for impressed current CP System for all underground piping.

1.1.3 **Above Ground Storage Tank Bottoms**: Long line linear MMO Titanium wire anode or polymeric anode pre-packed with coke breeze at anode manufacturer's factory and /or close distributed MMO Titanium tubular anode pre-packed with coke breeze at anode manufacturer's factory shall be considered as anodes for impressed current CP System for all underground piping. The depth of the linear anodes shall not exceed 1 meter from the tank bottom plate and the maximum spacing between the anode strings shall not exceed 1.5 meters.

1.2 The CP contractor need to supply all materials, consumables in their scope of supply and provide all construction tools, tackles equipment and personnel necessary for the work and prepare detailed engineering package including construction drawings before starting of the work.

1.3 After commissioning of the system, commissioning report along with as built drawings including soft copies in latest version of AutoCAD and operating manuals to be prepared and submitted to owner/PMC.

2.0 APPLICABLE STANDARDS

2.1 The cathodic protection system design, performance and materials to be supplied shall, unless otherwise specified, conform to the requirements of the following latest relevant applicable standards & codes as below:

Standard	Description
DIN EN-14505	Cathodic Protection of Complex Structures
NACE SP-0169-2013	Control of external corrosion on underground or Submerged metallic piping system
NACE SP-0286-2007	Electrical isolation of cathodically protected pipelines
NACE TM0101-2012	Measurement Techniques Related to Criteria for Cathodic Protection of Underground Storage Tank Systems
NACE TM0497-2012	Measurement techniques related to criteria for cathodic protection on submerged metallic piping system
ISO 15589-1: 2016	Petroleum and natural gas industries-CP of pipe line transportation systems- on land pipelines
IS 8062 part-2: 2006	Code of Practice for Cathodic Protection of Steel Structures, Part II: Underground Pipelines [MTD24: Corrosion Protection
IS 3043: 2007	Code of practice for Earthing
BS EN 12954: 2001	Cathodic Protection of Buried or Metallic structure – General Principles and application for pipelines
BS EN 16299: 2013	Cathodic protection of external surfaces of above ground storage tank bases in contact with soil or foundations
BS EN 13636:2004	Cathodic protection of buried metallic tanks and related piping

3.0 PRE-DESIGN SURVEY, TESTING AND CONSIDERATIONS

3.1 The CP specialist shall review the construction drawings to determine the feasibility and design requirements of the CP system, and its compatibility with the structure's design and construction.

3.2 For successful operation of a CP system, the structure shall be electrically continuous, otherwise the discontinuous structures will be subject to stray current corrosion. Therefore, structure layout drawings shall be checked for theoretical continuity. The discontinuous structures in areas to be cathodically protected shall be identified.

3.3 The design shall avoid the stray current interference with adjacent structures.

3.4 **Electrolyte Resistivity**

3.4.1 Resistivity of soil or liquid in areas of buried structure to be cathodically protected shall be measured using Wenner four pin method.

3.4.2 For CP of plant piping, soil resistivity measurements shall be conducted at 200 m intervals over the full length of the proposed anode ground bed location. The CP contractor shall take a minimum of ten (10) readings in each section of the facility to obtain an average of layer resistivity value for each section. Soil resistivity survey shall be measured with the terminals spaced at 1, 2, 3, 4 and 5 m intervals to assess variation in resistivity with depth.

3.5 **Site Visit & Survey Report**

3.5.1 Before proceeding with CP design of system, the CP contractor shall submit a written report documenting site survey findings to Owner. The written report shall include methodology, test conditions, observations, and resistivity values. The CP contractor shall also prepare an overall plan drawing of the facility showing proposed location of CP equipment.

3.5.2 The site visit is required to collect the data for cathodic protection design calculations and select suitable location for installing anode ground beds. It shall be the CP contractor's responsibility to have a thorough understanding of the reference documents, site conditions and specification included therein. The CP contractor shall be deemed to have visited the site and have studied the conditions before submitting the Bids. Non-familiarity with the site conditions will not be considered a reason either for extra claims or for not carrying out the work in strict conformity with the drawings and specifications.

4.0 DESIGN BASIS

4.1 **U/G Piping:** Design guidelines for cathodic protection of piping network in plant complex:

4.1.1 All buried pipelines/piping shall be cathodically protected by impressed current cathodic protection (ICCP).

4.1.2 The current density to be considered for Polymeric tape/ High build Liquid Epoxy or equivalent coated piping is 3mA/m^2 and for bare structures, incidental structures 20 mA/m^2.

4.1.3 The CP System for piping network in plant complex shall be designed and installed in two stages by providing first preliminary or basic design and then supplementary design if required based on actual site performance of CP system as per preliminary/basic design.

4.1.4 Supplementary design: After energising CP System as per preliminary design, the unprotected/ under protected and over protected areas shall be identified and a supplementary design is to be made to bring all structures intended to be protected within acceptable potential limits.

4.1.5 The impressed current anode system in which anodes are distributed along the structure at relatively close intervals such that the structure is within the anode's voltage gradient anodebed system

4.1.6 Following types of anodes can be used for ICCP of plant piping:

1. MMO tubular anodes (In shallow horizontal/vertical configuration)
2. Close distributed Continuous MMO wire / polymeric with pre-packed factory fitted coke breeze

4.1.7 Linear anodes-MMO wire or polymeric shall be installed for the protection of buried pipelines/piping in the congested area, where the distributed anodes can't be installed due to shielding by concrete foundations, parallel piping/pipelines, etc i.e. there should be no foreign structure between the anode and the buried piping.

4.1.8 The CP contractor shall locate such congested area and non congested area and obtain approval from the Owner for using linear anode and distributed anodes.

4.1.9 Distance of close, distributed beds from underground piping in congested areas of process units shall be maximum 3 m (such that there is no foreign structure between piping and anode) and anode to anode separation for close, distributed beds shall be such that the complete piping structure shall be within anode voltage gradient.

4.1.10 For linear anodes, the length of anode string shall be same as length of U/G pipe for single run of pipe. In case of parallel run of pipes, the no. of continuous anode strings to be considered shall be as per discretion of Owner depending on factors such as diameter of pipes, congestion of the area etc. However following general guideline shall be considered while deciding the number of anode strings for parallel run of pipelines:

i. One string for max. two lines when any one or all the lines are up to 6 inch diameter pipe.

ii. One string for max. one line for above 6 inch diameter and up to 30 inch diameter pipeline.

iii. Two strings for each line for line size above 30 inch diameter and up to 70 inch Dia. pipeline.

iv. When pipeline diameter is more than 70 inch and number of pipeline is one or more, the number of string anode to be considered shall be decided by considering cathode structure current requirement and anode current capacity 30mA/m. When more than one string is considered for parallel run of pipes, each string shall be preferably laid in different trench with suitable markers for their easy retrieval in future.

v. Each continuous linear anode string shall be of 200m (max.) length and shall be fed at both ends from a single T/R Unit using same or different anode junction box. String anode shall be laid laterally along the pipe axis at a distance 2D or 500mm from the pipe whichever is decided by Owner/ Consultant during review of detailed engineering.

4.1.11 The cathodic protection current requirement for plant piping designed using linear / distributed anodes shall be governed by ensuring

- For coated structures such as pipelines, coating defects / holidays of 50% shall be considered at the end of life for calculation of current.
- Earthing system shall be considered for ICCP designing of plant piping as 100% bare.
- Incidental structures to be considered as 100% of total known calculated piping surface area to be protected and shall be considered bare for current calculation purposes.
- Current required so that all sections of the buried piping are in within each anode's voltage gradient in case of design by distributed anodes.

4.1.12 Safety margin of 30% in current calculations shall be considered while designing.

4.1.13 Electrical continuity shall be ensured for all underground pipelines through bonding across the manholes if applicable and other pipelines.

4.1.14 As a matter of design philosophy, the underground piping network intended to be cathodically protected shall be considered in electrical continuity with many foreign structures within plant complex such as RCC pavement, earthing grids, other U/G piping which are not intended to be protected.

4.1.15 Unless otherwise specified in data sheet, no insulating joint shall be installed to isolate any incidental structure/ above ground piping within battery limit of plant from underground piping network intended to be cathodically protected.

4.1.16 Adjacent anode beds protecting different structures and powered from separate power sources shall be separated such that there is no interference.

4.1.17 Minimum two drainage cables and two measurement cables from each pipeline or from each structures to be protected shall be terminated in one cathode junction box (Cathode JB).

4.1.18 Structures protected or influenced by CP systems shall be electrically continuous. Bonds shall be installed (where required) to ensure electrical continuity.

4.1.19 For mechanical protection of the string at unpaved areas one layer of brick shall be laid along the string after back filling with soil by 150mm. The axis of the brick shall be perpendicular to the axis of the anode string.

4.1.20 For future access of each anode string at paved areas, concrete slabs sealed with cement shall be laid along the string after back filling with soil. Care should be taken to ensure that anode string does not touch the structure to be protected or any foreign structure.

4.1.21 Continuity test of the string and short circuit test of the string with structure intended to be protected as well as foreign structure shall be carried out before energizing the CP System. In case any abnormality is found during this test, CP contractor needs to do the needful to rectify the fault before energizing the system.

4.1.22 Buried reference electrodes shall be a saturated copper/copper sulfate electrode if the soil resistivity is greater than 2,000 ohm.cm or silver/silver chloride (Saturated KCl) if soil resistivity is less than 2,000 ohm-cm.

4.1.23 Minimum 10 no. of reference cells to be installed for piping at equidistant locations for each TR Unit.

4.1.24 Coupon assemblies with buried reference electrodes shall be installed within the piping network for true CP polarized potential measurement at every test station location.

4.1.25 A number of test stations with soil access holes (for every 70 m pipeline/piping length) shall be provided in each area of the pipeline/piping network for potential measurement using portable reference electrode. These test stations shall be located midway between CP anodes. Each test station shall be provided with buried reference electrodes and coupons.

4.1.26 Soil access holes along with test stations provided with shunt resistance shall be provided for potential measurements.

4.1.27 CP contractor shall work in close coordination with plant installation contractors.

4.1.28 **Additional guidelines for Sacrificial anode cathodic protection in plant complex**

4.1.28.1 Temporary CP system is required for ICCP systems when period between installation of structure intended to be protected and commissioning of the CP system exceeds 6 months. The same may be obtained either by installing temporary power to the Transformer-Rectifier unit and energizing the impressed current system or by installation of sacrificial anodes.

4.1.28.2 CP contractor shall provide Zinc/ Magnesium ribbon anodes for temporary protection and ensure that protection of the plant piping in the period prior to commissioning of permanent ICCP system is attained.

4.1.28.3 Zinc anodes shall be used if the layer soil resistivity is less than 1,000 ohm.cm. Magnesium anodes shall be used when the layer soil resistivity is greater than 1,000 ohm.cm.

4.1.28.4 Electrically isolated short buried sections of piping, small isolated coated structures or buried sections of normally above-grade pipelines/piping such as road crossings may be cathodically protected with galvanic anodes.

4.1.28.5 Short pipes, which are less than 300 meters, can be protected by SACP if the piping is not electrically continuous with any other buried structures and if all piping parts are 75 meters away from the nearest impressed anodes.

4.1.28.6 Buried fire hydrants, risers, valves, gas accumulators, electrically isolated pipe casings, sleeves, fence crossings and pipe vents, thrust anchors, thrust bore, shall be protected by SACP using Mg or Zn galvanic anodes. The net weight of each magnesium or zinc anode shall be 27 Kg excluding the anode backfill. Impressed anodes may be used for these structures if the use of galvanic anodes is not practical, especially when impressed current distributed anodes are within 75 meters from the structure to be protected.

4.1.28.7 Special design considerations (e.g., additional CP current) are also required for buried pipelines/piping at and inside the fence for plants. CP contractor to coordinate these designs with site, and obtain approval from the Owner.

4.2 **FOR U/G VESSELS:** All u/g vessels shall be cathodically protected by impressed current cathodic protection (ICCP):

4.2.1 The current density to be considered for coated u/g vessel shall be 3 mA/m^2, for bare structures - 20 mA/m^2.

4.2.2 Consider coating breakdown factor: Initial- 5% and end of life:30%

4.2.3 Anode material shall be mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke breeze

OR Conductive Polymer Anode factory prepacked with coke breeze (carbonaceous material).

4.2.4 These vessels can be directly buried or installed inside RCC pits. If underground vessel are installed in RCC pit backfilled with sand then the RCC structure have to be isolated from the vessel by installing PE sheets in inner surface of RCC walls to prevent Cathodic protection current drainage.

4.2.5 No anode to cable joints shall be permitted in the vessel, all the cable joints shall be performed outside the RCC pit through soil holes in the wall for future maintenance.

4.2.6 The anode strings shall be located within the RCC pit. Specific installation requirements of String Anode shall be as follows:

- Anode strings shall be installed in the sand cushion surrounding the vessel at a distance of 300mm from the vessel.
- Separation distance between consecutive String anode loop shall be uniform.
- Length of each longer side of the loop string anode shall be same as the length of the vessel + 0.6m.
- Minimum 4 No. of strings should be considered for each vessel.

4.3 **Above Ground Storage Tanks:** All tank bottom plate- soil side shall be cathodically protected by impressed current cathodic protection (ICCP):

4.3.1 The current density to be considered for tank bottom plate shall be 20 mA/m^2, considering 100% bare.

4.3.2 Anode material shall be mixed metal oxide coated on titanium wire anode, piggyback connected with anode lead cable, factory pre-packed with coke breeze OR Conductive Polymer Anode factory prepackaged with coke breeze (carbonaceous material).

4.3.3 The anode strings shall be laid in the sand cushion or soil under the tank bottom plate extending straight from one end to other end of the tank rim. Following guide lines shall be considered for installation of String Anode for coated tank bottom plates:

- Separation distance of String anode from bottom plate to be protected shall be 1000mm.
- Maximum spacing between consecutive anode strings = 1.5m.

In case 1m space is not available between bottom plate and string anode, suitable shielding arrangement to be provided on string anode so that it does not touch the bottom plate. For such case, Maximum spacing between consecutive anode

strings shall depend on available separation distance of String anode from bottom plate

4.3.4 Dedicated TRU with suitable rating to be considered for each tank more than 20 meter diameter. However, common power supply unit with suitable rating may be considered if tanks are installed in same location/ area of less than 20 meter dia.

4.3.5 No anode to cable joints shall be permitted in the tank foundation, all the cable joints shall be performed outside the tank ring wall through soil holes in the ring wall for future maintenance.

4.3.6 Cathodic protection is not required for tank bottom installed on full reinforced concrete foundation.

4.3.7 Min. 5 nos. of saturated copper/Copper sulphate reference electrodes shall be installed under tank bottoms. One RE shall be placed at the center of the tank base and the balance one in each quadrant.

4.3.8 A perforated high density PE pipe (1 ½ inch dia) properly encapsulated in the geotextile fiber/cloth shall be placed under the tank bottom. This pipe shall be crossing the center of the tank bottom and extended either side of the concrete ring wall. This monitoring tube shall not run parallel to the anode strings. If tank diameter is more than 20 meters, two monitoring tubes shall be installed.

4.3.9 Minimum 4 no. of soil access holes (1½ inch in diameter) under the bottom through the ring-wall shall also be provided for potential measurements using portable reference electrodes.

4.3.10 In case tank is mounted on RCC pile foundation, one insulating PE film is to be laid on the pile cap before sand filling of the cap to ensure minimum C.P. system current is diverted to the pile cap.

4.3.11 Contractor need to lay one layer of insulating P.E. film of thickness 1.2mm on the concrete surface of the RCC cap before sand filling for the tanks mounted on RCC pilling. The Roll size of the P.E. film shall be decided by the contractor. While laying, overlap of 5mm is to be made between consecutive longitudinal P.E. strips. Also, the overlaps need to be sealed using blow lamp or plastic welding method.

5.0 PROTECTION CRITERIA

5.1 Acceptance criteria to demonstrate the effectiveness of the CP system shall be the most stringent of those specified in the standards listed in this specification. All representative monitoring points for structures to be protected shall meet the following criteria:

5.1.1 An instant off potential (measured between 0.1 s and 1 s after switching off the DC circuit) more negative than -850 mV and less negative than -1,200 mV with respect to a saturated copper/copper sulphate (Cu/CuSO4) reference electrode.

5.1.2 A minimum of 100 mV of cathodic polarization between the structure surface (surface of the tank bottom in case of tank) and a stable reference electrode contacting the electrolyte. This criterain based on measurement of formation or decay of polarization may be used only in rare circumstances with prior approval of owner.

5.2 After Commissioning of the C.P. System, if it is found that structure to electrolyte potential achieved at some location is in the range which is below acceptable limit as per code, then a supplementary C.P. System need to be installed to bring the potential level at such locations within acceptable limit without any additional cost to Owner.

5.3 Any positive shift of 50 - 100mV will be investigated for interference and mitigation measures shall be taken.

6.0 EQUIPMENT AND MATERIALS

6.1 DC Power supply and Transformer-Rectifier (TR) unit

DC Power supply & the TR units control system equipment shall confirm Transformer rectifier as per design datasheet and the following:

6.1.1 Each rectifier unit shall be complete with instrument cabinet, enclosure, transformer, voltage control taps, and necessary appurtenances.

6.1.2 The TR units shall be natural air cooled or shall be oil cooled silica gel breather as per the hazardous area requirement.

6.1.3 The TR units shall have switchable constant current, constant voltage mode, Automatic Potential Control Mode (shall be provided only as option if so specified).

6.1.4 Transformer shall be double wound fully isolated with earthed electrostatic shield between both the windings.

6.1.5 All TR units shall be supplied with a synchronisable built-in current interrupter. The interrupter shall be capable of switching the full load current at maximum output on a variable time cycle of up to 10 seconds "on" and 10 seconds "off". Programmable interrupter ON/ OFF cycle varying ratio from 1s to 999s shall be made available in TR unit.

6.1.6 TR unit shall be installed in non-hazardous area as far as possible. For units located in classified areas, the instrument control cabinet and circuit breaker enclosures shall be made of corrosion resistant explosion-proof enclosures in accordance with Hazardous area classification.

6.1.7 For units located in unclassified areas, the instrument control cabinet shall be bolted to the oil tank and readily accessible to conduits and monitoring. Enclosures shall be IP55 protected as a minimum and fabricated thick mild steel sheet with all external surfaces shall be protected against corrosion.

6.1.8 Each rectifier shall be suitable for concrete pad mounting. All mounting/bolting hardware & accessories shall be stainless steel.

6.1.9 All rectifier units shall be provided with an integral shield to protect the unit and control cabinet for direct sunlight impingement.

6.1.10 TR shall be selected with 50% excess capacity to allow for adjustments during the life of the cathodic protection system and to prevent damage due to voltage overload.

6.1.11 Transformer efficiency at full load shall not be less than 95%.

6.1.12 Temperature rise test shall be run for 48 hours (at least) till getting stable readings. The maximum acceptable rise in that period from ambient temperature shall be less than 25°C.Maximum temperature of oil shall not exceed 85 Deg C at full load. Temperature test points shall be placed top, middle side, middle back and bottom of the enclosure. Temperature measurement shall be made by thermocouple or resistance change method.

6.1.13 The TR components shall be mounted on a slide out, or tilt out removable air cooled chassis. Lower compartment shall contain main transformer, auto transformer, chokes and oil while upper compartment shall contains SCRs, Diodes, meters, protective devices, electronic control & cards etc.

6.1.14 Conduit/ Gland entries shall be provided for AC and DC conductors. The conduit size shall be $1^{1/2}$ inch, unless otherwise specified. Conduit entries shall be located directly in line with the conductor termination to avoid cable bending inside the enclosure.

6.1.15 Cables and wires shall be stranded copper conductors with XLPE as per standards. Different voltage level wires with different colour coding as per standards shall run in different cable trough / duct inside TR unit.

6.1.16 Wires shall not be taped or spliced between termination points. Wiring shall be bundled and secured with plastic ties. Only one conductor per terminal shall be permitted.

6.1.17 The positive and negative terminal posts shall be screw terminal type machined from brass and shall be positioned to permit ready and easy connection of the DC cables. All the live terminals shall be shrouded.

6.1.18 DC output terminal posts shall have a minimum 76 mm (3 in) clearance from each other and from all other metal parts and be located at least 200 mm (8 in) above their conduit entries.

6.1.19 Each DC terminals shall be double post type shall be supply with two nuts, two flat washers, one lock washer and compression lugs. The compression lugs and the post shall be made of a copper alloy, plated with tin, silver or electro less nickel.

For DC outputs, the socket terminals for measurement shall be red for the DC positive terminal connections and black for the DC negative terminal connections

6.1.20 DC output current shall be measured with a 50 mV precision block shunt. Shunt size for the current measurement shall be 25, 50, 75, 100, etc. ampere ratings, to provide a whole number ratio of current to mV.

6.1.21 A variable timer controlled D.C. relay system interrupting the output to facilitate “instantaneous off” structure potential measurement shall be provided. The current circuit breaker on the output shall be capable of interrupting the DC output in a period of less than seconds at any load. The interrupter shall be capable of switching the full load current at maximum output on a variable time cycle of up to 10 seconds "on" and 10 seconds "off". The operation of the interrupter shall not affect the electrical supply to, or accurate operation of, any of the other circuits during its operation.

6.1.22 A separate isolating unit shall be connected between the AC power input cable and the TR to allow the safe removal of the TR if necessary.

6.1.23 Power rectifying diodes and Silicon Control Rectifiers (SCRs) shall be mounted on aluminium heat sink size to limit device case temperature to 90°C at 50°C ambient conditions at rated load. Heat sink for air cooled shall be anodized.

6.1.24 The peak inverse voltage rating of diode and SCR shall be 1200 volt (rms) minimum. The diode forward current rating shall be a minimum of 50% greater than the full load conducted current.

6.1.25 DC fuses shall be rated at not more than 120% of rate current output, 250 volts, and shall be installed in each positive phase leg.

6.1.26 Fuses for hazardous area TR shall be placed inside the oil tank.

6.1.27 Design life of TR unit shall be 30 years of continuous operation with minimum level of maintenance.

6.1.28 Each Diodes/ SCRs shall be provided with surge suppressors & shall be designed for 400% excess current capacity. Surge and transient suppression protection for the diode and SCR shall consist of MOV across each AC input terminal to rectifying element and electronics board to protect the semiconductors and across the DC output terminals. The MOV shall be voltage coordinated for the circuit and component to be protected. Each MOV shall be rated of 15% minimum above nominal line voltage.

6.1.29 The electronic modules shall be built on PCBs of fiberglass reinforced cards & all cards shall be tropicalized by providing suitable coating.

6.1.30 All internal components such as electronic cards, fuses, MCBs, relays, contactors, timers etc. shall be identified with either painting marks or with nameplates as per

schematic drawings. Identification with stickers is not acceptable. Nameplates shall be of anodized aluminum 3mm thick.

6.1.31 Auxiliary wiring shall have copper. Wires shall not be taped or spliced between termination points. Wiring shall be bundled and secured with plastic ties. Only one conductor per terminal shall be permitted.

6.1.32 Reference electrode input shall be tested from local control unit, master control unit and digital multimeter. The readings shall be accurate and the error % shall be less than 0.5%.

6.1.33 Each TR unit shall include two pairs of socket terminals to facilitate measurement using external hand held devices.

6.1.34 TR unit shall be provided with steel channel under the base plinth mounting, lifting lugs, sunshade/ canopy, Oil filling arrangement & drain plug, Oil sight gauge, removable type dial thermometer and lockable control cabinet with viewing window.

6.1.35 Each rectifier shall be provided with a bolted or riveted stainless steel 304, engraved or stamped nameplate. This nameplate shall be located for easy visibility on the outside of the enclosure door on all units. For hazardous area TRs, the nameplate shall be located on the oil enclosure or associated fixtures. Each nameplate shall indicate the following as a minimum:

- Manufacturer and Address
- Descriptive Name
- Manufacturer's Serial Number:
- Input Rating:
- kVA
- Nominal Voltage
- Current
- Single or three phase
- Frequency (Hz) - 60
- Minimum Power Factor
- Output Rating:
- kW
- Voltage
- Current
- Oil Capacity: Liters
- Maximum Operating Temperature
- Date of Manufacture

6.2 ANODES

6.2.1 ICCP Anodes

6.2.1.1 Mixed Metal-Oxide (MMO) Coated Titanium Tubular Anodes:

a. They are available in solid rods, tubes.

b. The consumption rate of these anodes shall not be more than 1.0 mg/amp-yr.

c. Length, diameter, quantity and distribution pattern of these anodes shall be selected to meet the current requirement locally, and to also conform to the anode design and the maximum anode current density.

d. The MMO coating thickness shall be minimum 6 gm / m^2sufficient to provide a service life of 25 years.

e. Calculations shall be provided to verify their service life.

f. The anode cable connection to the anode shall be crimped made using hydraulic compression. The connection shall be appropriately covered with moisture resistance tapes and sealed with heat shrink sleeve.

6.2.1.2 Mixed Metal Oxide (MMO) Coated Titanium wire anodes

a. The anode shall be factory prepackaged with coke breeze with acid resistance fabric and protective braid to prevent mechanical damage. Splices between the MMO anode wire and anode cable shall be at 3 meter interval.

b. The MMO coated titanium wire diameter shall be of minimum 1.5 mm.

c. The minimum MMO coating thickness shall not be less than 6 gm/ m^2.

d. The net diameter of the wire anode shall be 35 mm minimum.

e. Anodes shall be surrounded with a minimum calcined coke breeze of 1.15kg/m encapsulated with acid resistant fabric and nylon braid

6.2.1.3 Polymeric anodes

a. Conductive polymer anodes shall be used for new tank bottoms, underground pipelines/piping in congested areas.

b. Conductive polymer anodes shall be surrounded with a minimum calcined coke breeze of 1.15kg/m encapsulated with acid resistant fabric and nylon braid.

c. The total diameter with anode backfill shall be 35mm minimum.

d. The max current output of this type of anode shall be 40 mA/m for a life of 25 years.

e. The coke breeze weight shall be 1.15 kg/m.

6.2.2 **Sacrificial Anodes**

a. The weight of sacrificial solid anodes installed in soil shall be 27Kg excluding the anode backfill.

b. Sacrificial anode backfill that is installed in soil shall be 75% hydrated gypsum, 20% bentonite clay and 5% hydrated gypsum. Zinc anodes can also be packaged in a backfill consisting of 50% hydrated gypsum and 50% bentonite clay.

c. Sacrificial anodes shall be one of the following:

6.2.2.1 **Magnesium**

Magnesium anodes shall exhibit an open circuit potential of -1550 mV or more negative with reference to an $Cu/CuSO_4$ electrode.

Magnesium anodes shall conform to the following Specification:

Cu	0.02% Maximum
Al	0.01% Maximum
Fe	0.03% Maximum
Mn	0.5 - 1.3%
Ni	0.001% Maximum
0.05%	Maximum, any one other impurity and
0.30%	Maximum, total of all other impurities
Mg	Balance.

6.2.3 **Zinc**

Zinc anodes for 50 °C or less operation shall conform to the following Specification:

Al	0.005% Maximum
Cu	0.002% Maximum
Fe	0.0014% Maximum
Pb	0.003% Maximum

Cd	0.003% Maximum
Zn	Balance.

Zinc anodes operating at temperatures between 50 °C and 70 °C shall conform to the following Specification:

Al	0.10% - 0.25%
Mg	0.05% - 0.15%
Cl	0.001% Maximum
Fe	0.002% Maximum
Cu	0.001% Maximum
Pb	0.006% Maximum
0.10%	Maximum, total of all other impurities
Zn	Balance.

6.3 **Reference electrodes**

6.3.1 Performance and effectiveness of the CP system shall be monitored and recorded using permanently buried reference electrodes. These electrodes shall be commercially available devices, with a proven track record of use in soil or water, particularly in hot climate environments.

6.3.2 All permanent reference electrodes shall be supplied with a test certificate and fitted with a suitable length of cable, so that no splices are required between placement location and test stations.

6.3.3 Buried reference electrodes shall have a life expectancy of over 25 years. The half-cells shall have a predicted accuracy of +/-20mV for the 25 year electrode life expectancy and shall have a tested accuracy of +/- 5 mV against a calibrated sulphate reference electrode (same type).

6.3.4 Reference electrode shall be designed to operate in an environment between 0°C and 60°C. The manufacturer shall also provide the temperature coefficient and its temperature range.

6.3.5 The connection between the cable and the electrode shall only be factory fitted and completely sealed, and capable of total burial/immersion without leakage.

6.3.6 The CP contractor shall use reference electrodes of those manufacturers which have proven track record in use for a minimum of 10 years.

6.3.7 Reference electrodes shall be installed in a backfill material, such as gypsum, that provides a stable, uniform environment, capable of retaining moisture.

6.3.8 Permanent Cu/CuSO4 reference cells :

i. Shall be installed at a distance of 300mm from the UG Piping for monitoring of C.P. System.

ii. Minimum 10 no. of reference cells to be installed for piping at equidistant locations for each TR Unit.

iii. Minimum 4 no. of reference cells to be installed for each Vessel.

iv. Minimum 16 no. of reference cells to be installed for each mounded bullet at equidistant locations.

6.4 **Cables**

6.4.1 The positive DC feed cable from the rectifier shall feed a multi-terminal resistor controlled junction box.

6.4.2 Each terminal from this positive junction box shall feed an individual anode.

6.4.3 The negative cables from the rectifier shall be connected to the structure.

6.4.4 The negative from the rectifier shall be connected to the tank at two points 180 degrees apart.

6.4.5 All cables shall be stranded copper and shall have a minimum of seven strands.

6.4.6 All cables shall have a minimum of one layer of insulation and a single layer of sheathing. DC cables shall be copper conductor. The insulation shall be high molecular weight polyethylene (HMWPE) insulation or XLPE with PVC sheathing. Anode tail cables for MMO long line wire anodes the insulation shall be Halar or Kynar with HMWPE as sheath. For shallow / deep /semi deep anode beds the anode lead cable shall be EPR/CSPE/Halar/Kynar insulated with HMWPE as sheath. The minimum insulation thickness shall be 0.8 mm.

6.4.7 Color coding shall be same for all areas.

6.4.8 Multi-core cables shall be color or number coded.

6.4.9 All cables shall be run in appropriate size conduits between the structure and the junction box / test station and also between the junction box and the power supply or TR unit.

6.4.10 All cables shall be clearly labelled at termination points with permanent labels.

6.4.11 All underground wire attached to the positive rectifier terminal is at a positive potential with respect to ground. If not completely insulated, the wire may discharge current (act as an anode), which will result in corrosion of the wire and rapid failure of the cathodic protection installation.

6.4.12 Splices in the anode lead wires, positive cable from the transformer rectifier to the junction box and negative cables from the TR to structure are not allowed. Cable insulation shall be carefully inspected prior to backfilling.

6.4.13 Backfill shall be sifted sand free of sharp stones or other material that could damage wire insulation. All cables between the protected structure, the junction box and /or the transformer rectifiers shall be run in appropriately sized conduits. Cable conduits below grade level shall be rigid PVC, above grade level shall be PVC coated rigid galvanized steel. All fittings and accessories shall meet the conduit type specification respectively.

6.4.14 Test lead wires should be color coded, numbered, or otherwise permanently identified.

6.4.15 Sufficient slack should be left to avoid strain on all wires.

6.4.16 Cable sizes for tanks, underground pipelines/piping and other isolated structures shall be as follows:

6.4.17 Minimum 10/16 mm² for anode tails and negative cables connected to structures.

6.4.18 Minimum 25 mm² from anode junction boxes to rectifiers.

6.4.19 In case if there are main positive and negative junction boxes, 35 or 50 mm² shall be used to connect between these boxes and rectifiers.

6.4.20 Minimum 10 mm² cables for testing.

6.4.21 Minimum 16 mm² for bonding between structures.

6.4.22 Minimum 6 mm² for buried reference electrodes, monitoring and coupon cables.

6.4.23 Cable shall be encased in conduit or other protective method at road crossing and where area subject to frequent excavation.

6.4.24 If armoured cable is used then the same shall be isolated from any earthing system.

6.4.25 All anode cable connections, splices, test lead connections, surge arrestor etc. shall be made in junction/ test/ bond boxes , certified for hazardous area classification in which they are installed.

6.4.26 Connections of cable to structures shall ensure that an electrically conductive and mechanically secure bond is made. Fusion welding, thermit welding, stud welding or thermit brazing are acceptable. Where connections are to be made to structures that have an internal protective coating or lining, they shall be made prior to the installation of the internal protective coating/ lining.

6.4.27 To avoid cable damage in the long run, all cables are to be laid at the cable trays wherever possible; underground cable laying should be considered only when no cable trays are available nearby. All C.P. System cables need to be laid at power cable trays, all multi core-monitoring cables may be laid in either electrical or instrumentation cable trays whichever is available. For road crossing of C.P. System cables, suitable RCC duct or PVC PIPE duct embedded in concrete at proper depth need to be prepared by CP contractor. CP contractor should get the construction drawing approved by Owner before execution of the work.

6.4.28 At R.C.C covered areas a narrow trench shall be cut in the existing concrete. The cables shall be installed in a properly sized G.I. conduit (to accommodate the cables) the minimum trench dimension for a single 2” diameter G.I. conduit shall be 150mm wide by 750mm deep. The trench dimension shall be increased to accommodate larger diameter conduit pipe or multiple conduit pipe. After the conduit and cable has been installed, trench shall be properly paved to restore the R.C.C. to its original condition.

6.4.29 The cable routes shall be identified with permanent cable markers.

6.5 **Test Coupon**

6.5.1 The test coupon shall consist of a bare surface and a coated surface equivalent to the coating of piping1 with two cables of 1c x 6 sq mm for connection to the piping and potential measurement. The coupon test station to the piping shall be through a magnetic reed switch for measurement of instant OFF potential. A 50mm PVC tube shall be inserted alongside the coupon. The PVC tube shall shields the reference electrode from potential gradients.

6.6 **Test Station**

6.6.1 MOC & type of test station shall be as as per hazardous area classification.

6.6.2 Each test station shall be visibly marked by permanent ink in red color. This shall be followed by the date of installation. Test station numbering, Symbols and other notations used for sequence of the test stations shall be approved by owner/consultant.

6.6.3 Test station enclosure shall meet the appropriate degree of protection/ explosion protection depending on their location.

6.6.4 Permanent monitoring facilities shall be installed at the following locations as a minimum:

- Piping as defined in earlier part of document
- At each buried vessel or tank.

6.7 **Junction boxes**

6.7.1 Each Anode & Cathode junction box shall be complete with enclosure MOC as per hazardous area classification.

6.7.2 Anode (positive) junction box shall have variable resistors, current measuring shunts, and necessary appurtenances in accordance with IP-65 protection as a minimum.

6.7.3 Each box shall be designed for outdoor installation.

6.7.4 Each box shall be provided with a sunshade/ canopy.

6.7.5 Each box shall have a stainless steel permanent nameplate which shall include, as a minimum, the following items :

- Manufacturer's name and address
- Model and serial numbers
- Resistor manufacturer's name and address
- Resistor model and serial numbers (Resistor ratings).
- Ambient temperature rating
- Nameplate shall be affixed to the outside of the door

6.7.6 Each box shall have a stainless steel plate indicating the connection scheme

6.7.7 Junction boxes shall be sized to dissipate heat generated by the variable resistors at their maximum output in an outdoor environment.

6.7.8 All doors shall be lockable and locks shall be capable of being opened with the same key.

6.7.9 Junction box enclosures shall be explosion proof if installed in hazardous area.

6.7.10 All junction boxes shall be marked clearly with tags.

6.7.11 Cathode junction box shall be provided for multiple pipelines connections.

7.0 DRAWINGS AND DOCUMENTS

7.1 4 hard copies & 1 soft copy of drgs. & doc. shall be supplied with bid.

4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.

8 hard copies & 2 soft copies in pen drive shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

7.2 All drawings and documents shall have the following description written boldly.

i) Name of client

ii) Name of consultant

iii) Enquiry / order number with plant / project name

iv) Equipment Code no. and Description

8.0 SPARES

8.1 Spares for operation and maintenance

Item wise unit prices of spare parts with recommended quantity shall be quoted along with the equipments.

Mandatory spares as specified elsewhere in the NIT shall be quoted.

8.2 Commissioning Spares

Commissioning spares, as required, shall be supplied with the main equipment. Item wise list of recommended commissioning spares shall be furnished for approval.

8.3 Any other spare parts not specified, but required, shall also be quoted along with the offer.

8.4 All spare parts shall be identical to the parts used in the equipments.

9.0 DEVIATIONS

9.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

TECHNICAL SPECIFICATION

CATHODIC PROTECTION POWER SUPPLY MODULE (CPPSM)

CONTENTS

SECTION NUMBER	DESCRIPTION
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1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Power Supply Module (CPPSM) working on controlled switch mode principle intended to supply power to cathodic protection system

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

IS: 1248 (Parts-I, 2, 8 & 9)	Direct acting indicating analogue electrical measuring instruments and accessories.
IS: 3700 (Parts-I to 11)	Essential rating and characteristics of semiconductor devices
IS: 3715 (Parts-I to 4)	Letter symbols for semiconductor devices
IS: 4411	Code of designation of semiconductor devices.
IS: 5469 (Parts-I to 4)	Code of practice for the use of semiconductor junction devices.
IS: 6619	Safety code for semiconductor rectifier equipment.
IS:7204 (Parts-I to 4)	Stabilised power supplies DC output.
IS: 12021 (Parts-I to 4)	Control transformers for switchgear and control gear for voltages not exceeding 1000 V AC.
IS: 13703 (Parts-I to 4)	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
IS: 13947 (Parts-4, section-I)	Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications/ and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards.

3.0 SITE CONDITION

The CPPSM shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk in locations having generally corrosive, warm, humid and dusty atmosphere. Service conditions shall be as per actual site conditions. If not specifically mentioned therein, a design ambient temperature of 45°C and an altitude not exceeding 1000 m above mean sea level shall be considered.

4.0 GENERAL REQUIREMENTS

The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

4.1 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.2 Vendor shall give a notice of at least one year to the end user of equipment and owner before phasing out the product / spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

CPPSM shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The Unit shall be freestanding type. Hinged doors "Shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided. Degree of protection for the panel shall be minimum IP-41. The CPPSM panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm2' shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm" conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPPSM shall be suitable for bottom cable entry unless otherwise specified and shall be supplied complete with crimping type tinned copper lugs and cable glands. Cable glands shall be of brass, nickel plated, single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for termination of required number and sizes of cables.

5.1.6 The CPPSM shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable. Layout of panel components shall enable easy access to the components for maintenance.

5.1.7 All the control equipment like switches, push buttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel.

5.1.8 The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used gold plated male-female connectors shall be used for the purpose.

5.1.9 The panel shall be provided with space heater to prevent moisture condensation. The space heaters shall be located at the bottom of the panel and shall be provided with a manually operated switch and HRC fuse. The space heater shall have porcelain-insulated connectors. Where space heater is not provided, the electronic PCBs/components and other control devices shall be made immune to moisture condensation.

5.1.10 Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/flat/channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/channel.

5.1.11 An earth bus bar of minimum (25 x 3) mm^2 copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of (40x5) mm" GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.

5.1.12 All panel mounted equipments (e.g. lamps, push buttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-whiteblack) lamicoid sheets or anodised aluminium. Back-engraved perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.

5.1.13 Where specified, the CPPSM shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. Acrylic transparent glass window shall be provided on the front door of the kiosk so that the meters, indications and positions of the control switches on the CPPSM can be seen without opening the door of the· kiosk. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPPSM against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPPSM. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the kiosk.

5.1.14 **Painting**

All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.

Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow zinc chromate primer. The undersurface shall be made free from all imperfections before undertaking the finishing coat.

After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing ovens in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint, etc.

All unpainted steel parts shall be cadmium plated or suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 EQUIPMENT DESCRIPTION

The CPPSM shall be complete with following main sections:

- Input controls.
- Power converter and filters.
- Output protections
- System controls
- Current interrupter
- Control, indication and metering

6.1 Input Controls

6.1.1 A moulded case circuit breaker with thermal over load and short circuit release (rated for the input power supply short circuit current) shall be provided at the input for power supply control.

6.2 Power Converter and Filters

6.2.1 The CPPSM shall convert and control the input DC power supply voltage/current into variable DC output voltage/current through switching power semiconductor devices (Thyristor/power transistor/power MOSFET, etc.). The variation in the output voltage/current shall be achieved through control of duty cycle of conduction of the switching power semiconductor devices. The current and voltage ratings of the power semiconductor devices shall be at least two times the maximum device current and min. two times the maximum voltage coming across it respectively. The voltage rating of the power semi-conductor devices shall be co-coordinated with the breakdown voltage of lightning arrestor provided at the output so that the power semiconductor devices are protected from any voltage surge coming from the pipeline. Shunt zeners / MOV shall be provided across the power semiconductor devices for protection. The power semiconductor devices shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The power semiconductor devices shall have adequate protection against high dv/dt and di/dt.

6.2.2 Where specified, the converter shall electrically isolate the input power to CPPSM from its output so that the grounding of the positive output of the CPPSM through anode

ground bed shall not affect the grounding system of the input power supply. Alternatively, a separate DC to DC converter having electrical isolation between input and output power supply shall be provided at the input of the CPPSM.

6.2.3 The power semiconductor devices shall be protected by semiconductor fuses or the system shall have instantaneous short circuit-current limit feature to protect the devices against output short circuits. An adjustable output over current limit feature shall be provided.

6.2.4 Filter shall be provided in the input power supply circuit to minimise the AC injected into the DC input power supply system.

6.2.5 Adequate filtering shall be provided on the DC output of the converter to limit the ripple content in the output to less than 5% at rated output.

6.2.6 The converter system shall be of natural air cooled type.

6.2.7 For CPPSMs with multiple output circuits, each output circuit shall have independent output converter and output filters.

6.3 **Output Protections**

Two pole moulded case circuit breaker or miniature circuit breaker rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrestor rated for minimum 10KA impulse current discharge capacity and rated voltage & max. spark over voltage rating suitable to protect the CPPSM components against lightning and switching surges shall be provided at the output. For CPPSMs with multiple output circuits, each output circuit shall have independent protections.

6.4 **System Controls**

6.4.1 The CPPSM shall have two distinct modes of operation (independent for each output circuit) as below:

a) Constant Voltage - Constant Current Mode (CVCC)

In this mode the output voltage (Vos) of CPPSM shall be continuously adjustable from 0.5V DC to the rated output voltage. Current limit feature shall be provided in this mode of operation. The current limit (Ios) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) **Auto PSP Mode**

In this mode of operation the output of the CPPSM shall operate in an external closed loop with pipe-to -soil potential (PSP) in feedback loop. The CPPSM control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (Vps) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range as required. An adjustable over current limit shall be provided to limit the maximum output current.

The unit shall be designed to operate with the number of reference cells connected to it (to be provided by others). In case of more than one reference cell being specified, CPPSM shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysterisis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

In case of open circuit or short circuit of the reference cell or potential being less negative than a minimum set potential (Vrs), for the controlling reference cell, the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPPSM shall adjust automatically to a preset value (Vas/las), which shall be adjustable.

In both CVCC and auto PSP modes of operation the electronic over current limit shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (Vpm) or remaining lower than the specified minimum limit (Vpn).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5 % of rated voltage throughout the range of output voltage and over the specified ambient temperature variation, in CVCC-constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum shall be within 20mV throughout the PSP setting range specified.

In CVCC- constant current mode of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% throughout the range of output current.

6.4.4 The output of the unit shall be ungrounded and shall allow grounding of positive terminal of the output through the anode ground bed.

6.4.5 For CPPSMs with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 A current interrupter for CPPSM output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPPSM and a digital timer to operate it.

6.5.3 The timer shall have 'ON' and 'OFF' timings. When the timer is turned on the 'ON' timing shall start and shall close the output contactor till the end of the 'ON' timing. At the end of the 'ON' timing the 'OFF' timing shall start and keep the contactor open till the end of the 'OFF' timing. At the end of the 'OFF' timing the 'ON' timing shall start again. This process of 'ON' and 'OFF' timing shall continue.

6.5.4 The 'ON' and 'OFF' timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from 1 to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON 'timing'. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button, the timer shall restart with 'ON' timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPPSM.

6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

a) Controls

- Timer power 'ON' / 'OFF'
- Timer reset
- Thumb wheel switch for 'ON' timing
- Thumb wheel switch for 'OFF' timing

In case of microprocessor based system, keypad with display may be provided in place of thumbwheel switches.

b) Indications (LED)

- Timer power 'ON'
- 'ON' timing
- 'OFF' timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPPSM. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 The current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the contactor in the timer output. The input power supply and the rating of the timer output contactor shall be as required.

6.5.10 Where the current interrupter is not specified with CPPSM or is specified as portable type external to the CPPSM, then the CPPSM shall have provision for connection of input power supply terminals and output contacts of external current interrupter for current interruption test. A link shall be provided for shorting the output terminals provided in CPPSM for current interruption, whenever the current interrupter is not connected.

6.5.11 For CPPSMs with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPPSM front door.

a) ON/OFF control for input through MCCB.

b) ON /OFF control for output through MCCB/MCB.

c) Auto/CVCC mode selector switch.

d) Potentiometers for Vos, Vps and los settings.

e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

a) Potentiometer for Vrs, Vpm, Vpn and Vas/las settings.

b) Controls for current interrupter:

- Timer power 'ON' / 'OFF'

- Timer reset

- Thumb wheel switch for 'ON' timing

- Thumb wheel switch for 'OFF' timing

6.6.3 CPPSM shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

a) CPPSM ON/OFF

b) Unit in auto/CVCC (2 lamps)

c) Reference cell controlling the closed loop control of the CPPSM (number of lamps same as number of reference cells).

d) Reference cell faulty (number of lamps same as number of reference cells).

e) Pipeline over protected.

f) Pipeline under protected

g) Indications for current interrupter:

- Timer power 'ON'

- 'ON' timing

- 'OFF' timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl. 1.5 accuracy shall be provided on the CPPSM:

a) Digital meter for output voltage

b) Digital meter for output current

c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from (-) 4 V to 0 V and shall have cl. 0.5 accuracy.

e) Digital meters for measuring Vrs, Vpm, Vpn and Vas/las settings.

f) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 If specified, CPPSM shall incorporate provision for remote monitoring of the unit through SCADA system as below:

a) Potential free contacts for the following:

- All the reference cells failed. (Contact open on alarm condition)
- Pipeline overprotected. (Contact open on alarm condition)
- Pipeline under protected. (Contact open on alarm condition)
- System in auto-mode. (Contact close in auto condition)
- System in CVCC mode. (Contact close in CVCC mode)

b) 4 to 20 mA electrically isolated signal for the following:

- PSP (-4V to OV)
- CPPSM output voltage
- CPPSM output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2 kV, 50 Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving upto 600 ohms load impedance located upto 500 m away and wired with 0.5 mm- copper conductor cable. The transducers shall be suitable for minimum 125% continuous over load in the input voltage/current parameter.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During fabrication, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 Visual Inspection

This shall include-

- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided and satisfactory.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

7.2.2 Insulation tests

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

Withstand voltage	Control electronics <60V	Power electronics Un_1	Auxiliary circuits Un_2
To earth	700VD.C.	$2xUn_1$ + 1000V	$2xUn_2$+ 1000V
To control electronics	-	$2xUn_1$+ 1000V	$2xUn_2$+ 1000V
To power electronics	$2xUn_2$+ 1000V	-	$2xUn_2$+ 1000V
To auxiliary circuits	$2xUn_2$+ 1000V	$2xUn_1$ + 1000V	-

(Un, and Un_2 are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

7.2.3 **Heat run test**

All CPPSMs shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPPSM of each rating shall be loaded to its rated output throughout 16 hour test period. All other CPPSMs shall be energized under partial load or zero load current condition throughout the test period.

7.2.4 **Functional tests**

Functional tests as below shall be performed on each CPPSM. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

7.2.4.1 **CVCC mode operation testing**

a) **Constant voltage operation**

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b) **Constant current operation**

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input voltage, current, ripple in the output, input, evaluation of output current regulation of the unit shall be carried out during the testing.

7.2.4.2 **Auto PSP mode operation**

Suitable set-up shall be arranged for output loading and reference cell feedback. The closed loop performance and regulation shall be checked with the PSP set voltage varied from 0.85V to 1.2V.

Disconnecting the reference cell feedback connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/las provided inside the CPPSM. The settings on Vas/las shall be varied and the output voltage/current shall be observed.

7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPPSM. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPPSM.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the power semiconductor device, the protection of same shall. be tested as below:

A switch rated for making and carrying CPPSM output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as

'Fragile', 'This side up', 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.

TECHNICAL SPECIFICATION

CATHODIC PROTECTION TRANSFORMER RECTIFIER UNIT

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
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1.0 SCOPE

This specification covers the requirements for the design, manufacture and testing of Cathodic Protection Transformer Rectifier units (CPTR units) working on controlled rectification principle intended to supply power to cathodic protection system for underground pipelines/ structures.

2.0 CODES AND STANDARDS

2.1 The system design, performance and materials to be supplied shall conform to the requirements of the latest revision of following standards:

IS: 1248 (Parts-I, 2, 8 & 9)	Direct acting indicating analogue electrical measuring instruments and accessories.
IS: 3700 (Parts-I to 11)	Essential rating and characteristics of semiconductor devices
IS: 3715 (Parts-I to 4)	Letter symbols for semiconductor devices
IS: 4411	Code of designation of semiconductor devices.
IS: 5469 (Parts-I to 4)	Code of practice for the use of semiconductor junction devices.
IS: 6619	Safety code for semiconductor rectifier equipment.
IS:7204 (Parts-I to 4)	Stabilized power supplies DC output
IS: 12021 (Parts-I to 4)	Control transformers for switchgear and control gear for voltages not exceeding1000 V AC.
IS: 13703 (Parts-I to 4)	Low voltage fuses for voltages not exceeding 1000 V AC or 1500 V DC.
IS: 13947 (Parts-4, section-I)	Low voltage switchgear and control gear.

2.2 In case of imported equipment, standards of the country of origin shall be applicable if these standards are equivalent or stringent than the applicable Indian standards.

2.3 The equipment shall also conform to the provisions of Indian Electricity rules and other statutory regulations currently in force in the country.

2.4 In case of any contradiction between various referred standards/ specifications and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.
- Codes and standards

3.0 SITE CONDITIONS

The CPTR unit shall be suitable for installation in non air-conditioned room with restricted ventilation or in outdoor kiosk, in locations having generally corrosive, warm, humid and dusty atmosphere. Service conditions shall be as actual site conditions. If not specifically mentioned therein, a design ambient temperature of 45°C and an altitude not exceeding 1000 m above mean sea level shall be considered

4.0 GENERAL REQUIREMENTS

4.1 The offered equipment shall be brand new with state of art technology and proven field track record. No prototype equipment shall be offered.

4.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply.

4.3 Vendor shall give a notice of at least one year to the end user of equipment and PDIL before phasing out the product/spares to enable the end user for placement of order for spares and services.

5.0 TECHNICAL REQUIREMENTS

5.1 Fabrication and General Details

5.1.1 CPTR unit shall be housed in sheet steel enclosure. The front, rear walls and doors shall be made by using minimum 2 mm thick sheet steel and side walls shall be made of minimum 1.6 mm thick sheet steel. Wherever required, suitable stiffeners shall be provided. The Unit shall be freestanding type. Hinged doors shall be provided at the front and back as required. The unit shall be natural cooled type. Louvered openings with wire mesh for natural ventilation may be provided. Degree of protection for the panel shall be minimum IP-41. The CPTR unit panel shall, preferably, not need rear access for operation, maintenance and shall be suitable for mounting flushed to the wall.

5.1.2 Suitable hooks shall be provided for lifting the panel. These hooks when removed shall not leave any hole in the panel or imperfection in the paint finish.

5.1.3 All instruments shall be panel mounted type and back connected. All fuses shall be provided inside the panel and shall be of link type. 660 V grade PVC insulated BIS approved wires with stranded copper conductor of size minimum 2.5 mm^2 shall be used for power and auxiliary wiring. Control wiring for electronic circuits shall be through flat ribbon cable or through copper wire of minimum 0.5 mm diameter. All wirings shall be ferruled with PVC ferrules at both ends for ease of identification. Clamp type terminals suitable for termination up to 10 mm conductor shall be provided for all control cable connection. Suitable power terminals shall be provided for power cables. Minimum 20% spare terminals shall be provided. The terminal blocks shall be mounted minimum 300 mm above the gland plate.

5.1.4 All live parts shall be properly shrouded. This shall ensure complete safety to personnel intending routine maintenance by opening the panel doors.

5.1.5 CPTR unit shall be suitable for bottom cable entry unless otherwise specified and shall be supplied complete with crimping type cable termination lugs and cable glands. Cable glands shall be of brass, nickel plated, single compression type for indoor installations and double compression type for outdoor installations. The space in the terminal chamber shall be adequate for. termination of required number and sizes of cables.

5.1.6 The input power factor of the unit at rated load shall be 0.8 lag or better.

5.1.7 The CPTR unit shall be field proven. The design, internal component layout and rating of component shall ensure high MTBF and low MTTR. Prototype equipment shall not be acceptable.

5.1.8 All the control equipment like switches, pushbuttons, potentiometers etc. shall be located at a convenient height of minimum 300 mm and maximum 1800 mm from the bottom of the panel .

5.1.9 The printed circuit boards (PCBs) shall be of copper clad glass epoxy laminate. PCB tracks shall be tinned and solder masked. The PCB shall be coated with suitable lacquer to make it immune to dust, moisture and fungal growth. Where plug in type of PCBs are used gold plated male-female connectors shall be used for the purpose.

5.1.10 The panel shall be provided with space heater to prevent moisture condensation. The space heaters shall be located at the bottom of the panel. and shall be provided with a manually operated switch, HRC fuse and link for phase and neutral respectively. The space heater shall have porcelain connectors. Where space heater is not provided the electronic PCBs/components and other control devices shall be made immune to moisture condensation.

5.1.11 Panel shall be provided with integral base frame channel. The integral base frame of panel shall be suitable for directly bolting with the help of foundation bolts and shall also be suitable for tack welding to purchaser's insert plate/flat/channel embedded in the floor. Amply dimensioned oblong holes shall be provided at the bottom of the panel for its bolting to the embedded insert plate/channel.

5.1.12 An earth bus bar of minimum (25 x 3) m^2 copper or equivalent aluminium shall be provided throughout the length of the panel. Provision shall be made for connecting this earth bus at two ends with the plant earth grid by means of (40x5) mm- GI flat. All non-current carrying metallic parts of the panel and mounted equipment shall be connected to the panel earth bus. All doors and movable parts shall be connected to the earth bus by flexible copper cables.

5.1.13 All panel mounted equipments (e.g. lamps, pushbuttons, switches, meters, PCBs, etc.) shall be provided with suitable nameplates. Nameplates shall be engraved out of 3-ply (black-whiteblack) lamicoid sheets or anodised aluminium. Back-engraved Perspex sheet nameplates may also be acceptable. Engraving shall be done with groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable. Nameplates shall be fastened by screws and not by adhesive. Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel.

5.1.14 Where specified, the CPTR unit shall be housed in an outdoor kiosk. The kiosk shall be made of sheet steel of minimum 3 mm thick and epoxy painted on both internal and external surfaces. Hinged lockable doors shall be provided at the front and back. The kiosk shall be suitable for outdoor mounting and shall give proper protection to the CPTR unit against rain, other harsh weather conditions. Necessary ventilation arrangement with louvers and wire mesh shall be provided for proper operation of the CPTR unit. The cable entry to the kiosk shall be from bottom through cable glands. Suitable canopy shall be provided on the top of the Kiosk.

5.1.15 **Painting**

All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt.

Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be prepared by applying a coat of phosphate paint and a coat of yellow

zinc chromate primer. The under surface shall be made free from all imperfections before undertaking the finishing coat.

After preparation of the under surface, the panel shall be spray painted with two coats of final paint or shall be powder coated. Colour shade of final paint shall be approved by the purchaser before final painting is started. The finished panels shall be dried in stowing ovens in dust free atmosphere. Panel finish shall be free from imperfections like pin holes, orange peels, run off paint, etc. All unpainted steel parts shall be suitably treated to prevent corrosion. If these parts are moving elements, then they shall be greased.

6.0 EQUIPMENT DESCRIPTION

The CPTR unit shall be complete with following main sections:

- Transformer and input controls.
- Rectifier and filter
- Output protections
- System controls
- Control, indication and metering

6.1 Transformer and Input Controls

6.1.1 The transformer shall be natural cooled dry type with separate primary and secondary windings.

An intermediate earth screen shall be provided between primary and secondary windings. CPTR Units having multiple output circuits shall have separate secondary windings for each output circuit. Transformer shall be vacuum impregnated with epoxy varnish and baked. The safety factor for transformer rating shall be minimum 125%.

6.1.2 Single-phase transformers may be provided up to 50V, 50A DC output rating of the CPTR units. Beyond this rating, 3 phase transformers shall be provided. A moulded case circuit breaker with thermal over load and short circuit release shall be provided at the input of the transformer. Miniature circuit breaker with thermal overload and short circuit release in place of moulded case circuit breaker may be provided, where the miniature circuit breaker rated for the incoming AC supply short circuit current.

6.2 Rectifier and Filters

6.2.1 The rectifier shall be made of thyristors and diodes as basic components. The CPTR unit shall be suitable for 415 V AC, 3-ph power supply. Rectifier shall be 3 phase full wave type and controlled type. For CPTR units rated 50V, 50A DC or less, the unit may be suitable for 240V AC, 1 ph power supply and the rectifier shall be full wave type and controlled type. Alternatively, for single phase AC CPTR units, diode rectifier of full wave type in the secondary of the transformer and triac or back to back connected thyristors in the transformer primary AC supply circuit may be provided. The current and voltage ratings of thyristors, diodes shall be at least two times the actual maximum device current and minimum two times the actual maximum voltage coming across the device respectively. The thyristors/ triac/ rectifier elements shall be protected against voltage surges coming from the incoming power supply and from output side from the pipeline. Required shunt zeners / MOV shall be provided across the rectifier elements for protection.

The rectifier elements shall have humidity/moisture resistant finish and mounted in sufficiently sized heat sink designed to provide adequate cooling under worst conditions of operation. The rectifier elements shall have adequate protection against high dv/dt and di/ dt. 6.2.2 The thyristors/triacs shall be protected by semiconductor fuses. For units rated 50V, 50A DC or less, if the thyristors or triacs are adequately over rated and system has enough inductance so that in case of sudden output short circuit the over current limit feature comes into action before short circuit current rises beyond the rating of the thyristors/triacs, then the semiconductor fuses may not be provided. This feature shall be demonstrated during testing of the unit at works.

6.2.3 Adequate filtering shall be provided on the DC output of the rectifier to limit the ripple content in the output to less than 5% at rated output.

6.2.4 The rectifier system shall be of natural air cooled type.

6.2.5 For CPTR units with multiple output circuits, each output circuit shall have independent rectifier and filter.

6.3 **Output Protections**

Two pole moulded case circuit breaker or miniature circuit breaker (if available) rated for the DC output current, short circuit current and having thermal over load, short circuit release shall be provided in the output. A lightning arrestor rated for minimum 10KA impulse current discharge capacity and rated voltage & maximum spark over voltage rating suitable to protect the CPTR unit components against lightning and switching surges shall be provided at the output. For CPTR units with multiple output circuits, each output circuit shall be provided with circuit breaker and lightning arrestor.

6.4 **System Controls**

6.4.1 The CPTR unit shall have two distinct modes of operation (independent for each output circuit) as below:

a) **Constant Voltage and Constant Current Mode (CVCC)**

In this mode the output voltage of CPTR unit shall be continuously adjustable from O.5V DC to the rated output voltage. The set output voltage (Vos) shall remain constant irrespective of output current. Current limit feature shall be provided. The current limit (los) shall be continuously adjustable from zero to rated output current.

For constant voltage mode of operation the output current limit shall be set at maximum and output voltage setting shall be varied. Irrespective of output current demand the chosen value of the output voltage shall be maintained by the control system till the current limit is reached. After that the output current limit shall be maintained and output voltage shall decrease to keep the current constant.

For constant current mode of operation the output voltage shall be set at maximum and output current shall be varied through varying the setting of output current limit. Irrespective of output voltage requirement the control system shall maintain the output current to the set current limit value till the voltage limit is reached. After that the output voltage limit shall be maintained and output current shall decrease to keep the voltage constant.

b) **Auto PSP Mode**

In this mode of operation the output of the CPTR unit shall operate in an external closed loop with pipe to soil potential (PSP), measured by reference cell, in feedback loop. The CPTR unit control shall adjust the output voltage such that the PSP as measured by reference cell always remains equal to the set potential on the unit. The set potential (Vps) shall have high long time stability and minimum temperature drift. The set potential shall be continuously adjustable over the range required.

The unit shall be designed to operate with number of reference cells connected to it (to be provided by others). In case of more than one reference cell being specified, CPTR unit shall have feature to automatically select the reference cell having less negative potential than the others and use the same for auto control of the unit (e.g. (-) 0.8 V is less negative than (-) 0.9 V). Adequate hysterisis shall be provided in selecting the less negative potential reference cell, to avoid hunting between the reference cells at change over conditions.

In case of open circuit or short circuit of reference cell or potential being less negative than a minimum set potential (Vrs), the unit shall sense these conditions as reference cell failure and shall automatically switch over to the other healthy reference cell for control. Should fault occur in all the reference cells, the output voltage or current of the CPTR unit shall adjust automatically to a preset value (Vas/Ias), which shall be adjustable.

In both CVCC and auto PSP modes of operation a fast acting electronic over current limit protection shall be provided. This protection shall be fast enough to protect the active devices of the unit and fast enough to act before tripping of MCCB/MCB or blowing of fuse.

6.4.2 The unit shall continuously monitor the PSP and necessary annunciation shall be provided in case of PSP either exceeding the specified maximum limit (Vpm) or remaining lower than the specified minimum limit (Vpn).

6.4.3 The output voltage regulation for no load to full load variation with input voltage variation from maximum to minimum shall not be more than 2.5 % of rated voltage throughout the range of output voltage and over the specified ambient temperature variation, in CVCC-constant voltage mode of operation. In auto PSP mode the closed loop PSP regulation for no load to full load variation with input voltage variation from maximum to minimum and PSP feedback varying over the specified range shall be within Zf mV.

In CVCC- constant current mode 'of operation, the current regulation for minimum to maximum output voltage and minimum to maximum variation in input voltage shall not be more than 2.5% throughout the range of output current.

6.4.4 The DC output of the CPTR unit shall be floating (ungrounded) in the Unit. However the CPTR Unit shall allow grounding of positive output terminal through the anode ground bed.

6.4.5 For CPTR units with multiple output circuits, each output circuit shall have independent control system.

6.5 Current Interrupter

6.5.1 A current interrupter for CPTR Unit output current interruption shall be provided.

6.5.2 The current interrupter shall have an output contactor with current rating minimum 125% of the output current rating of the CPTR unit and a digital timer to operate it.

6.5.3 The timer shall have 'ON' and 'OFF' timings. When the timer is turned on the 'ON' timing shall start and shall close the output contactor till the end of the 'ON' timing. At the end of the 'ON' timing the 'OFF' timing shall start and keep the contactor open till the end of the 'OFF' timing. At the end of the 'OFF' timing the 'ON' timing shall start again and close the output contactor. This process of 'ON' and 'OFF' timing shall continue.

6.5.4 The 'ON' and 'OFF' timings of the timer shall be settable by separate 2 digit thumbwheel switches, each settable from I to 99 seconds. The timing error of the timer shall be less than 5 parts per million. In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

6.5.5 Whenever the timer is switched on it shall always start with ON 'timing'. A timer-reset push button shall be provided. On pressing this pushbutton during operation of the timer, the timer shall get reset and upon release of the button the timer shall restart with 'ON' timing.

6.5.6 The power required for operation of the timer and contactor shall be derived from the main power supply to the CPTR unit.

6.5.7 The following controls and indications shall be provided for current interrupter. The controls shall be housed in a lockable cover, so that normally they are not accessible. The indications shall be mounted on the door.

a) Controls
- Timer power 'ON' / 'OFF'
- Timer reset
- Thumb wheel switch for 'ON' timing
- Thumb wheel switch for 'OFF' timing

In case of microprocessor based system keypad with display may be provided in place of thumbwheel switches.

b) Indications(LED)

- Timer power 'ON'
- 'ON' timing
- 'OFF' timing

6.5.8 The output contact of the current interrupter contactor shall be wired in the positive DC output of the CPTR unit. A link shall be provided for shorting these terminals whenever the current interrupter is not in use.

6.5.9 The current interrupter shall be an independent unit of portable type. The interrupter unit shall have terminals for input power supply and terminals of the output contactor. The input power supply and the rating of the output contactor shall be as required. Terminals shall be provided in the CPTR unit for taking power supply to the current interrupter.

6.5.10 Where the current interrupter is not specified with CPTR unit or is specified as portable type external to the CPTR unit, then the CPTR unit shall have provision/ terminals for connection of input power supply and output contacts of external current interrupter, for current interruption test. A link shall be provided for shorting the output terminals provided in CPTR unit whenever the current interrupter is not connected.

6.5.11 For CPTR units with multiple output circuits, each output circuit shall have independent current interrupter.

6.6 Controls, Indication and Metering

6.6.1 Following controls shall be provided on CPTR unit front door.

a) ON/OFF control for input through MCCB/MCB.

b) ON /OFF control for output through MCCB/MCB.

c) Auto/CVCC mode selector switch.

d) Potentiometers for Vos, Vps and los settings.

e) Selector switch for selecting indication of PSP set and PSP actual for all the reference cells.

6.6.2 Following controls shall be provided inside the module at user accessible common location:

a) Potentiometer for Vrs, Vpm, Vpn and Vas/las settings.

b) Controls for current interrupter:

- Timer power 'ON' / 'OFF'
- Timer reset
- Thumb wheel switch for 'ON' timing
- Thumb wheel switch for 'OFF' timing

6.6.3 TR unit shall have following indicating lights (lamps or minimum 5 mm dia LEDs):

a) CPTR unit ON/OFF

b) Unit in auto/CVCC (2 lamps)

c) Reference cell controlling the closed loop control of the CPTR unit (number of lamps same as number of reference cells).

d) Reference cell faulty (number of lamps same as number of reference cells).

e) Pipeline over protected.

f) Pipeline under protected

g) Indications for current interrupter:

- Timer power 'ON'
- 'ON 'timing
- 'OFF' timing

It shall be possible to switch-off all the indication lamps by a single switch. In case of LED indication lights this facility may not be provided.

6.6.4 Following meters having min cl.1.5 accuracy shall be provided on the CPTR unit:

a) Digital meter for output voltage

b) Digital meter for output current

c) Digital voltmeter to measure PSP set (Vps) and PSP actual for all the reference cells. The meter shall have range from -4 V to 0 V and shall have cl.0.5 accuracy.

d) Digital meters for measuring Vrs, Vpm, Vpn and Vas/las settings.

e) Meters for input voltage and current

It shall be possible to switch-off all the digital meters preferably by a single switch.

6.6.5 CPTR unit shall incorporate provision for remote monitoring of the unit through SCADA system as below:

a) Potential free contacts for the following:

- All the reference cells failed. (Contact open on alarm condition)
- Pipeline overprotected. (Contact open on alarm condition)
- Pipeline under protected. (Contact open on alarm condition)
- System in auto-mode. (Contact close in auto condition)
- System in CVCC mode. (Contact close in CVCC mode)

b) 4 to 20 mA electrically isolated signal for the following:

- PSP (-4V to OV)
- CPTR unit output voltage
- CPTR unit output current

The transducers shall have electrical isolation between input and output. The isolation insulation shall withstand 2kV, 50Hz for minimum 1 minute. The accuracy class of the transducer shall be 0.5. The transducers shall be protected against input and output voltage surges. The transducer shall be suitable for driving up to 600 ohms load impedance located up to 500 m away and wired with 0.5 mm? copper conductor cable.

6.6.6 For units having multiple outputs, each output circuit shall have independent controls, indication and metering.

7.0 TESTS AND ACCEPTANCE

7.1 During manufacture, the equipment shall be subjected to inspection by owner or his authorised representative to assess the progress of the work as well as to ascertain that only quality raw materials are used for the same. He shall be given all assistance to carry out the inspection.

7.2 Final acceptance test shall be carried out at manufacturer's works under his care and expense. Instruments and equipments required for testing shall be arranged by manufacturer. Owner's representative shall be given minimum 2 weeks prior notice for

witnessing the tests. Test certificates indicating test results shall be furnished by the manufacturer. Acceptance tests shall include but not be limited to the tests listed below.

7.2.1 **Visual Inspection**

This shall include-

- Completeness of the equipment in line with specification.
- Checking of all settings.
- All labels provided.
- Dimensional checking.
- Proper mounting of components and neatness of wiring etc.
- Model number.

7.2.2 **Insulation tests**

The voltage specified in the table below shall be applied for one minute to the circuits indicated:

Withstand voltage	Control electronics <60V	Power electronics Un_1	Auxiliary circuits Un_2
To earth	700VD.C.	$2xUn_1$ + 1000V	$2xUn_2$+ 1000V
To control electronics	-	$2xUn_1$+ 1000V	$2xUn_2$+ 1000V
To power electronics	$2xUn_2$+ 1000V	-	$2xUn_2$+ 1000V
To auxiliary circuits	$2xUn_2$+ 1000V	$2xUn_1$ + 1000V	-

(Un, and Un_2 are nominal voltage rating of power electronics and auxiliary circuits respectively).

D.C. test voltages may be applied instead of A.C. The magnitude of D.C. test voltages to be applied shall be 2 times the above-mentioned A.C. (r.m.s) Values.

Insulation resistance test shall be conducted before and after heat run test.

7.2.3 **Heat run test**

All CPTR units shall be subjected to a heat run test performed at rated voltage for period not less than 16 hours prior to execution of functional tests.

At least one CPTR unit of each rating shall be loaded to its rated output through out 16 hour test period. All other CPTR units shall be energized under partial load or zero load current condition throughout the test period.

7.2.4 **Functional tests**

Functional tests as below shall be performed on each CPTR unit. If during execution of functional tests, any electronic component of the unit is required to be replaced e.g. due to malfunction or failure of the unit to fulfil the performance requirements of the specification, then the load test shall be repeated at rated current following which functional tests shall be carried out.

7.2.4.1 **CVCC mode operation testing**

a. **Constant voltage operation**

During the test, current limit shall be set to rated output current. Performance testing shall be carried out for various output voltage settings and load varying from zero to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output voltage regulation and efficiency of the unit shall be carried out during the testing.

b. **Constant current operation**

During the test, voltage limit shall be set to rated output voltage. Performance testing shall be carried out for various output current limit settings and load resistance varied to achieve output voltage from minimum to maximum. The verification of operation of the control functions, measurement of output voltage, current, input AC voltage, current, power factor, ripple in the output, evaluation of output current regulation of the unit shall be carried out during the testing.

7.2.4.2 **Auto PSP mode operation**

Suitable set up shall be arranged for output loading and reference cell feedback. The closed loop performance and regulation shall be checked with the PSP set voltage varied from O.85V to 1.2V.

Disconnecting the reference cell feedback connection in the above set up shall simulate the reference cell failed condition. The output voltage/current of the unit shall go to the value set on the potentiometer Vas/las provided inside the CPTR UNIT. The settings on Vas/las shall be varied and the output voltage/current shall be observed.

7.2.4.3 Operation of sensors for pipeline over protection, under protection, reference cell failure and reference cell selection logic in auto PSP mode shall be verified by connecting variable external voltage sources to reference cell inputs of the CPTR unit. The number of external voltage sources shall be same as number of reference cell inputs specified for the CPTR unit.

7.2.4.4 The unit shall be checked for operation of the current limit by over loading the unit in both CVCC and auto PSP modes of operation. For Units where semiconductor fuses are not provided for protection of the thyristors/triacs, the protection of same shall be tested as below:

A switch rated for making and carrying CPTR unit output short circuit current shall be connected to the output terminals of the unit. The output voltage and the output current limit settings of the unit shall be set to the maximum rated values. The switch connected in the output shall be shorted quickly.

The unit shall go to current limit mode and shall not damage any active component of the unit.

7.2.4.5 The current interrupter shall be tested for time interval settings and specified operation.

8.0 PACKING AND DESPATCH

The equipment shall be properly packed for selected mode of transportation i.e. by ship/rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up' , 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., P.O. Nos. etc.

The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains/high ambient temperature.

TECHNICAL SPECIFICATION

FIRE DETECTION AND ALARM SYSTEM

CONTENTS

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Abbreviations:

BIS	Bureau of Indian Standards
BASEEFA	British Approvals Service for Electrical Equipment in Flammable Atmosphere
CCE	Chief Controller of Explosives
CFAP	Central Fire Alarm Panel
CMRI	Central Mining Research Institute
CPU	Central Processing Unit
DGFAP	Data Gathering cum Fire Alarm Panel
ERTL	Electronic Regional Test Laboratory
FAT	Factory Acceptance Tests
FDD	Floppy Disk Drive
FM	Factory Mutual
FRP	Fibre Reinforced Plastic
FO	Fibre Optic
GUI	Graphic User Interface
HAB	Hooter acknowledgement box (to mute hooters)
HDD	Hard Disk Drive
ISDN	Integrated Service Digital Network
ITU-T	International Telecommunication Union- (Telecom)
LED	Light Emitting Diode
LPC	Loss Prevention Council
LIFO	Last In First Out
MCP	Manual call point (break glass unit; BGU)
MMI	Man Machine Interface
MR	Material Requisition
Ni-Cd	Nickel Cadmium (battery)
PO	Purchase Order
RF	Radio Frequency
SAT	Site Acceptance Tests
SOE	Sequence Of Event
TAC	Tariff Advisory Committee
UWL	Under Writers Laboratory
UPS	Uninterrupted Power Supply
VRLA	Valve Regulated Lead Acid (battery)
WP	Weather Proof
ZFAP	Zonal Fire Alarm Panel

1.0 SCOPE

1.1 The intent of this specification is to define the functional and design requirements for an Integrated Fire Alarm System for industrial plants and buildings. This specification covers the requirements for selection, design, and engineering, manufacture, testing at vendor's works, supply, installation, testing at site and commissioning of the system.

1.2 The Integrated Fire Alarm System shall be microprocessor based analog addressable system comprising of MCP, detectors, microprocessor based Fire Alarm panels, panels, hooters, sirens, exit signs, Loop / network / power cables, earthing, Junction box & associated equipments detailed hereunder and as per codes standards mentioned below and in Project data sheets / drawings.

1.3 The fire alarm system shall integrate

2.0 CODES AND STANDARDS

2.1 The system and equipment shall comply with relevant BIS (Bureau of Indian Standards) and other Indian/ International standards, as applicable. In case Indian standards are not available for any equipment, standards issued by IEC / BS / VDE / IEEE / NEMA / NFPA or equivalent agency shall be applicable. In case of imported equipment, the standards of the country of origin shall be applicable if these standards are equivalent or more stringent than the applicable Indian standards.

2.2 The equipment shall also conform to the special requirement/ provisions of applicable statutory regulations currently in force in the country.

2.3 In case of any contradiction between various referred standards/ specifications and statutory regulations, the following order of decreasing priority shall govern:

- Statutory regulations
- This specification
- Codes and standards

2.4 The fire alarm system and the components used shall conform to the latest edition of the following and also the other Indian and International Standards as applicable.

IS-5	Colours for ready Mixed Paint & Enamels.
IS - 513	Specification for cold rolled low carbon steel sheets and strips
IS/IEC: 60079	Flameproof enclosures for electrical apparatus
IS - 1646	Code of practice for fire safety of buildings (general): Electrical Installations
IS - 2175	Specification for heat sensitive fire detectors for use in automatic fire alarm system
IS - 2189	Code of practice for selection; installation and maintenance of automatic fire detection and alarm system.
IS - 3034	Code of practice for fire safety of Industrial buildings: Electrical generating and distributing stations

IS - 3700	Essential ratings and characteristics of semi conducting devices (Applicable parts)
IS - 3826	Connectors for frequencies below 3 kHz General requirements Part-I and tests
IS/IEC: 60079	Code of practice for the use of semi-conductor junction devices (Applicable parts)
IS - 5780	Specification for Intrinsically safe electrical apparatus and circuits
IS - 11360	Specification for smoke detectors for use in automatic electrical fire alarm system.
IS - 12459	Code of practice for fire safety in cable runs
IS - 13346	General requirements for electrical apparatus for explosive gas atmosphere
IS-14154 Part 2	Electrical apparatus with protection of enclosure for use in the presence of combustible dust
NFPA 72 Vol 4	National Fire Alarm code
LPC	Loss prevention council recommendations.
BS - 5839	Specifications for manual call points.
BS-EN 50081-1	EMC (Electromagnetic compatibility test)
BS-EN 50082-1	EMC (Electromagnetic compatibility test)

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of the art technology and a proven field track record. No prototype equipment shall be offered.

3.2 Bidder shall consider adequate nos. of Fire Alarm panels which shall be located at plant and control room of building/substation.

3.3 Bidder shall also consider repeater panels (min. 3 nos.) which shall be installed in fire station. All the fire alarm and repeater panels shall be connected in ring network.

3.4 Repeater panel shall be replica of main fire alarm panel.

3.5 Minimum 3 nos. Siren shall be provided with 5 Km audio range.

3.6 In case of a Fire alarm initiation by a alarm initiating device, the audio-visual fire alarm shall be generated at Fire Alarm Control Panels (FACP) located at each substation & building and repeater panels for each Fire Alarm panel at Fire safety station as well as in CCR which also initiate signal to operate hooters/siren located in various locations in building and plant area.

3.7 The Fire Alarm System envisaged for Building shall be “2-Wire Analog Addressable” type.

3.8 The communication between detectors and the FACP is by means of digital communication over 2-wire, which further provides power to the detectors, devices & Sounders. There shall be A/D and D/A conversion happening inside the detectors and FACP.

3.9 All the detectors shall be incorporated with microprocessors and shall be provided with Analog to Digital Converter (ADC), which enables the detector to provide linear output corresponding to the quantity of smoke or fire, the detector encounter.

3.10 All types of detectors offered will be of restorable type i.e. suitable for operating a fresh after each actuation on alarm without replace mentor adjustment.

3.11 Detector shall be provided with in-built isolator.

3.12 Redundancy shall be provided at input power supply, processor / controller etc. Loop card shall be hot swappable type.

3.13 The sensitivity of each sensor shall be individually adjusted from the FACP to suit the conditions of each location. Each detector shall have self-test facility, which is monitored in the FACP. Each detector shall have drift compensation.

3.14 The response sensitivity shall also be field adjustable and not only from fire panel over a wide range to suit site shall conditions. It shall be possible to test the sensitivity of a detector in the field. The sensitivity / threshold value of detectors which are cross zoned must be compatible.

3.15 The FACP shall also check each sensor for contamination of dust/dirt and give signal for “Service” in case of accumulation of dust / dirt reaches a preset limit.

3.16 The fire alarm system shall work without any problem both in networked mode and in standalone mode.

3.17 The electronic circuit shall be of solid state and of failsafe design and virtually hermetically sealed to have resistance to humidity and corrosion and to prevent its operation from being impaired by dust and dirt.

3.18 The circuit shall be protected against usual electrical transients, electromagnetic and electrostatic interference (EMI & RFI) present in the Building.

3.19 Reverse polarity or fault in the field wiring shall not damage the detector.

3.20 No moving parts subject to wear & tear shall be provided.

3.21 The system shall have following self diagnostic features:

- Detector cabling shall be completely supervised for open circuit and short circuit and exact location of fault shall be displayed in the panel under Trouble / Faults.
- Un-authorized removal of a detector head from its base shall be supervised to give an alarm on the connected control panel.
- Annunciation shall be provided for DC fuse blown and loss of main AC supply etc.
- Alarm verification features.

3.22 If the Equipments to be located in hazardous areas, then same shall have test certificates issued by recognized independent test house such as CIMFR, ERTL, BASEEFA, VDS. All indigenous equipment shall conform to Indian standards and shall be certified by Indian testing agencies. All equipment (indigenous & imported) shall also have valid statutory approvals e.g. PESO, DGMS as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authority.

3.23 Fire alarm system shall be interfaced with the owner's system.

3.24 The system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically as selected by operator from Fire Alarm panel located at fire station / other buildings.

3.25 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 15 years from the date of supply. The spares shall be available ex-stock with the vendor.

3.26 Vendor shall give a notice of at least one year to the end user of equipment and PMC before phasing out the product / spares to enable the end user to place order for spares and services.

3.27 The vendor shall be responsible for design, engineering and manufacturing of the complete system and equipment to fully meet the intent and requirements of this specification.

3.28 All equipment and accessories required for completeness of the system, whether specifically mentioned or not but considered essential for satisfactory performance, shall be included as a part of the offered system.

3.29 The system integrator shall coordinate with the manufacturers of various bought-out items associated with the system, as required, and shall freely and readily supply all technical information as and when called for.

4.0 DEFINITIONS

4.1 Hazardous Area

4.2 An area in which an explosive gas/ dust atmosphere is present or likely to be present in quantities such as to require special protection for the construction, installation and use of electrical apparatus.

5.0 SYSTEM AND SITE CONDITIONS

All equipment shall be designed to operate with power supply and site conditions as specified below:

5.1 Input Power Supply

5.1.1 Power supply for fire alarm panels shall have battery backup as per IS-2189. Battery AH rating shall be determined on the basis of maintaining the system in normal operation for a period of not less than 48 hours (quiescent condition) and successive full load alarm condition of period not less than 30 min after the failure of normal mains supply.

5.1.2 The switch over from mains to back up, in the event of mains failure, shall be automatic.

5.1.3 Batteries shall be Ni-Cd type. Suitable and adequately rated battery charger shall be supplied as a part of back up battery system.

5.1.4 The secondary power supply capacity required shall include all power supply loads that are not automatically disconnected upon the transfer to secondary power supply.

5.1.5 Battery sizing shall consider the maximum quantity of detector/equipment that can be connected in the loops, as well as 5 hooters and 5 exit signs per loop in Fire Alarm panels. Battery sizing calculations shall be reviewed during detailed engineering and there shall be no cost/time implication for providing adequately sized batteries and chargers of approved rating during the order execution. Separate battery charger shall be provided in case battery charger part of the Fire Alarm panel cannot cater to the boost charging requirement of battery.

5.1.6 An overall ageing factor of 0.8 and a temperature correction factor corresponding to minimum temperature of 5°C shall be considered for battery sizing. The battery calculations shall include a 10 percent safety margin to the calculated amp-hour rating.

5.1.7 Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.

5.1.8 Operation on secondary power shall not affect the required performance of a fire alarm system or supervising station facility. The system shall produce the same alarm, supervisory and trouble signals and indications.

5.1.9 The switch-over from primary source to secondary source, in the event of mains failure, shall be automatic. Battery shall be Ni-Cd type.

5.2 **Site Conditions**

5.2.1 The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.

5.2.2 Unless specified otherwise, fire alarm panels along with associated hardware shall be suitable for installation and operation in a closed building / room with restricted ventilation. Any specific requirements for air conditioned / dust free environment, etc. for the panels, if absolutely necessary, shall be clearly highlighted by the vendor in the offer.

6.0 FIRE ALARM SYSTEM DESCRIPTION

6.1 **General**

6.1.1 Fire alarm system under this specification is envisaged to provide fire monitoring in industrial plants/ chemical plants / plant and non- plant buildings. The system shall be designed to detect incipient fires and generate audio/ visual alarm in case of fire.

6.1.2 The system shall consist of automatic fire detectors and manual call point or break glass unit. Automatic fire detectors shall work on the principle of sensing of smoke, heat or infrared rays. Depending on type of smoke, optical or ionization type detectors shall be used. Detectors shall generally be provided in plant / non-plant buildings. Manual Call Point shall be provided at exit doors of the buildings and at exit route of industrial plants. Number of detectors and break glass unit shall be decided as per guidelines given in applicable codes and standards.

6.1.3 Alarms, if specified, shall be relayed to repeater panel provided in buildings like control rooms / administrative buildings to provide zone wise annunciation. In addition facility shall be provided to actuate siren / hooter.

6.1.4 For integrated fire alarm system where plant-wide large numbers of fire alarm panels are envisaged, these panels shall be integrated to CFAP, which shall be located in fire station or in administrative control room of the building as per the job requirements. The connectivity shall be achieved using data high way or dedicated cable connection from each fire alarm panel to CFAP. Mimic at CFAP shall be provided for fire / fault annunciation on geographical location in addition to the text / LED. If defined, CFAP shall have provision for automatic and manual actuation of plant-wide siren as per operator's choice. Interface with other systems such as telephone exchange / plant's public address system / Pager system shall be provided for communication required for disaster management.

6.1.5 As specified in data sheet, the system shall be provided with siren/s to be located at a suitable location/s in the plant and it shall be actuated manually and automatically.

7.0 ENGINEERING REQUIREMENTS

7.1 Vendor shall design entire fire alarm system including design of system architecture with details of integration, cabling requirement and protocol selection etc. Vendor's scope shall also include basic design and preparation of layouts for fire alarm system for plant/ buildings as specified in the data sheet/ purchase documents.

8.0 ADDRESSABLE FIRE ALARM SYSTEM

8.1 ANALOGUE ADDRESSABLE FIRE ALARM CONTROL PANEL (FACP)

The FACP used in the Building shall confine to the EN54 standards having the following features.

i) FACP provided shall have the capacity to expand from at least loop for Future expansion.

ii) Each loop shall accommodate maximum 250 detectors and devices in any combination with a loop length capable up to 2kms with 2Cx1.5 sq. mm cable. However bidder shall consider maximum number of detectors / MCP / addressable devices in a signal loop shall be 60.

iii) It shall have facility to discriminate between a real fire alarm and false alarms.

iv) FACP will function as fully stand-alone panel& also networked to other FACPs & repeater with peer to peer communication.

v) Each FACP shall have redundant controller to takeover in case of a Failure in the Primary Controller and also redundant loop card for each loop to takeover in case of a Failure in the Primary Loop Card.

vi) Each FACP shall have inbuilt LCD colour touch screen (320*240 pixels) to clearly indicate the location of fire, type of device activated other indications like service requirement of a component etc.

vii) In case of a Loop Card Failure, the FACP shall allow to replace the Loop card without switching off the panel and reprogramming.

viii) The FACP shall be capable of Public Address system integration with the use of RS232 / RS485 module or with the use of relays.

ix) FACPs shall have inbuilt buzzer to alert the personnel in case of maintenance requirement.

x) FACP shall have facilities for sequence of events to happen in case of fire like closing of fire dampers, shutting down supply fans for HVAC, Deactivating the access control system and activating the hooters with the help of a control relay module provided near the system to be activated.

xi) The fire alarm control panel shall be suitable for Class-A type of wiring as per NFPA-72.

xii) The fire alarm control panel shall work on positive sequence as per NFPA-72.

xiii) The fire alarm control panel shall be capable of disabling an individual detector, a group and or zone off or building maintenance purposes. Facility shall be provided on the FACP for simulating the fire condition to enable testing of the various alarm circuits.

xiv) All the fire alarm modules (loop cards, networking cards, and communication card etc.) should be hot pluggable and hot swappable to facilitate easy replacement of faulty modules. All the electronic components shall be compatible to non-air-conditioned environment for working satisfactorily.

xv) The fire alarm control panel normal power supply failure shall be annunciated audio-visually.

xvi) In case of multiple alarms the multiple alarm indication shall be ON. The multiple alarm indication shall be displayed in chronological order.

xvii) FACP shall have the facility such that each detector can be identified as a separate zone.

xviii) The FACP shall be reset only by authorized users after the clearance of a fault.

xix) Whenever there is a third party actuation to happen, like closing of fire dampers, switching off supply / exhaust units etc, the actuation shall happen only when the fire signal is received from two different initiating devices located in a zone connected to different fire alarm panels. The communication between the FACPs shall happen with two pair cables and the fire alarm status of one panel shall be communicated to the second panel in which the control relay module of the third party device is connected to. Inter panel communication is a must and needs to be provided for controlled actuations. All the necessary systems to ensure reliable communications between panels are to be built into the FACPs.

xx) FACP shall have the facility to silence / acknowledge / reset the alarm. Apart from the FACP.

xxi) The FACP shall have FALSE ALARM REDUCTION algorithms like.

- Alarm Verification, Dual Detector / Group Dependency, and Intermediate Alarm Storage to eliminate False alarms due to Dirt / Dust / Disturbance values.
- EMC/EMI Monitoring - Signal-to noise ratio shall be high. To inform the possibility of a false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals etc. The panel shall display the EMI / EMC Current and Average Values reported by the detector. The User / Installer shall have access to this reading during Maintenance (with password protection).

xxii) When fire condition is confirmed, the following sequence of annunciation will take place on the FACP:

Alarm Condition	Audible Alarm	Visual Alarm
First Fire Condition	ON	ON FLASHING / Description of area of fire origin with detector type
Acknowledge (first Alarm)	OFF	ON STEADY
New Fire Alarm Condition (after acknowledge of First alarm)	ON	ON FLASHING
Acknowledge (New fire alarm)	OFF	ON STEADY
Back to normal	OFF	ON STEADY
Reset	OFF	OFF
Reset Before Normal	OFF	ON STEADY

xxiii) System shall provide adequate EEPROM size to store minimum of 200 events fire / fault. The event shall be stored in LIFO structure. All events shall be time stamped. FACP shall have real time clock for event time stamping.

xxiv) Software access for either Zone programming or access to plant / building graphic on monitor shall be password protected. For viewing status of various field devices e.g. fire and fault status password protection shall not be given.

xxv) Fire Alarm & repeater panels shall be certified/ approved by an international approving agency / approving agency of country of origin as applicable.

xxvi) The FACP shall have a process or which shall be of at-least 32 bit, which shall be designed to accept all the input sand process the outputs within the time stipulated by the standards.

xxvii) The CPU shall have the facility to communicate with other FACPs and process the fire signals received from other FACPs to actuate a third party device.

xxviii) The processor shall be designed in such a way that the parameters in the repeater panel shall be refreshed in 1sec.

xxix) The capacity of the processor shall be adequately designed include all input / output signals and various functional requirements.

xxx) It shall have its own, built in advanced microprocessor, sophisticated software and extensive memory for storing the logs of alarms, times and action taken report.

xxxi) Loop module shall have a line length up to 1600m or 3000m depending upon the configuration & cable type. It shall have an LED test button.

xxxii) The loop module shall be encapsulated & shall be hot pluggable.

xxxiii) The front fascia of the loop cards shall be visible for easy identification of faults.

xxxiv) In case of the failure of loop card, it should be replaced without the need of any additional programming.

8.2 **Repeater Panels**

i) These panels shall be required for repeat of alarm in buildings / plant control rooms / Fire station.

ii) It shall be a LCD touch screen same as main panel. The MMI shall be the same as the main Controller.

iii) Repeater panels shall be suitable for Wall mounting which will be displayed from all the major entrances and staircases which will enable the staff and fire fighting personnel to exactly locate the fire.

iv) It shall be compatible to received at a FACPs.

v) Audio visual Alarms during fire shall be generated in case of fire.

vi) All fire alarm panels including repeater panel shall be networked through copper / FO communication cable.

vii) The Power supply to the Repeater Panel shall be drawn from the Fire Panel

viii) The Repeater Panel shall display Messages like Alarm & Fault similar to the Main Panel and shall be accessed only by Authorized Users through a passcode.

ix) The Repeater Panel shall be connected to the Main Panel and other repeater panels in such a way-1 pt Failure in the cable shall not affect the performance and shall intimate the exact location of failure in all Panels.

x) The Repeater Panel shall be equipped with a Key switch that allows Authorized users to Acknowledge / Reset Alarms.

xi) The Repeater Panel shall be equipped with 2 different power inputs. On failure of primary power, the secondary shall take over.

xii) The Repeater panel shall allow the users to login locally or login to the remote FACP.

xiii) The repeater panels shall integrate with the main panels without any additional interface or the bidder shall consider necessary accessories required to complete the system and quote as part of this model.

9.0 INTEGRATION WITH VARIOUS PLANT SYSTEMS

9.1 Fire Alarm System shall have required hardware to have interface with following plant systems as specified in data sheet.

i) Public Alarm Announcement system

ii) Paging and plant intercom systems.

iii) Plant data network

iv) ISDN telephone exchange and pager system

v) Fire suppression system

vi) PLC Data Communication through serial common modbus

vii) Shutdown signals to various air-handling units relative to the zone of fire.

viii) Siren

10.0 PANEL CONSTRUCTION

10.1 Equipment Mounting

10.1.1 All apparatus, display screen, instruments and indicating lamps mounted on the panel front shall be flush mounting type. The external cabling shall not be terminated directly on the base connector of PCBs but shall be terminated on separate terminal block. Further connection to PCBs shall be as per manufacturer's standard. Routine calibration, adjustments, programming and operation shall be accessible from the front of the panel without opening the door. External cabling shall preferably be done from the rear.

10.1.2 Power supply system including battery bank shall be mounted inside the panel.

10.1.3 Doors shall be provided with pistol grip handle with lock. Lamps shall be provided inside the panel to provide adequate light for maintenance of equipments.

10.1.4 Cable entry shall be from bottom unless otherwise specified in the data sheet. Terminal strip shall be provided for incoming / outgoing cables.

10.2 Wiring and Terminals

10.2.1 Wiring within the panel shall be laid in slotted plastic raceways enclosed with cover. Control connections shall be done with 660V grade XLPE insulated wires having stranded copper conductors. 1.5mm^2 size of wire shall normally be used for circuits with control fuse rating of lOA or less. Control wiring for electronic circuits shall be through ribbon cable or through copper wire minimum of 0.5mm dia. Panels shall be supplied completely pre-wired, such that only field termination shall be required at site before it is energized.

10.2.2 PCBs for identical functions shall be interchangeable. PCBs shall be plug in type having pin/edge connectors. PCBs shall be suitable for use in tropical, humid and dusty environment. These shall be protected with anti fungus treatment.

10.2.3 Cables shall be terminated on terminal blocks. Clamp type terminals shall be of spring-loaded, stacking type, mounted on rails. Terminals shall be sized to accept, as a minimum 2.5mm^2 cross section conductors. Not more than one conductor shall be terminated on the outgoing side of each terminal. At least 20 % spare terminals shall be provided in each panel for termination of spare cores of cables.

10.3 Earthing

10.3.1 A common earth bar of minimum 25 x 3 mm. copper or equivalent aluminium shall be provided throughout the length of the panel. All non-current carrying metallic parts of the panel mounted equipment shall be earthed. Flexible jumpers shall connect all doors and movable parts to the earth bus. Two numbers earth lugs shall be provided outside the panel.

10.3.2 The FACPs shall be provided with triplicated earthing terminals on the either side. The grounding terminal G1 shall be for safety grounding, G2 shall be for shield grounding and G3 shall be for signal grounding.

10.4 **Name Plates / Warning plates**

10.4.1 All nameplates for panel shall be engraved out of 3 ply (black-white- black) lamicoid sheets or anodized aluminium. Back-engraved Perspex sheet nameplates will also be acceptable. Engraving shall be done with square groove cutters. Hard paper or self-adhesive plastic tape nameplates shall not be acceptable.

10.4.2 Labels shall be provided for every component on the cards, connecting wires as well as for the terminals in the terminal strip inside the panel. Wiring diagram shall be pasted inside the panel door as required for termination and maintenance.

10.4.3 Special warning plates shall be provided on all removable covers or doors giving access to energized metallic parts above 24 volts.

10.5 Painting

10.5.1 All metal surfaces shall be thoroughly cleaned and degreased to remove mill scale, rust, grease and dirt. Fabricated structures shall be pickled and then rinsed to remove any trace of acid. The under surface shall be made free from all imperfections before undertaking the finishing coat.

10.5.2 After preparation of the under surface, the panel shall be powder coated. The colour shade of final paint shall be as approved by the purchaser. The finished panels shall be dried in dust free atmosphere. Panel finish shall be free from imperfections like pinholes, orange peels, fun-off paint etc.

10.5.3 All unpainted steel parts shall be cadmium plated or suitably treated to prevent rust-corrosion. Moving elements shall be greased.

11.0 AUTOMATIC FIRE DETECTORS AND ACCESSORIES

i) Detectors for microprocessor shall be addressable type. Detectors shall be plug-in type and shall have twist lock action fitting. Multicolour LEDs provided on the detectors shall indicate Normal and Alarm state. Essential features of detectors are indicated as below.

ii) Detectors shall be supplied with mounting bases. Mounting base shall be identical for all type of detectors. Detector housing (body and cover) shall be made up of damage resistant, fire resistant polycarbonate and shall be suitable for either surface or recess mounting. Detector base shall be mounted on Junction boxes having terminals for cable termination. Installation equipment such as GI conduits, GI junction box / conduit box etc. shall also be included in vendor's scope.

iii) Detectors shall be suitable for storage at ambient condition specified in data sheet.

iv) All detectors shall be on the approved list of LPC, VDS approving agency as applicable.

11.1 **Intelligent Addressable Dual Optical Smoke / Heat (Multi-sensor) Detector**

i) The Intelligent Addressable Multi sensor Detector with 2 LED's-Infrared & Blue used and shall confine to the relevant standard shaving the following features.

ii) It shall be combination of Smoke detection and heat detection. The smoke detection system shall work on Light scattering type principle using Infrared & Blue LED's, and the Heat detection system shall be of Rate of rise of temperature and Fixed Temperature.

iii) The Intelligent Addressable Multi sensor Detector shall be of Spot type and Addressable type.

iv) The Intelligent Addressable Multi-sensor Detector shall be addressed either by DIP switches or through Programming from the Panel.

v) The Detector shall monitor EMC / EMI values in the surroundings on a continuous basis and report the current & average values to the panel. The detector and the panel shall together avoid the possibility of false alarm caused due to interferences from sources such as Motors, power cables, Wi-Fi routers, fluorescent lamps, network switches, mobile signals etc.

vi) All the detectors shall have a visible multi-color LED to indicate the healthiness / trouble / alarm condition of the detector. The LED shall be located in such a way that it shall be visible from all the 360 degree from below. In some cases where the visibility of the detector is obstructed by cable trays, false ceiling etc. Facility for connecting the detector to a response indicator has to be present. The response indicator derives the power to glow from the loop.

vii) It shall possess False alarm immunity and a superior signal to noise ratio.

viii) It shall have drift compensation facility built-in.

ix) The detectors shall communicate the ambient reading to the FACP on time to time basis, and the FACP shall make the decision about the current status of the detector, whether it is in fire / pre-alarm / maintenance requirement etc.

x) The detector shall have different levels of sensitivity settings based on the application and room where it is installed.

xi) The detector shall provide a chamber maid plug to blow out the dust / dirt using a blower.

xii) In case of a failure, panel shall allow to replace the detector with the same type without the need of additional programming

xiii) The detector shall be programmed to work as Optical only or Thermal only detectors. It shall a provision to switch off any component (optical or thermal) of the detector.

xiv) The detector shall work with 2 different sensitivity settings at any point of time and the User shall have access to choose the desired settings without programming or Laptop / PC for configuration.

xv) The detector shall change sensitivity settings based on day / night mode or with schedules based on the programming.

xvi) The detector shall have Intermediate Alarm Storage, Dual Detector Dependency, Dual group Dependency features that shall be programmed based on site application.

xvii) The detector shall be capable of detecting both smoldering fires and open fires and shall be EN54 / VdS approved

11.2 **Heat Sensing Cables**

Heat sensing cable shall be analogue type. It shall consist of four copper conductors each covered with a colour coded, negative temperature co-efficient material. The cores shall be twisted together and protected by an outer sheath of high temperature, flame retardant XLPE insulation. External mechanical protection shall be provided over the

sensor cables. Vendor shall provide control unit for each 100 m length of the sensor cable.

11.3 **Manual Call Point (MCP) / Break Glass Unit (BGU)**

i) Manual break glass unit shall be fabricated out of 14-gauge cold rolled sheet steel. Alternately the break glass unit may be made of die cast aluminium alloy such as LM6.

ii) It shall have IP-55 enclosure and weatherproof construction suitable for outdoor installation. The break glass unit shall have a minimum dimension of 100x100x80mm.

iii) The box shall be fabricated in such a way it can be mounted flush to the wall or on the surface without any modification. Two nos. 19 mm knockouts shall be provided at the bottom of the box to facilitate cable / conduit entry. The glass shall cover at least 30cm2 area and shall have a thickness not exceeding 2mm.

iv) The box shall have a push button element kept in pressed condition by a glass sheet fitted in the front of the box.

v) The enclosure shall be painted with fire red colour (shade 536 of IS-5) epoxy painting and an inscription" Break Glass in case of Fire", shall be painted in white letters or riveted on the enclosure by a steel nameplate. A suitable nickel-plated brass hammer, duly chained to the box with stainless steel chain shall be provided with each box for breaking the glass. Each box shall have a distinct identification number boldly painted on it.

vi) One no. blanking plug shall be provided for 5% of the total quantity of MCPs.

vii) Hazardous area Break Glass Units shall meet the requirement of clause 13 of this specification.

11.4 **Response Indicator**

Response indicators shall be provided suitable for wall / ceiling mounting as required. Response indicator shall be provided where the detector is located either above false ceiling or below false floor or where detectors are not directly visible. The response indicators shall be connected to the detectors directly and shall be complete with terminal blocks suitable to accept cables with up to 1.5mm2 copper conductor. In the normal state of detector, the LEO shall flicker, but in the event the detector goes into alarm condition, the LEO shall glow steadily. LEOs shall be red in colour with 5mm dia. as a minimum.

11.5 **Exit signs**

Exit signs shall be fabricated out of 1.6mm thick cold rolled sheet steel. This shall be suitable for wall mounting or suspension from ceiling. Exit signs suspended from the ceiling shall have text / direction printed on both the side of exit sign.

Fire exit shall be displayed by means of 5mm dia. LEDs or backlit text. It shall be powered from the fire alarm panel. Exit sign shall operate on DC power supply.

The exit sign shall be either in red letter on white background or white letter on green background.

Where specified in data sheet, self-luminous exit sign shall be provided.

11.6 **Hooters**

The unit shall consist of solid-state circuitry on a printed circuit board, a loudspeaker and a flashing lamp housed in a weatherproof dust tight, wall mounting type enclosure. The hooter shall, at least, have 102 db (A) output measured at I-meter distance. The unit shall be powered from the fire alarm panel and operate on DC power. In the event of fire, the hooter shall raise pulsating audio alarm and the lamp shall start flashing.

HAB shall be provided at exit doors of buildings to mute the hooters after evacuation.

11.7 **Flashing Lights (Beacon)**

The unit shall consist of solid-state circuitry on a printed circuit board and a red-capped incandescent lamp and audio unit housed in a dust tight, wall / ceiling mounting type enclosure. It shall derive power from the Fire Alarm Panel and shall operate on DC supply.

Flashing lights shall be installed in the enclosed areas where clean agent / CO2 to be released. In the event a signal for clean agent / CO2, release is given, the lamp shall start blinking with a warning sound enabling operating personnel to evacuate the area. The audio unit (hooter) shall have 102 db (A) output measured at 1-meter distance.

11.8 **Fault Isolator**

Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

Fault isolator modules shall be housed in an enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

11.9 **Sirens**

Sirens shall be industrial type with minimum 2.5 km unidirectional range (i.e. 5km diametrical range) against the wind direction.

The decibel level of the siren shall, at least be 132 db(A) at 1 meter, to meet the audibility requirement for the above range. Unless otherwise specified, Sirens shall operate at 240 V, AC supply. Sirens shall be housed in weatherproof enclosure.

Starter shall be DOL and shall be housed in a separate IP55 enclosure suitable for installation indoor/ outdoor.

The siren shall provided with five tones suitable for various conditions as follows:

i) SMALL FIRE: No siren.

ii) MAJOR FIRE: A wailing siren for two minutes.

iii) DISASTER: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of one minutes i.e. (wailing siren 2min + gap 1 min + wailing siren 2min + gap 1 min + wailing siren 2min) total duration of Disaster siren to be eight minutes.

iv) ALL CLEAR (For fire): Straight run siren for two minutes.

v) TEST: Straight run siren for two minutes at frequency at least once a week.

The siren controller shall be as below:

a. The operation of siren shall be in Manual mode with single button operation through Push Buttons - 5 Nos. mounted on the control desk for tone selection.

b. The siren shall be initiated with a single pulse from the Push Button. The logic shall be such that first Push Button pressed shall be accepted till the completion of cycle of that particular siren tone.

c. One no Push Button shall be provided for EMG STOP in case the siren tone is required to be stopped mid way.

The operation of the siren shall also be possible in Auto mode. The arrangement for the same shall be possible from the Fire Alarm panel

11.10 **Clean Agent / CO_2 Release and Inhibit Switches**

This unit is required to be provided at the exit of the protected buildings / rooms. If specified, this unit is integrated with *DGFAP* / ZFAP. This shall consist of pull type release and inhibit switches clean agent / CO2. The unit shall be fabricated out of 2mm thick cold rolled sheet steel suitable for wall mounting. Switches shall be pulled to release or inhibit clean agent / CO_2. Release switches shall have inscription:

"PULL TO RELEASE CLEAN AGENT / CO_2"

And inhibit switches shall have inscription:

"PULL TO INHIBIT CLEAN AGENT / CO_2"

11.11 **Zener Barrier**

11.11.1 Preferably flameproof (Ex'd') equipment that does not require the use of Zener barrier shall be used. When necessary, intrinsically safe (Ex 'i') detectors and MCPs, Zener barriers shall be provided. These shall be located in unclassified / non-hazardous areas.

11.11.2 Normally not more than 10 detectors shall be connected to one zener barrier. However vendor shall indicate maximum number of detectors MCPs that can be connected to one Zener barrier without compromising on working of loop zone. Vendor shall also indicate the maximum loop length from zener barrier considering 1.5 mm^2 copper conductor, screened cable.

11.11.3 In case loop length permits, zener barrier shall be located at DGFAP itself else it shall be located in safe area nearest to the *detector* / MCP.

11.11.4 Wherever zener barriers are provided in safe area outside the Zonal panel or DGFAP, these shall be housed in their own enclosure with IP-55 degree of protection as a minimum.

11.12 **Fault Isolator**

11.12.1 Fault isolator shall be installed, if specified in the data sheet.

11.12.2 Fault isolator shall be designed to provide short circuit protection to an addressable detector loop. It shall be possible to wire the fault isolator at any point in the detector loop.

11.12.3 On occurrence of a fault (short circuit), the isolator shall cut power to all devices installed between the two isolators minimizing the outage of all the detectors in a loop.

11.12.4 The fault isolator shall have the capability to continuously check the faulted side of the loop to determine if the fault still exists. On rectification of the fault, the isolator shall automatically reset itself.

11.12.5 Fault isolator modules shall be housed in a enclosure having IP-55 degree of protection as a minimum. If located in hazardous area, it shall also be tested and approved for use in area classification defined in the data sheet.

12.0 FIELD DEVICES FOR HAZARDOUS AREA

12.1 Hazardous area is classified as Zone 1 / Zone 2, gas group IIA / IIB or IIC, temperature class T3 *(200 DC)* as specified in data sheet. The field devices shall be suitable for installation in hazardous area as per specified area classification.

12.2 Field devices such as detectors, MCPs, fault isolators, Beacons, hooters etc for use in hazardous area, if specified in the data sheet shall have flame proof enclosure conforming to IS 2148. All equipment for hazardous area installation shall be complete with flame proof, weather proof cable glands as specified in clause 11.5.

12.3 Equipment, which cannot have flameproof construction, shall be intrinsically safe in design and shall be used with Zener barriers located in safe area.

12.4 Equipment that are tested / certified by a recognized test laboratory of country of origin shall only be offered. The vendor shall possess valid test certificate issued by a recognized independent test house such as CMRI/ BASEEFA/ VDS for the offered equipment.

12.5 All equipment (indigenous or imported) shall have valid statutory approval as applicable for the specified hazardous location from CCE or any other applicable statutory authority. All indigenous flameproof equipment shall also have valid BIS license and corresponding marking as required by statutory authority.

12.6 A separate name plate shall also be provided on each equipment to indicate details of testing agency, test certificate number with date, statutory approval number with date, approval agency, BIS license number with date, applicable gas group, temperature class etc. The nameplate shall be riveted / fixed with screws and not pasted. In case above information are embossed on the enclosure, the same need not be repeated.

13.0 CABLE AND CABLE ACCESSORIES

a) Supply and laying of FA cables shall be as per the requirement. Vendor shall provide JBs for detectors, BGUs, exit signs, hooters etc as required.

b) Supply and installation and terminations of all cables at both ends shall be in bidder's scope.

c) Bidder, as a part of integration and selection of fire alarm equipment, shall furnish detailed specifications for loop / zone cables, data highway cables, cables for hooter / exit signs etc giving details such as type of cables, number of pairs, size of cable, inductance and capacitance data, number of fibres / connectors etc.

d) Data Cables

Unless specified otherwise, vendor shall supply Copper cable / FO type data communication cable to suit system design and equipment specification. Copper cables, if supplied, shall be of adequate size, twisted pair, XLPE insulated, overall screened, PVC inner sheathed, armoured, FRLS type PVC outer sheathed as the minimum requirement. Fibre Optic cables, if supplied, shall be armoured, overall FRLS PVC outer sheathed and shall be as per ITU-T recommendation as a minimum.

Vendor shall supply and install all hardware and cabling accessories as per data high way design including modems, repeaters etc as part of the FA system. Modems / repeaters shall be powered by the supply provided for Fire Alarm panel.

e) Cable Glands / Accessories

All cable glands / lugs / connectors as required for the equipment shall be included in bidder's scope and shall be supplied along with the system.

All the cable glands for outdoor application shall be weatherproof, nickel-plated brass and double compression type, whereas those for indoor application shall be single compression type.

Cable glands for hazardous area equipments shall be flameproof, weatherproof and nickel plated brass double compression type.

14.0 INSPECTION, TESTING AND ACCEPTANCE

14.1 All the equipment shall be tested to the defined specifications as per mutually agreed test plan / FAT procedure, which shall be submitted and got approved from Purchaser at least one month before inspection. PMC / Purchaser's inspectors shall witness all the tests.

14.2 During manufacture, the equipment shall be subject to inspection as per attached inspection plan to assess the progress of work and to ascertain that the quality controls are being maintained. Vendor shall provide all necessary assistance and information concerning the supply to PDIL / Purchaser's inspectors.

14.3 Tests shall be carried out at the vendor's works under his care and expense and Purchaser shall be informed at least 4 weeks in advance regarding this.

14.4 FAT shall include simulation of operational field conditions and test for functional adequacy. Besides all routine, and acceptance tests specified by applicable codes and standards, shall be performed on the complete system.

14.5 For bought out items, the routine and acceptance tests shall be conducted at the respective equipment manufacturer's works.

14.6 At the time of inspection, vendor shall produce original of all the type test certificates, test and approval certificates for hazardous area equipment from testing and approving authority and any other certificates as required from statutory authority for the review of inspectors.

14.7 Vendor shall submit a SAT procedure for PMC / Purchaser's approval. All equipment and systems shall be tested at site as per the approved SAT procedure.

14.8 SAT shall be conducted by vendor after the entire fire alarm system is installed and inter connected by cables. These tests shall establish the operational correctness of the system. Vendor shall rectify deficiencies noticed during SAT with no commercial implication to Purchaser including replacement of system components and supply of new component for making system successfully operational.

15.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for selected mode of transportation i.e. by ship / rail or trailer. The panels shall be wrapped in polythene sheets before being placed in crates to prevent damage to finish. Crates shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight' etc., shall be clearly marked on the package together with Tag nos., Purchase order Nos. etc. The equipment may be stored outdoors for long periods before erection. The packing shall be completely suitable for outdoor storage in areas with heavy rains / high ambient temperature.

16.0 INSTALLATION AND COMMISSIONING

As installation of the system is included in the scope of the vendor, vendor shall arrange all necessary manpower and equipment required for the same. Commissioning of the complete system is to be carried out by vendor in all cases irrespective of whether the installation was performed by vendor or not. All tools, test equipment etc. for the successful commissioning of the system shall be arranged by the vendor. Only the cabling specifically excluded from vendor's scope shall be installed by others. However, termination at panels for purchaser's cables shall be done by the vendor.

17.0 TRAINING

The vendor shall provide, free of cost, comprehensive training to Purchaser's personnel on various operation and maintenance aspects of the Fire Alarm system as agreed during ordering.

TECHNICAL SPECIFICATION

COMMUNICATION AND FIRE ALARM CABLES

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	SCOPE
2.0	CODES AND STANDARDS
3.0	SITE CONDITIONS
4.0	TECHNICAL REQUIREMENTS -NON JELLY FILLED CABLES
5.0	TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES
6.0	INSPECTION, TESTING AND ACCEPTANCE
7.0	PACKING AND DESPATCH

1.0 SCOPE

The intent of this specification is to define the requirements for design, manufacture and supply of Flame Retardant type PVC sheathed cables for use in plant communication and fire alarm systems and Jelly filled telecommunication cables.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of the latest revision of the following standards issued by BIS and DOT, unless otherwise specified:

2.1.1 **BIS standards:**

IS-7098 (Part-I)	XLPE insulated (heavy duty) electric cables-(Part-I for working voltages up to and including 1100V).
IS-8130	Conductors for insulated cables and flexible cords.
IS-10418	Drums for electric cables.
IS-10462 (Part-1)	Fictitious calculation method for determination of dimensions of protective coverings of cables:(Part-I Elastomeric and thermoplastic insulated cables).
IS-10810 (Part-58)	Methods of test for cables (Part 58. Oxygen Index test).
IS-10810 (Part- 61)	Methods of test for cables (Part 61. Flame retardant test)
IS-10810 (Part-62)	Methods of test for cables (Part 62. Fire resistance test for bunched cables).
IS-12444	Continuously cast and rolled electrolytic copper wire rods for electrical conductors.

2.2 DOT Standards:

GRJWIR-06/03	Specification for cable - switchboard (Screened and Unscreened) Generic Requirements.
G/CUG-O1/02	Specification for solid polythene insulated fully filled, Polythene sheathed underground telecom cables.

2.3 In case of imported cables, standards of the country of origin shall be applicable, if these standards are equivalent to or stringent than the applicable Indian standards.

2.4 The cables shall also conform to the provisions of the Indian Electricity rules and other statutory regulations currently in force in the country.

2.5 In case Indian standards are not available for any material, standards issued by IEC / BS / VDE / IEEE / NEMA or equivalent agency shall be applicable.

2.6 In case of any contradiction between various referred standards/ specifications/ datasheets and statutory regulations the following order of priority shall govern:

- Statutory regulations.
- This specification.

- Codes and standards.

3.0 SITE CONDITIONS

Cables shall be suitable for installation in following conditions:

i. Above ground in open-air locations (trays / ducts) in tropical, humid and corrosive atmosphere prevalent in refineries/petrochemical plants with severe weathering and exposure to solar radiation.

ii. Directly buried in underground trenches, conduits with uncontrolled back-fill and possibility of flooding by water and chemicals.

iii. Unless otherwise specified, the design ambient air temperature of 45° C / ground temperature of 30° C.

iv. Cables shall be operating near electromagnetic radiations due to high voltage installation and other wireless equipments. Adequate screening shall be provided to make build the electromagnetic immunity.

4.0 TECHNICAL REQUIREMENTS -NON JELLY FILLED CABLES

4.1 Conductors

4.1.1 The size of conductor shall be as per job requirement.

4.1.2 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to Cl. 3.0 of DOT specification GR/WIR-06/03. For telecommunication cables conductor shall be 0.5 mm and for PA system conductot dia shall be 0.6 mm as minimum. For fire larm cables size of conductor shall be chosen based on sum of the current drain of all field points in that circuit.

4.2 Insulation

4.2.1 The core insulation shall be with XLPE.

4.2.2 The colours used for insulation shall conform as nearly as practicable to the standard colours as per 18-9938. The wire insulation shall have colours in accordance with Table-2 of DOT specification GR/WIR-06/03. The applied colour shall neither have deleterious effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.

4.2.3 For single pair cables, the colour shall be incorporated in the insulation.

4.2.4 For multi pair cables, cores shall have uniform pattern of continuous spiral (Pitch not exceeding 25mm) to facilitate easy identification. This may be done by the application of one or more coloured strips on a base colour or by direct extrusion.

4.2.5 Alternately, colouring may consist of concentric coloured rings or dots or dashes on the base colour. The coloured rings, dots or dashes shall have a width of not less than 1.0mm and shall be repeated along the length of the insulation at an interval not less than 15mm and not more than 25mm.

4.2.6 The dots or dashes shall be applied on diametrically opposite sides of the insulation, so that all colours are visible when the insulation is viewed from any side.

4.3 **Twisting**

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 80mm.

4.4 Core Formation

The core formation shall conform to C1.6.0 of DOT specification no. GR/WIR-06/03.

4.5 **Screen**

4.5.1 Unless otherwise specified the cables used for fire alarm and detection shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.04mm. The overlap shall be minimum 3mm for cables up to 50 pair & minimum 6mm for cables above 50 Pair. The screen shall be backed by an outer protective layer of 0.13mm PVC tape or other non hygroscopic material lapped applied longitudinally or helically with overlap.

4.5.2 The cables shall be provided with a drain wire. Drain wire shall have a minimum cross-section of 0.5mm^2, shall be composed of multistrand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the overall screen. The drain wire resistance including screen shall not exceed 30 ohm/km.

4.6 **Ripcord**

A non-metallic ripcord of suitable quality shall be laid longitudinally under the inner sheath & screen. The ripcord when pulled shall cut through the sheath and strip the core.

4.7 **Inner Sheath**

4.7.1 An extruded inner sheath of type ST1 PVC, as per IS-5831, with minimum thickness as per Table-4 of IS-1554 (Part-1) shall be applied over the laid up core, by extrusion to fit closely on it.

4.7.2 The inner sheath shall be as circular as possible. It shall be possible to remove the inner sheath without damage to the insulation.

4.7.3 When one or more layers of non-hygroscopic tape is helically applied over the laid up cores, as a binder, the thickness of such tape(s) shall not be construed as a part of the inner sheath.

4.8 **Armour**

4.8.1 The cables shall be provided with armouring, made of hot dip galvanised steel wire /strip over the inner sheath.

4.8.2 The armour shall be by means of *1o4mm* thick round wires for cables with under armour diameter upto 13mm. For cables with an under armour diameter above 13mm, the armour shall either be of steel strip or round wire with thickness as per IS-1554 (Part-1).

4.9 **Outer Sheath**

4.9.1 The cables shall be provided with an extruded PVC FRLS sheath for external protection. The PVC shall be type ST1 PVC, as per IS-5831.

4.9.2 The other sheath shall be with oxygen index 29 at 27±2^{0}C and possess flame retardant properties meeting the requirements of IS 10810 Part-62 category - AF. In addition,

suitable chemicals shall be added to the PVC compound of the outer sheath to protect the cable against rodent and termite attack.

4.9.3 The thickness of outer sheath shall be as per IS-7098 (Part 1).

4.9.4 The outer sheath shall fit tightly on the armour and shall be applied in such a manner that no undue residual strain is left in the material.

4.9.5 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.

4.9.6 Sequential marking of the length of the cable, in meters, shall be provided on the outer sheath at every one meter. The marking shall be legible and indelible by suitable method.

4.9.7 The overall diameter of the cables shall be strictly as per the values declared in the technical information furnished along with the bids, subject to a maximum tolerance of ±2 mm.

4.10 Cable Capacitance

4.10.1 The core to core capacitance of the cables shall not exceed *100nF/Km* at 1KHz.

4.10.2 The core to screen capacitance for the screened cables shall not exceed *250nF/Km* at 1KHz.

5.0 TECHNICAL REQUIREMENTS FOR JELLY FILLED CABLES

5.1 Jelly filled telecom cables shall in general conform to the requirements of DOT specification G/CUG-01/02, unless otherwise specified in this specification.

5.2 Conductors

5.2.1 The conductors shall consist of annealed, high conductivity solid copper wire, smoothly drawn, circular in cross-section, uniform in quality, free from defects and uniformly coated with pure tin and shall conform to cl. 3.0 of DOT specification G/CUG-01/02.

5.3 Insulation

5.3.1 Each conductor shall be insulated with insulating grade PE conforming to C1.4.0 of DOT specification G/CUG-O1/02.

5.4 Twisting

The two insulated conductors of a pair shall be uniformly twisted with a suitable right hand lay, which shall not exceed 150mm.

5.5 Core Formation

The core formation shall conform to C1.6.0 of DOT specification *G/CUG-01/02.*

5.6 Filling Compound

5.6.1 The cable shall be filled with a suitable stable water resistant compound, which shall be compatible with the insulation, binders and tapes used in the cable.

5.6.2 It shall be homogeneous and uniformly mixed material containing an anti-oxidant.

5.6.3 The compound shall not obscure the identification of the colour of the insulation of the conductors.

5.6.4 It shall not contain dirt, metallic particles or other foreign matter.

5.6.5 The compound shall be readily removable from the insulated conductors by wiping.

5.6.6 It shall be free from any unpleasant odour and shall have no toxic or dermatic hazards.

5.6.7 The flash point of the compound shall not be less than 200°C.

5.6.8 The volume Resistivity measured at 100°C shall not be less than 1010 ohm-ern.

5.6.9 The permittivity at 1 MHz tested as per ASTM 0-924 shall not be greater than 2.3 at 20°C.

5.7 **Core Wrapping**

At least one closed helical or longitudinal application of a non-hygroscopic and non-wicking polyester tape or tape of any other suitable material shall be provided over the cable core.

5.8 **Screen**

5.8.1 The cables shall be provided with overall screen. The screen shall be of aluminium tape with minimum thickness of 0.2mm. The overlap shall be minimum 3mm for cables having maximum diameter over inner sheath < 30mm & minimum 6mm for cables having maximum diameter over inner sheath ~ 30mm. The screen shall be coated with 0.05 mm nominal thickness polythene/copolymer on both sides. The thickness of the composite tape shall be 0.3mm±15%.

5.8.2 The aluminium tape shall be electrically continuous throughout the length of the cable.

5.9 **Inner Sheath**

5.9.1 The inner sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.9.2 The inner sheath shall be of polythene conforming to type 03C or H03C of BS 6234 and shall contain a suitable antioxidant system. The material shall be virgin as per ASTM 0-883 and meet the following requirements.

Density 0.910 to 0.940 glee for 03C and> 0.940 glee for H03C

Melt Flow index Maximum 1.0 g/10 minutes (190 °e, 2160 g load)

5.9.3 The thickness of inner sheath shall conform to Table - 6 of DOT specification no. G/CUG01/02.

5.9.4 The maximum diameter over inner sheath shall conform to Table - 7 of DOT specification no. G/CUG-O 1/02.

5.10 **Armour**

5.10.1 The cables shall be provided with bedding and armour over the inner sheath.

5.10.2 The bedding shall consist of two close helical lappings of polythene or polypropylene tape. Each tape shall be applied with a minimum of 5% overlap.

5.10.3 The armour shall be made of hot dip galvanised steel tape of thickness as per Table - 8 of DOT specification G/CUG-01/02.

5.11 **Outer Sheath**

5.11.1 The external protection shall consist of a polythene sheath conforming to the material specification defined in Clause 5.9 above.

5.11.2 The thickness of outer sheath shall conform to Table - 9 of DOT specification G/CUG-01/02.

5.11.3 The outer sheath shall be as circular as possible and free from pinholes and other defects. It shall be possible to remove the inner sheath without damage to the insulation.

5.11.4 The outer sheath shall be grey in colour except for cables to be used for fire alarm system where it shall be red.

5.11.5 The maximum diameter over outer sheath shall conform to Table - 7 of DOT specification G/CUG-01/02.

5.12 Cable Capacitance

The average mutual capacitance of the pairs measured at 800 to 1000Hz shall be 52 ± 3 nF/km.

However, the mutual capacitance of individual pairs shall be within the limits of 52 ±4.5 nF/km.

6.0 INSPECTION, TESTING AND ACCEPTANCE

6.1 The cables shall be tested and examined at the manufacturer's works. All the materials employed in the manufacture of the cable shall be subjected to examination, testing and approval by PDIL/Owner. Manufacturer shall furnish all necessary information concerning the supply to PDIL/Owner's inspectors. The inspector shall have free access to the manufacturer's works for the purpose of inspecting the process of manufacture in all its stages and he will have the power to reject any material, which appears to be of unsuitable description or of unsatisfactory quality.

6.2 The following acceptance tests shall be conducted on the completed jelly filled cables as per the test procedures given in DOT specification G/CUG-01/02 and this specification:

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.

ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.

iii. Measurement of Resistance of conductor.

iv. Measurement of Resistance unbalance.

v. Continuity Check & Measurement of Resistance of Poly-al tape.

vi. Colour coding.

vii. Conductor continuity test.

viii. Mutual Capacitance test.

ix. Capacitance Unbalance test.

x. Cross talk test.

xi. Attenuation test.

xii. Insulation resistance test.

xiii. Dielectric strength test.

xiv. Drip test.

xv. Armour Galvanisation Test.

xvi. Conductor Annealing Test.

xvii. Measurement of drum length.

6.3 The following tests shall be conducted on the completed non jelly filled cables as per the test procedures given in DOT specification GR/WIR-06/03 and this specification:

6.3.1 **Acceptance tests:**

i. Measurement of diameter of conductor, over inner sheath & over outer sheath.

ii. Measurement of Thickness of insulation, inner sheath, screen, armour & outer sheath.

iii. Measurement of Resistance of conductor.

iv. Colour coding.

v. Conductor continuity test.

vi. Mutual Capacitance test.

vii. Capacitance Unbalance test.

viii. Insulation resistance test.

ix. High Voltage test.

x. Armour Galvanisation Test.

xi. Conductor Annealing Test.

xii. Measurement of drum length.

6.3.2 **Special Tests**

The non jelly filled cables shall also be subjected to following special tests.

i. Oxygen Index test as per IS-I 0810 (Part 58).

ii. Flammability test on finished cable as per IS-I0810 (part 61 & 62).

The special test shall be conducted on one sample from each lot. The sample will be selected by the inspector.

7.0 PACKING AND DESPATCH

7.1 Cables shall be despatched in non-returnable wooden drums of suitable barrel diameter, securely battened, with the take-off end fully protected against mechanical damage. The wood used for construction of the drum shall be properly seasoned, sound and free from defects. Wood preservatives shall be applied to the entire drum. Ferrous parts used shall be treated with a suitable rust preventive finish or coating to avoid rusting during transit and storage.

7.2 On the flange of the drum, necessary information such as project title, manufacturer's name, type, size, length of cable in meters, drum no., cable code, BIS certification mark, gross weight, 'Owner's particulars', 'P.O. numbers' etc., shall be printed. An arrow shall be printed on the drum with suitable instructions to show the direction of rotation of the drum.

7.3 Cables shall be supplied in drum lengths of 1000 meters, if not specified otherwise.

7.4 For non jelly filled cable, PVC / rubber end caps shall be supplied free of cost for each drum with a minimum of eight per thousand meter length. In addition, ends of the cables shall be properly sealed, with caps, to avoid ingress of moisture/water during transit and storage.

7.5 For jelly filled telephone cables, the ends of the cable shall be sealed by thermo shrinkable end caps of adequate wall thickness. Alternately ends may be sealed by enclosing them in rubber or PVC caps of wall thickness not less than 1.8mm. The caps shall be secured to the outer sheath with hose clips or ties or black adhesive tape or heat shrinkable sleeves.

7.6 The cables may be stored outdoors for long periods before installation. The packing shall be suitable for outdoor storage in areas with heavy rains / high ambient temperature, unless otherwise agreed.

TECHNICAL SPECIFICATION

HIGH MAST LIGHTING

CONTENTS

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12.0	Deviation
--	Annexure-A (Drawing & Document Schedule)

1.0 SCOPE

1.1 The scope covers technical requirements of design, engineering, manufacture, testing before despatch at works and delivery in well packed condition of high mast lighting structure, LED light fittings including lamps, earthing of units, aviation lights for towers, supply of spares for 2 years operation and maintenance etc. for RCF, Trombay. The scope shall also include the erection including civil foundation & piling design, as required (except casting of piling at site), testing, commissioning of the system by High Mast Lighting manufacturer.

1.2 The scope shall broadly include all the equipment and accessories described under clause no. 7.0. All other items not specified, but required for satisfactory and trouble free operation of the system, shall also be included.

2.0 APPLICABLE STANDARDS

2.1 The following shall be the reference standards for the loading of the high mast:

Sr. No.	Code No.	Title
a)	BS Code of Practice CP-3 Chap V Part-II	Gradient of wind speeds related to height above ground
b)	BS 4360	Grades of MS Plates
c)	BS 5135	Welding
d)	BS 729	Galvanising
e)	Technical report (TR) No. 7	High Mast Lighting specification for design, manufacture assembly, erection, testing and maintenance–2000,published by the Institution of Lighting Engineers, United Kingdom
f)	IS 875 (Part III), 1987	Structural stability to sustain maximum reaction arising from wind
g)	BS EN 10025/10027	Yield strength of steel structure.
h)	BS EN ISO 1461	Environmental protection of the fabrication by hot dip galvanization
i)	BS 5135/AWS	Welding
j)	IS 325	Three Phase Induction motor
k)	IS 3043	Code of Practice for Earthing
l)	IS 2309	Protection of building & Allied structure against Lightning
m)	UL 1029	Standard for high intensity discharge lamp ballast
n)	EN 61347	Lamp Control gear
o)	UL 1059	Standard for Terminal Block
p)	EN 60947	Low Voltage Switchgear & control gear
q)	EN 60598	Luminaries general requirements & test
r)	IE rule	
s)	Any other regulations laid by statutory authorities	

3.0 INSTRUCTIONS TO BIDDER

3.1 As it is not possible to cover all aspects of design, the basic requirements only have been covered in this specification. Bidder shall ensure that design and installation is carried out as per the latest engineering practices, satisfying the requirements of safety, reliability, ease of maintenance and operation, aesthetics and maximum interchangability.

3.2 Piling Design for high mast shall be furnished by bidder including its details drawings, documents etc. However erection/installation of Pilings shall be done by Owner.

3.3 Compliance with this standard and / or approval of any of the bidder's documents shall not relieve the bidder of his responsibility towards his contractual obligation with regard to the completeness and satisfactory operation of the equipment.

3.4 **Power Supply (Feeder Pillar)**

The owner shall provide 415V, 3 phase & neutral power supply at the bottom of each mast through suitable XLPE-A-PVC (FRLS) (Al) cable. Suitable FLP/weatherproof arrangement for receiving & distribution of this power including suitable TPN MCCB/MCB incomer, outgoing MCB for switching on/off luminaries, contactors with suitable MCB/MCCB for motor, push button for raising & lowering of lantern carriage through motor operation etc. shall be provided by the bidder.
Above mentioned arrangement shall be weatherproof for the high mast to be installed in non-hazardous area.

3.5 2 nos. earth Pit shall be provided by bidder within 10 m of each mast for body earthing. Further 2 nos. earthing connections from high mast to earth pit (one earthing connection to one pit) shall also be provided by the bidder with GI strip of size not less than 50X6 mm^2.

4.0 SERVICE CONDITIONS

4.1 Ambient Conditions

These shall be as indicated in Design Philosophy-Electrical.

4.2 System Details

These shall be as indicated in Design Philosophy-Electrical.

5.0 OPERATIONAL REQUIREMENTS

5.1 The equipment shall be suitable for operating at rated capacity continuously under the ambient conditions and with voltage and frequency variations indicated above without exceeding the permissible temperature limits as per relevant standards and without any detrimental effect on any part.

6.0 GENERAL DESIGN REQUIREMENTS

6.1 The electrical system and installation shall be designed as per latest practice to provide maximum reliability, flexibility, safety to personnel and equipment and ease of operation and maintenance.

6.2 All equipment shall have adequate and standardised ratings.

6.3 Masts shall be of 30m height and unipolar (single pole) structure. Special consideration shall be taken in respect of lamp replacement, operation and maintenance.

6.4 Manufacture of masts and components, light fittings, lamps, control gears for fittings, control gears for lantern carriage movement (i.e. raise/lower) with self sustaining winch/stainless steel wire/rope, flameproof/weatherproof motors, control push button stations and flexible cables shall be as per relevant Indian / International Standards.

7.0 EQUIPMENT DETAILS

7.1 High Masts

7.1.1 Structure

The High mast shall be of continuously tapered, polygonal cross section, at least 16 sided, presenting a good and pleasing appearance and shall be based on proven In-tension design conforming to the standards referred to above, to give an assured performance, and reliable service. The structure shall be suitable for wind loading as per IS 875 Part III 1987 as well as for prevailing wind condition at RCF, Trombay.

The mast height shall be 30m, with minimum diameter of 150mm at the top and 610mm at the bottom. Minimum plate thickness of bottom section shall be 5mm and other sections 4mm.The structure shall be suitable for wind loading as per IS 875 Part III, 1987 & for 24 nos. 350W LED light fitting complete with lamp. The PCD of the mast flange shall be minimum 740mm.

7.1.2 Construction

The mast shall be capable of safely withstanding the strong winds prevailing at site. The deflection at the top during heavy monsoon periods shall therefore be considered in the design and the mast designed in such way that the above deflection during worst periods is kept to a minimum value.

The High mast shall be fabricated from special steel plates, conforming to BS-EN10025, cut and folded to form a polygonal section and shall be telescopically jointed and fillet welded. The welding shall be in accordance with BS: 5135. The procedural weld geometry and the workmanship shall be exhaustively tested on the completed welds. Mast shall be delivered in multiple sections of length approx.10 metres. Thus a 30 meter mast shall be delivered in three sections.

Each mast section, delivered to site, shall include one no. circumferential welded diaphragm stiffener to reduce the deflection of the mast in heavy winds. At site, the sections shall be joined together by slip-stressed-fit method. No site welding or bolted joint shall be done on the mast. The minimum overlap distance shall be 1.5 times the diameter at penetration.

The mast shall be provided with full penetrated flange which shall be free from any lamination or incursion. The welded connection of the base flange shall be fully developed to the strength of the entire section. The base flange shall be provided with supplementary gussets between the bolt holes to ensure elimination of helical stress concentration. For the environmental protection of the mast, the entire fabricated system shall be hot dip galvanised, internally and externally, having a uniform thickness of 65 microns for the bottom and top sections.

7.1.3 Door Opening

An adequate door opening of size 1000mm x 300mm shall be provided at the base of the mast and the opening shall be such that it permits clear access to equipment like winches, cables, plug and socket, etc. and also facilitate easy removal of the winch. The door opening shall be complete with a close fitting, vandal resistant, weather proof door, provided with a heavy duty double internal lock with special paddle key.

The door opening shall be carefully designed and reinforced with welded steel section, so that mast section at the base shall be unaffected and undue buckling of the cut portion is prevented.

7.1.4 Dynamic Loading for the Mast

The mast structure shall be suitable to sustain an assumed reaction arising from a wind speed as per IS 875 (three second gust), and shall be measured at height of 10m above ground level. The design life of the mast shall be a minimum of 25 years. Wind excited oscillations shall be dampened by the method of construction and adequate allowance shall be made for the related stresses.

7.1.5 Earthing Terminals

2 Nos. earthing terminals for earthing of the mast, using 12mm dia. stainless steel bolts shall be provided at convenient location on the base of the mast.

7.2 Lantern Carriage

7.2.1 Fabrication

A fabricated Lantern Carriage shall be provided for fixing and holding the LED flood light fittings and control gear boxes. The Lantern Carriage shall be of special design and shall be of steel tube construction, the tubes acting as conduits for wires, with holes fully protected by grommets. The Lantern Carriage shall be so designed and fabricated to hold the required number of flood light fittings and the control gear boxes, and also have a perfect self balance.

The Lantern Carriage shall be fabricated in two halves and joined by bolted flanges with stainless steel bolts and plastic lock type stainless steel nuts to enable easy installation or removal from the erected mast. The inner lining of the carriage shall be provided with protective PVC arrangement, so that no damage is caused to the surface of the mast during raising and lowering operation of the carriage. The entire Lantern Carriage shall be hot dip galvanised after fabrication.

7.2.2 Junction Box

Weather proof junction box with IP55 enclosure, made of cast Aluminium shall be provided on the Carriage assembly as required, from which the inter-connections to the designed number of the flood light LED luminaries and associated control gears fixed on the carriage, shall be made.

7.3 Raising and lowering mechanism

For the installation and maintenance of the luminaries and lamps, it will be necessary to lower and raise the Lantern Carriage assembly. To enable this, a suitable winch arrangement shall be provided, with the winch fixed at the base of the mast and the specially designed head frame assembly at the top.

7.3.1 Winch

The winch shall be of completely self sustaining type, without the need for brake shoe, springs or clutches. Each driving spindle of the winch shall be positively locked when not in use, gravity activated PAWLS. Individual drum also should be operated for fine adjustment of lantern carriage. The capacity, operating speed, safe working load of the winch and the recommended lubrication and serial number of the winch shall be clearly marked on each winch.

The gear ratio may be according to manufacturer's standard. However, the minimum working load shall not be less than 750Kg. The winch shall be self lubricating type by means of an oil bath and the oil shall be readily available grades of reputed producers.

The winch drums shall be grooved to ensure perfect seat for stable and tidy rope lay, with no chances of rope slippage. The rope termination in the winch shall be such that distortion or twisting is eliminated and at least 5 to 6 turns of rope remains on the drum even when the lantern is fully lowered and rested on the rest pads.

It should be possible to operate the winch manually by a suitable handle and / or by integral power tool. It shall be possible to remove the double drum after dismantling, through the door opening provided at the base of the mast. Also, a winch gear box for simultaneous and reversible operation of the double drum winch shall be provided as part of the contract. A test certificate shall be furnished by the Bidder from the original equipment manufacturer, for each winch in support of the maximum load operated by the winch.

7.3.2 Head Frame

The head frame, which is to be designed as a capping unit of the mast, shall be of welded steel construction, galvanised both internally and externally after assembly. The top pulley shall be of appropriate diameter, large enough to accommodate the stainless steel wire ropes and the multicore electric cable. The pulley block shall be made of non-corrodible material, and shall be of die cast Aluminium alloy (LM-6). Pulley made of synthetic materials such as plastic or PVC is not acceptable. Self lubricating bearings and stainless steel shaft shall be provided to facilitate smooth and maintenance free operation for a long period. The pulley assembly shall be fully protected by a canopy galvanised internally and externally. Close fitting guides and sleeves shall be provided to ensure that the ropes and cables do not get dislodged from their respective positions in the grooves. The head frame shall be provided with guides and stops with PVC buffer for docking the lantern carriage.

7.3.3 Stainless Steel Wire Ropes

The suspension system shall essentially be without any intermediate joint and shall consist of only non-corrodible stainless steel of AISI 316 or better grade. The stainless steel wire ropes shall be of 7/19 construction, the central core being of the same material. The overall diameter of the rope shall not be less than 6mm. The breaking load of each rope shall not be less than 2350Kg individually, giving a factor of safety of over 5 for the system at full load as per the TR-7 referred to in the beginning of this specification. The end constructions of ropes to the winch drum shall be fitted with telluric.

The thimbles shall be secured on ropes by compression splices. Two continuous lengths of stainless steel wire ropes shall be used in the system and no intermediate joints are acceptable in view of the required safety. No intermediate joint either bolted or else is provided on the wire ropes between winch and lantern carriage.

7.4 Electrical System, cable and Cable Connections

The electrical connection from bottom to top shall be made with at least 5 core 2.5 sq.mm flexible round sheath power cables using copper conductors of appropriate rating. A suitable flameproof/weatherproof socket arrangement shall be provided at the bottom of the mast. The trailing cable shall also have an FLP/weatherproof plug connected at the bottom end. Also, suitable provision shall be made at the base compartment of the mast to facilitate the operation of electrically operated integral FLP/weatherproof power tool for raising and lowering

of the lantern carriage assembly. The trailing cables at the top shall be terminated in the weather proof junction box.

7.5 **Power Tool for the Winch**

A suitable, high powered, electrically driven, flameproof/weatherproof, integral power tool to be provided in the base compartment coupled with winch and suitable for manual & motorised operation shall be supplied for the raising and lowering of the lantern carriage for maintenance purposes. The speed of the power tool may, preferably, be slow of 1.5 to 1.8 metre/minute, so that vibrations associated with high speed operation are avoided. The power tool shall be single speed, provided with a flameproof/weatherproof motor of required rating. The power tool shall be supplied with suitable reversible starter in flameproof/weatherproof enclosure. The capacity and speed of the electric motor used in the power tool shall be suitable for the lifting of the design load installed on the lantern carriage.

Also, a handle for the manual operation of the winch in case of problems with electrically operated tool, shall be provided and shall incorporate a torque limiter.

7.6 **Luminaries: 350W LED Flood Lighting Fixture complete with lamp**

7.6.1 The LED Flood Lighting Fixture complete with lamp suitable for High Mast.

7.6.2 The fixture shall have efficiency long life LED with high efficacy and minimum of 100 lm/w with high brightness LED for glare free homogenous illumination.

7.6.3 Fixture housing shall be made of Epoxy powder coated die-cast aluminium housing (LM-24).

7.6.4 Fixture cover shall be made of high quality toughened glass fixed to housing with screws.

7.6.5 The fixture shall have in-built electronic driver with THD ≤ 10%.

7.6.6 Twin dome LED type (2x40W) Aviation Obstruction Lights of reliable design and reputed manufacturer shall be provided on top of each mast. It shall have cast aluminium housing finished in aviation yellow colour, suitable rated step-up transformer, thick glass dome mounted on cast aluminium ring and spring loaded high tension porcelain socket fitted with neon cold cathode helix light source. The light source shall be designed to give Omni-directional red colour light distribution to have maximum light output in the zone between 10°C to 90°C above horizontal plane.

8.0 TESTS AND INSPECTION

Routine testing shall be carried out on the supplied items at manufacturer's works as per relevant standards. For imported items of masts, relevant test certificates need to be produced for the purpose. However, testing shall not absolve the supplier from his responsibility for making good any defect which may be noticed subsequently. Site testing to demonstrate working and performance of the system shall also be carried out.

9.0 DRAWINGS AND DOCUMENT

9.1 At the time of handing over of the installation, the bidder shall supply as built drawings taking into consideration the actual execution carried out at site.

9.2 Drawings and documents shall be submitted as per Annexure-A in number of copies as indicated therein.

10.0 SPARES

10.1 Spares for operation and maintenance:
Item wise unit prices of spare parts with recommended quantity shall be quoted along with the High Masts.

10.2 Commissioning spares as required shall be supplied with the main equipment without any price implication to owner. Item wise list of recommended commissioning spares shall be furnished for information.

10.3 All spare parts shall be identical to the parts used in the High Masts.

11.0 MAKE OF COMPONENTS

11.1 Make of all electrical items/components shall be as specified elsewhere in the NIT.

12.0 DEVIATIONS

Deviations, if any, must be highlighted by the bidder clause wise in the offer. In absence of any such deviation, it will be presumed that all the clauses of specification are fully complied in the bidder's offer.

Annexure-A
Drawing and Documents Schedule

Sr. No.	Description	With Bid	Documents Required (Y / N)		
			For Approval	For Information	Final
1.	Technical Particulars Completely filled in	N	Y	--	Y
2.	Typical Wiring Diagram/Arrangement	Y	Y	--	Y
3.	Technical data of light fittings	Y	Y	--	Y
4.	Technical literature / Catalogues	Y	--	Y	Y
5.	Civil foundation data / details including piling design	N	Y	--	Y
6.	Test Certificates	Y	--	--	Y
7.	Guarantee Certificates	N	--	--	Y
8.	List of spares	Y	Y	--	Y
9.	Installation & maintenance manual	N	--	Y	Y

Note:

1. 4 hard copies & 1 soft copy shall be supplied with bid.
2. 6 hard copies & 1 soft copy shall be supplied for approval / information after order within 4 weeks from the date of LOI.
3. 8 hard copies & 2 soft copies of pen drive in editable form shall be submitted as final documents prior to despatch of the equipment. These shall be made in sets and supplied in fine plastic coated folder.

   Y – Yes, N – No

PART-II, TECHNICAL

SECTION – 10

SCHEMATIC DIAGRAMS WITH LEGEND

FOR

HV SWITCH BOARD

(Drg. No. PDS-1201)

SL.NO.	SYM.	DESCRIPTION
1	d	CONTACTOR
2	e	RELAY
3	b	PUSH BUTTON
4	H	HOOTER
5	BZ	BUZZER
6	T	TIMER
7	h	INDICATION LAMP
8	S	SELECTOR SWITCH
9	L/R/A	LOCAL/REMOTE/AUTO
10	x	AUX. RELAY & CONTACTOR FOR MULTIPLICATION OF CONTACTS
11	LS	C.B. LIMIT SWITCH (SERVICE)
12	LT	C.B. LIMIT SWITCH (TEST)
13	IM	MOTOR FEEDER C.B.
14	IT	TRANSFORMER FEEDER C.B.
15	IF1/IF2	INCOMER C.B. FROM O/G FEEDER OF UP-STREAM SW.BD.
16	IFB	BUS-COUPLER C.B.
17	CC	CLOSING COIL OF C.B.
18	TC	TRIP COIL OF C.B.
19	RS	RESISTOR
20	HF	HT FUSE
21	F	CONTROL FUSE
22	TNC	TRIP-NEUTRAL-CLOSE CONT. SW.
23	e1	LOCKOUT RELAY (ELECT. FAULT)
24	e'1	LOCKOUT RELAY (PROCESS)
25	e2	TRIP CIRCUIT SUPERVISION RELAY
26	e3	MOTOR PROTECTION RELAY
27	e4	U/V RELAY
28	e5	O/C RELAY
29	e6	E/F RELAY
30	e7	SBEF RELAY
31	e8	REF RELAY
32	e9	DIFFERENTIAL RELAY
33	e10	HIGH SET INSTANTANEOUS RELAY
34	e11	AUX. RELAY FOR TRANSFORMER FAULT TRIP
35	e12	AUX. RELAY FOR TRANSFORMER FAULT ALARM
36	e13	AUX. RELAY FOR LOW OIL LEVEL ALARM
37	e14	AUX. RELAY FOR AUTO TRIP ALARM
38	e15	AUX. RELAY FOR NON-TRIP ALARM
39	e16	SYNCHRO CHECK RELAY
40	h1	'C.B. ON'
41	h1a	'C.B. ON' (REAR SIDE)
42	h2	'C.B. OFF'
43	ha2	'C.B. OFF' (REAR SIDE)
44	h3	'C.B. TRIPPED'
45	h4	'C.B. READY FOR SERVICE'
46	h5	'C.B. READY FOR TEST'
47	h6	'TRIP CIRCUIT HEALTHY'
48	h7	'MOTOR SPACE HEATER ON'
49	⌀	EXTERNAL TERMINALS
50	⊙	INTER PANEL TERMINALS
51	LCS	LOCAL CONTROL STATION NEAR MOTOR
52	HM	HOURMETER

NOTE: INSIDE DRAWINGS THERE SHALL BE CHANGE AS PER POINTS GIVEN BELOW

1. NO COMMON ALARM CIRCUIT (EXCEPT HOOTER/BELL) IN BUSCOUPLER FEEDERS AS EACH FEEDER WILL HAVE ITS OWN MICROPROCESSOR BASED ANNUNCIATOR.
2. EXCLUSIVE LV PT FUSE FOR e4.
3. BLOCKING DIODE FOR LAMP TEST INSTEAD OF d5.
4. SPACE HEATER LAMP IN LCS FOR MV MOTORS ARE NOT REQUIRED (O/L TRIP LAMP MAY BE USED)
5. LCS MAY HAVE 'READY FOR START' LAMP FOR AUTO STARTING MOTORS.
6. VIB./OIL LEVEL TRIP LAMP WITH RESET PB FOR CT FAN MOTORS.

पी डी आई एल
PDIL

SCHEMATIC DIAGRAM LEGEND

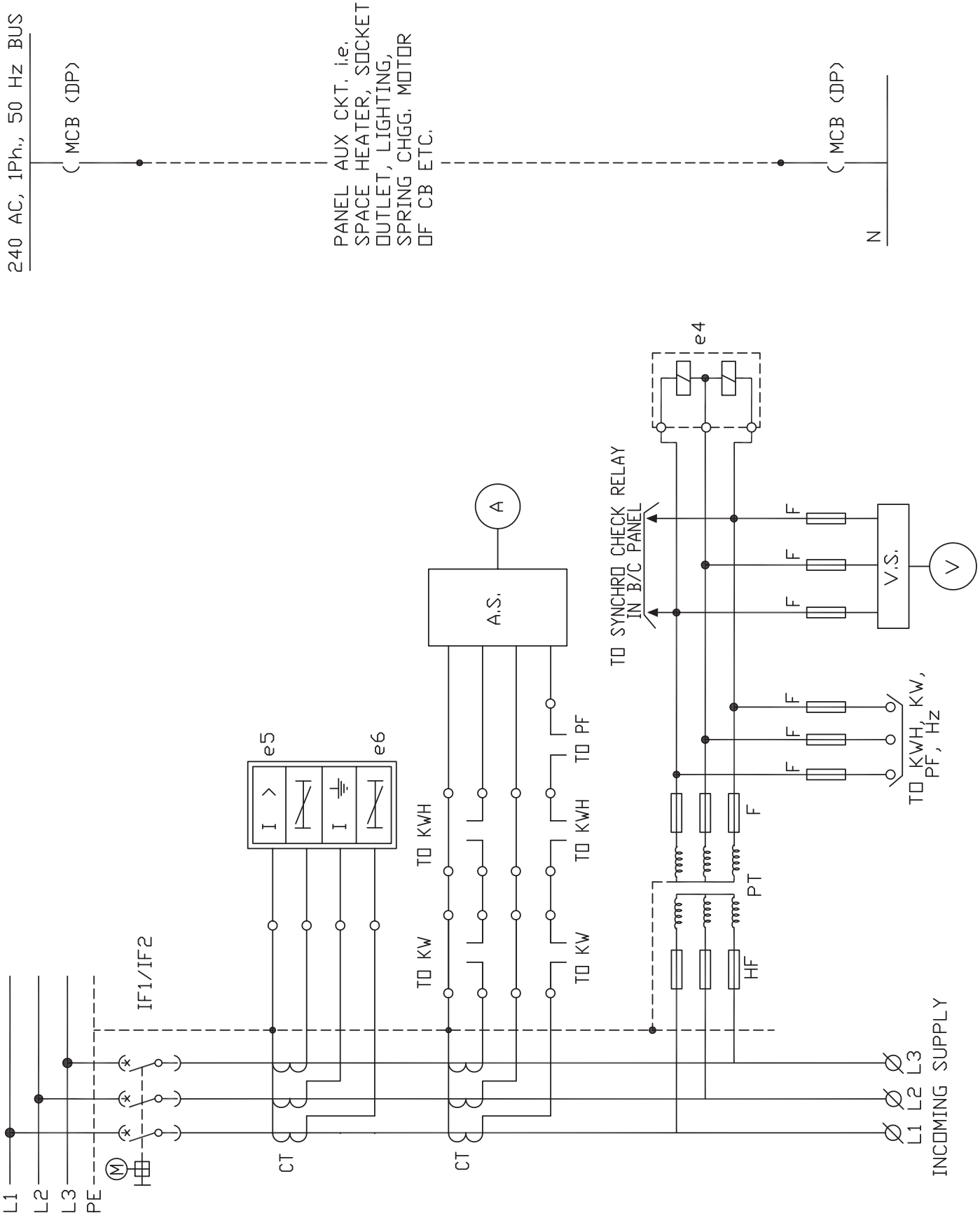
PDS-1201

DRAWING NO.

REV. 0

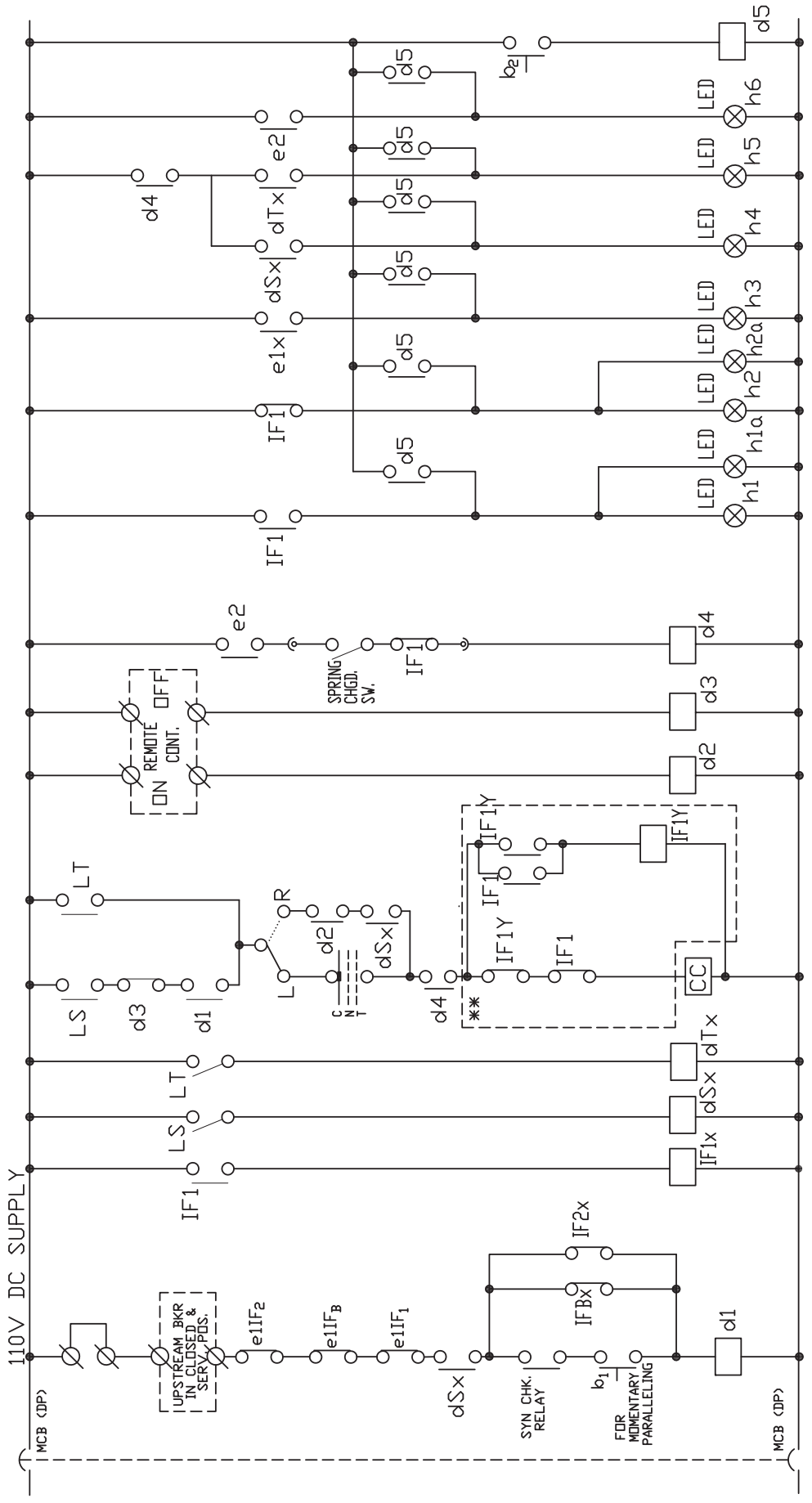
SHEET 2 OF 19

पी डी आई एल PDIL	SCHEMATRIC DIADRAM FOR INCOMER 1 & 2 (TYPE IF1 & IF2) – POWER CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 3 OF 19	



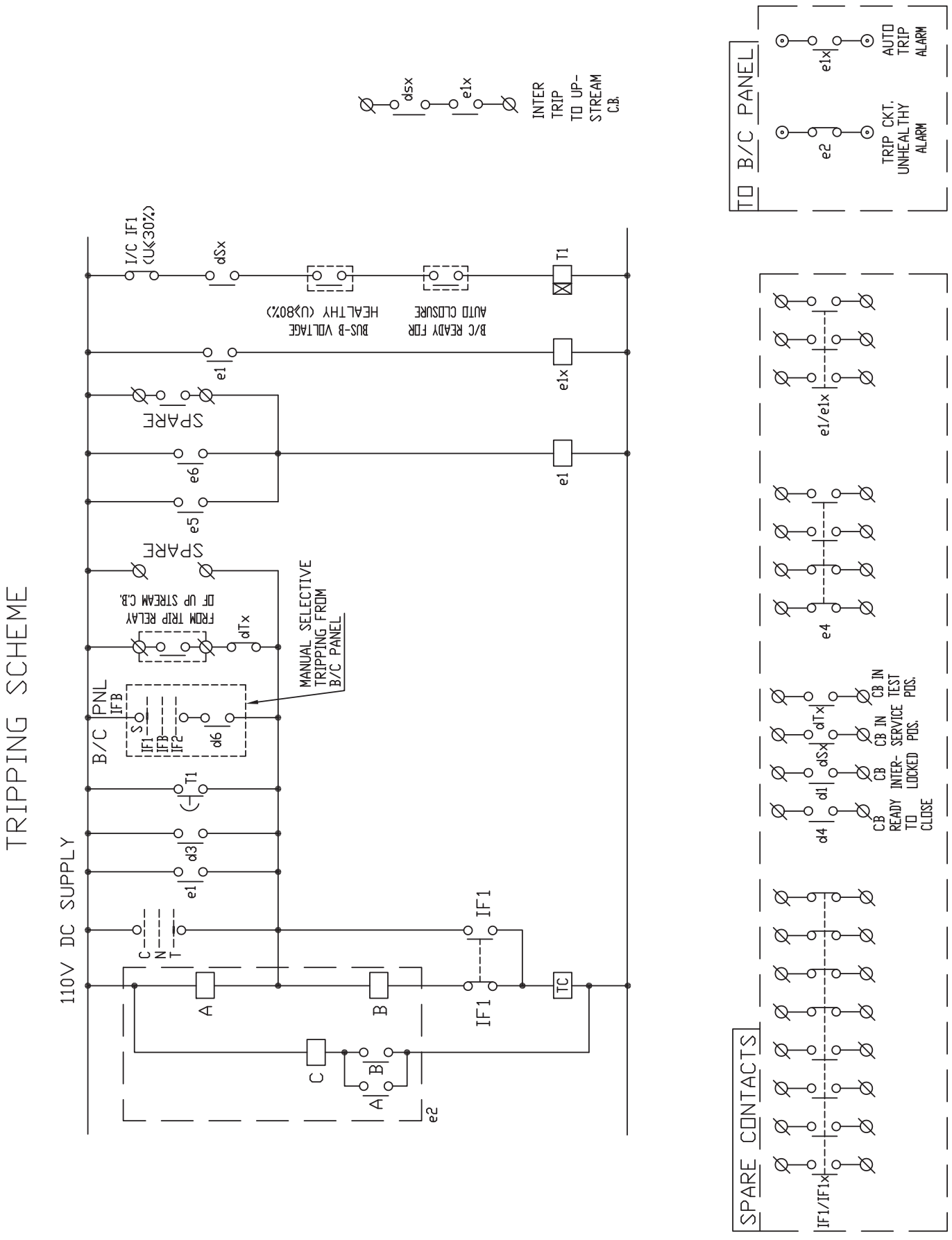
पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR INCOMER 1 (FEEDER TYPE IF1) – CONTROL CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 4 OF 19	

CLOSING & INDICATION SCHEME



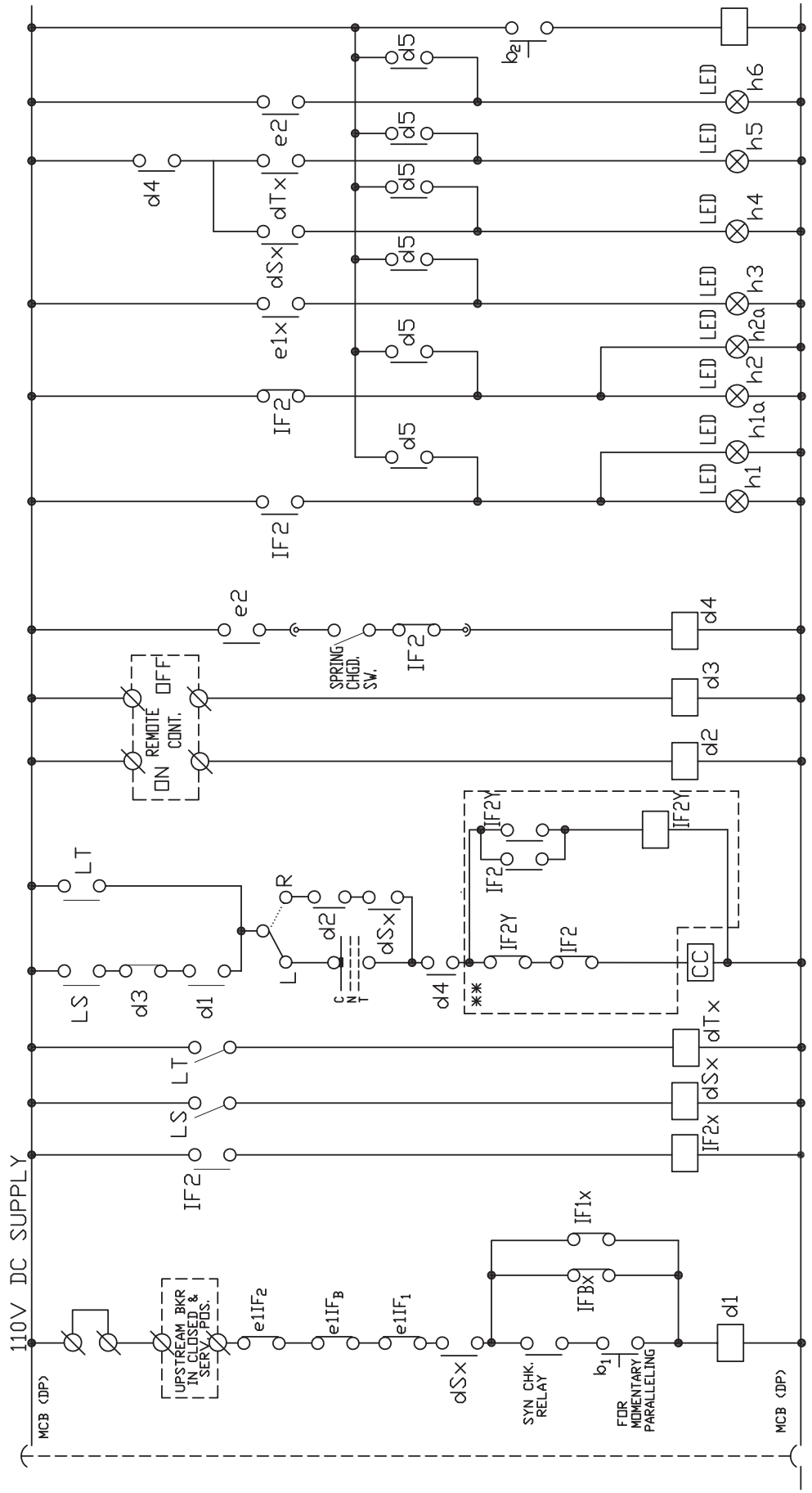
** TYPICAL SCHEME FOR ANTIPUMPING

पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR INCOMER 1 (FEEDER TYPE IF1) – CONTROL CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 5 OF 19	



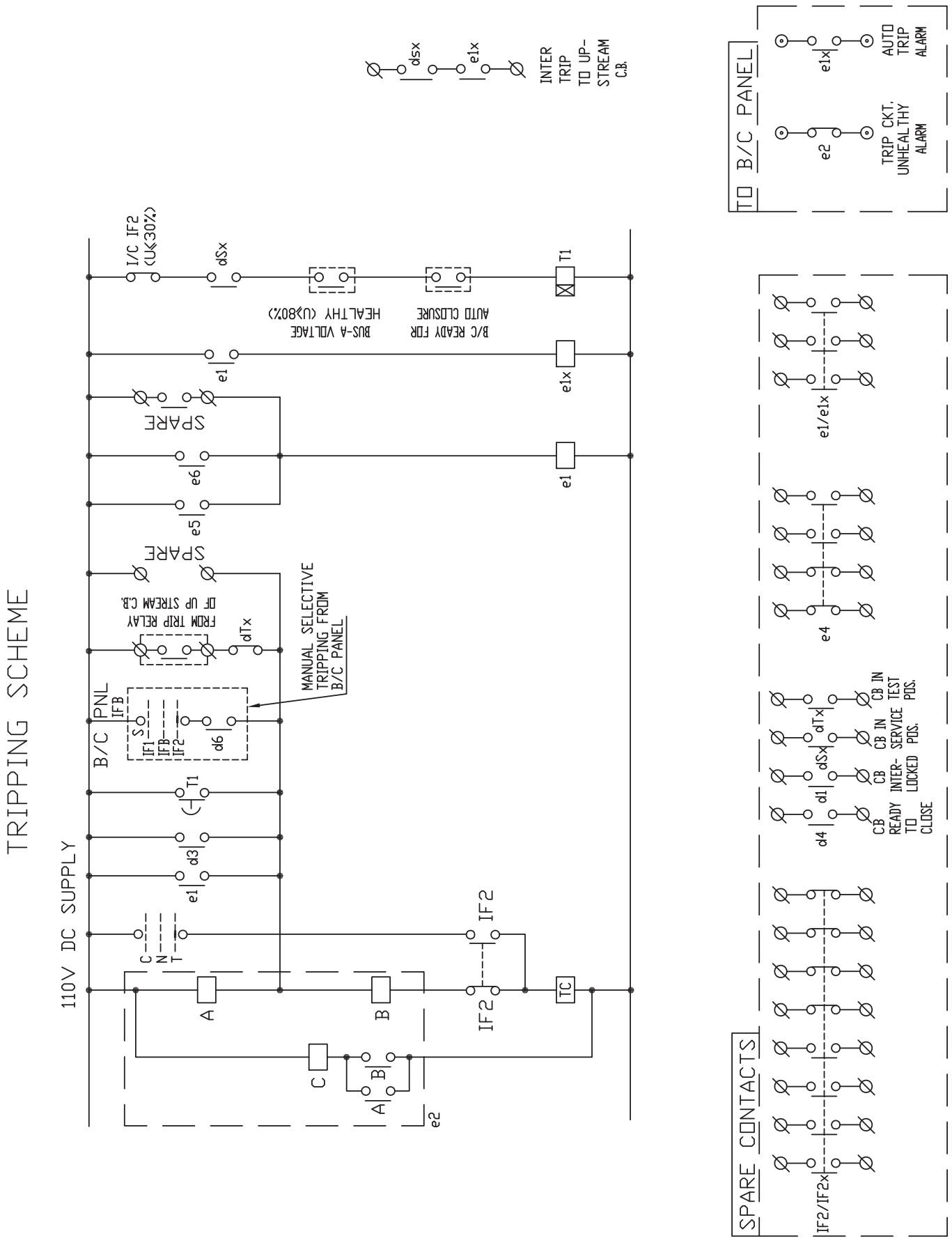
पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR INCOMER 2 (FEEDER TYPE IF2) – CONTROL CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 6 OF 19	

CLOSING & INDICATION SCHEME

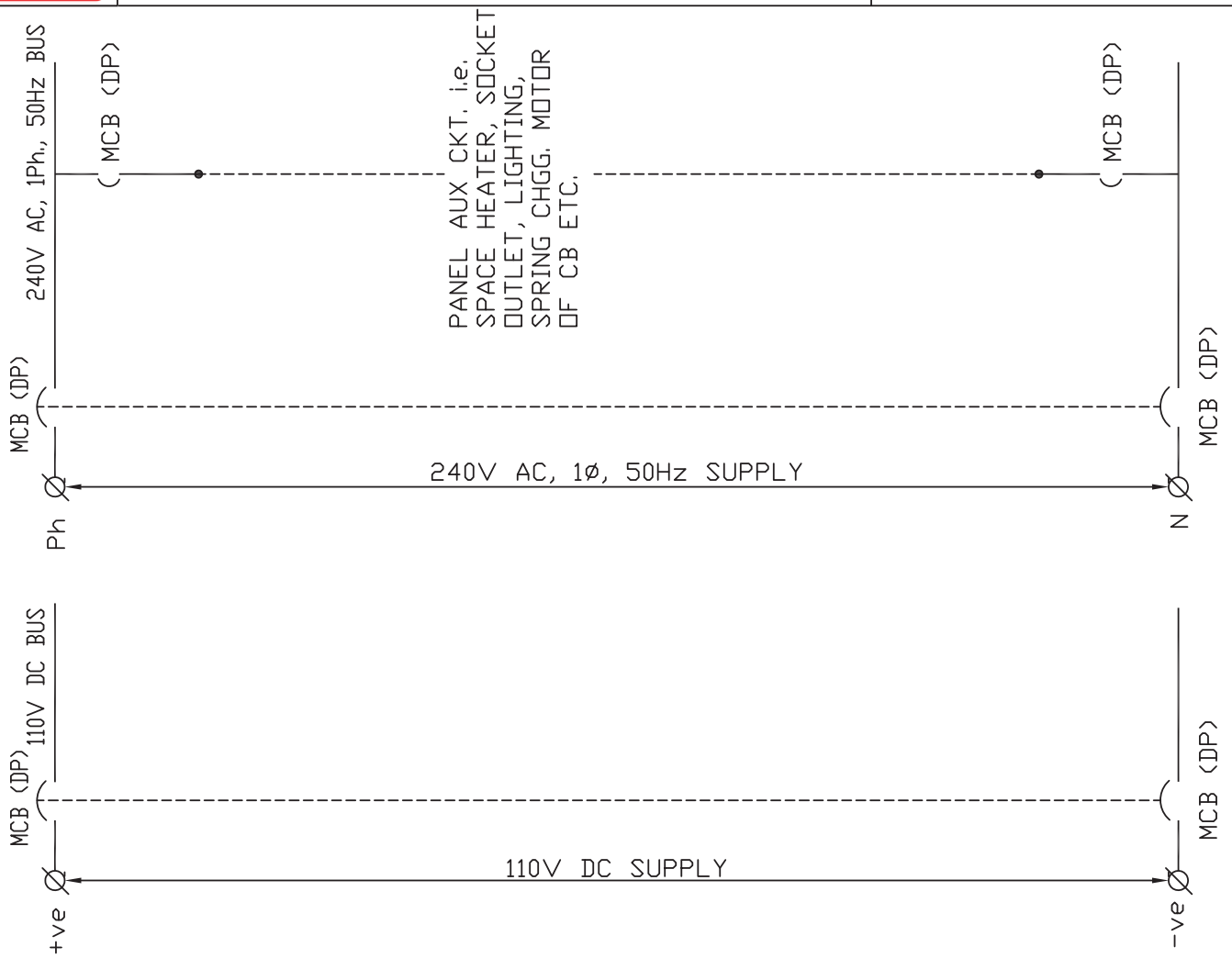


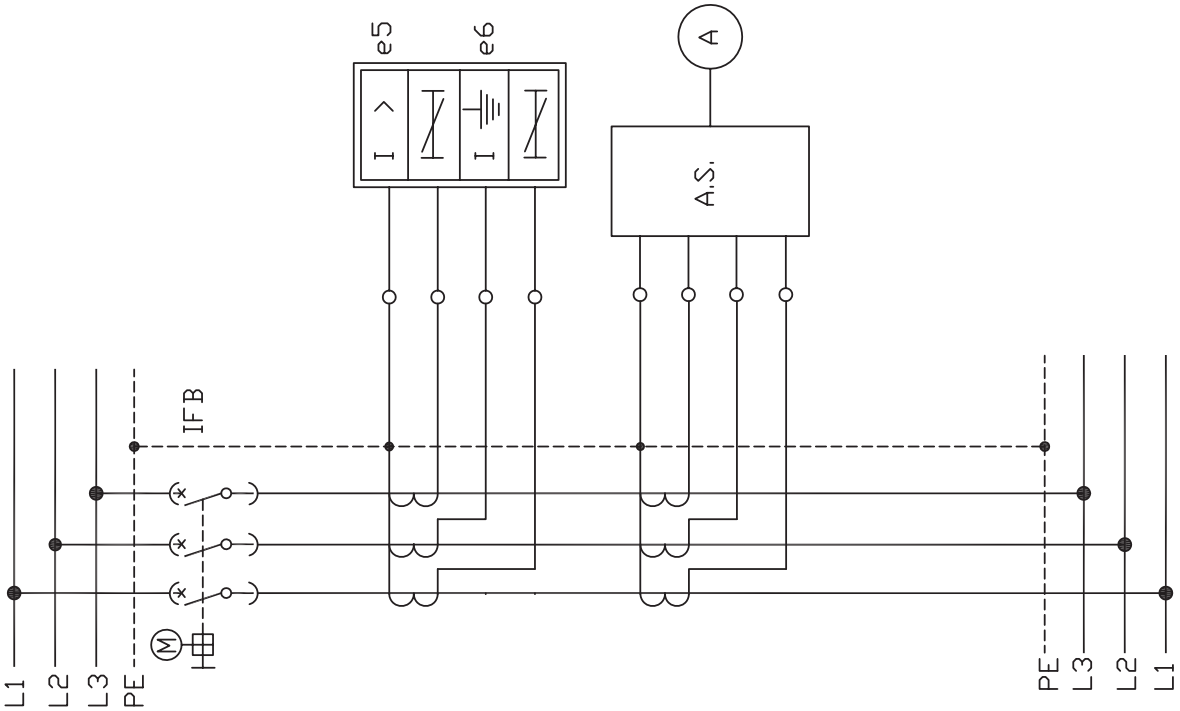
** TYPICAL SCHEME FOR ANTIPUMPING

पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR INCOMER 2 (FEEDER TYPE IF2) – CONTROL CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 7 OF 19	



पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR BUS–COUPLER (TYPE–IFB) – POWER CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 8 OF 19	





पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR BUS–COUPLER (TYPE–IFB) – CONTROL CIRCUIT	PDS-1201	0
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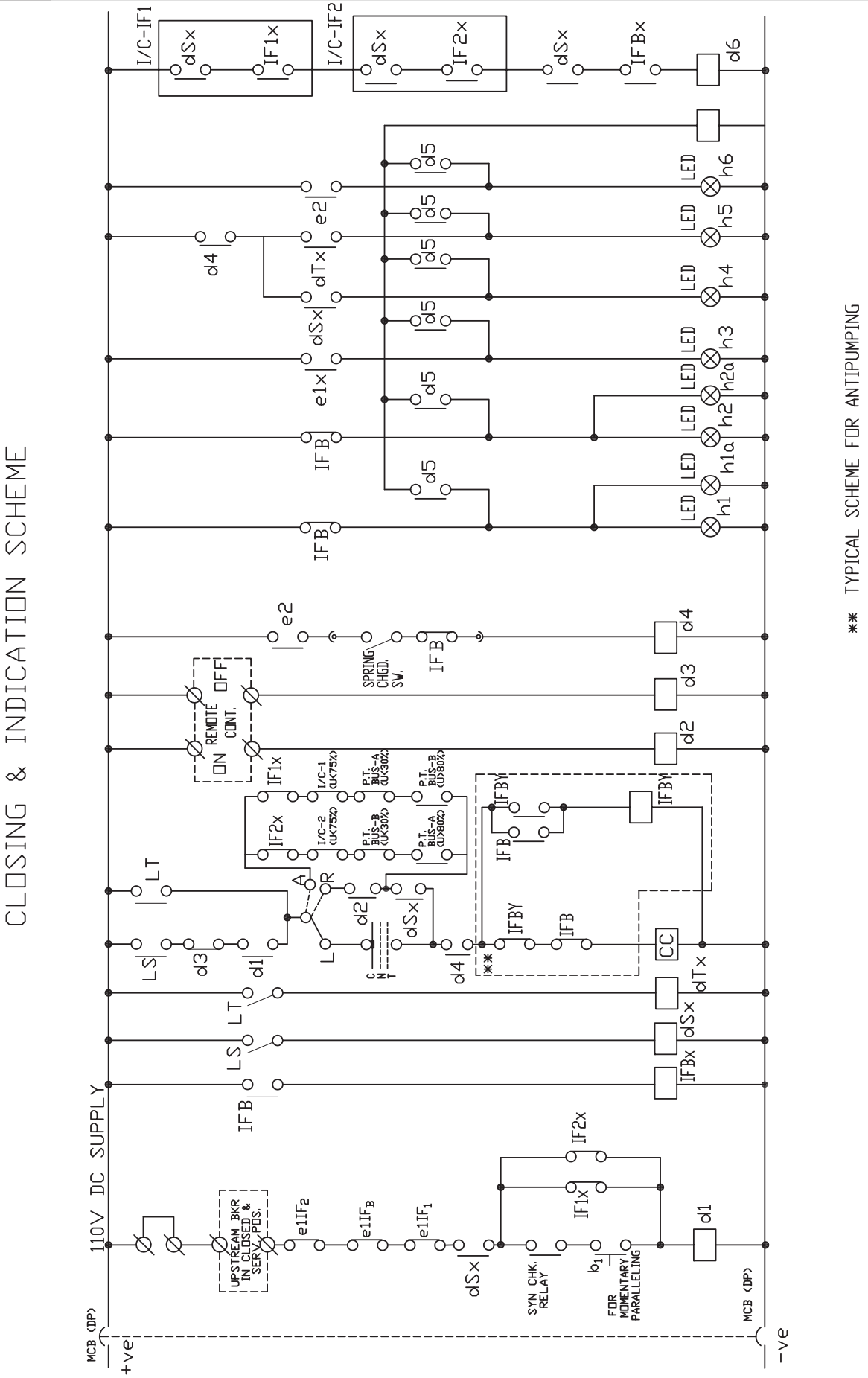
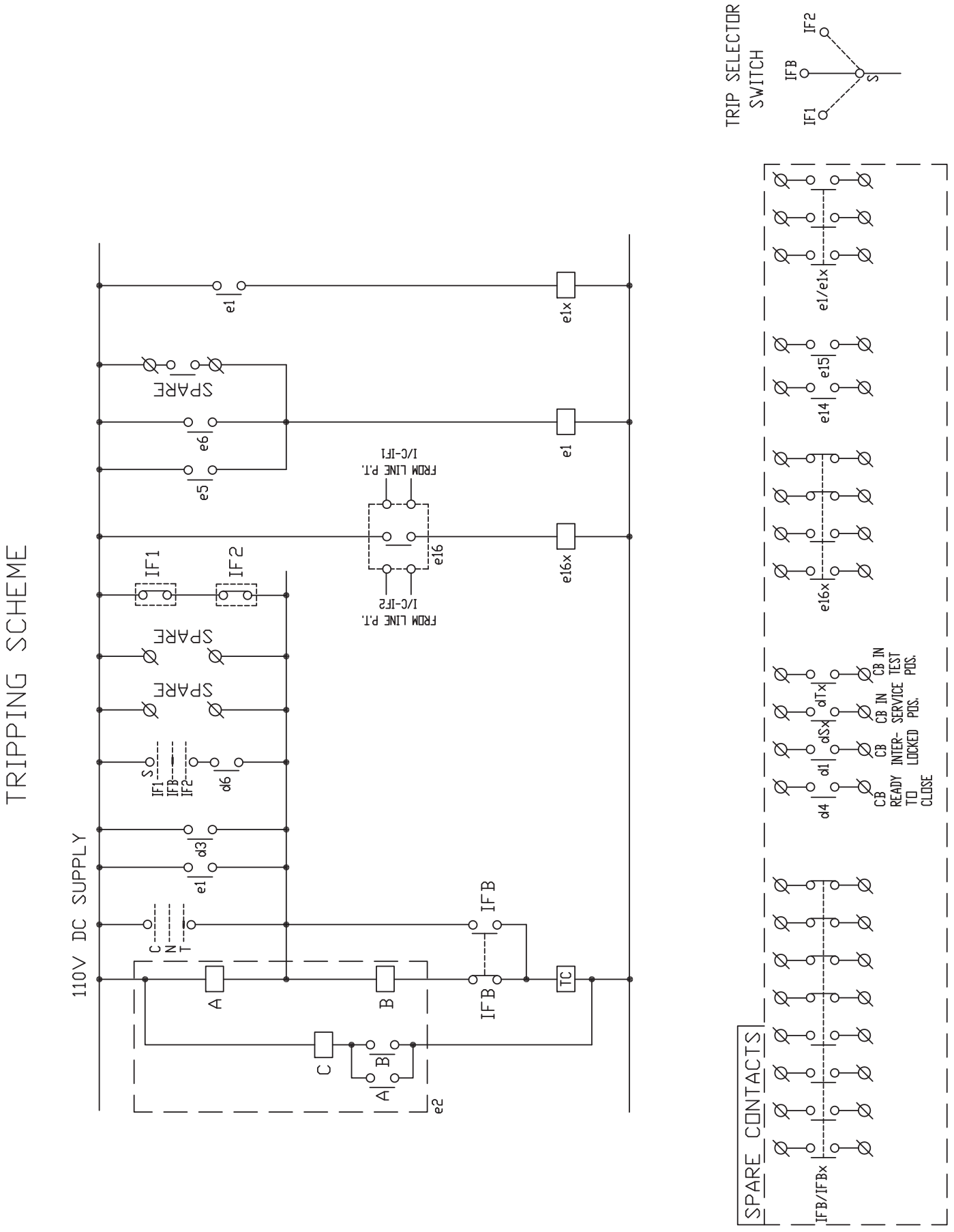
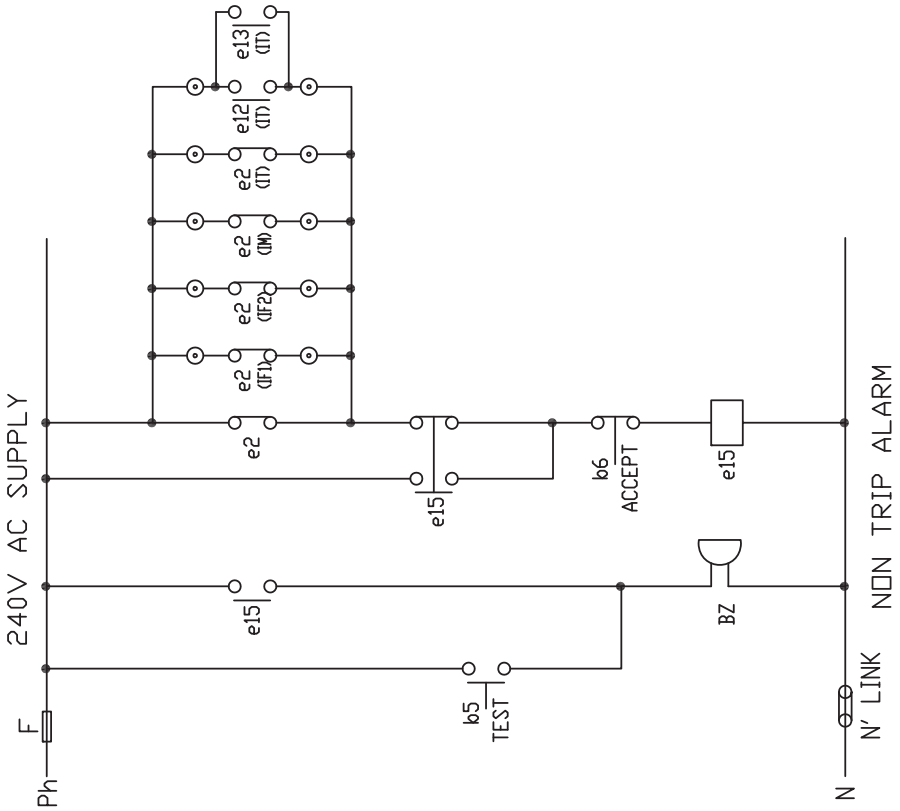
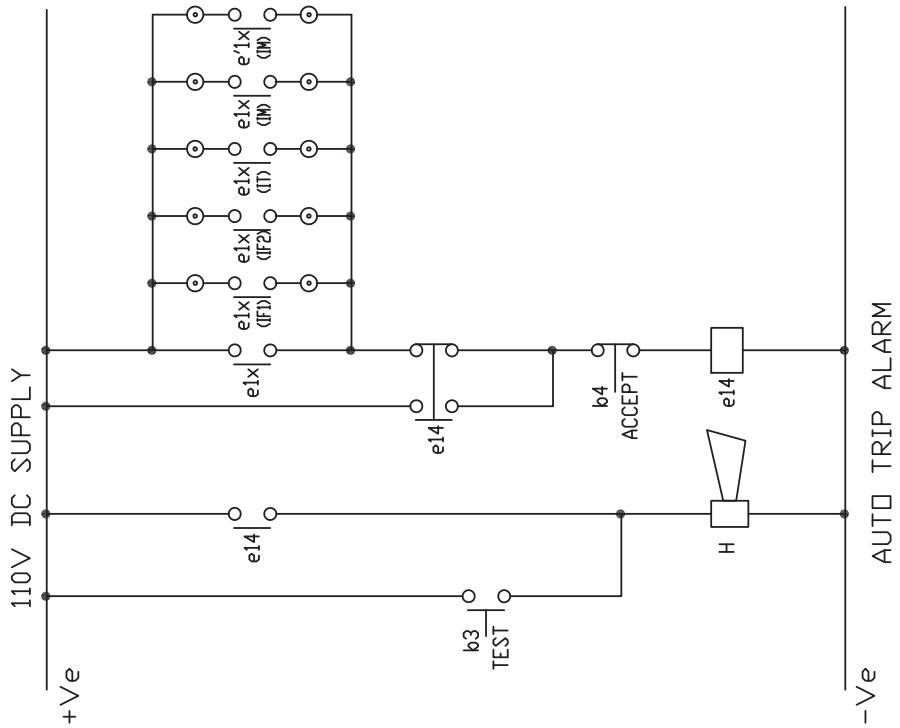
		SHEET 9 OF 19	

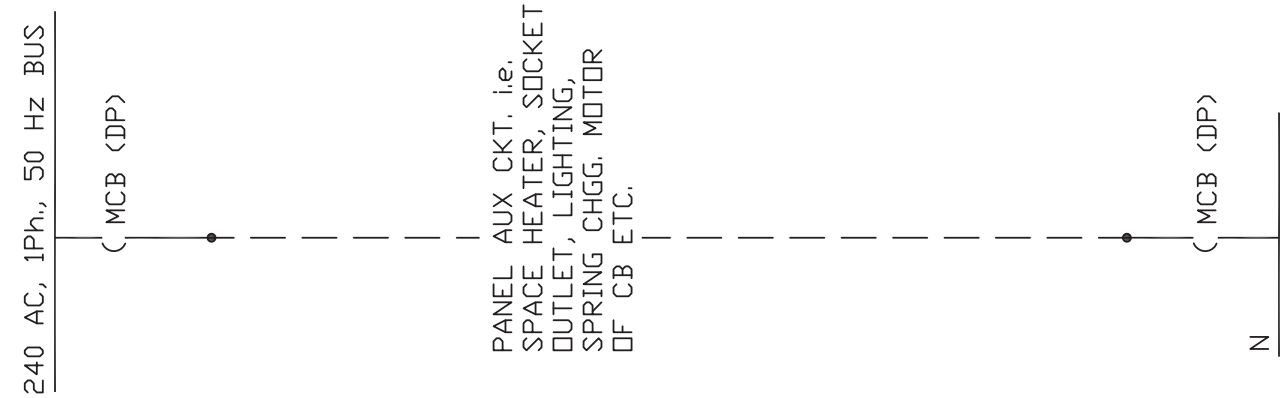


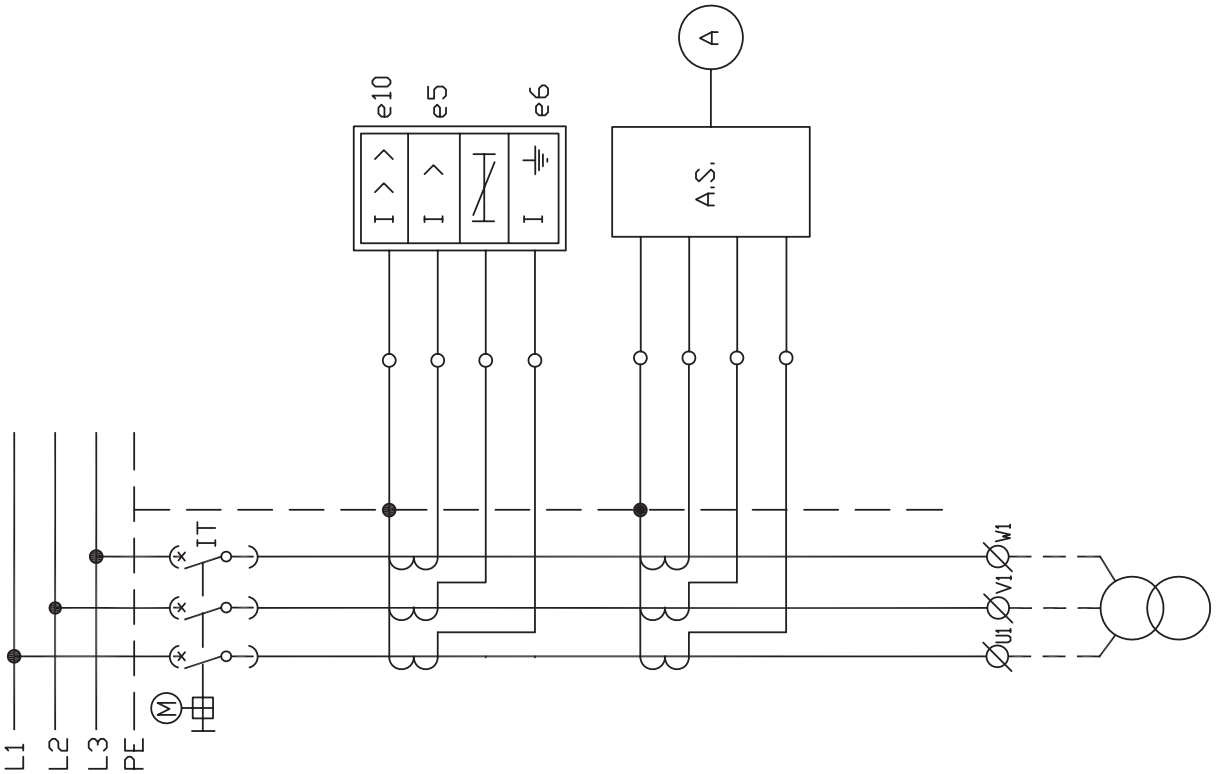
पी डी आई एल PDIL	SCHEMETIC DIAGRAM FOR BUS–COUPLER (TYPE–IFB) – CONTROL CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 10 OF 19	



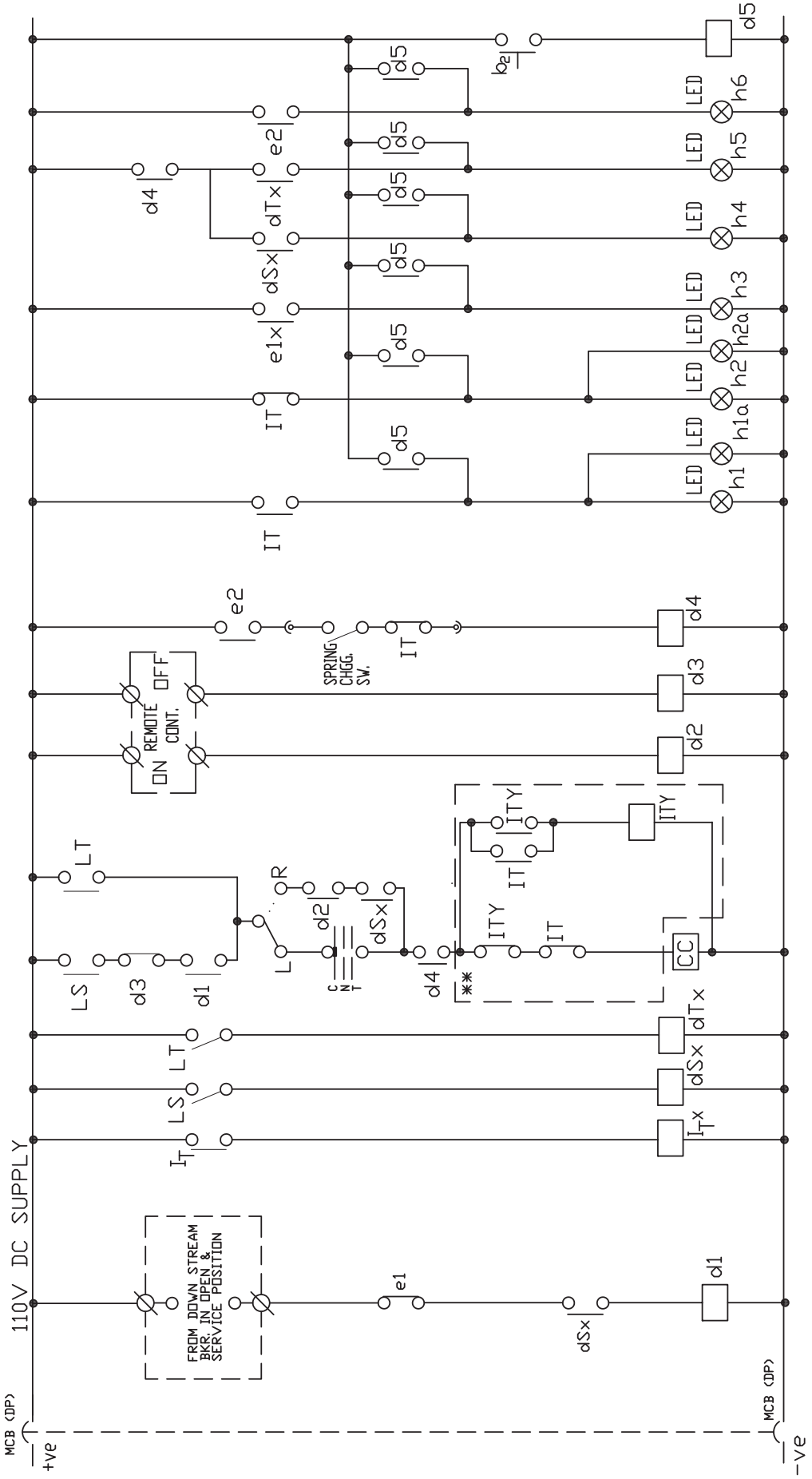

240V AC SUPPLY
Ph
F
N
N' LINK
NON TRIP ALARM
e13 (IT)
e12 (IT)
e2 (IT)
e2 (IM)
e2 (IF2)
e2 (IF1)
e2
e15
b6 ACCEPT
e15
e15
BZ
b5 TEST


110V DC SUPPLY
+Ve
-Ve
AUTO TRIP ALARM
e'1x (IM)
e1x (IM)
e1x (IT)
e1x (IF2)
e1x (IF1)
e1x
e14
b4 ACCEPT
e14
e14
H
b3 TEST

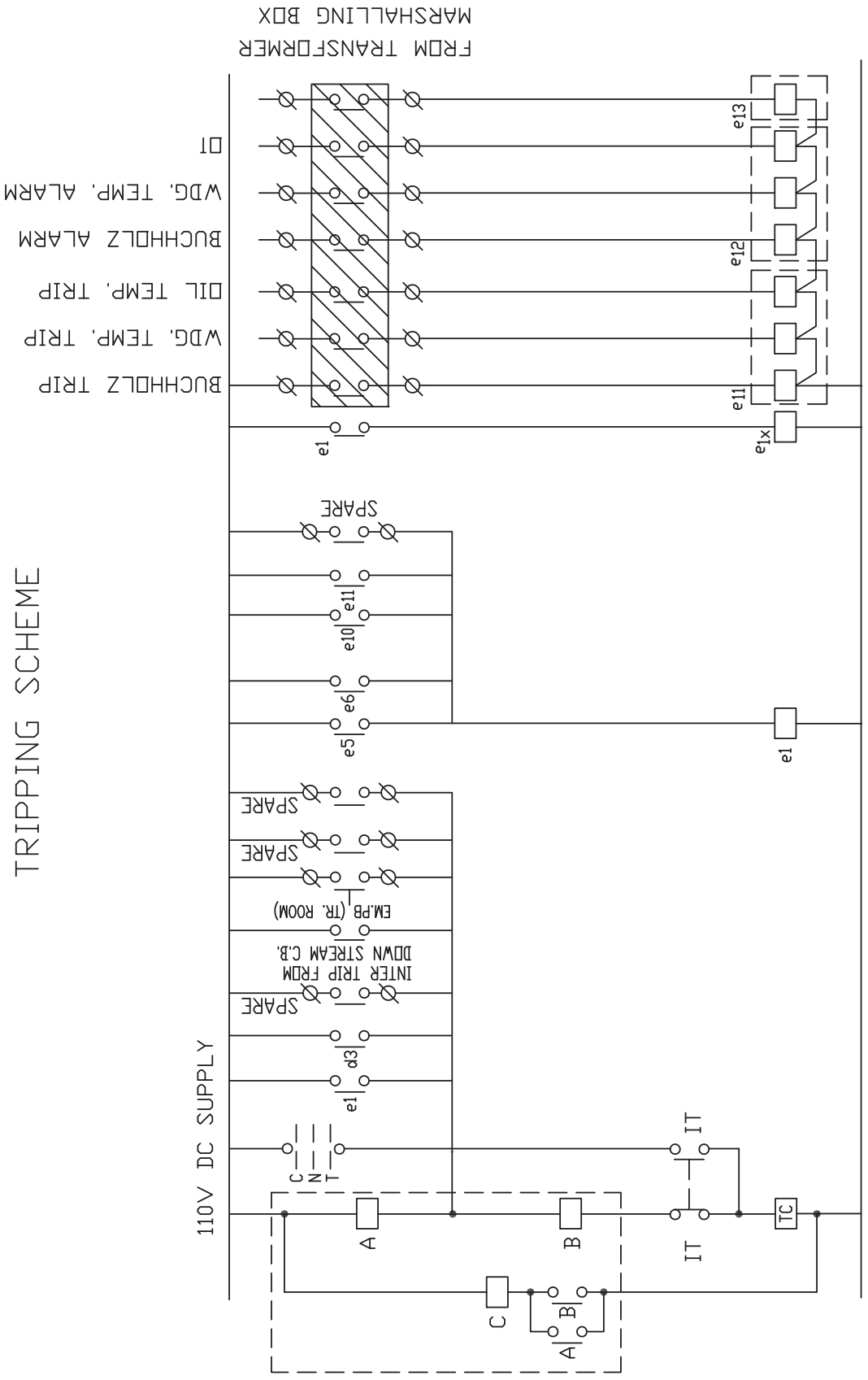

240 AC, 1Ph., 50 Hz BUS
MCB (DP)
PANEL AUX CKT. i.e,
SPACE HEATER, SOCKET
OUTLET, LIGHTING,
SPRING CHGG. MOTOR
OF CB ETC.
MCB (DP)
N

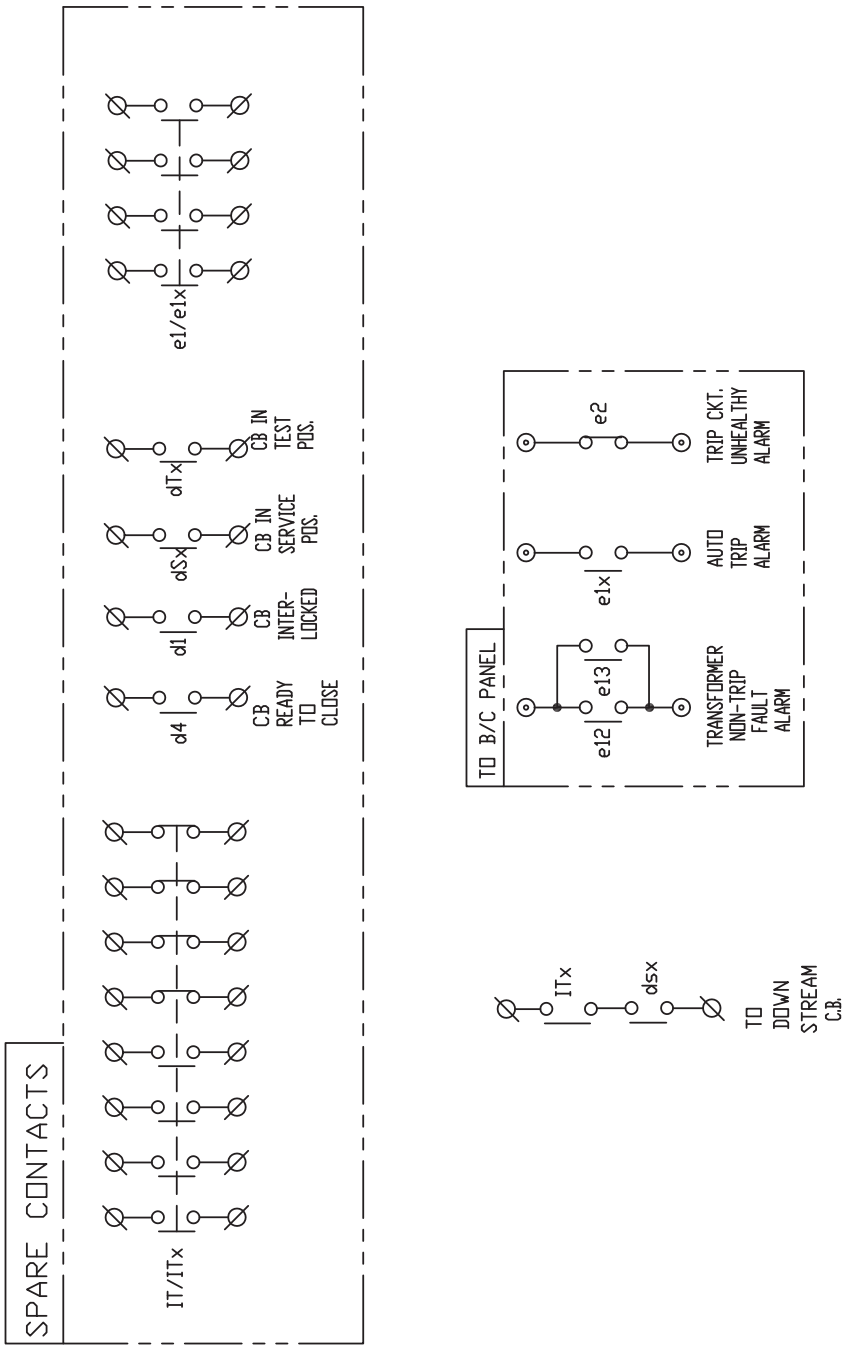

A
e10
e5
e6
I > >
I >
I
A.S.
IT
L1
L2
L3
PE
M
W1
V1
U1

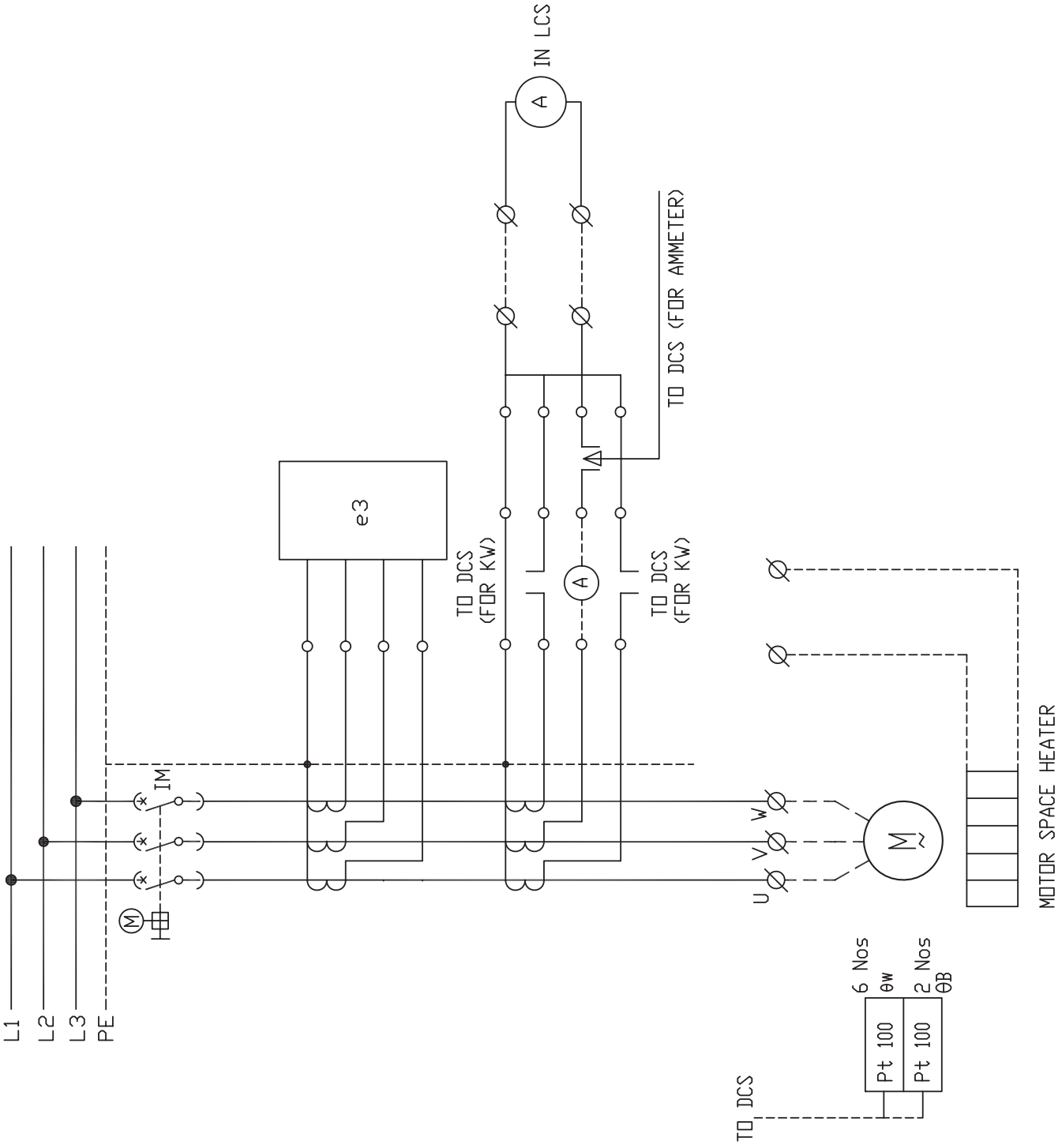
CLOSING & INDICATION SCHEME



पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR TRANSFORMER FEEDER CIRCUIT (TYPE–IT)	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 14 OF 19	

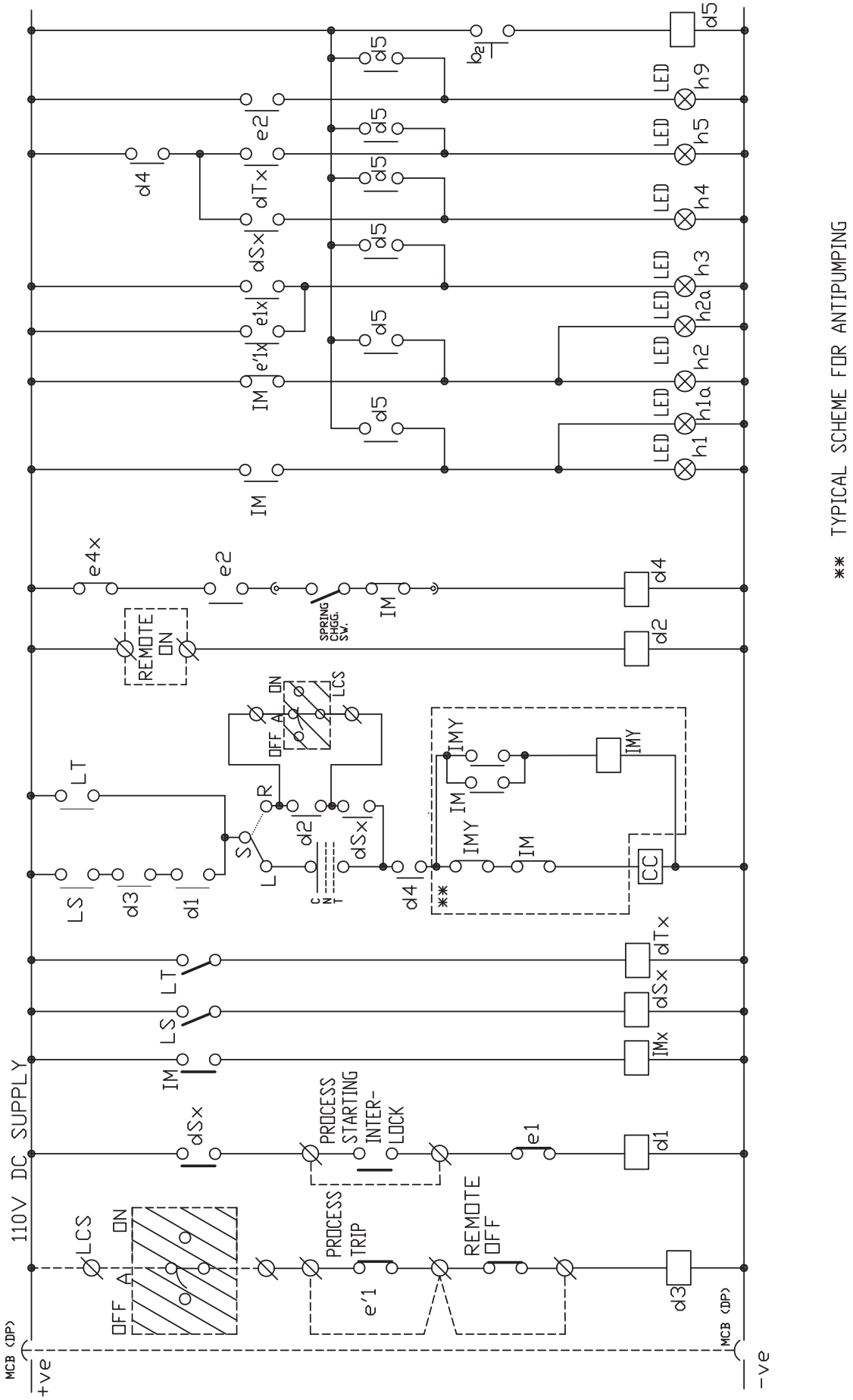



SPARE CONTACTS
IT/ITx
d4
CB READY TO CLOSE
d1
CB INTER-LOCKED
dSx
CB IN SERVICE POS.
dTx
CB IN TEST POS.
e1/e1x
TO B/C PANEL
e12
e13
TRANSFORMER NON-TRIP FAULT ALARM
e1x
AUTO TRIP ALARM
e2
TRIP CKT. UNHEALTHY ALARM
ITx
dsx
TO DOWN STREAM C.B.


IN LCS
A
TO DCS (FOR AMMETER)
e3
TO DCS (FOR KW)
A
TO DCS (FOR KW)
IM
M
W
V
U
M
MOTOR SPACE HEATER
L1
L2
L3
PE
6 Nos
θw
2 Nos
θB
Pt 100
Pt 100
TO DCS

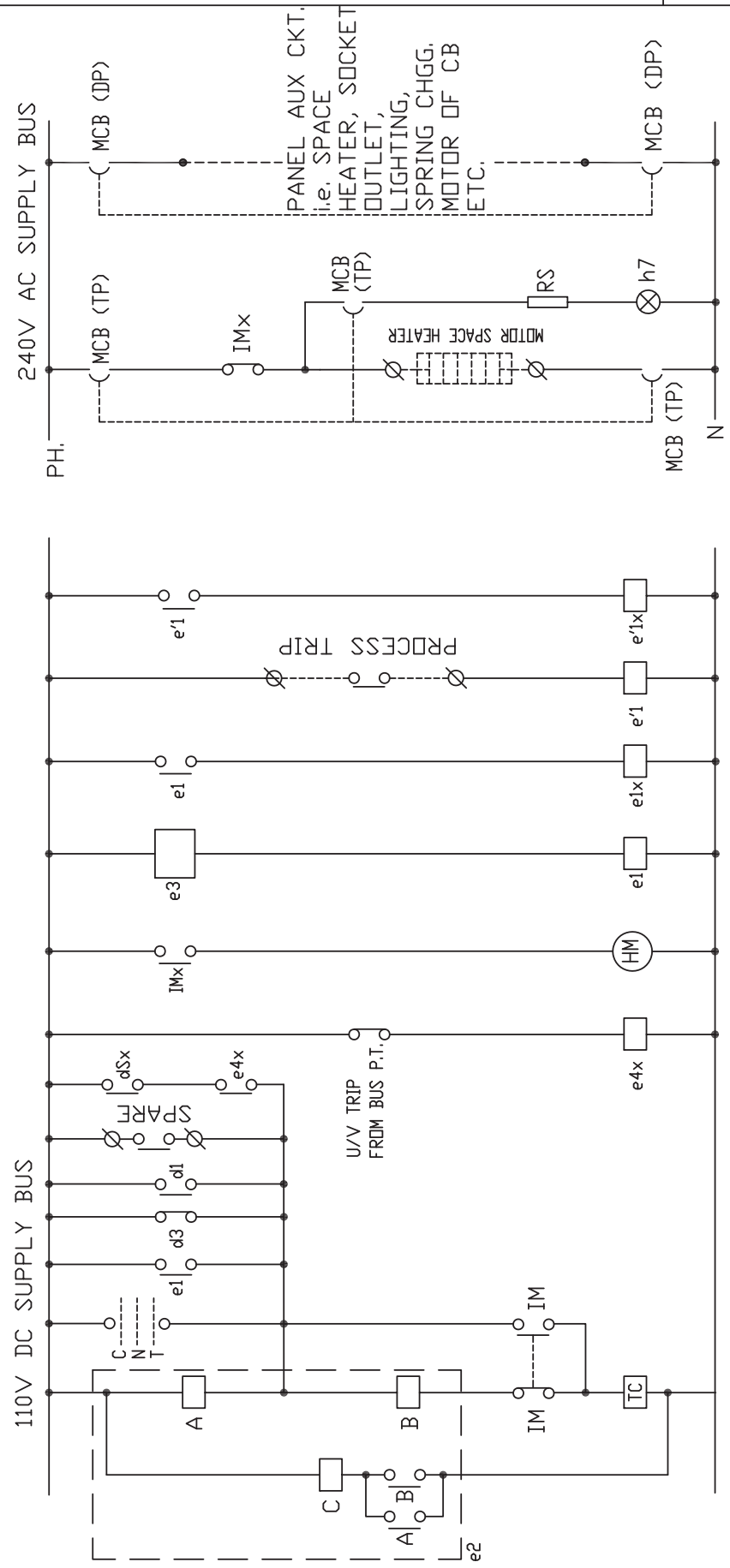
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR MOTOR FEEDER (TYPE–IM) – CONTROL CIRCUIT	PDS-1201	0
		DRAWING NO.	REV.
		SHEET 17 OF 19	

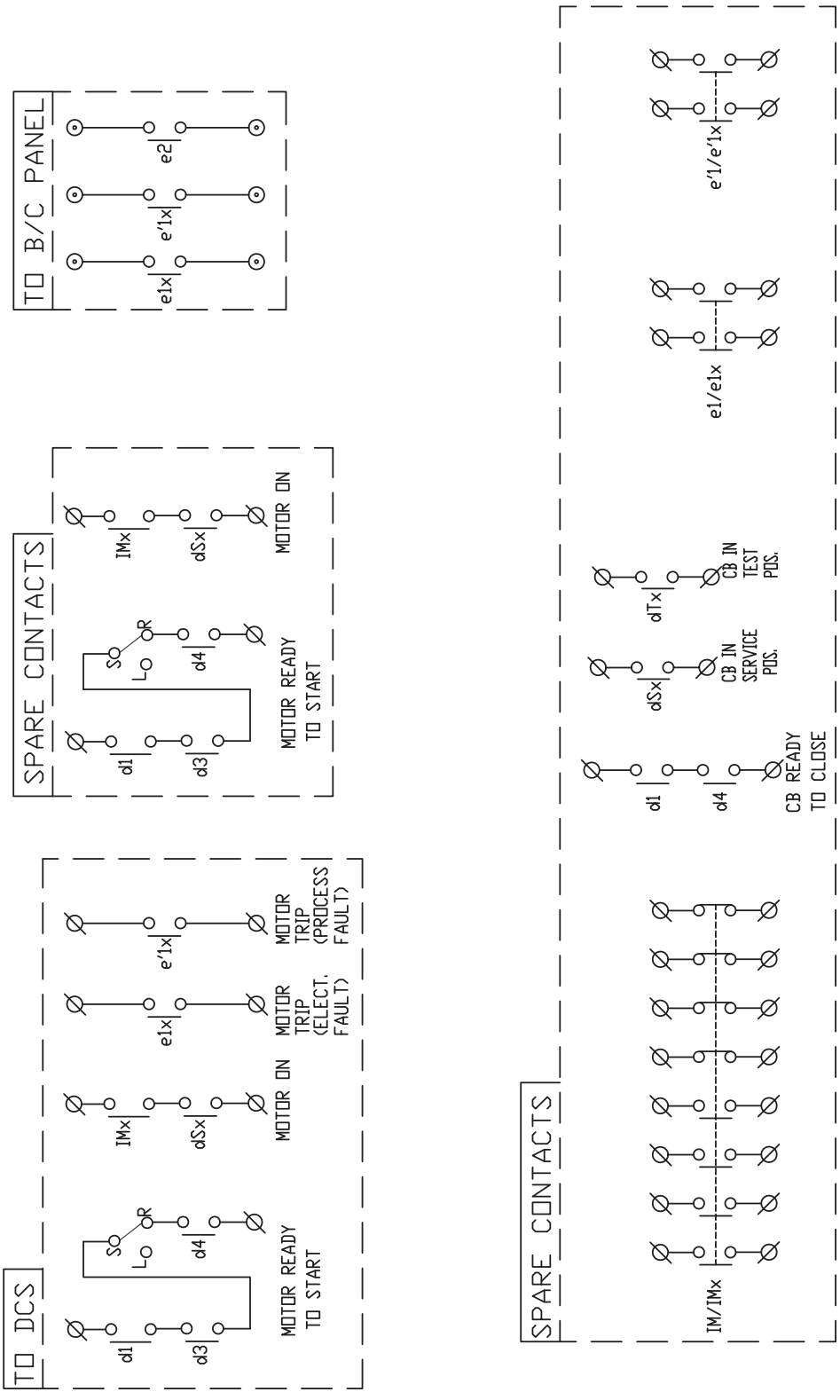
CLOSING & INDICATION SCHEME



** TYPICAL SCHEME FOR ANTIPUMPING

TRIPPING SCHEME




TO B/C PANEL
e1x
e'1x
e2
SPARE CONTACTS
d1
d3
S
R
L
d4
IMx
dSx
MOTOR READY TO START
MOTOR ON
TO DCS
MOTOR TRIP (ELECT. FAULT)
MOTOR TRIP (PROCESS FAULT)
SPARE CONTACTS
IM/IMx
e1/e1x
e'1/e'1x
CB READY TO CLOSE
CB IN SERVICE PDS.
dTx
CB IN TEST PDS.

PART-II, TECHNICAL

SECTION – 10

SCHEMATIC DIAGRAMS WITH LEGEND

FOR

LV SWITCH BOARD

(Drg. No. PDS-1202)

SL.NO.	SYM.	DESCRIPTION
1	d	CONTACTOR
2	e	RELAY
3	b	PUSH BUTTON
4	H	HOOTER
5	BZ	BUZZER
6	T	TIMER
7	h	INDICATION LAMP
8	S	SELECTOR SWITCH
9	L/R/A	LOCAL/REMOTE/AUTO
10	x	AUX. RELAY & CONTACTOR FOR MULTIPLICATION OF CONTACTS
11	LS	C.B. LIMIT SWITCH (SERVICE)
12	LT	C.B. LIMIT SWITCH (TEST)
13	IM	MOTOR FEEDER C.B.
14	IT	TRANSFORMER FEEDER C.B.
15	I1/I2	INCOMER C.B. FROM O/G FEEDER OF UP-STREAM SW.BD.
16	IB	BUS-COUPLER C.B.
17	CC	CLOSING COIL OF C.B.
18	TC	TRIP COIL OF C.B.
19	RS	RESISTOR
20	HF	HT FUSE
21	F	CONTROL FUSE
22	TNC	TRIP-NEUTRAL-CLOSE CONT. SW.
23	e1	LOCKOUT RELAY (ELECT. FAULT)
24	e'1	LOCKOUT RELAY (PROCESS)
25	e2	TRIP CIRCUIT SUPERVISION RELAY
26	e3	MOTOR PROTECTION RELAY
27	e4	U/V RELAY
28	e5	O/C RELAY
29	e6	E/F RELAY
30	e7	SBEF RELAY
31	e8	REF RELAY
32	e9	DIFFERENTIAL RELAY
33	e10	HIGH SET INSTANTANEOUS RELAY
34	e11	AUX. RELAY FOR TRANSFORMER FAULT TRIP
35	e12	AUX. RELAY FOR TRANSFORMER FAULT ALARM
36	e13	AUX. RELAY FOR LOW OIL LEVEL ALARM
37	e14	AUX. RELAY FOR AUTO TRIP ALARM
38	e15	AUX. RELAY FOR NON-TRIP ALARM
39	e16	SYNCHRO CHECK RELAY
40	h1	'C.B. ON'
41	h1a	'C.B. ON' (REAR SIDE)
42	h2	'C.B. OFF'
43	ha2	'C.B. OFF' (REAR SIDE)
44	h3	'C.B. TRIPPED'
45	h4	'C.B. READY FOR SERVICE'
46	h5	'C.B. READY FOR TEST'
47	h6	'TRIP CIRCUIT HEALTHY'
48	h7	'MOTOR SPACE HEATER ON'
49	⌀	EXTERNAL TERMINALS
50	⊙	INTER PANEL TERMINALS
51	LCS	LOCAL CONTROL STATION NEAR MOTOR
52	HM	HOURMETER

NOTE: INSIDE DRAWINGS THERE SHALL BE CHANGE AS PER POINTS GIVEN BELOW

1. NO COMMON ALARM CIRCUIT (EXCEPT HOOTER/BELL) IN BUSCOUPLER FEEDERS AS EACH FEEDER WILL HAVE ITS OWN MICROPROCESSOR BASED ANNUNCIATOR.
2. EXCLUSIVE LV PT FUSE FOR e4.
3. BLOCKING DIODE FOR LAMP TEST INSTEAD OF d5.
4. SPACE HEATER LAMP IN LCS FOR MV MOTORS ARE NOT REQUIRED (O/L TRIP LAMP MAY BE USED)
5. LCS MAY HAVE 'READY FOR START' LAMP FOR AUTO STARTING MOTORS.
6. VIB./OIL LEVEL TRIP LAMP WITH RESET PB FOR CT FAN MOTORS.

पी डी आई एल PDIL

SCHEMATIC DIAGRAM LEGEND

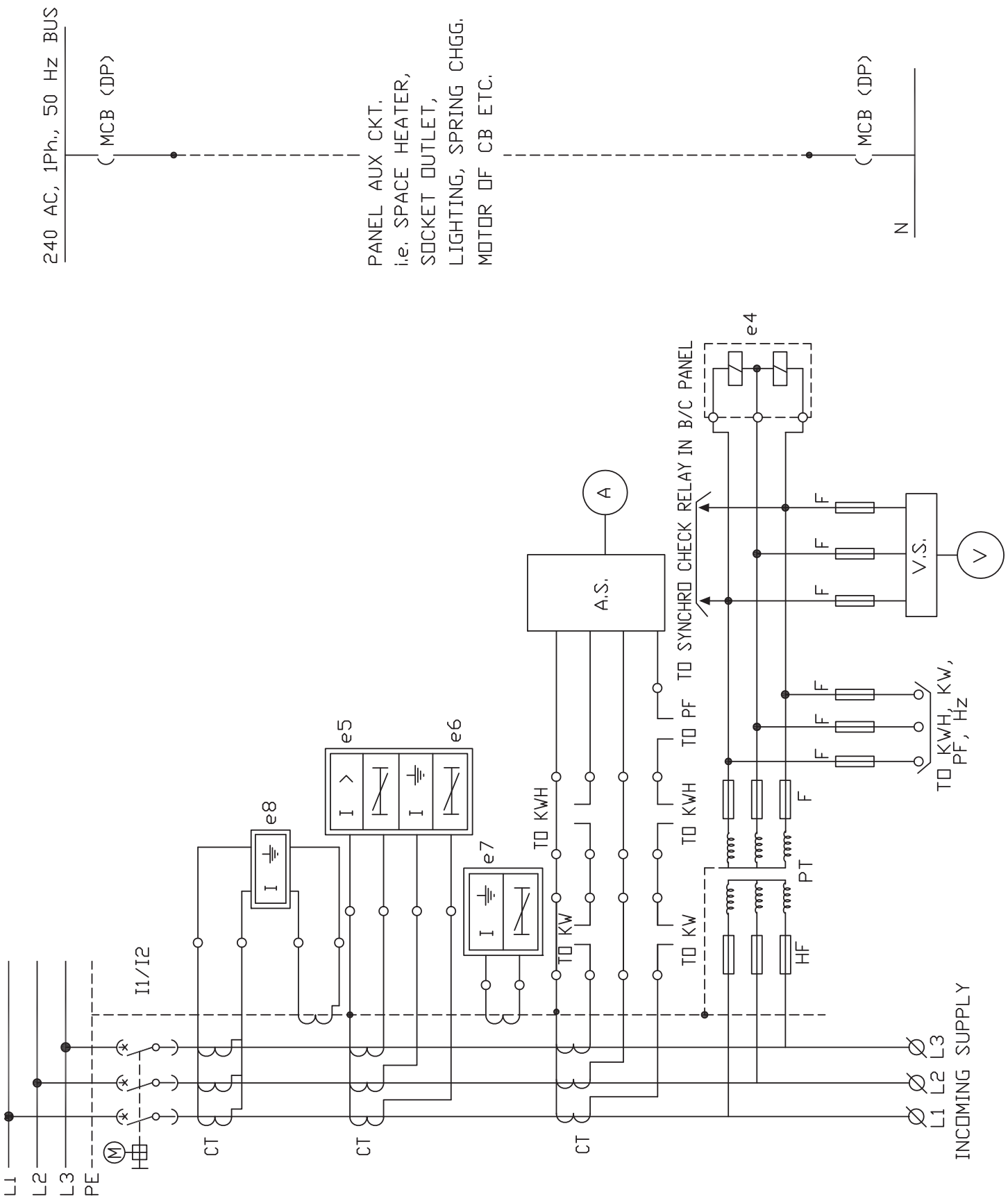
PDS-1202

DRAWING NO.

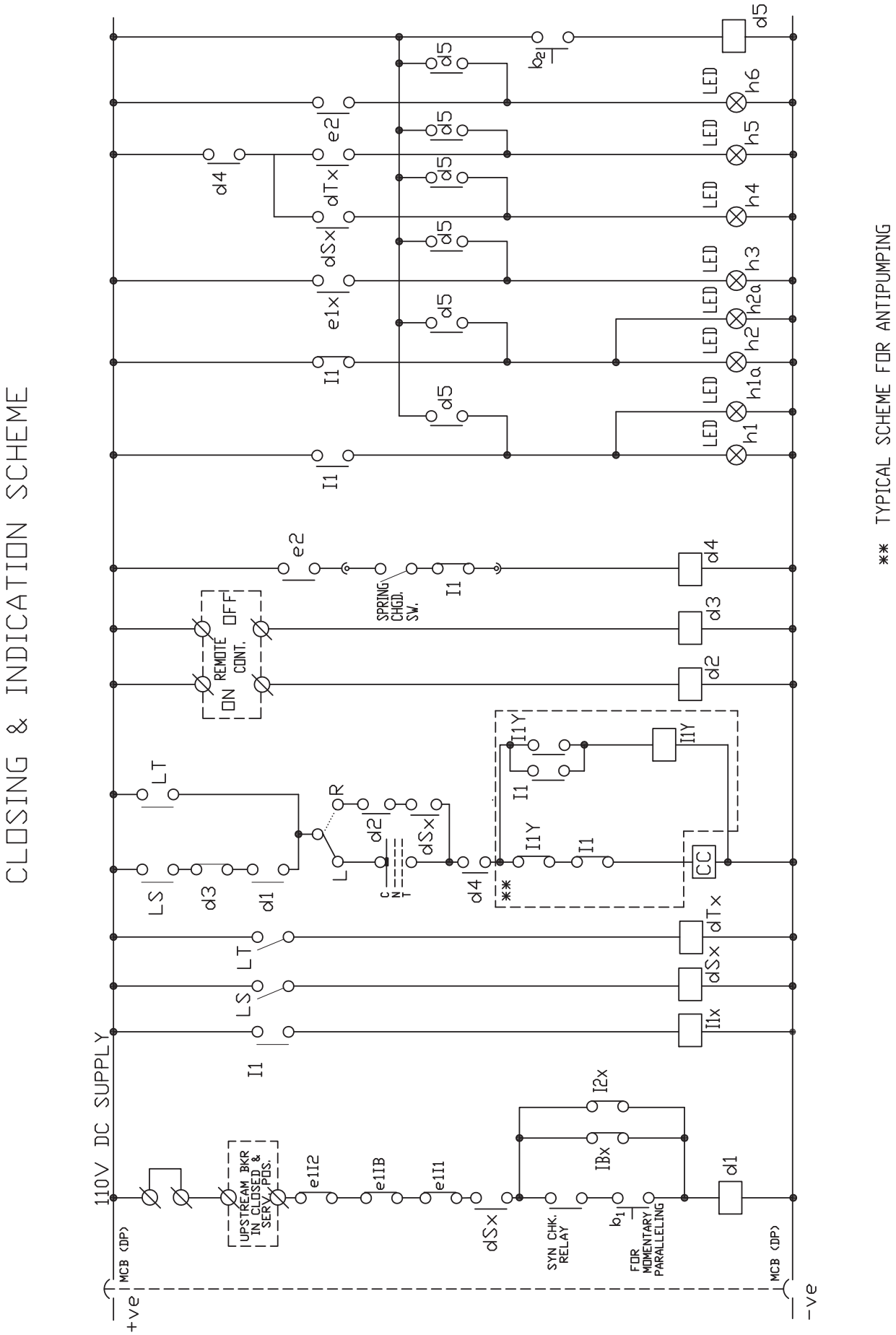
REV. 0

SHEET 2 OF 16

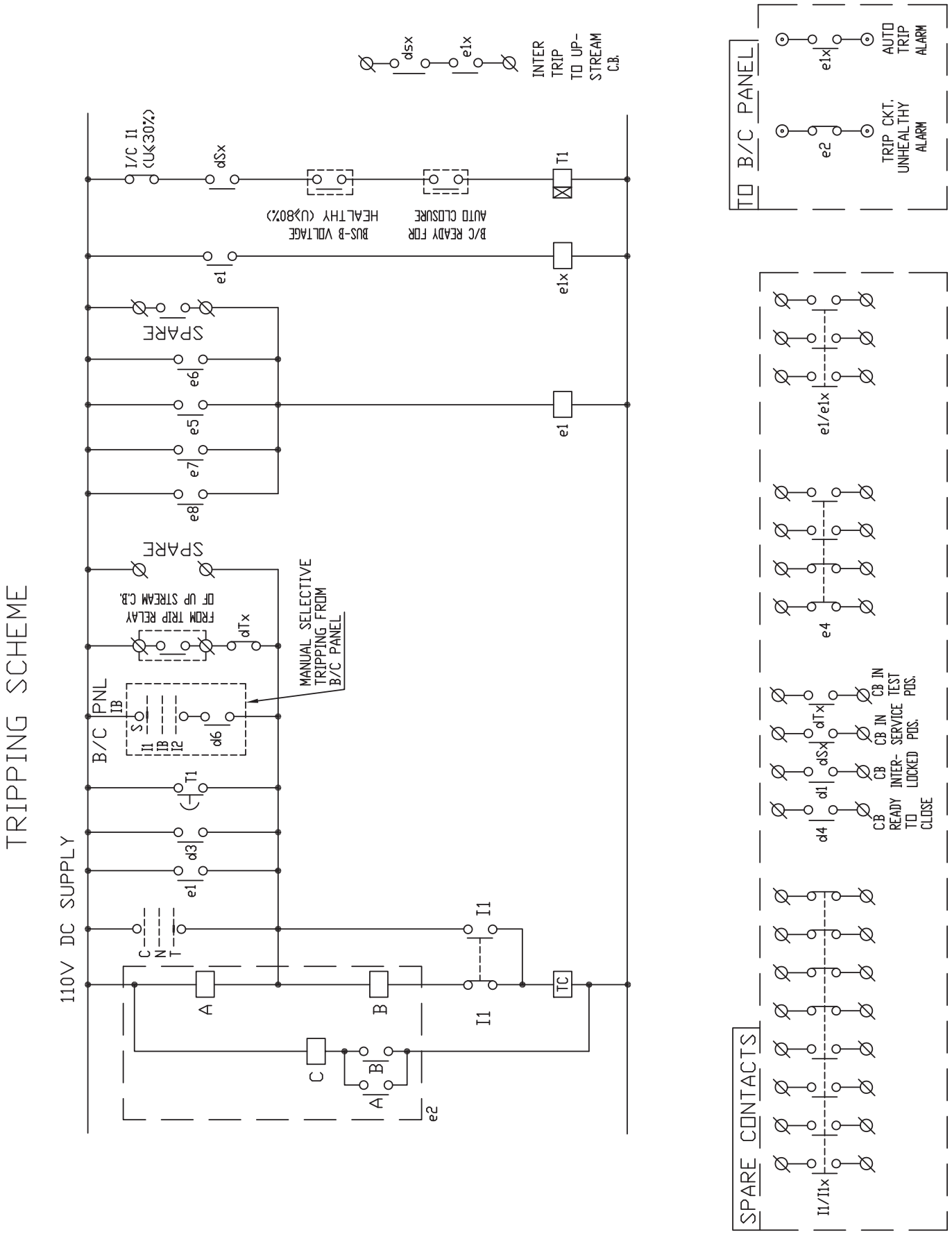
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR INCOMER 1 & 2 (TYPE I1 & I2) – POWER CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 3 OF 16	



पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR INCOMER 1 (FEEDER TYPE I1) – CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 4 OF 16	

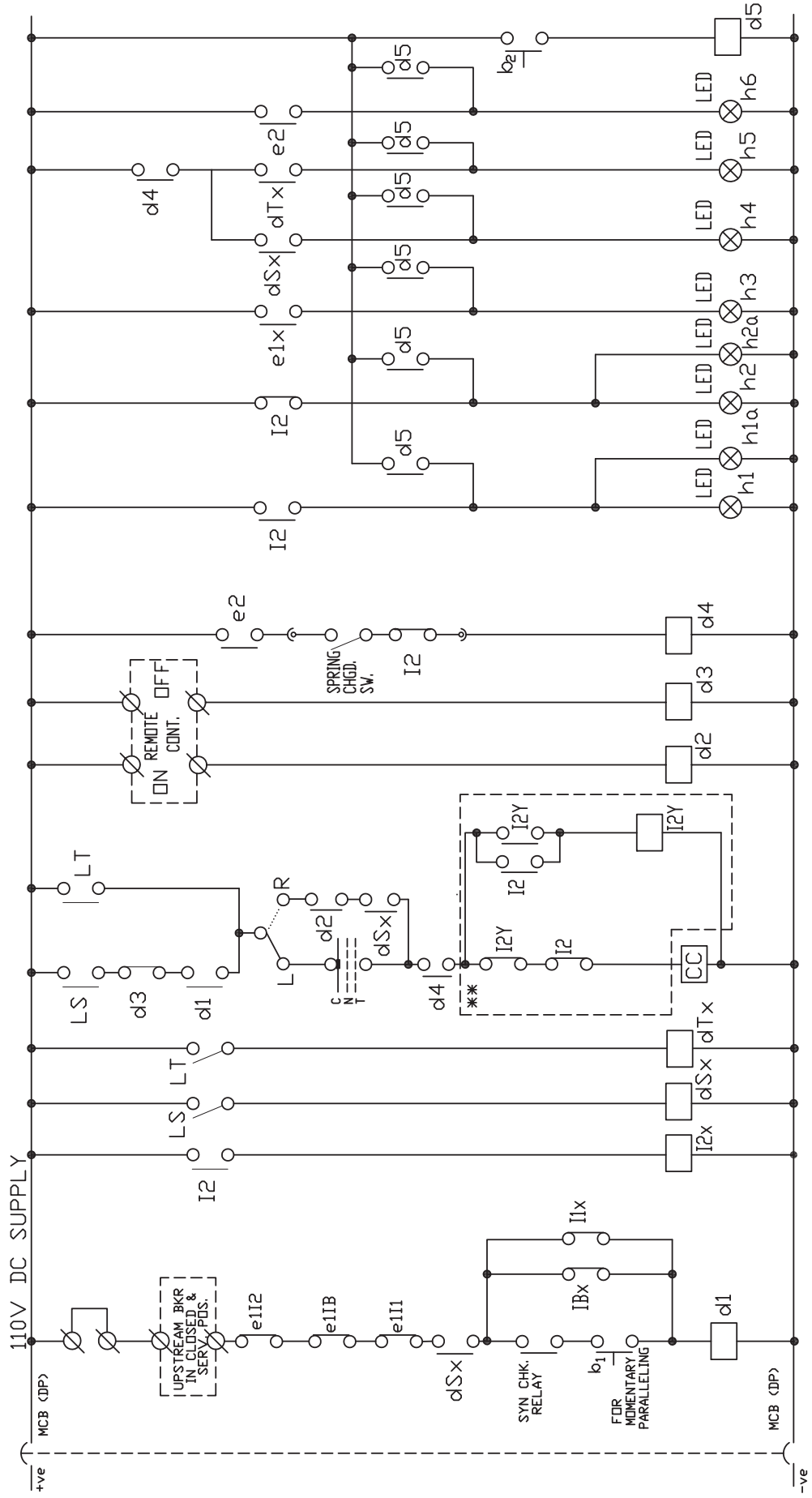


पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR INCOMER 1 (FEEDER TYPE I1) – CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 5 OF 16	



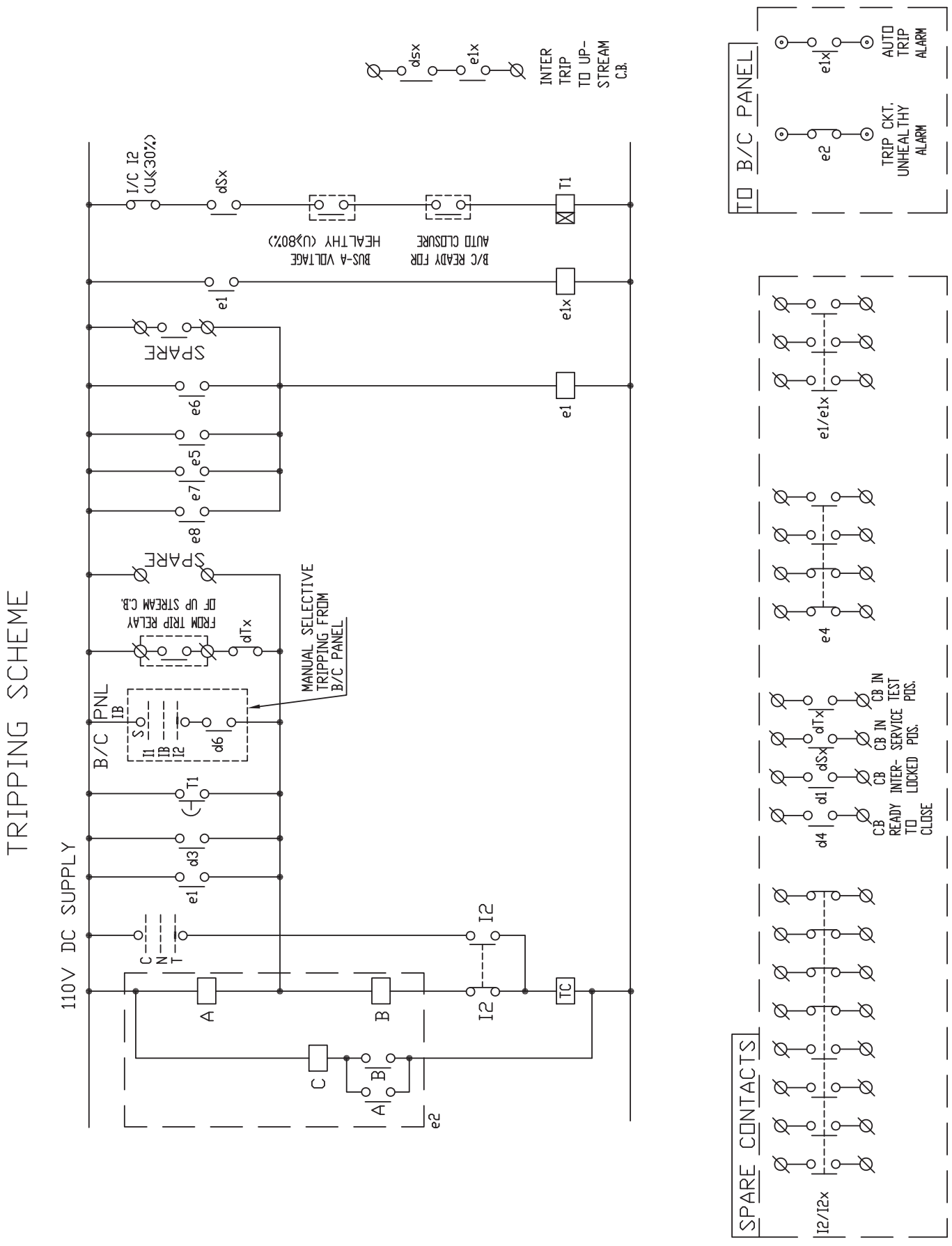
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR INCOMER 2 (FEEDER TYPE I2) – CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 6 OF 16	

CLOSING & INDICATION SCHEME

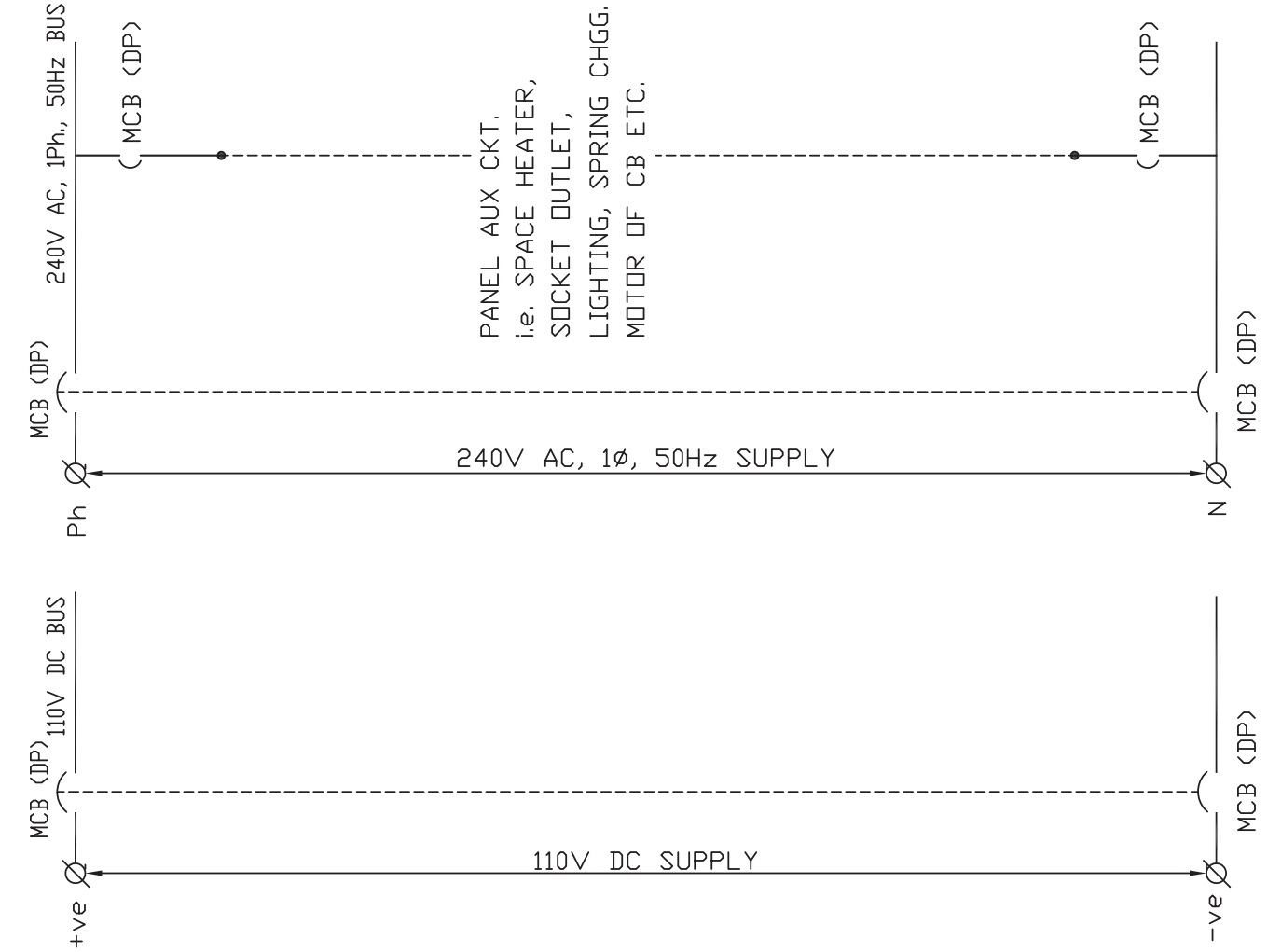


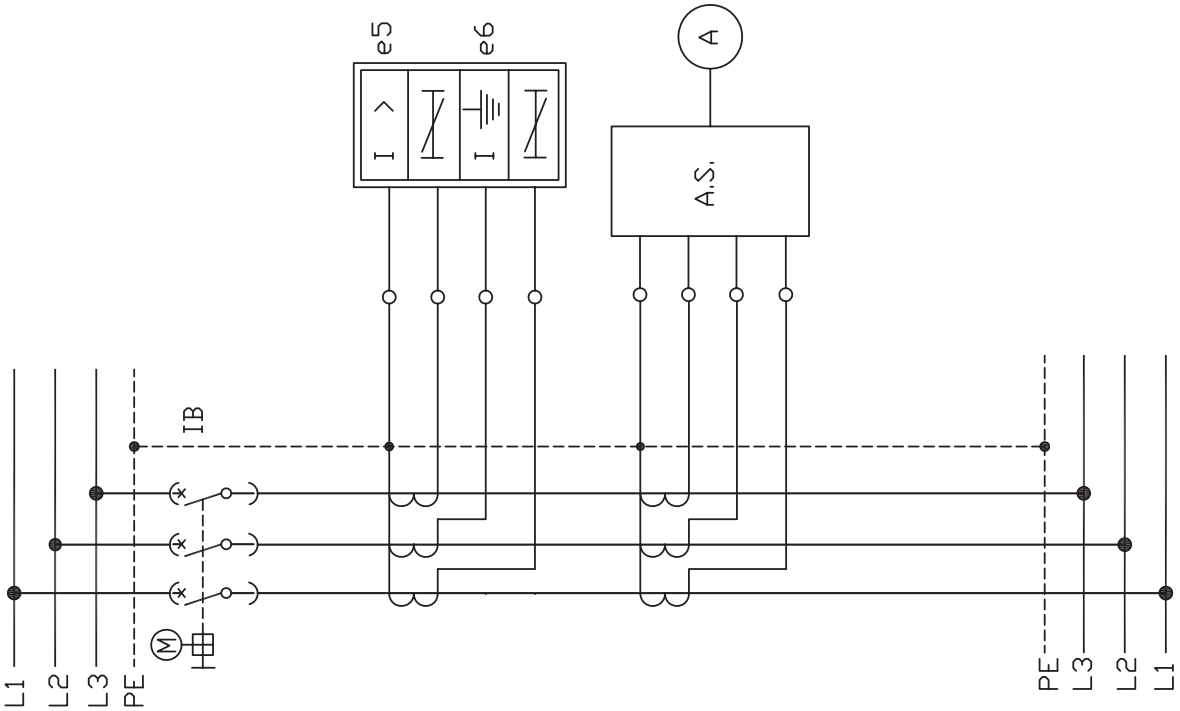
** TYPICAL SCHEME FOR ANTIPUMPING

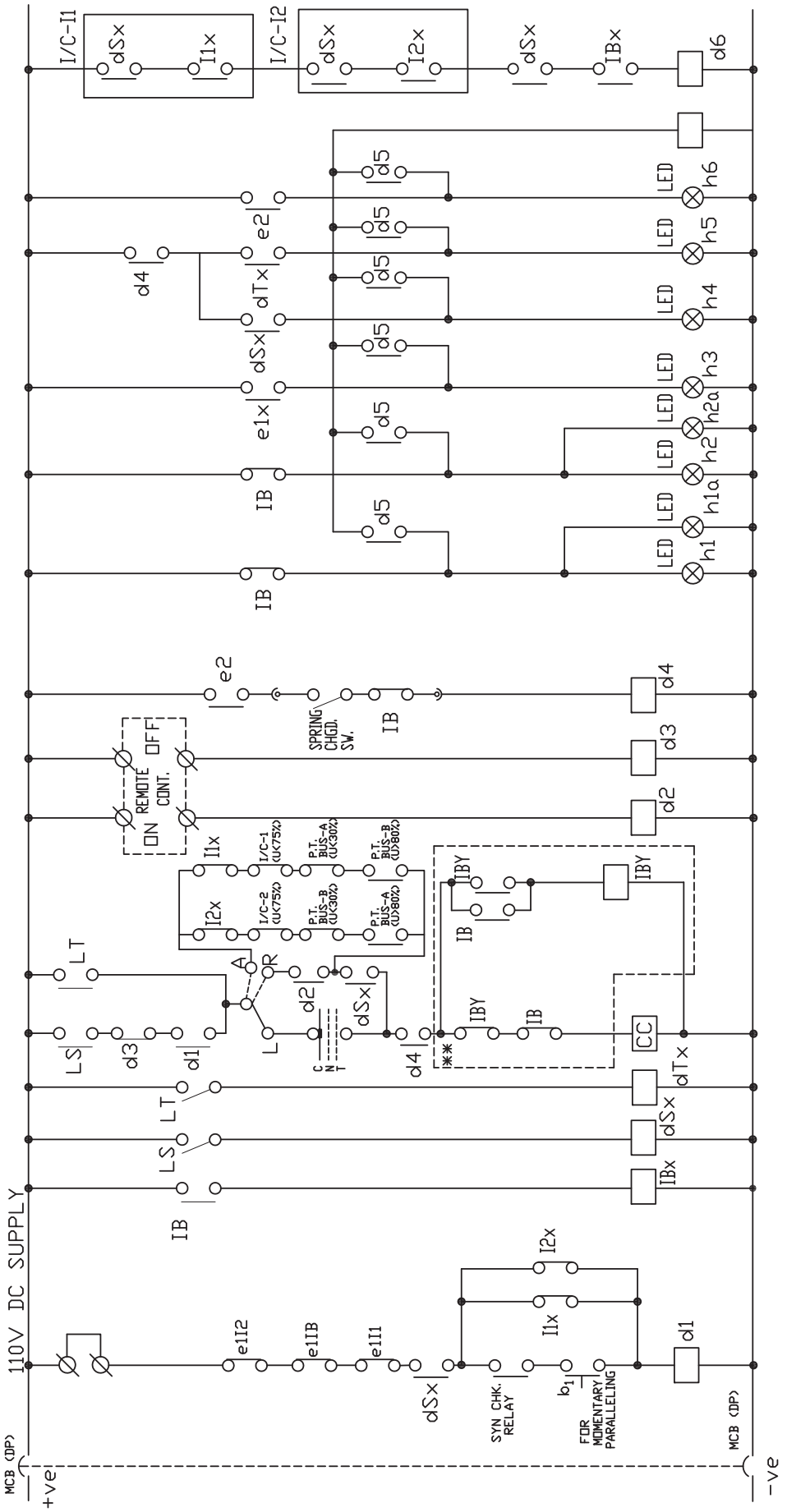
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR INCOMER 2 (FEEDER TYPE I2) – CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 7 OF 16	



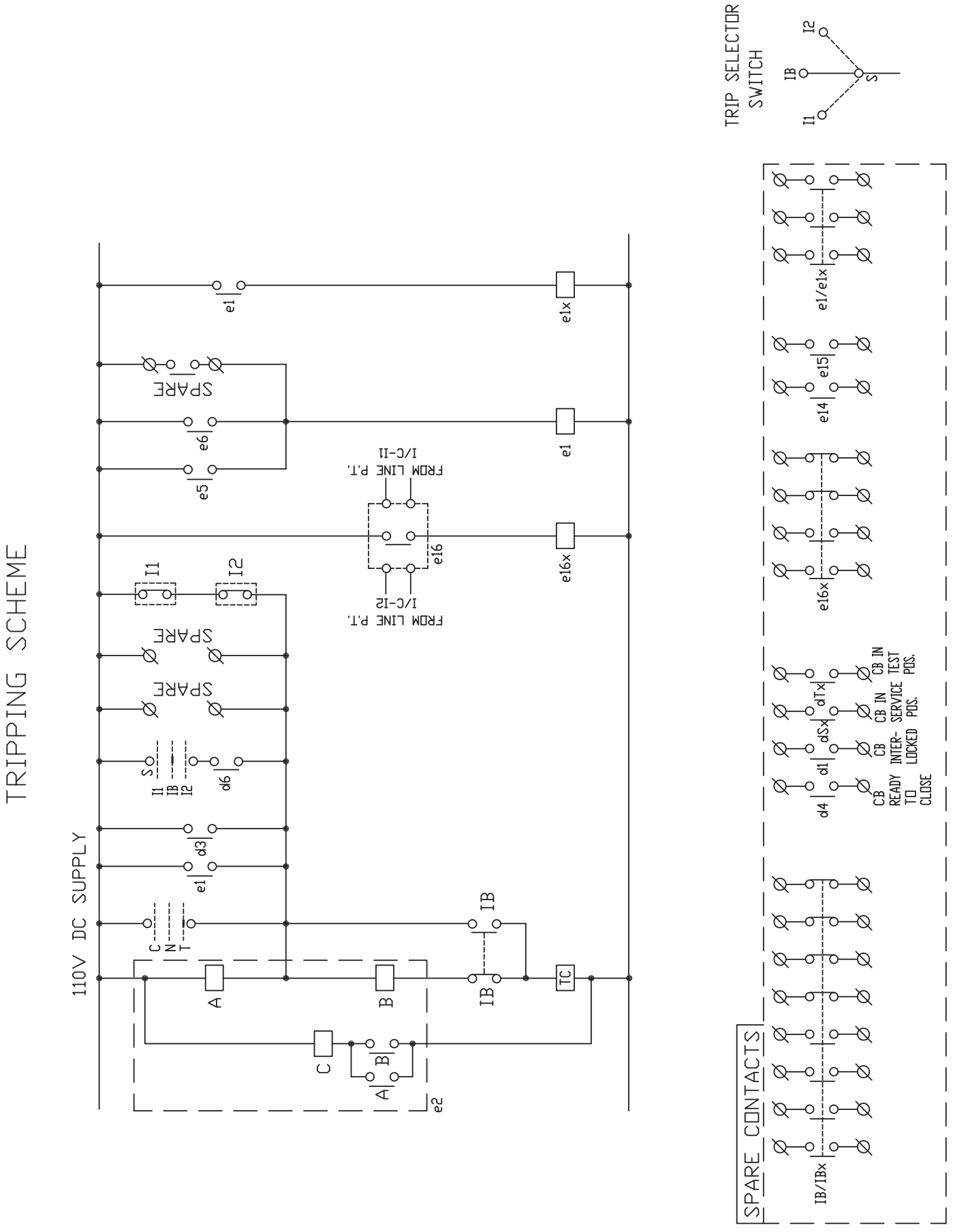
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR BUS–COUPLER (TYPE–IB) – POWER CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 8 OF 16	

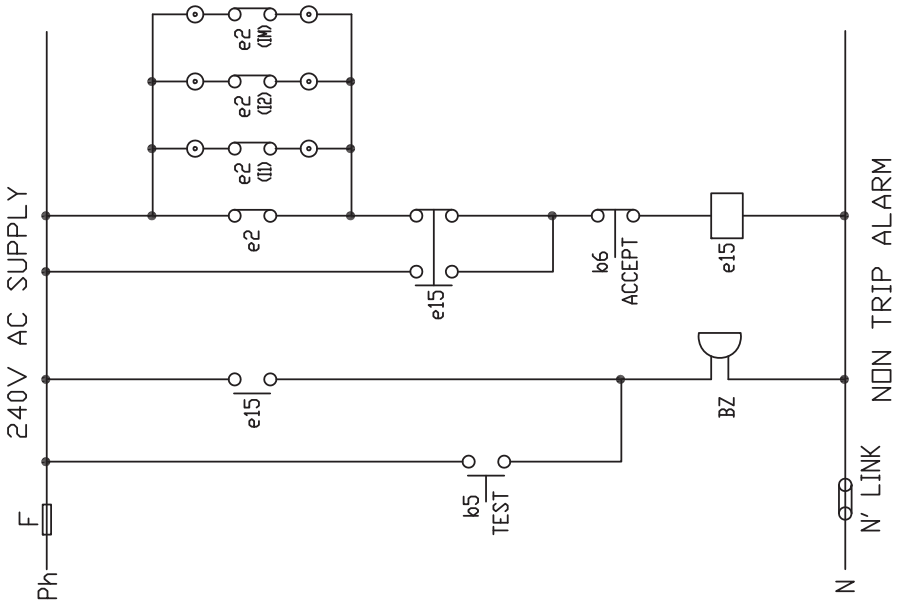


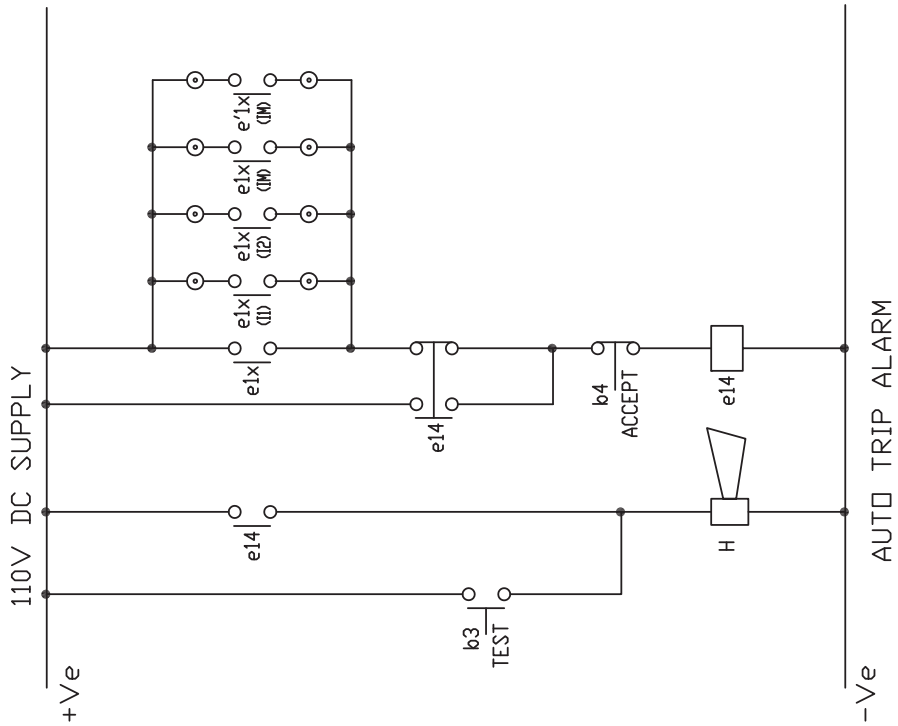



CLOSING & INDICATION SCHEME
110V DC SUPPLY
+ve
-ve
MCB (DP)
MCB (DP)
I/C-I1
I/C-I2
dSx
I1x
I2x
IBx
d6
LED
h6
h5
h4
h3
h2a
h2
h1a
h1
d5
e2
dTx
e1x
IB
d4
d3
d2
d1
SPRING CHGD. SW.
REMOTE CONT.
ON
OFF
I1x
I2x
I/C-1 (U<75%)
I/C-2 (U<75%)
P.T. BUS-A (U<30%)
P.T. BUS-B (U<30%)
P.T. BUS-B (U>80%)
P.T. BUS-A (U>80%)
IBY
LT
LS
A
R
L
C
N
T
CC
**
e1I2
e1IB
e1I1
SYN CHK. RELAY
FOR MOMENTARY PARALLELING
** TYPICAL SCHEME FOR ANTIPUMPING

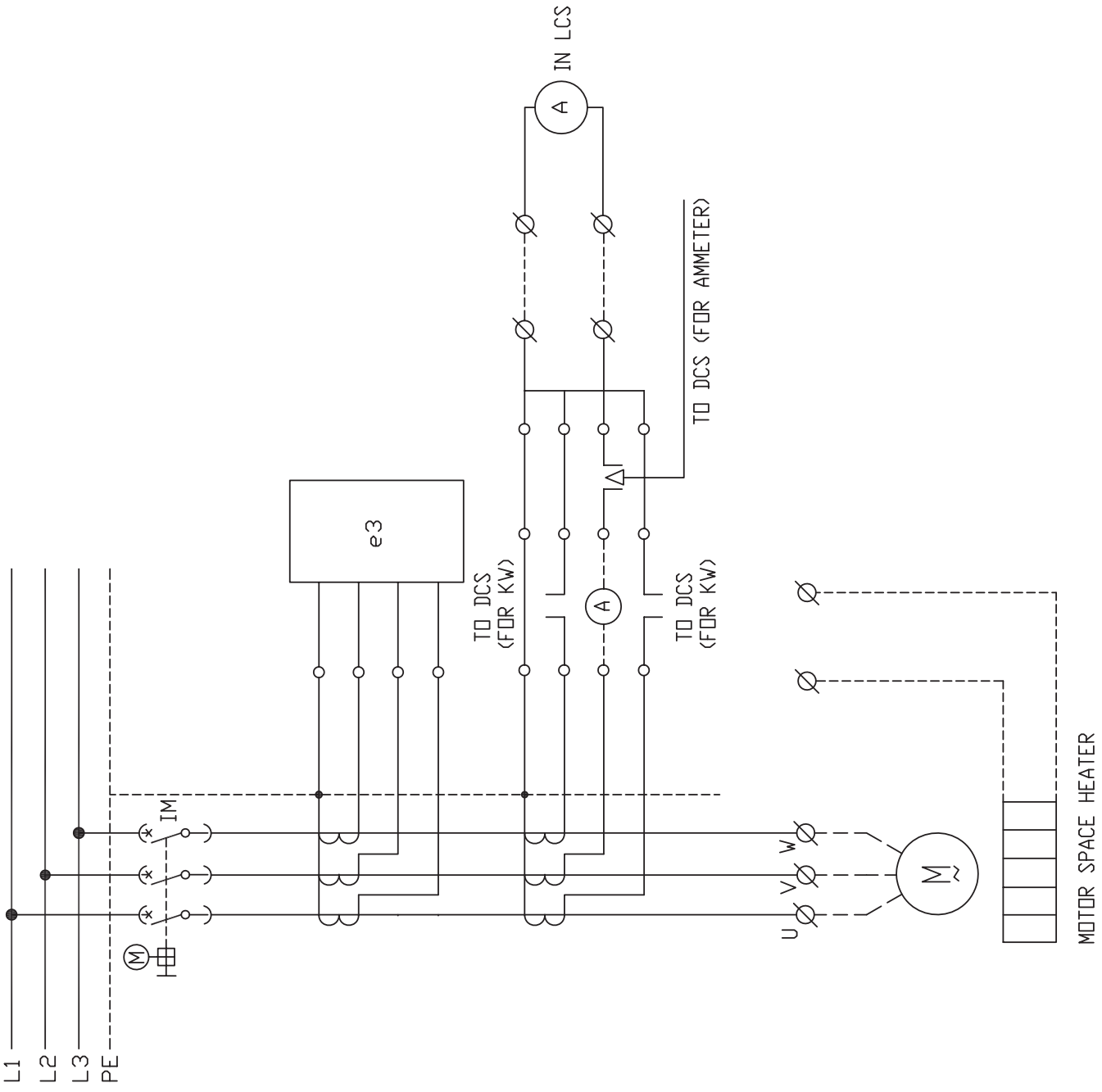
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR BUS–COUPLER (TYPE–IB) – CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 10 OF 16	



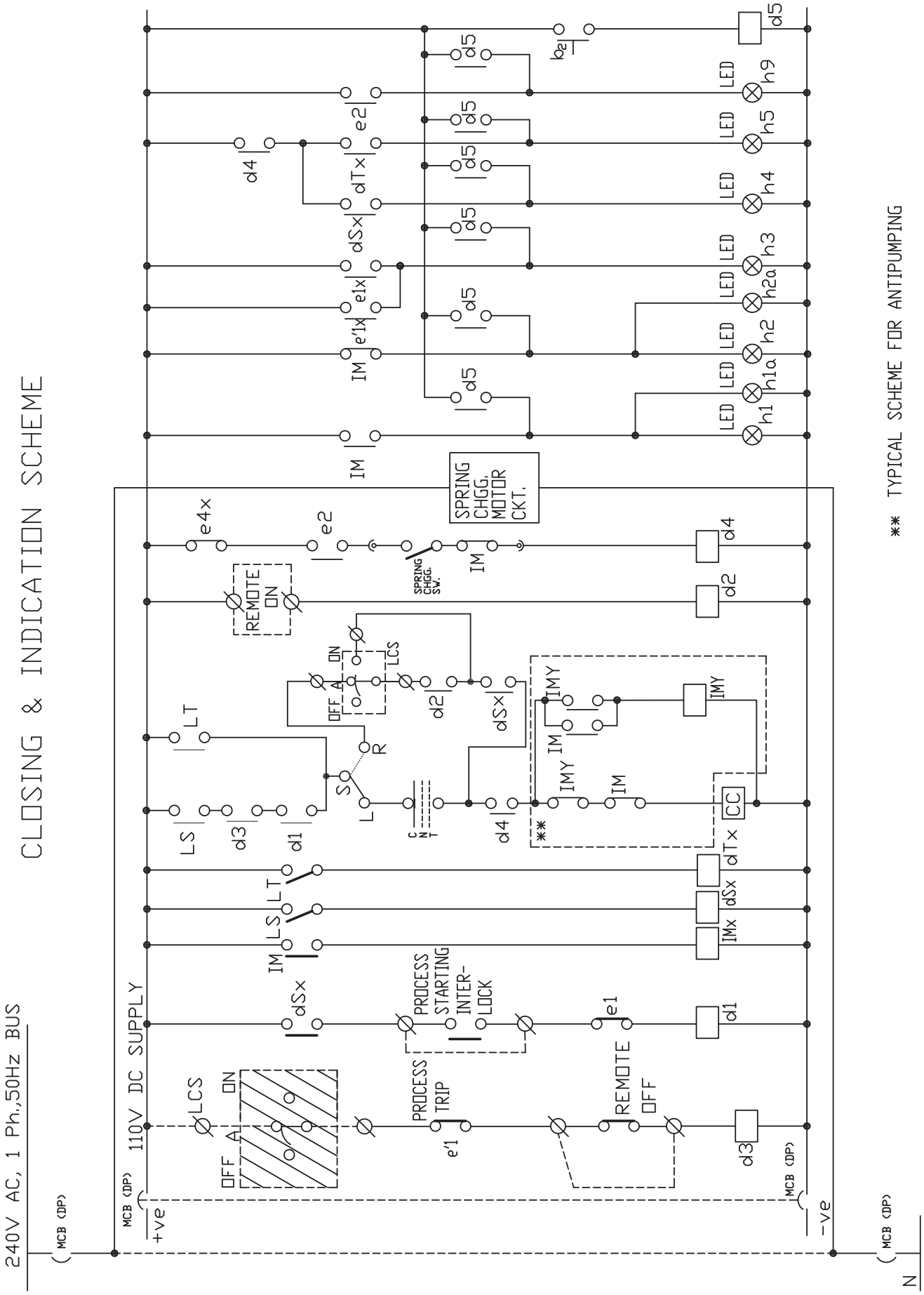

240V AC SUPPLY
Ph
F
e2 (M)
e2 (2)
e2 (1)
e2
e15
b5 TEST
b6 ACCEPT
e15
e15
BZ
N' LINK
N
NON TRIP ALARM


110V DC SUPPLY
+Ve
e'1x (M)
e1x (M)
e1x (2)
e1x (1)
e1x
e14
b3 TEST
b4 ACCEPT
e14
e14
H
-Ve
AUTO TRIP ALARM

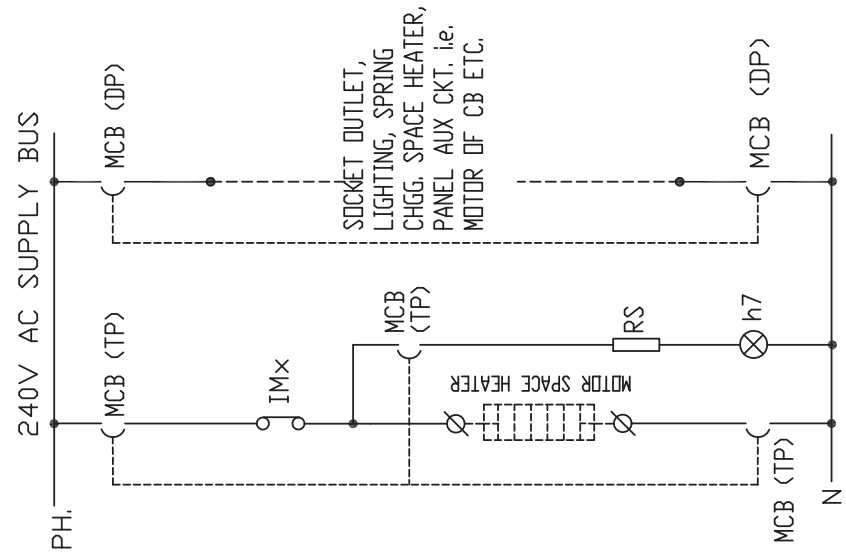
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR MOTOR FEEDER RATED ABOVE 110KW (TYPE-IM) – POWER CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 12 OF 16	



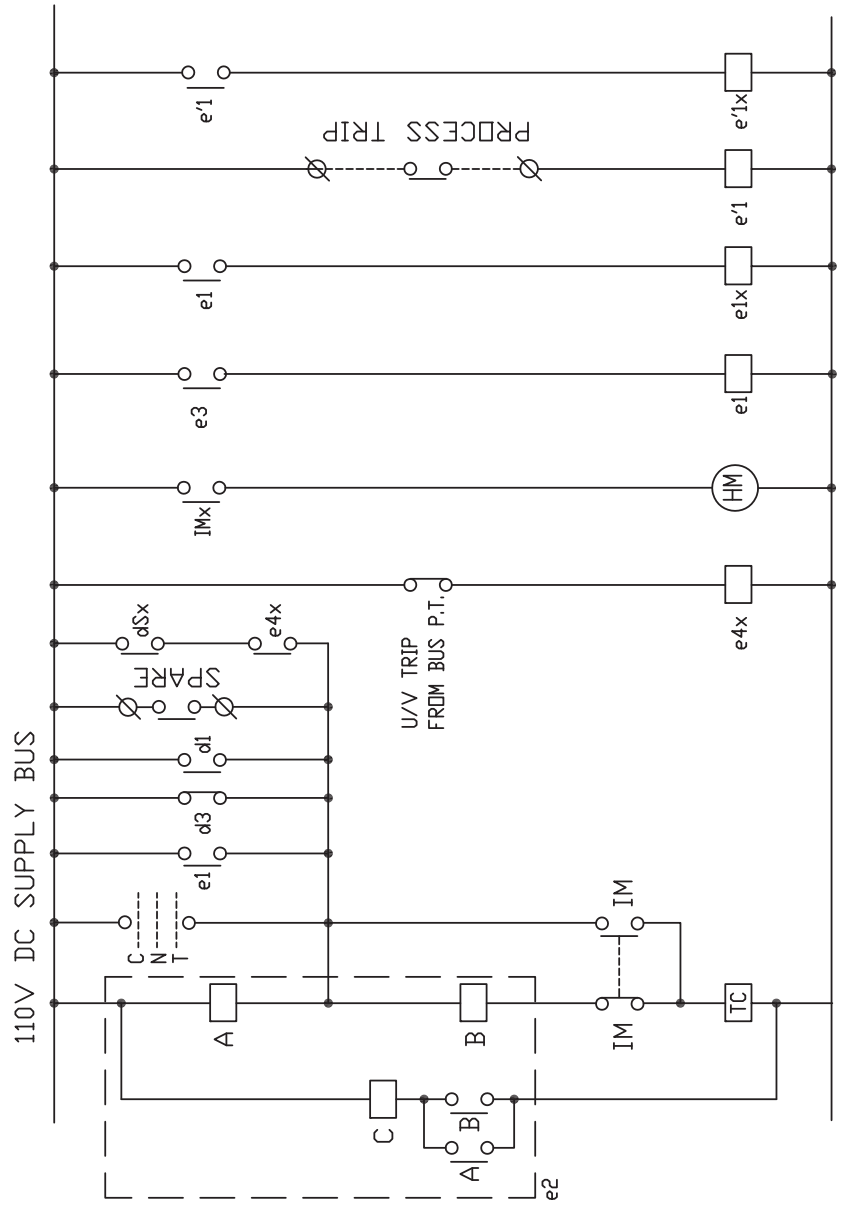
पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR MOTOR FEEDER RATED ABOVE 110KW (TYPE-IM) - CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 13 OF 16	

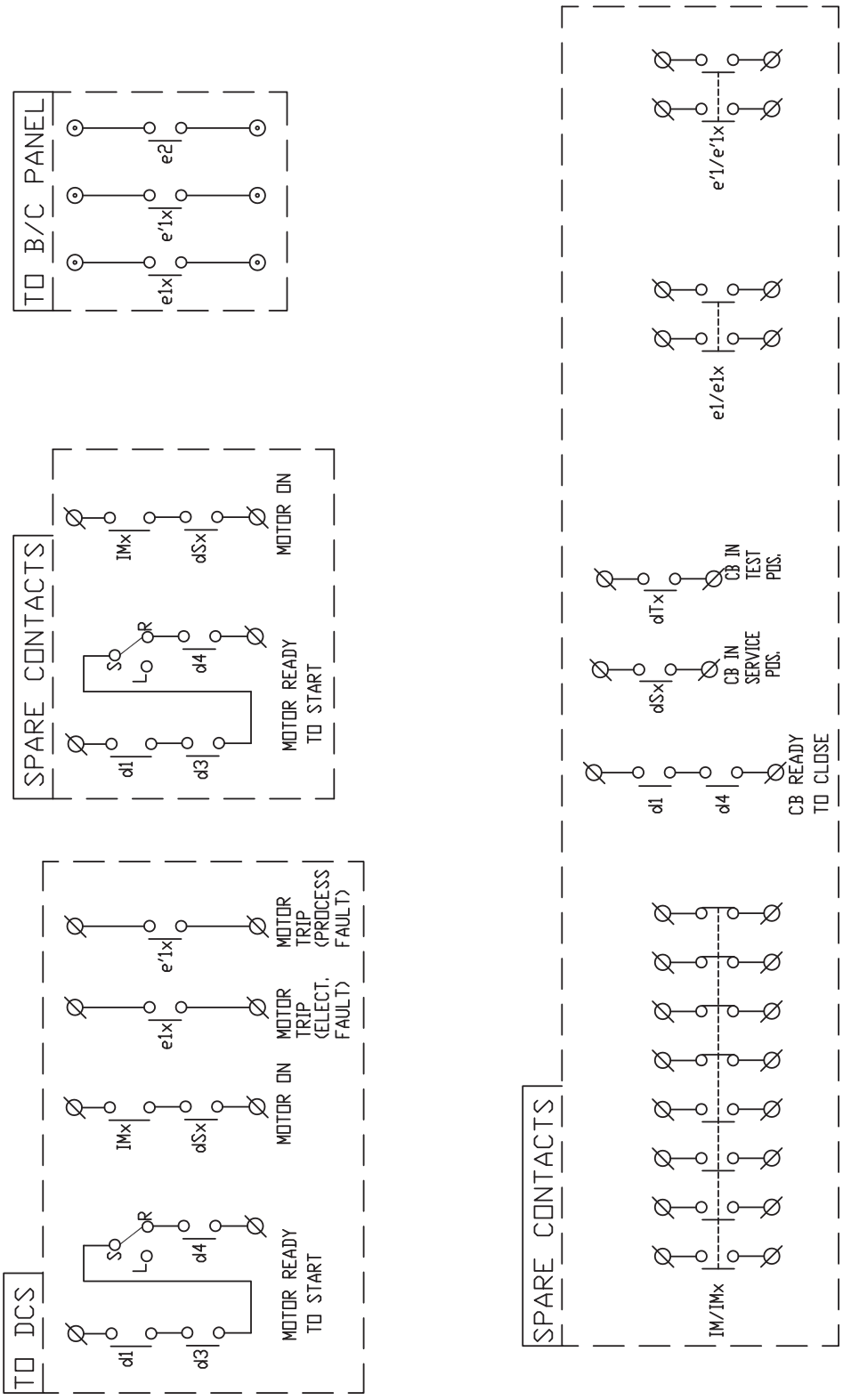


पी डी आई एल PDIL	SCHEMATIC DIAGRAM FOR MOTOR FEEDER RATED ABOVE 110KW (TYPE-IM) - CONTROL CIRCUIT	PDS-1202	0
		DRAWING NO.	REV.
		SHEET 14 OF 16	

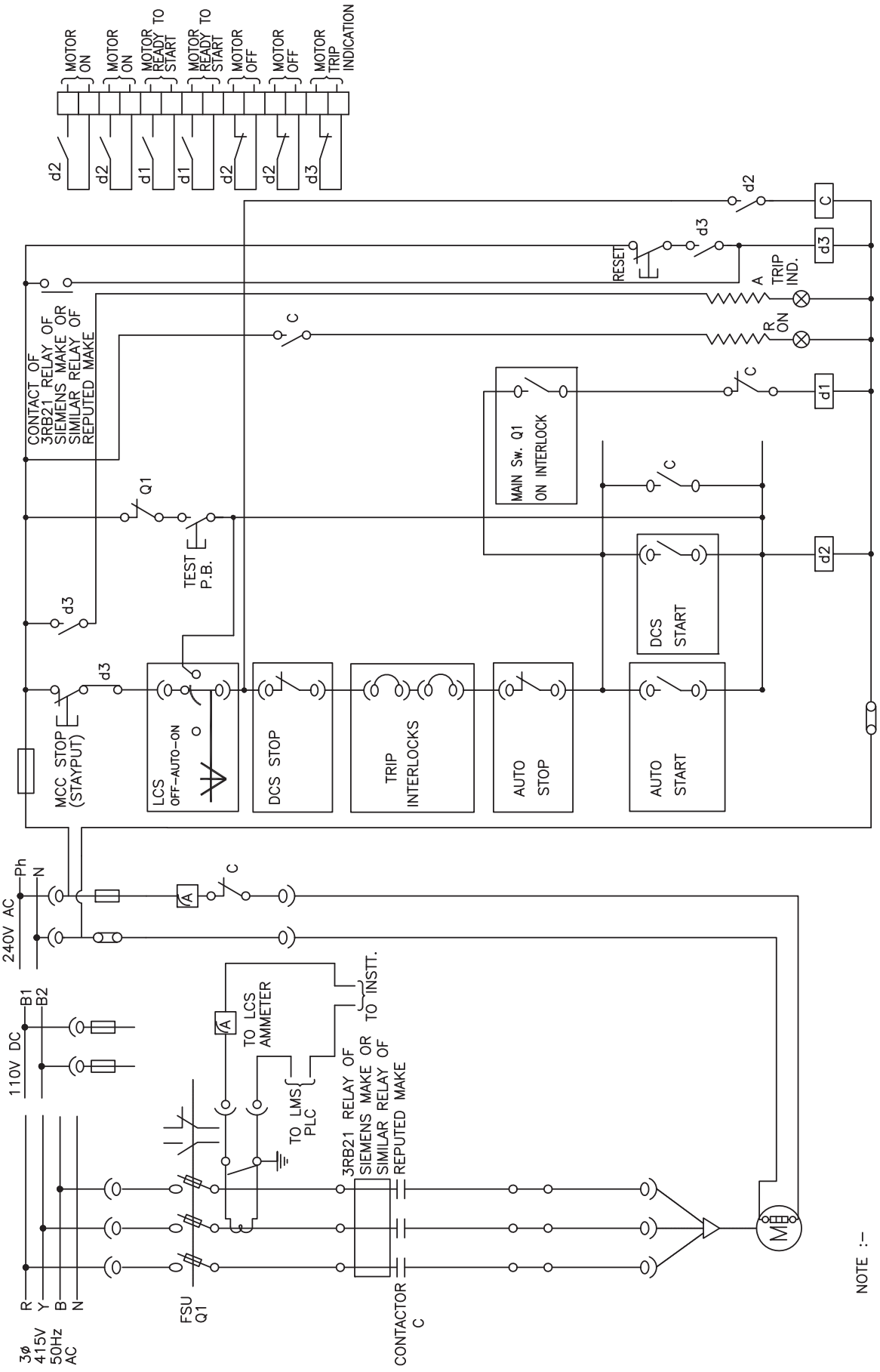


TRIPPING SCHEME




TO B/C PANEL
e1x
e'1x
e2
SPARE CONTACTS
d1
d3
S
R
L
d4
IMx
dSx
MOTOR READY TO START
MOTOR ON
TO DCS
d1
d3
S
R
L
d4
IMx
dSx
MOTOR ON
e1x
MOTOR TRIP (ELECT. FAULT)
e'1x
MOTOR TRIP (PROCESS FAULT)
MOTOR READY TO START
SPARE CONTACTS
IM/IMx
e1/e1x
e'1/e'1x
d1
d4
dSx
CB IN SERVICE PDS.
dTx
CB IN TEST PDS.
CB READY TO CLOSE

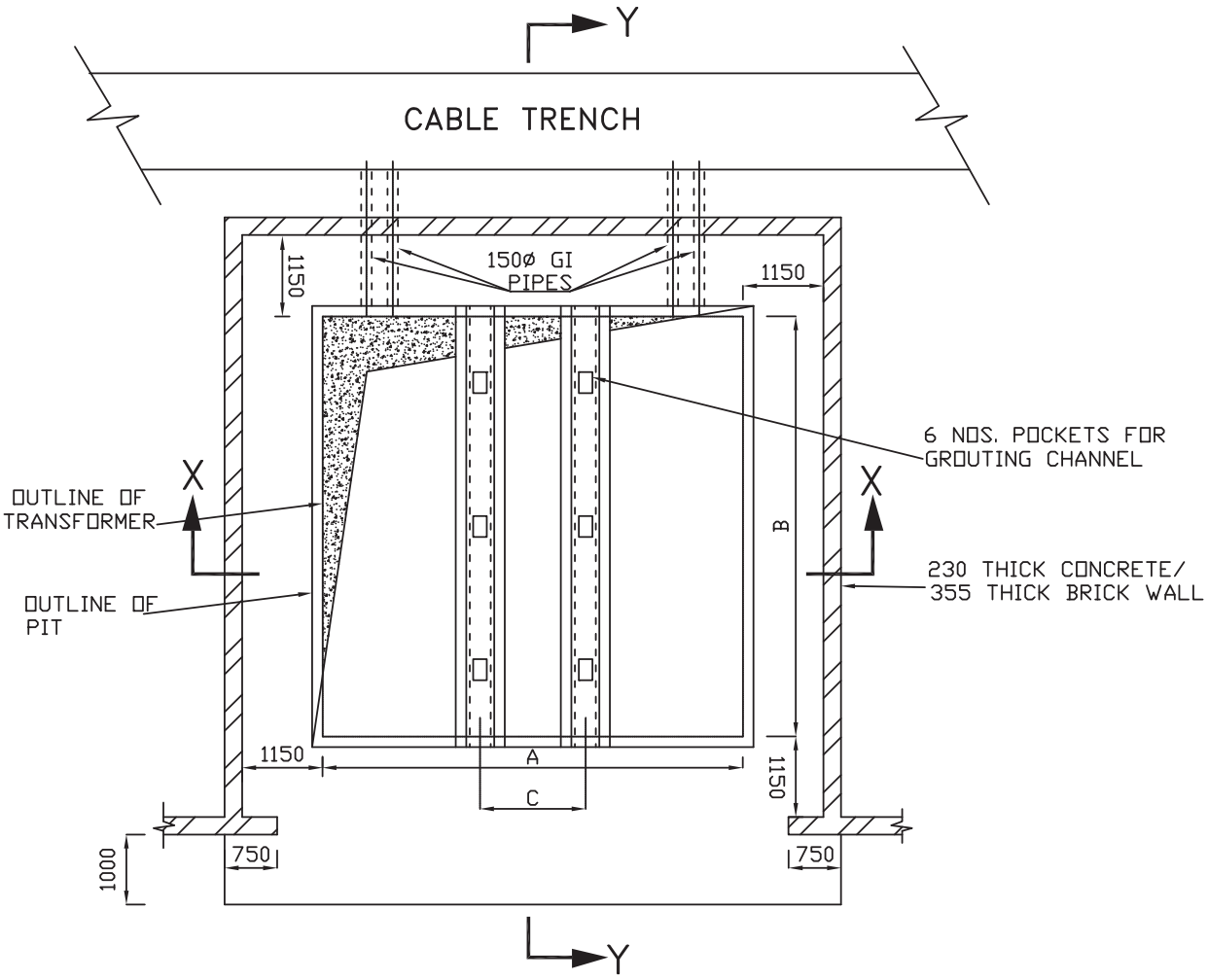
पी डी आई एल PDIL	TYPICAL MOTOR CONTROL SCHEMATIC DIAGRAM MOTOR UP TO 110 KW	PDS-1202	0
		DOCUMENT NO.	REV.
		SHEET 16 OF 16	



NOTE :-

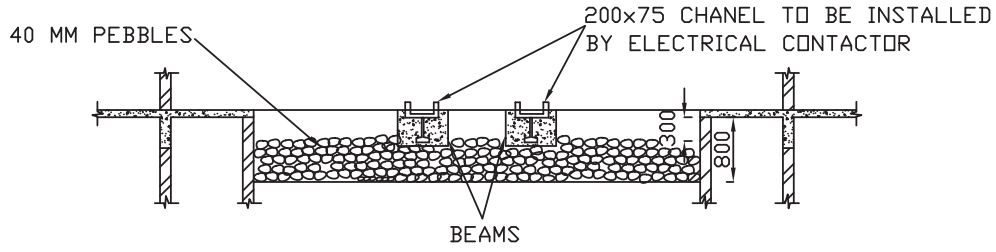
1. Space heater shall be provided for motor rated 30KW and above.
2. CT provision for ammeter shall be done for 15KW & above rating motor feeders.
3. Shorting link shall be provided between Interlock terminals.
4. All indicating lamp shall be LED type.

पी डी आई एल PDIL	FOUNDATION DETAIL OF 11/.433KV OR 3.3/.433KV TRANSFORMER	PDS: E 113	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	

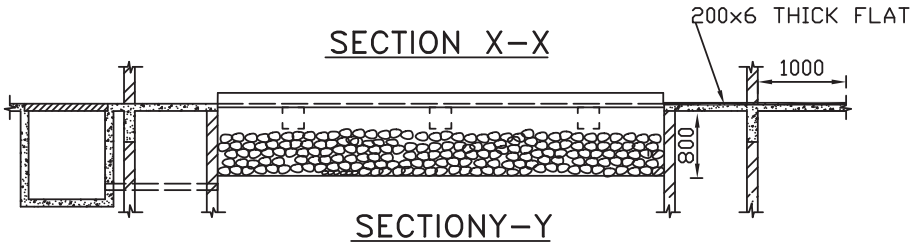


PLAN

TYPICAL DETAIL OF 11/.433KV T/F



SECTION X–X

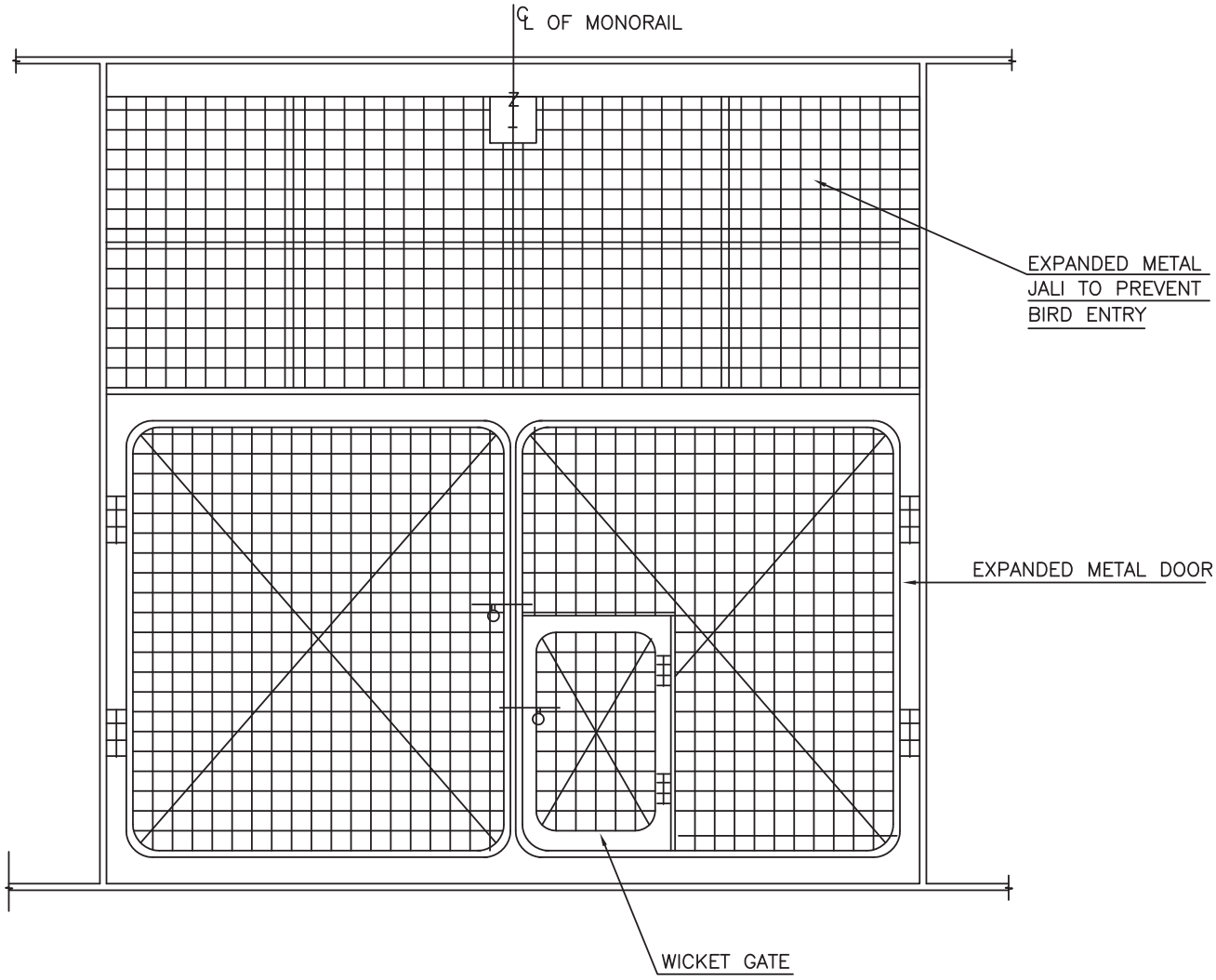


SECTIONY–Y

NOTE :

TRANSFORMERS RATED ABOVE 10MVA SHALL BE MOUNTED ON 200MM x 8MM THICK PLATES.

पी डी आई एल PDIL	TYPICAL DETAILS OF TRANSFORMER ROOM DOOR	PDS: E 115	0
		DOCUMENT NO.	REV
		SHEET 1 OF 1	

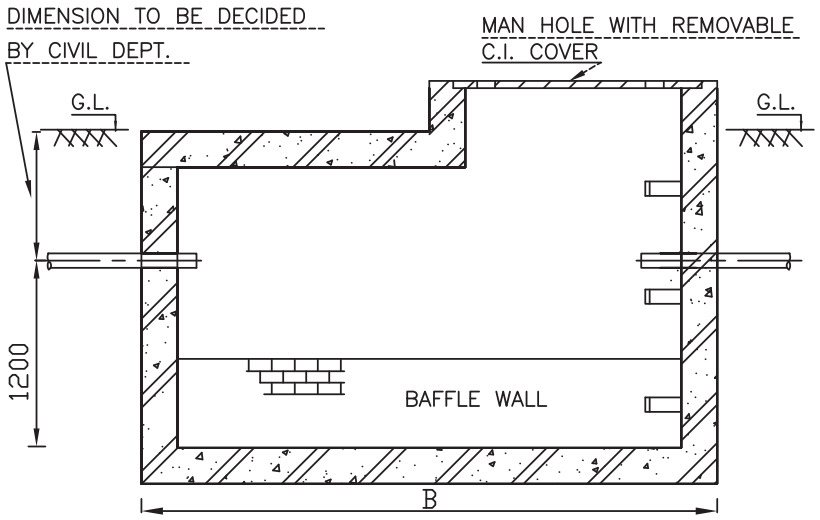


NOTE :–

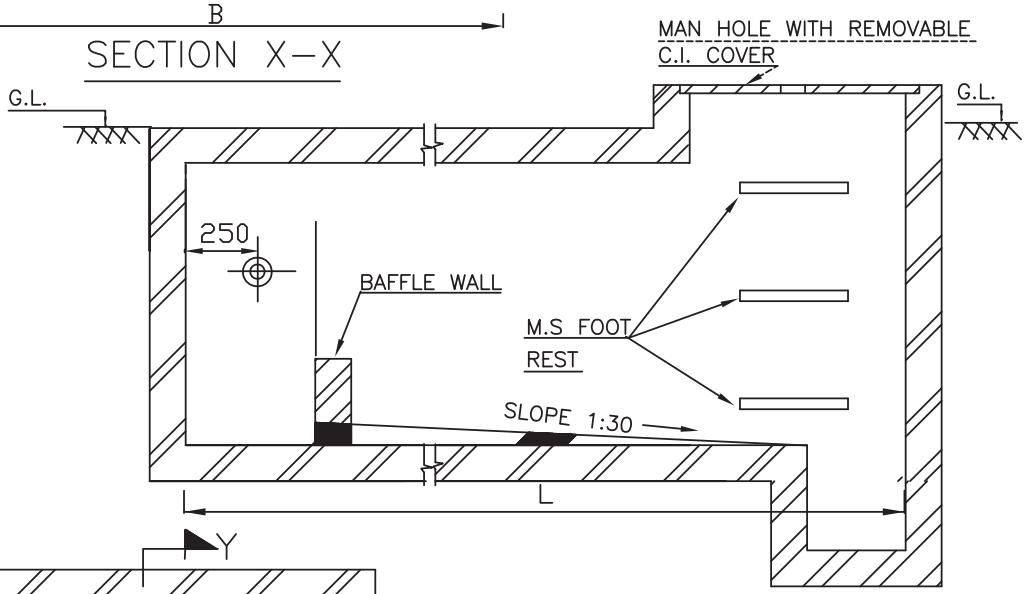
1. THIS STANDARD IS INDICATIVE ONLY, THE EXACT DIMENSIONS SHALL BE DECIDED AS PER TRANSFORMER SIZE & SUB–STATION LAYOUT.

2. TRANSFORMER GATE HEIGHT SHALL BE 250MM MORE THAN THE TRANSFORMER HEIGHT AND SHALL BE OPENABLE OUTSIDE.

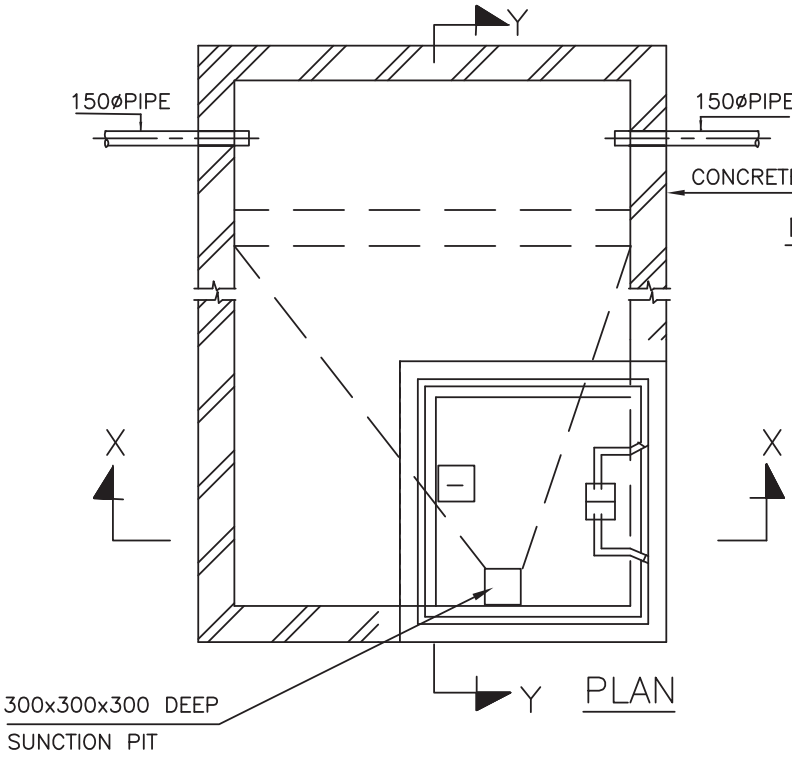
पी डी आई एल PDIL	SUMP PIT FOR TRANSFORMER OIL	PDS: E 116	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



SECTION X–X



SECTION Y–Y

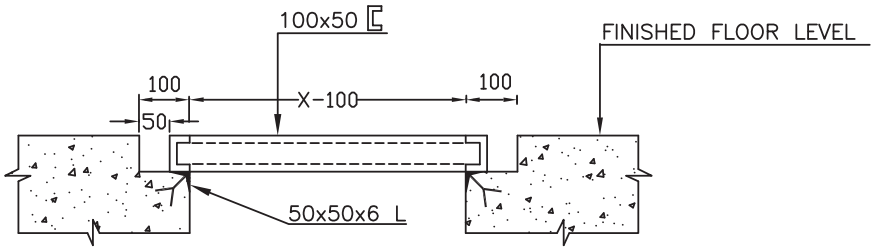


PLAN

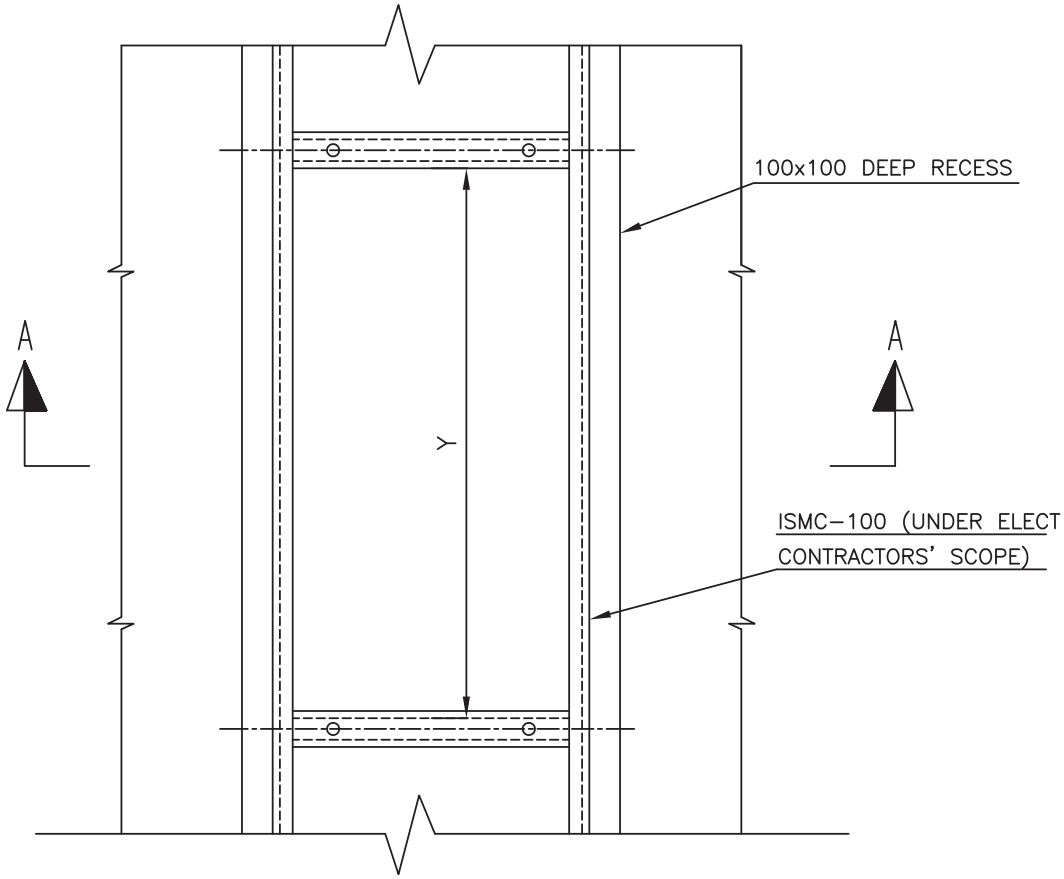
NOTES:–

1. DIMENSION 'L' AND 'B' SHALL BE DECIDED BASED ON OIL VOLUME OF HIGHEST RATED TRANSFORMER.
2. ALL DIMENSIONS ARE IN mm

SL. No.	OIL CAPACITY	L	B
6	2000	1.5	1.5
5	3000	1.5	2
4	5000	2.5	2
3	7000	3.0	2.5
2	8000	3.5	2.5
1	10000	4.0	2.5



SECTION–A A



PLAN

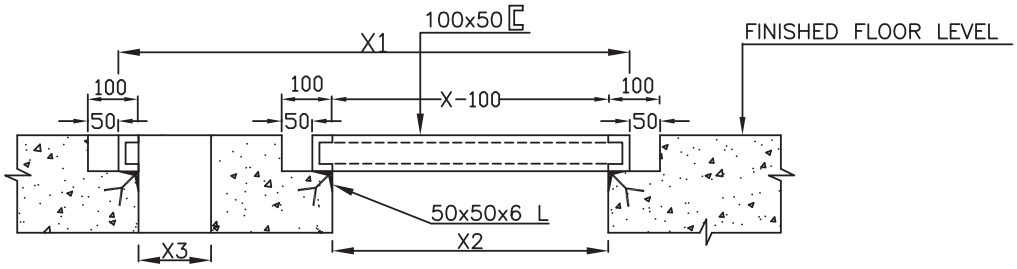
X– DEPTH OF PANEL

Y– LENGTH OF TWO PANELS

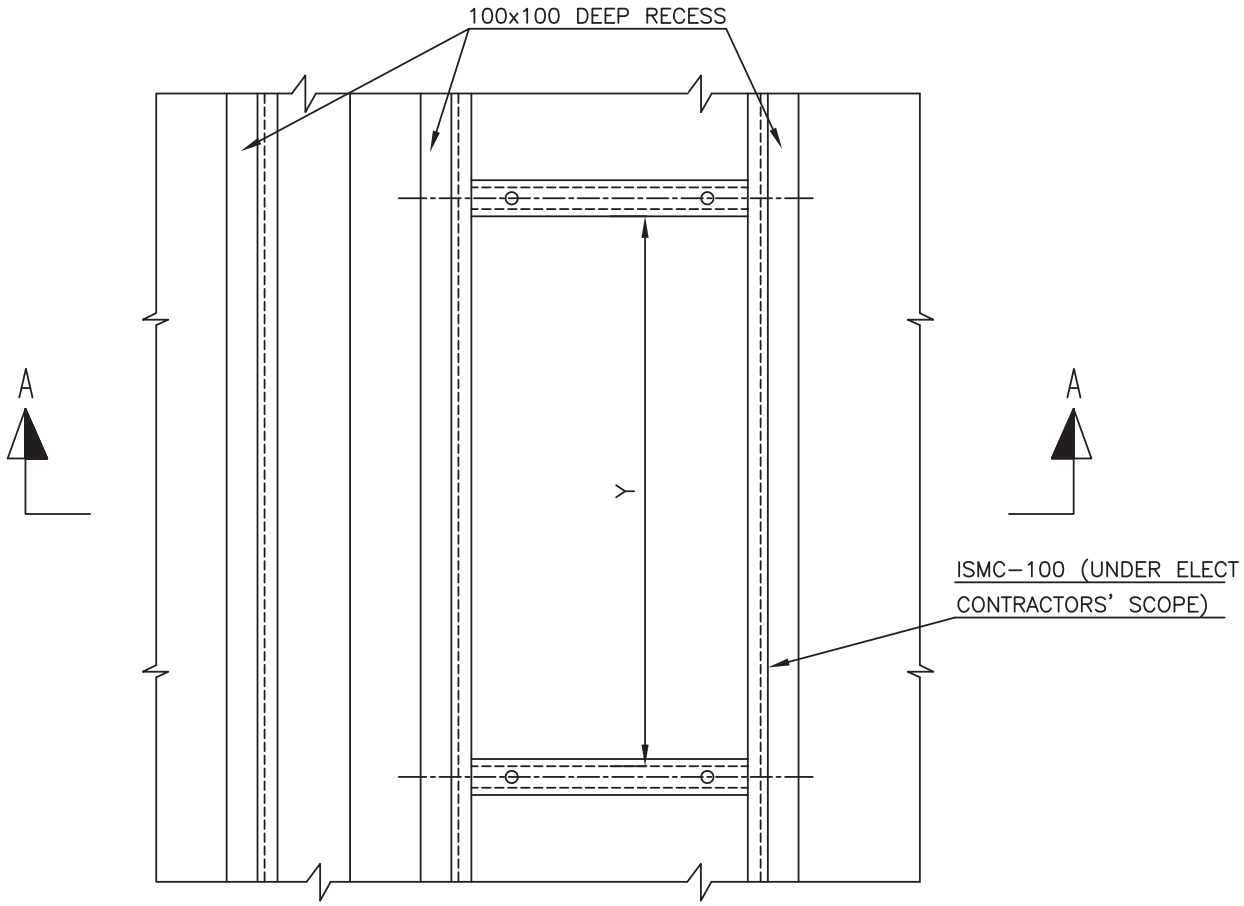
NOTES:–

1. THIS ARRANGEMENT SHALL BE APPLICABLE FOR M.C.C., DISTRIBUTION BOARDS, CONTROL PANELS ETC.
2. PANELS AFTER ERECTION SHALL BE TAG WELDED TO FOUNDATION CHANNELS

पी डी आई एल PDIL	TYPICAL FOUNDATION DETAILS FOR HT/LT CIRCUIT BREAKER PANELS	PDS: E 120	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



SECTION–A A



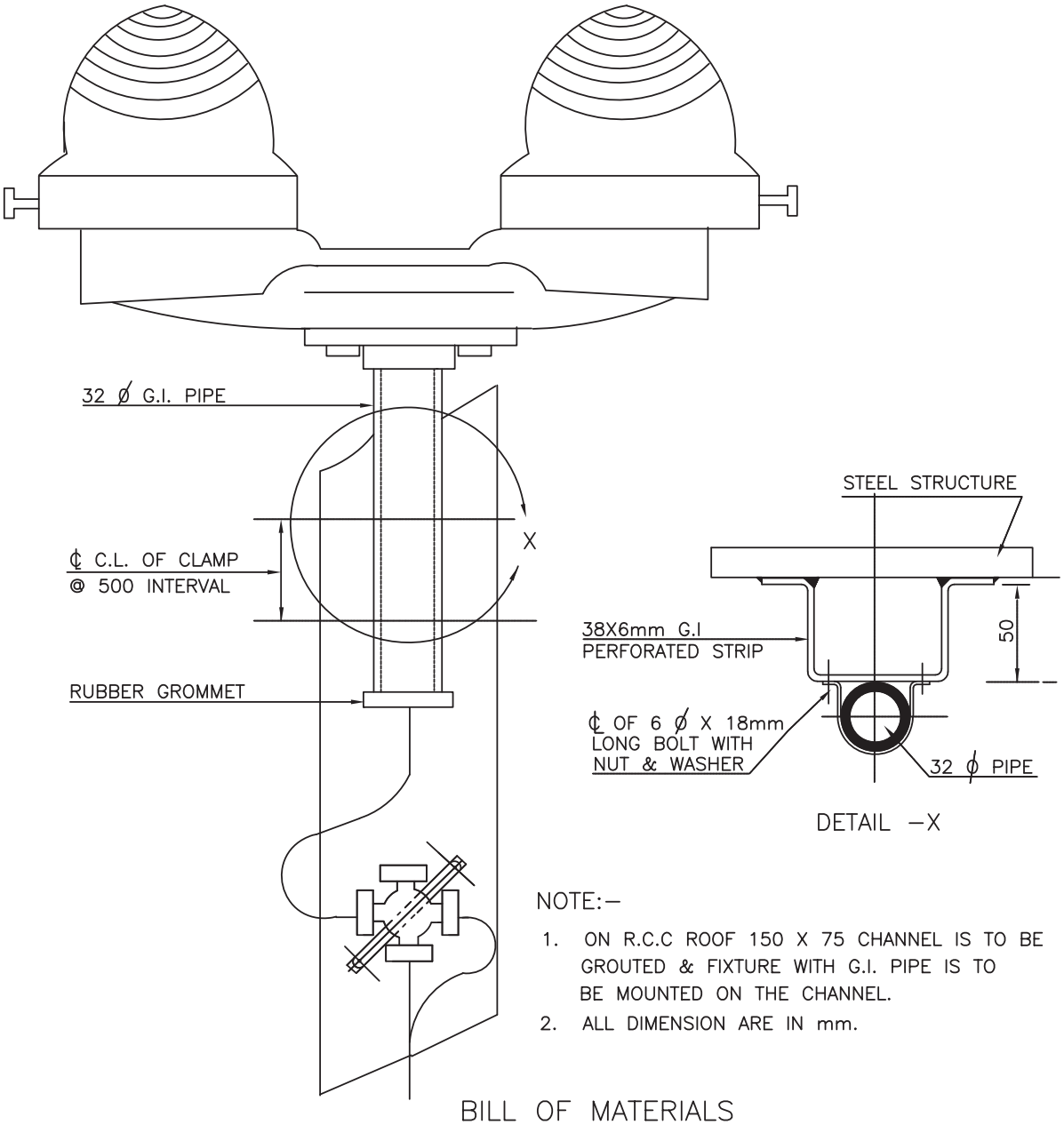
X1 = DEPTH OF PANEL
X2 = FOOR OPENING
X3 = FOOR OPENING
Y = LENGTH OF PANEL

PLAN

NOTES:–

1. PANELS AFTER ERECTION SHALL BE BOLTED TO FOUNDATION CHANNELS
2. POWER & CONTROL CABLES SHALL ENTER THROUGH OPENING X2
3. DEPENDING UPON THE FINAL DATA FROM THE VENDOR, ONLY TWO CHANNELS MAY BE NECESSARY IN WHICH CASE THE 3RD. RECESS SHALL BE FILLED AT SITE.

पी डी आई एल PDIL	FIXING ARRANGEMENT OF AIR OBSTRUCTION LIGHT (FOR GLC TYPE LAMP)	PDS: E 201	1
		DOCUMENT NO.	REV
		SHEET 1 OF 2	

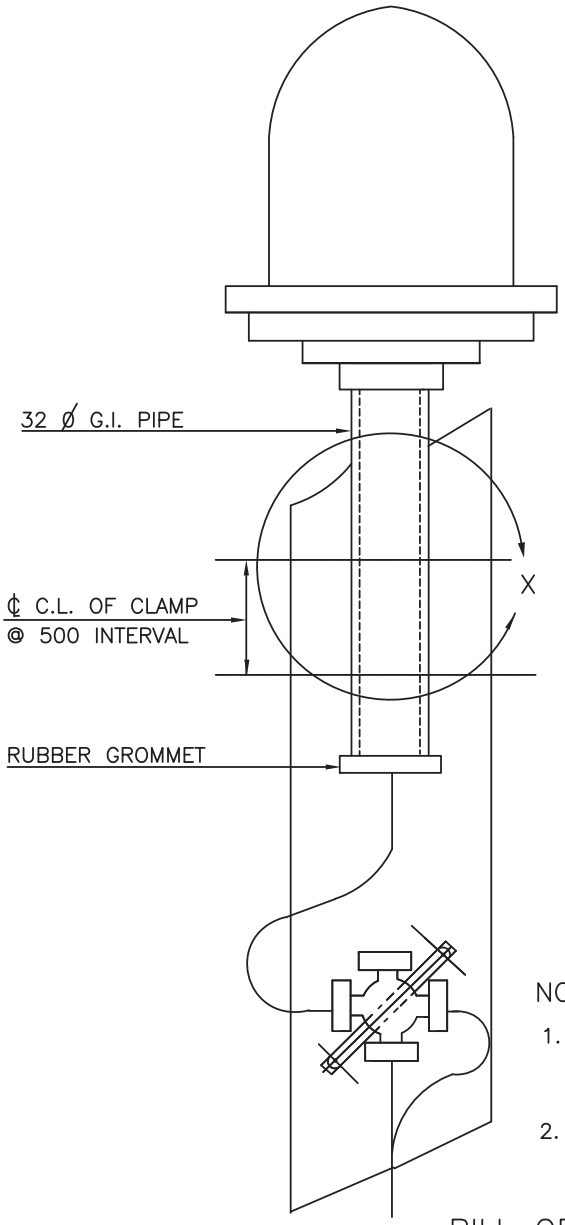


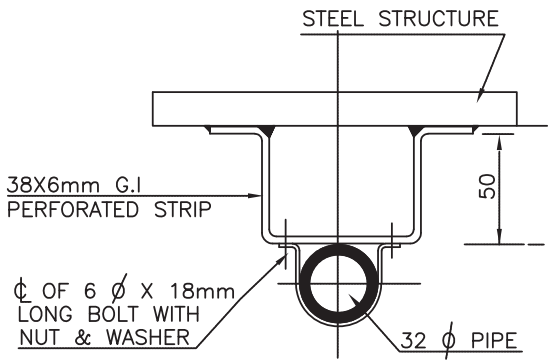
NOTE:–

1. ON R.C.C ROOF 150 X 75 CHANNEL IS TO BE GROUTED & FIXTURE WITH G.I. PIPE IS TO BE MOUNTED ON THE CHANNEL.
2. ALL DIMENSION ARE IN mm.

BILL OF MATERIALS

SL.NO.	ITEMS	QTY..
1	32 Ø G.I. PIPE –750 LENGTH	1 NO.
2	38 X 6mm G.I. PERFORATED STRIP 250mm LONG	2 NOS.
3	RUBBER GROMMET–32mm ϕ	1 NO.
4	38 X 6mm M.S. PERFORTED STRIP 100mm. LONG	2 NOS.
5	6ø x 18mm LONG BOLT	4 NOS.





DETAIL –X

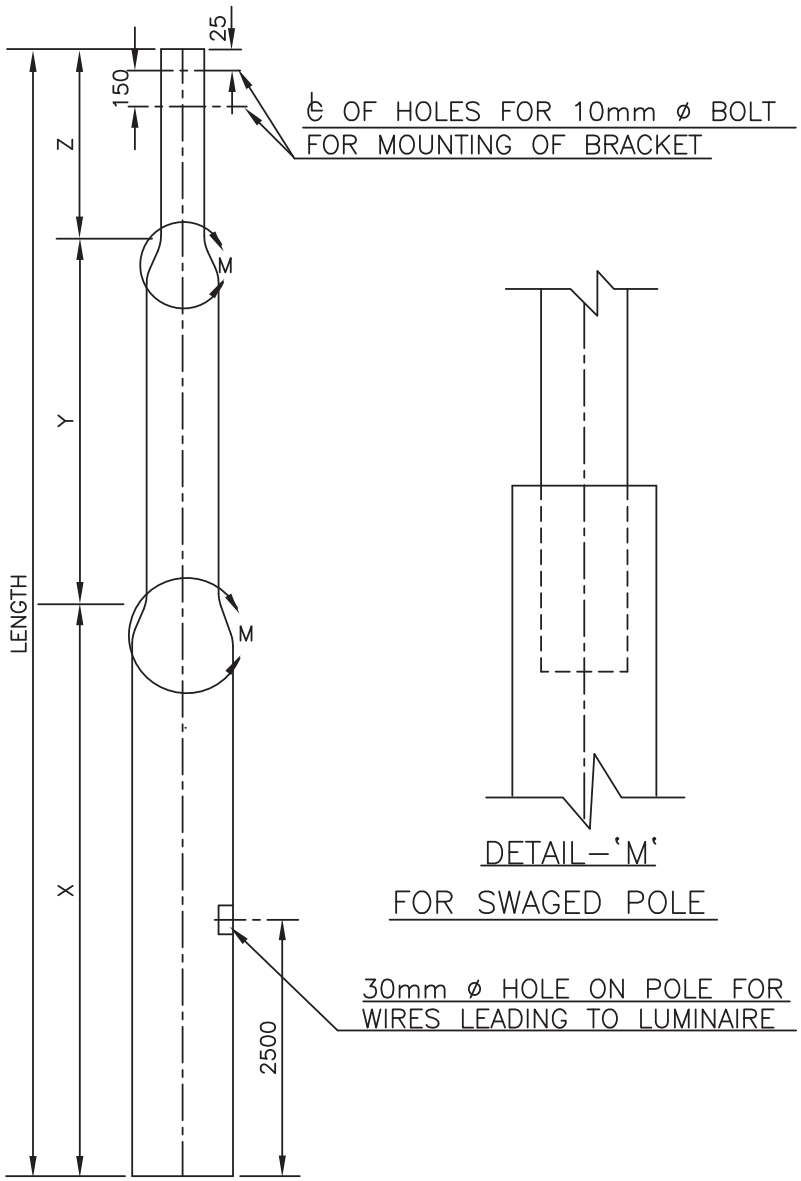
NOTE:–

1. ON R.C.C ROOF 150 X 75 CHANNEL IS TO BE GROUTED & FIXTURE WITH G.I. PIPE IS TO BE MOUNTED ON THE CHANNEL.
2. ALL DIMENSION ARE IN mm.

BILL OF MATERIALS

SL.NO.	ITEMS	QTY..
1	32ø G.I. PIPE –750 LENGTH	1 NO.
2	38 X 6mm G.I. PERFORATED STRIP 250mm LONG	2 NOS.
3	RUBBER GROMMET–32mmø	1 NO.
4	38 X 6mm M.S. PERFORTED STRIP 100mm. LONG	2 NOS.
5	6ø x 18mm LONG BOLT	4 NOS.

पी डी आई एल PDIL	STEEL TUBULAR LIGHTING POLE	PDS: E 203	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 3	

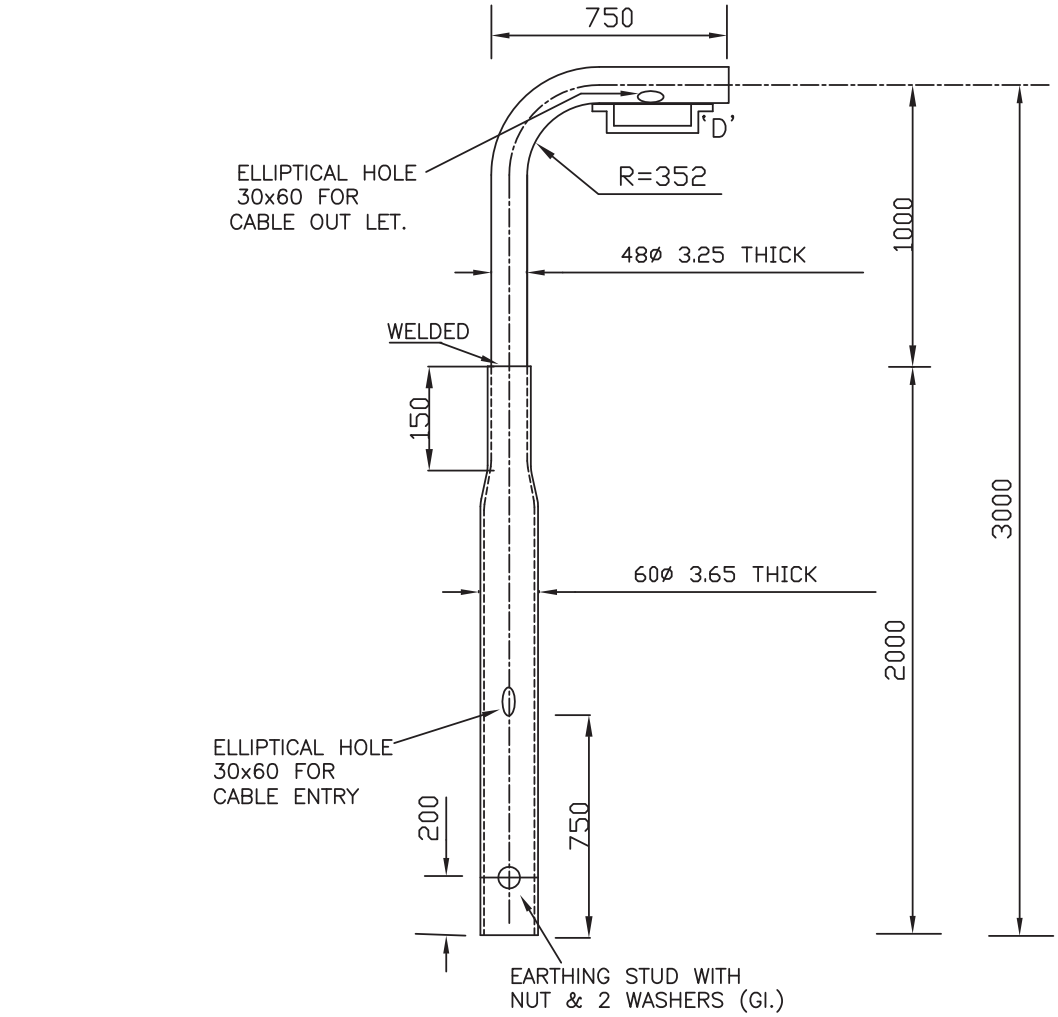


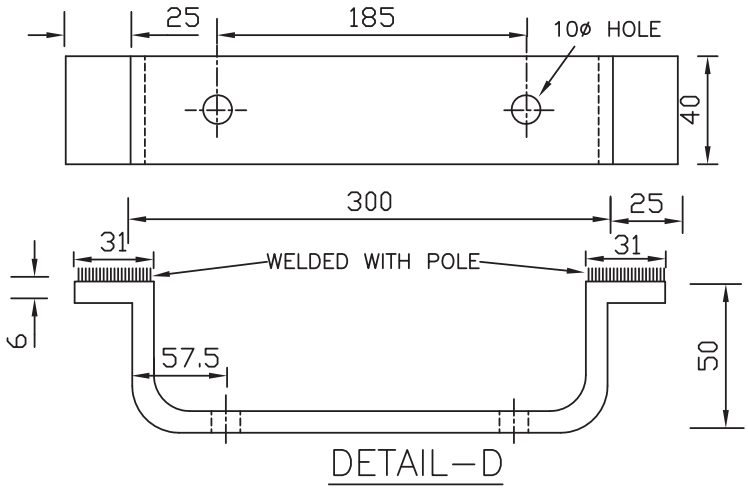
POLE DESIGNATION	LENGTH(M) X+Y+Z=L	PLANTING DEPTH(M)	DIAxTHICKNESS BOTTOM(mm)	DIA MIDDLE(mm)	DIA TOP(mm)	WEIGHT OF POLE (Kg)
410 TP3/SP3	X+Y+Z=7	1.25	114.3x4		78.1	87/85
410 TP12/SP12	X+Y+Z=8	1.5	114.3x4		78.1	101/97
410 TP13/SP13	X+Y+Z=8	1.5	139.7x4		88.9	125/119
410 TP27/SP27	X+Y+Z=9	1.5	114.3x4		76.1	113/108
410 TP30/SP30	X+Y+Z=9	1.5	139.7x4		88.9	140/133
410 TP33/SP33	X+Y+Z=9	1.5	165.1x4		114.3	170/184

NOTE:–

1. TP REFER TO STEPPED POLE.
2. SP REFER TO SWAGED POLE.
3. POLE DESIGNATION IS AS PER IS: 1239

SWAGED POLE TYPE 'B'



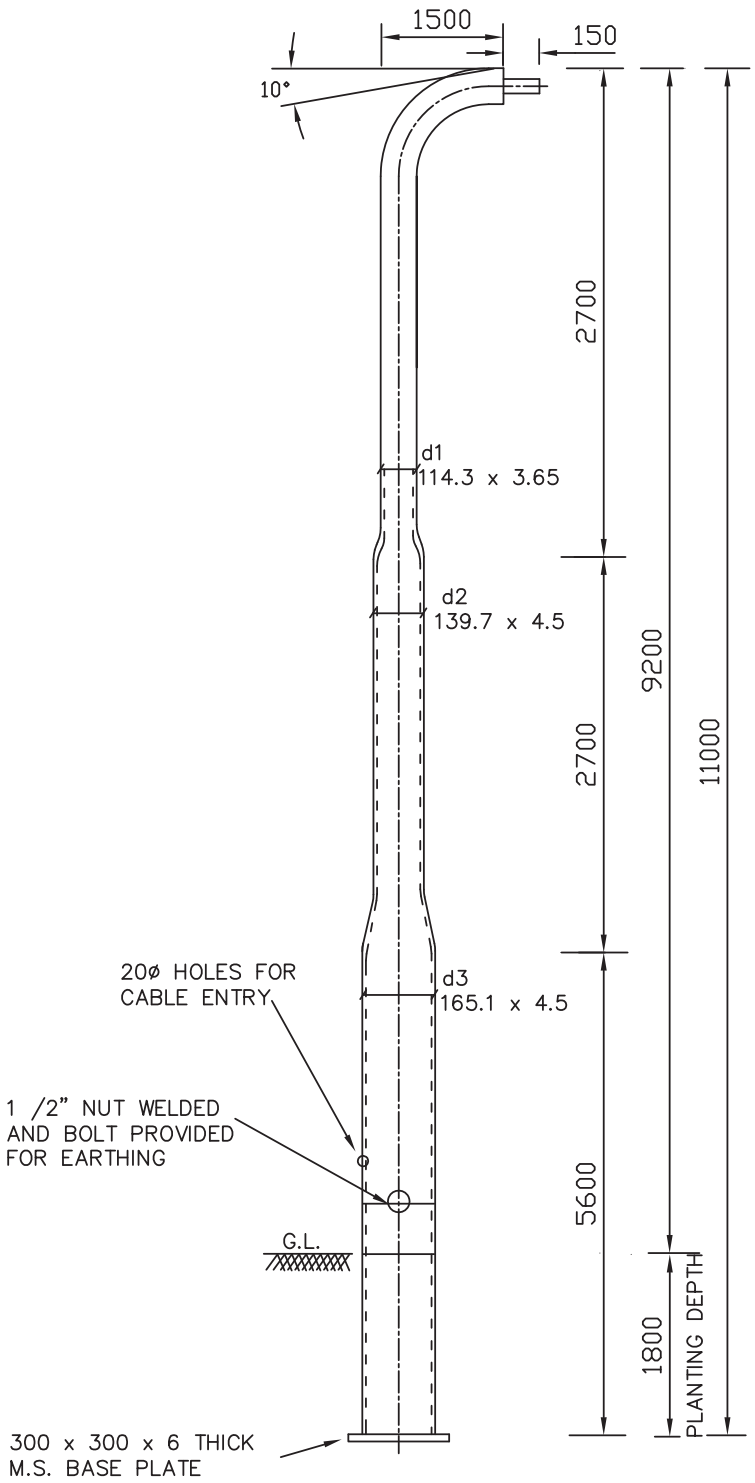


DETAIL–D

NOTE:–

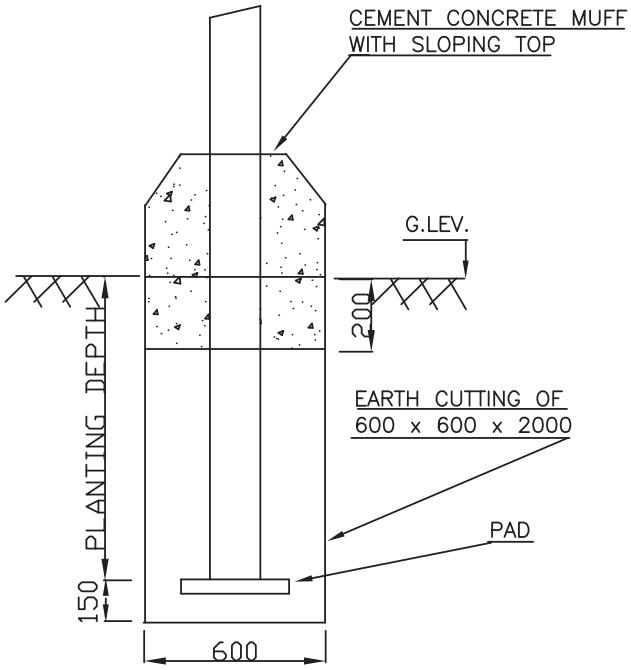
1. ALL DIMENSIONS ARE IN mm

SWAGED POLE TYPE 'C'
(FOR PLANT GROUND MOUNTING)



NOTES: –

1. NIPPLE OF DIA. 45 (NIPPLE TO BE PREPd. BY DIRECT REDUCTION OF DIA OF TOP PIPE WITHOUT USE OF ANY WASHER)
2. POLE MATERIAL MS AS PER IS 1239 ABOVE GROUND PORTION TO BE PAINTE 2 COATS OF RED OXIDE PRIMER,UNDER GROUND PORTION PAINTED BITUMINUS PAINT.
3. FOR FLOOD LIGHTING POLE THE TOP PORTION NOT TO BE TILTED BUT A 300 x 300 x 6mm THICK M.S. PLATE WELDED AT THE TOP SHALL BE PROVIDED TO MOUNT FLOOD LIGHT.
4. ALL DIMENSIONS ARE IN mm



1. FOR PAD USE:–

a) 400x400x70 CONCRETE BLOCK FOR POLES.

b) BASE PLATE AS SHOWN IN PDS:E 205 FOR STEEL TUBULAR POLES SHALL BE USED AS PAD

C) RCC / WOOD POLES DO NOT NEED ANY PAD.

2. MUFF IS MUST FOR STEEL TUBULAR POLES AND OPTIONAL FOR OTHERS POLES, MUFF SHALL BE PROVIDED AFTER UNDER GROUND CABLING FOR STREET LIGHTING IS COMPLETED.

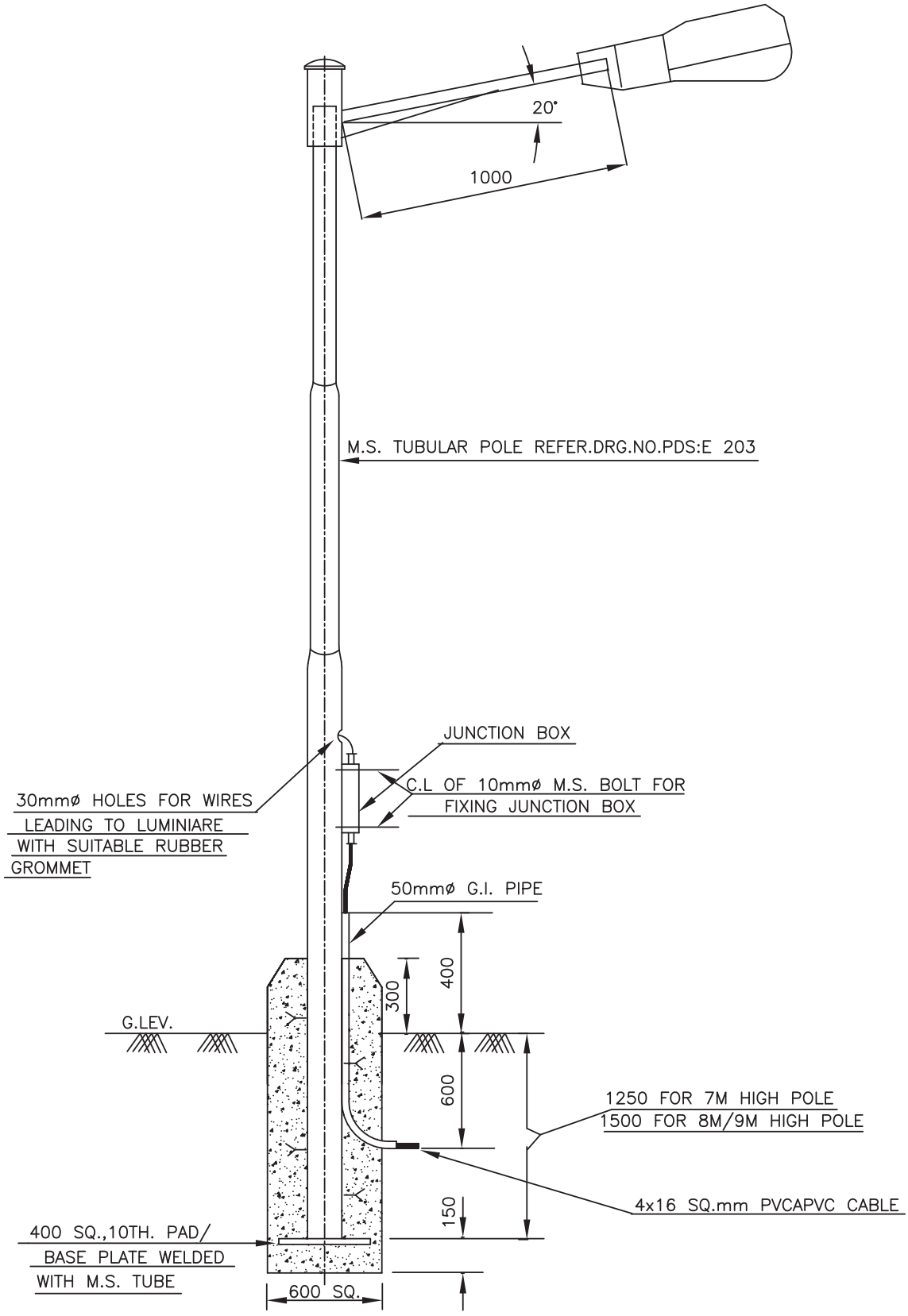
3. MUFF HEIGHT FROM GROUND LEVEL SHALL BE 300mm FOR ORDINARY POLES AND 457mm FOR STREET LIGHTING POLES HAVING J.B.LOCATED ON THE MUFF

4. FOR MOUNTING OF JBS' ON THE MUFF REFER PDS:E 209

5. FOR PLANTING DEPTH REFER RELEVANT ISS.

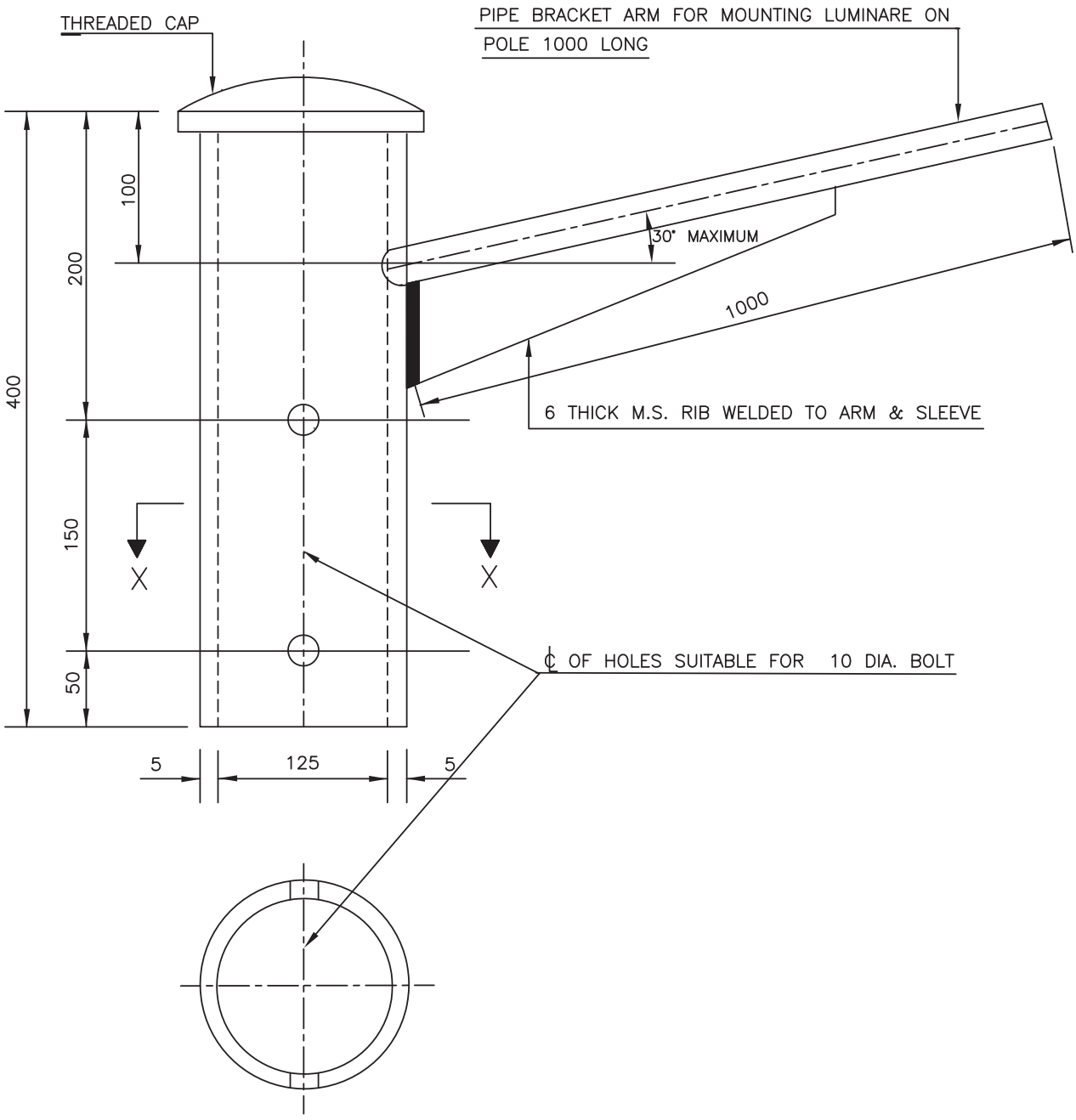
6. ALL DIMENSIONS ARE IN mm

पी डी आई एल PDIL	INSTALLATION ARRANGEMENT STREET LIGHTING FIXTURES	PDS: E 206	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



NOTE :–
ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	DETAILS OF BRACKET ARM FOR STREET LIGHTING POLE	PDS: E 207	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	

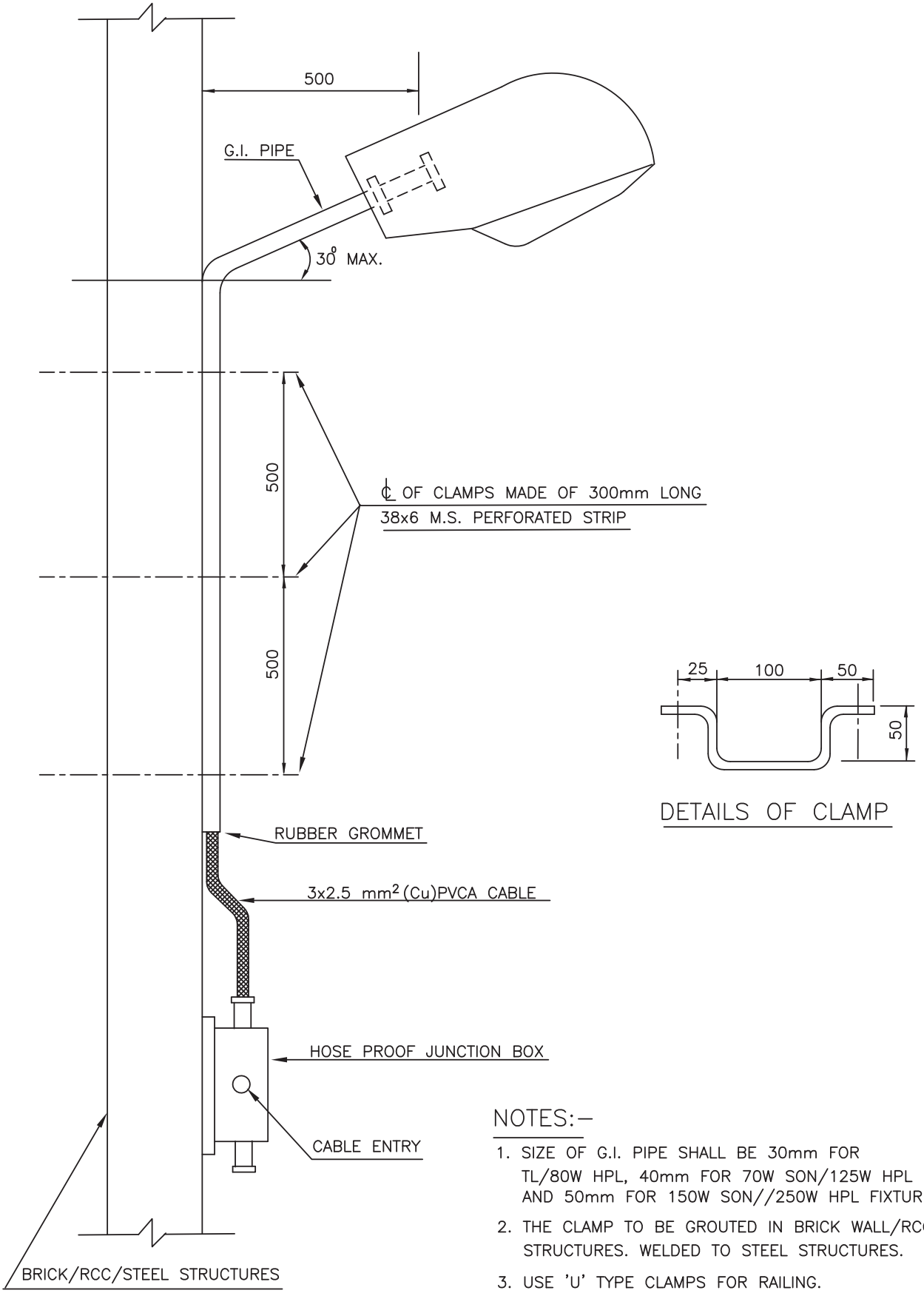


SECTION – XX

NOTES:–

1. SIZE OF PIPE SHALL BE 30mm FOR TL/80W HPL FIXTURES, 40mm FOR 70W SON/125W HPL FIXTURES AND 50mm FOR 150W SON/250W HPL FIXTURES.
2. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	INSTALLATION ARRANGEMENT AREA LIGHTING FIXTURES	PDS: E 208	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	

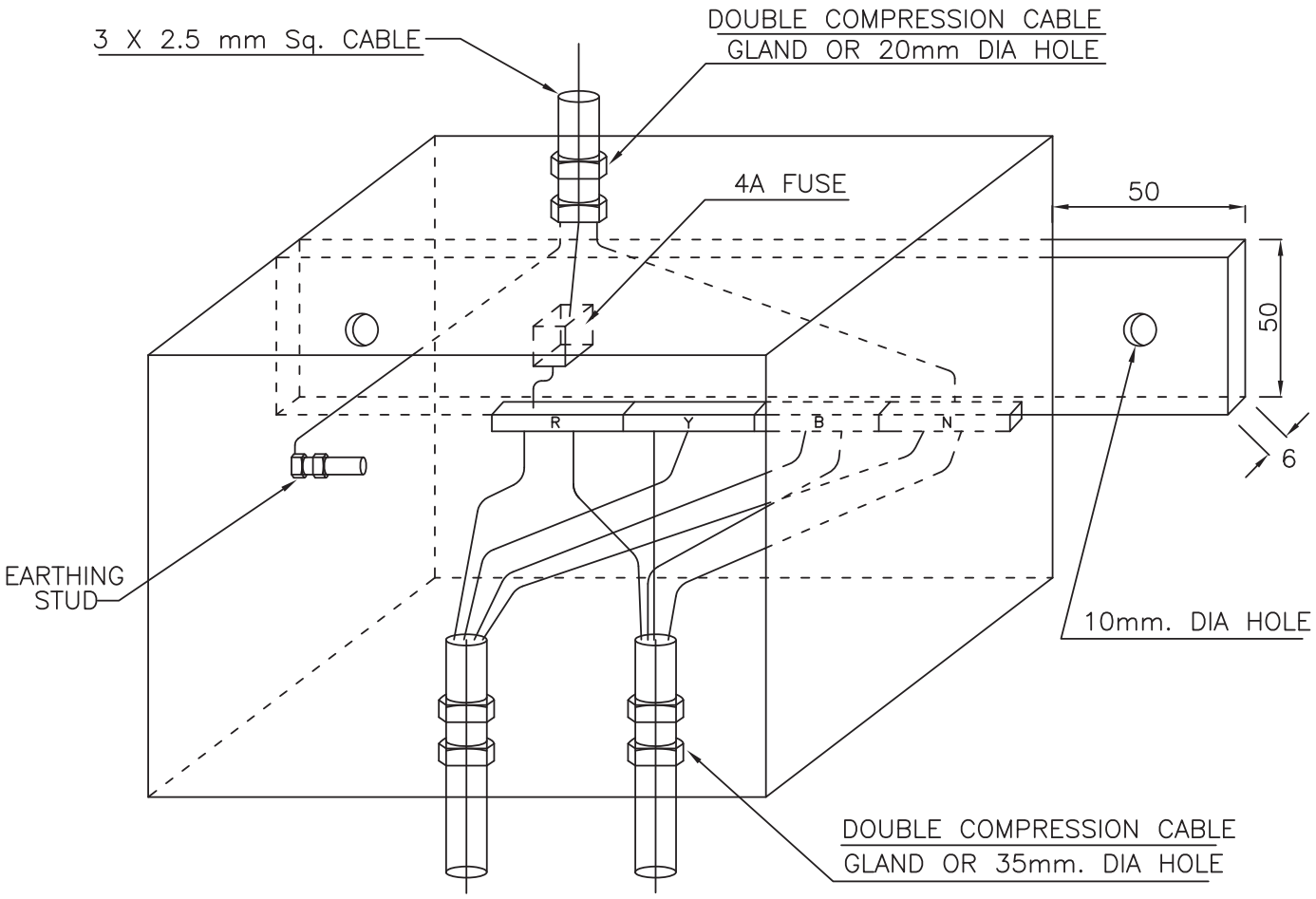


DETAILS OF CLAMP

NOTES:–

1. SIZE OF G.I. PIPE SHALL BE 30mm FOR TL/80W HPL, 40mm FOR 70W SON/125W HPL AND 50mm FOR 150W SON//250W HPL FIXTURES.
2. THE CLAMP TO BE GROUTED IN BRICK WALL/RCC STRUCTURES. WELDED TO STEEL STRUCTURES.
3. USE 'U' TYPE CLAMPS FOR RAILING.
4. ALL DIMENSIONS ARE IN mm.

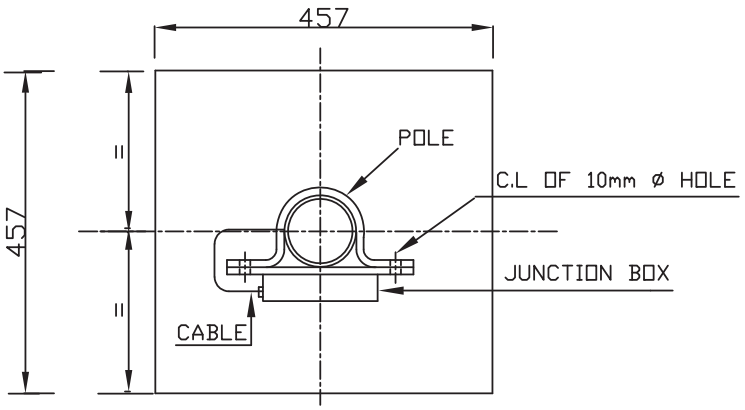
पी डी आई एल PDIL	JUNCTION BOX FOR STREET LIGHTING POLE	PDS: E 210	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



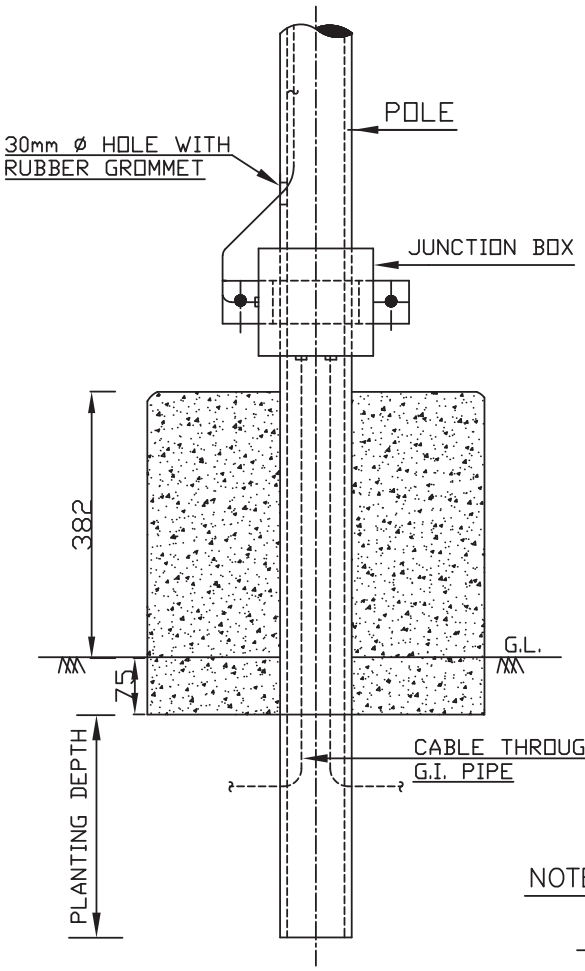
NOTE:–

1. THE MINIMUM INTERNAL DIMENSION OF THE J.B. SHALL BE 152 X 152 X 152.
2. THE FRONT DOOR SHALL BE HINGED & LOCKABLE TYPE.
3. THE CONNECTION OF FUSE TO THE PHASE 'R' IS TYPICAL ONE THE EXACT PHASE TO WHICH CONNECTION SHALL BE MADE SHALL BE DECIDED AT SITE.
4. FOR HAZARDOUS AREA'S THESE JUNCTION BOXES SHALL BE INCREASED SAFETY TYPE AND THE FUSE NEED NOT BE PROVIDED.
5. FOR POLE MOUNTED JUNCTION BOXED THE CABLE GLAND SHALL BE SIDE MOUNTED.
6. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	INSTALLATION OF JUNCTION BOX IN THE POLE FOR STREET LIGHTING POLE	PDS: E 211	1
		DOCUMENT NO.	REV
		SHEET 1 OF 1	



PLAN

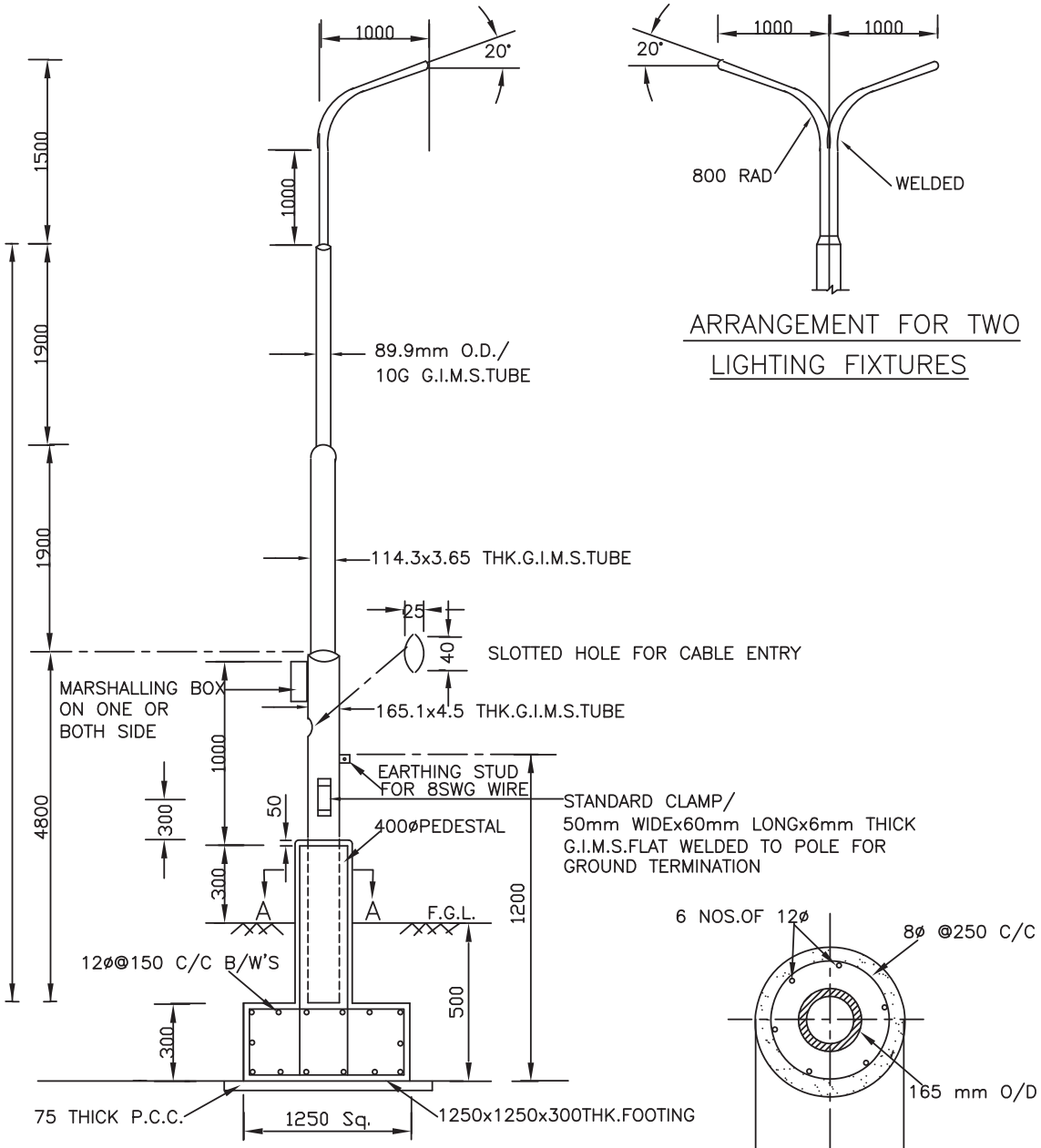


NOTE:-

ALL DIMENSIONS ARE IN mm

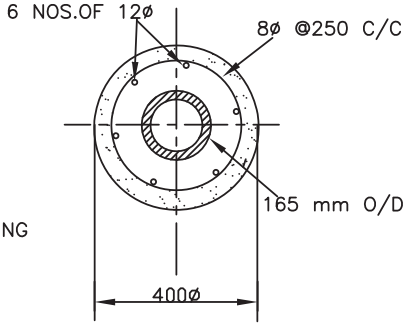
ELEVATION

पी डी आई एल PDIL	TYPICAL STREET LIGHTING POLE	PDS: E 213	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



ARRANGEMENT FOR ONE LIGHTING FIXTURE

ARRANGEMENT FOR TWO LIGHTING FIXTURES



SECTION A–A

NOTE :–

1. CONCRETING AND APPROVED MOUNTING HARDWARE FOR LIGHTING FIXTURES ARE INCLUDING IN SCOPE OF SUPPLY.
2. CONCRETE FOUNDATION OF GRADE M15 SHALL BE PROVIDED.

ALL DIMENSIONS ARE IN mm.

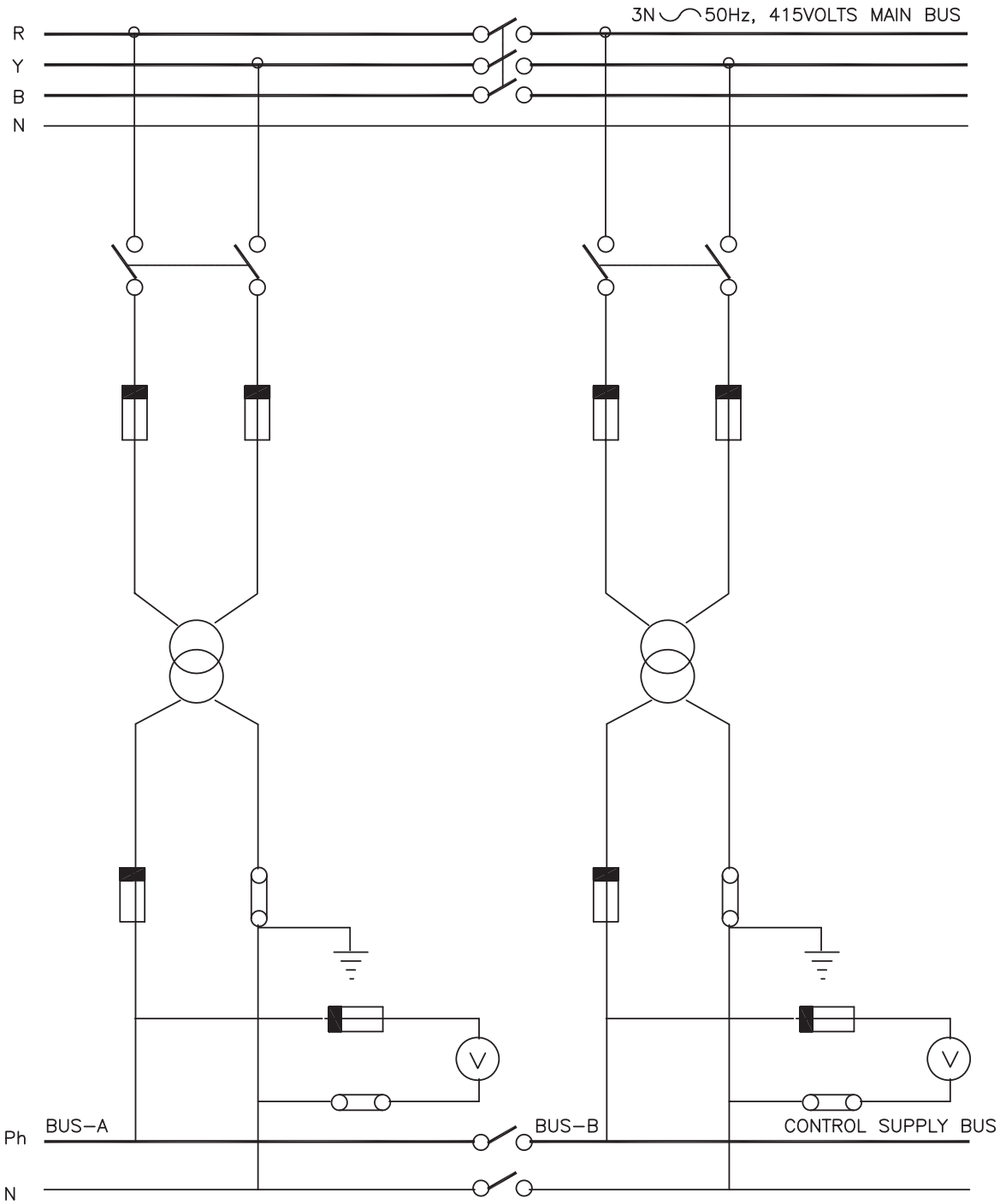
SL. NO.	MOTOR RATING IN KW	FULL LOAD CURRENT IN AMPS.	STARTING CURRENT IN AMPS.	MOTOR DUTY SWITCH RATING IN AMPS.	FUSE RATING IN AMPS.	CONTACTOR RATING IN AMPS.	THERMAL O/L RANGE IN AMPS.		C.T. RATIO	POWER CABLE SIZE sq. mm (PVCAPVC)
							L&T	SIEMENS		
1.	0.18	0.59	4.2	16	2	16	0.4–0.65	0.5–0.8	2/1	3x2.5(CU)
2.	0.25	0.88	6.3	16	4	16	0.6–1.0	0.8–1.2	2/1	3x2.5(CU)
3.	0.37	1.05	7.56	16	4	16	0.9–1.5	0.8–1.25	2/1	3x2.5(CU)
4.	0.55	1.50	10.8	16	6	16	1.4–2.3	1.0–1.6	2/1	3x2.5(CU)
5.	0.75	1.80	12.96	16	6	16	1.4–2.3	1.25–2.0	2/1	3x2.5(CU)
6.	1.10	2.50	18.0	16	10	16	2.3–3.0	2.0–3.2	5/1	3x2.5(CU)
7.	1.50	3.4	24.4	16	16	16	3.0–5.0	2.5–4.0	5/1	3x2.5(CU)
8.	2.20	4.60	33.1	16	16	16	4.5–7.5	3.2–5.0	5/1	3x2.5(CU)
9.	3.00	7.0	50.4	32	20	16	4.5–7.5	5.0–8.0	10/1	3x2.5(CU)
10.	3.70	7.3	52.5	32	20	16	6.0–10.0	5.0–8.0	10/1	3x2.5(CU)
11.	5.50	10.5	75.6	32	32	16	9.0–15.0	8.0–12.5	15/1	3x4(CU)
12.	7.50	14.0	100.8	63	32	16	9.0–15.0	10.0–16.0	20/1	3x6(CU)
13.	9.30	17.5	126.0	63	32	32	14.0–23.0	12.5–20.0	20/1	3x10(AL)
14.	11.0	20.6	148.3	63	63	32	14.0–23.0	16.0–25.0	25/1	3x10(AL)
15.	15.0	28.0	201.6	63	63	32	20.0–33.0	20.0–32.0	35/1	3x16(AL)
16.	18.5	33.0	237.6	100	80	40	30.0–50.0	25.0–36.0	40/1	3x25(AL)
17.	22.0	40.0	288.0	125	80	45	30.0–50.0	32.0–50.0	50/1	3x25(AL)
18.	30.0	52.0	374.4	125	100	70	45.0–75.0	40.0–57.0	60/1	3x35(AL)
19.	37.0	63.5	457.2	125	125	70	45.0–75.0	57.0–70.0	75/1	3x50(AL)
20.	45.0	76.0	557.2	200	160	110	66.0–110.0	70.0–95.0	100/1	3x70(AL)
21.	55.0	96.0	691.7	250	200	110	66.0–110.0	85.0–105.0	125/1	3x95(AL)
22.	67.5	119.0	858.0	250	200	200	90.0–150.0	85.0–135.0	125/1	3x150(AL)
23.	75.0	140.0	1008.0	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		150/1	3x185(AL)
24.	90.0	156.0	1123.2	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		175/1	3x240(AL)
25.	110.0	192.0	1382.4	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		225/1	3x300(AL)
26.	125.0	217.0	1627.5	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		250/1	3x400(AL)
27.	132.0	234.0	1684.8	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		250/1	3x400(AL)
28.	160.0	279.0	2008.8	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		300/1	2–3x185(AL)
29.	180.0	304.0	2188.8	A.C.B.	A.C.B.	A.C.B.	MICROPROCESSOR RELAY		350/1	2–3x240(AL)

NOTE:–

1. THE ABOVE DATA IS APPLICABLE FOR 415V, 4 POLE MOTORS.
2. AMMETERS SHALL HAVE UNIFORM SCALE UPTO C.T. PRIMARY CURRENT AND COMPRESSED END SCALE UPTO SIX TIMES THE C.T. PRIMERY CURRENT.
3. POWER CABLE SIZE SHALL BE SUBJECT TO VOLTAGE DROP CHECK.

SL. NO.	FEEDER RATING		SWITCH RATING AC–23	FUSE RATING (AMP)	C.T. RATIO	AMMETER SCALE RANGE	* POWER CABLE SIZE sq. mm (PVCAPVC)	REMARKS
	KVA	AMP						
1.	10	16	32	25	20/5	0–20	3/4x6(CU)	
2.	25	40	63	63	50/5	0–50	3/4x25(AL)	
3.	35	50	100	80	60/5	0–60	3/4x35(AL)	
4.	45	60	100	100	75/5	0–75	3/4x50(AL)	
5.	50	70	100	100	75/5	0–75	3/3.5x70(AL)	
6.	60	80	125	125	100/5	0–100	3/3.5x70(AL)	
7.	65	90	200	160	100/5	0–100	3/3.5x95(AL)	
8.	70	100	200	160	125/5	0–125	3/3.5x120(AL)	
9.	80	125	200	200	150/5	0–150	3/3.5x150(AL)	
10.	100	150	250	250	200/5	0–200	3/3.5x185(AL)	
11.	125	175	315	300	200/5	0–200	3/3.5x240(AL)	
12.	140	200	315	300	250/5	0–250	3/3.5x300(AL)	
13.	170	250	400	400	300/5	0–300	2–3/3.5x150(AL)	
14.	200	300	400	–	400/5	0–400	2–3/3.5x185(AL)	
15.	275	400	630	–	630/5	0–630	2–3/3.5x300(AL)	
16.	350	500	630	–	630/5	0–630	3–3/3.5x240(AL)	
17.	425	600	800	–	800/5	0–800	3–3/3.5x300(AL)	
18.	500	700	800	–	800/5	0–800	3–3/3.5x400(AL)	

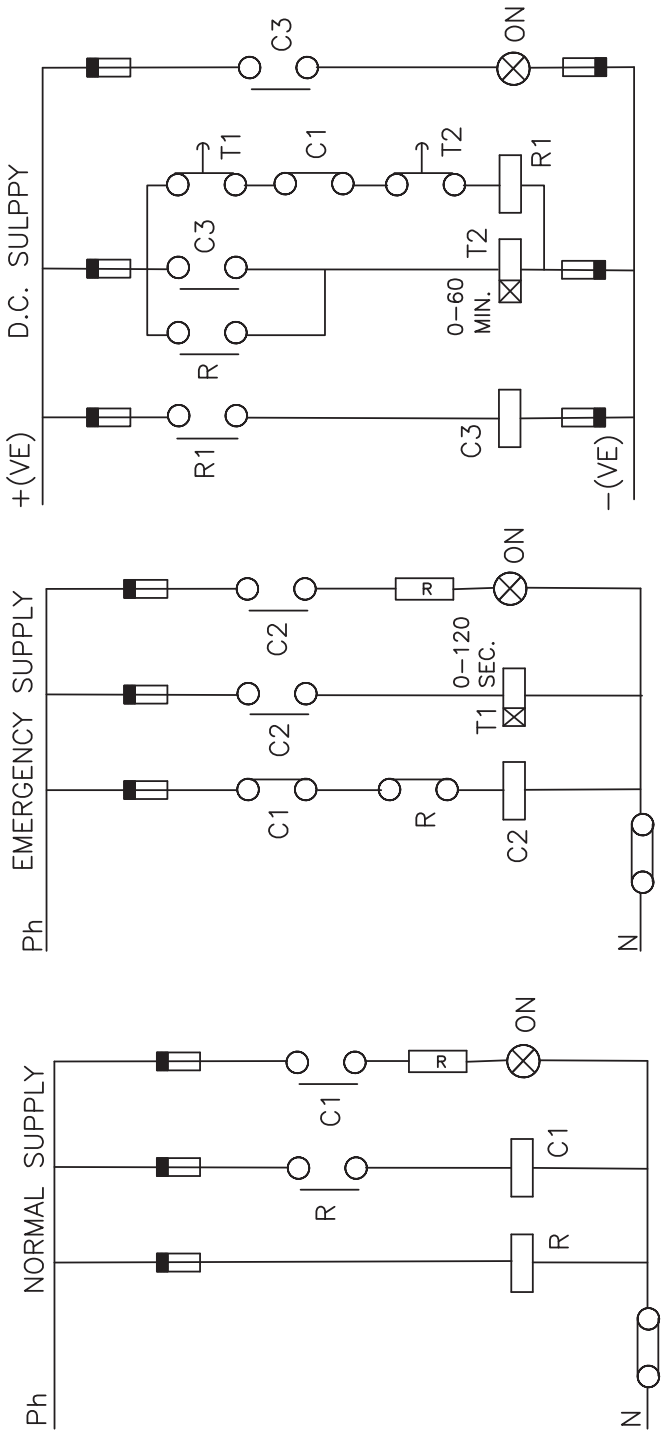
पी डी आई एल PDIL	SCHEMATIC DIAGRAM A.C.CONTROL SUPPLY THROUGH CONTROL TRANSFORMER FOR SWITCH BOARDS WITH BUS COUPLER	PDS: E 412	1
		DOCUMENT NO.	REV
		SHEET 1 OF 1	



NOTES:–

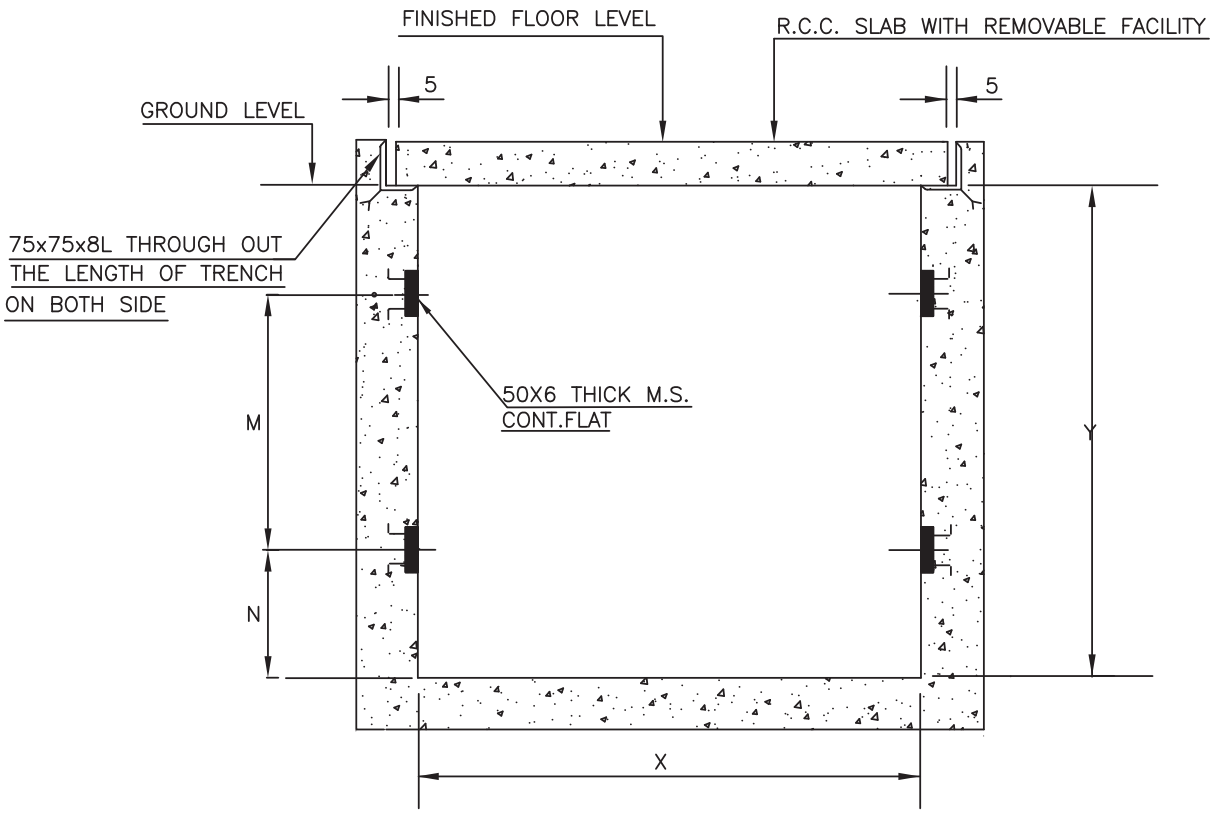
1. EACH TRANSFORMER SHALL BE RATED FOR 2.5 TIMES THE TOTAL CONTROL SUPPLY LOAD.
2. THE CONTROL BUS INTERCONNECTING SWITCH SHALL BE LOCKABLE IN OFF POSITION AND LOCATED IN BUS COUPLER PANEL.

पी डी आई एल PDIL	SCHEMATIC DIAGRAM PANIC LIGHT	PDS: E 464	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



NOTE:–

CONTACTORS C1,C2 AND C3 CONTROLS THE LIGHTING FEEDERS FOR NORMAL,EMERGENCY AND D.C. SUPPLY RESPECTIVELY.



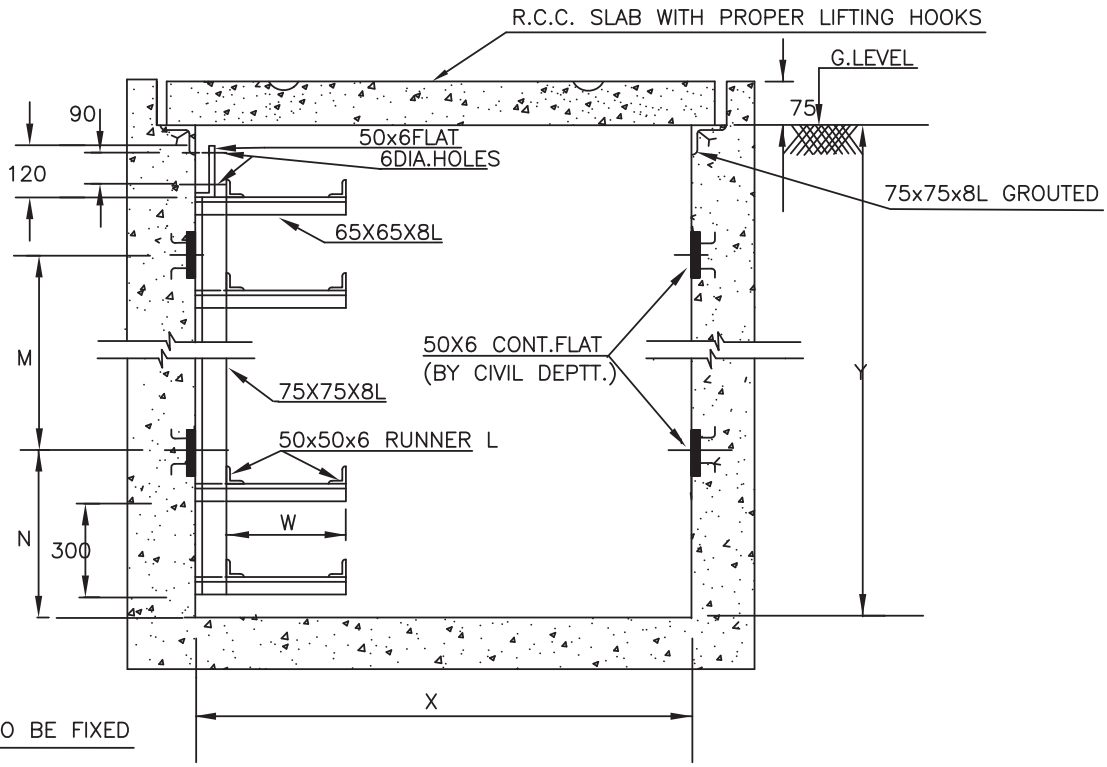
SECTION OF TRENCH

DESIGN TYPE	X	Y	N	M
5T 350DS.	1400	1500	400	650
4T 350DS.	1400	1200	250	650
3T 350DS.	1400	900	250	300
5T 350SS.	1000	1500	400	650
4T 350SS.	1000	1200	250	650
3T 350SS.	1000	900	250	300
5T 250DS.	1200	1500	400	650
4T 250DS.	1200	1200	250	650
3T 250DS.	1200	900	250	300
5T 250SS.	900	1500	400	650
4T 250SS.	900	1200	250	650
3T 250SS.	900	900	250	300

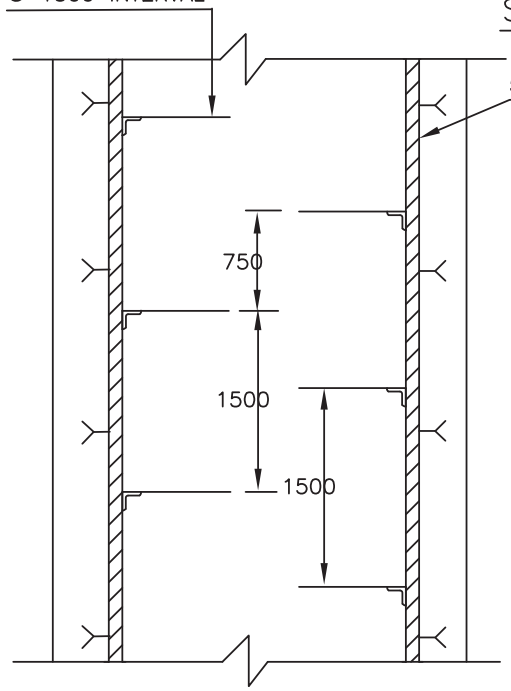
NOTES:–

1. THE TOP OF TRENCH SHALL MATCH THE FLOOR LEVEL IN PLANT AREA.
2. IN INDOORS INSTEAD OF RCC SLAB,20mm.THICK Al. EXTRUDED PLANK OR 10mm.THICK M.S.CHEQUERED PLATE SHALL BE USED AS PER PDS:E 507.
3. PROPER SLOPE TO BE GIVEN IN THE TRENCH FOR NATURAL DRAINAGE.
4. SS–SINGLE SIDE CABLE SUPPORTS.
5. DS–DOUBLE SIDE CABLE SUPPORTS.
6. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	CABLE RACK ARRANGEMENT IN TRENCHES	PDS: E 511	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



SECTION OF TRENCH

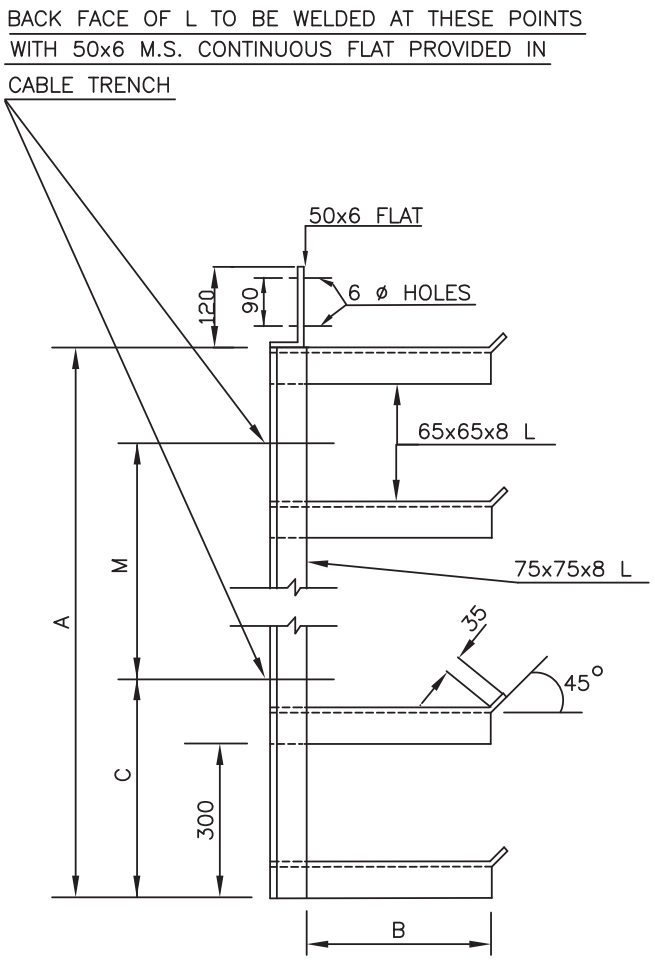


TYPICAL PLAN OF TRENCH

DESIGN TYPE	X	Y	N	M	W
5T–350–DS.	1400	1500	400	650	350
4T–350–DS.	1400	1200	250	650	350
3T–350–DS.	1400	900	250	300	350
5T–350–SS.	1000	1500	400	650	350
4T–350–SS.	1000	1200	250	650	350
3T–350–SS.	1000	900	250	300	350
5T–250–DS.	1200	1500	400	650	250
4T–250–DS.	1200	1200	250	650	250
3T–250–DS.	1200	900	250	300	250
5T–250–SS.	900	1500	400	650	250
4T–250–SS.	900	1200	250	650	250
3T–250–SS.	900	900	250	300	250

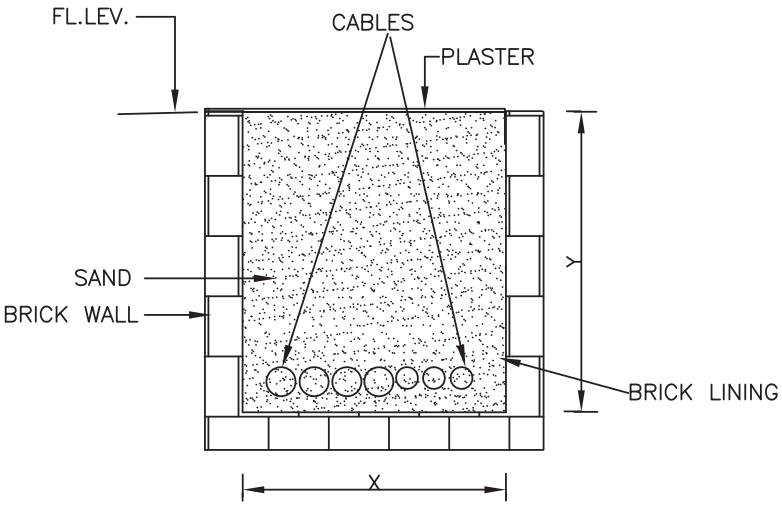
NOTES:—1. SS–SINGLE SIDE CABLE SUPPORT.
2. DS–DOUBLE SIDE CABLE SUPPORT.
3. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	FABRICATION DETAILS OF CABLE RACK IN TRENCH AND DUCT	PDS: E 512	1
		DOCUMENT NO.	REV
		SHEET 1 OF 1	



DESIGN TYPE	A	B	C	M	WT.OF STEEL PER UNIT(kg)
5T 350	1265	350	365	650	35
4T 350	965	350	215	650	28
3T 350	665	350	215	300	21
5T 250	1265	250	215	650	30
4T 250	965	250	215	650	25
3T 250	665	250	215	300	20

ALL DIMENSIONS ARE IN mm.



SECTION OF SLIT

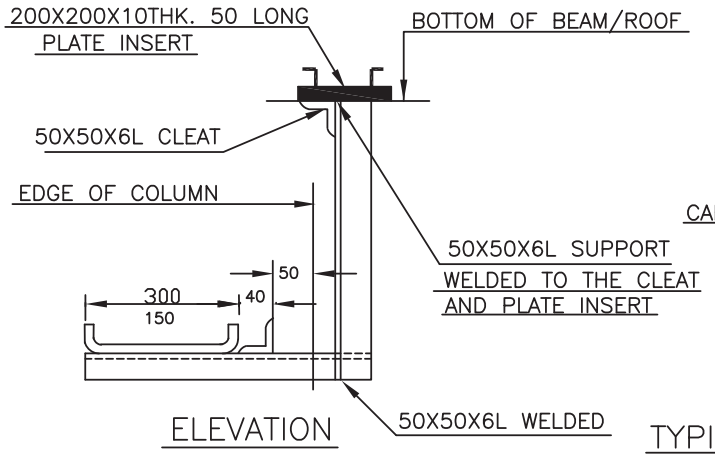
DESIGN TYPE	X	Y
S 300	300	300
S 200	200	200

NOTE:–

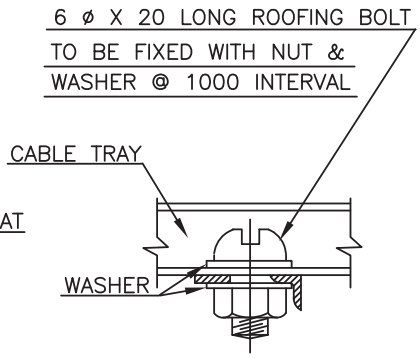
1. CABLE SLITS SHALL BE FILLED WITH SAND AND PROPERELY PLASTERED WITH LEAN CONCRETE AFTER LAYING OF CABLES.
2. WHEREVER CABLES ARE COMING OUT OF THE SLIT, SUITABLE MECH.PROTECTION TO BE PROVIDED.

पी डी आई एल PDIL	FIXING ARRANGEMENT OF PERFORATED CABLE TRAY (HORIZONTAL FORMATION CEILING SUPPORTED)	PDS: E 525	1
		DOCUMENT NO.	REV
		SHEET 1 OF 1	

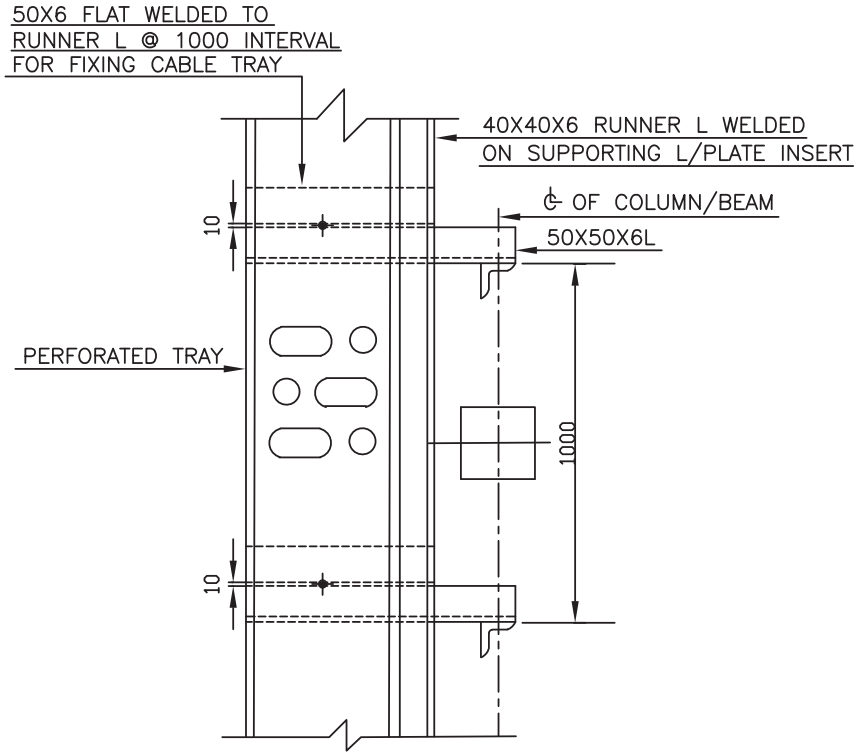
CEILING SUPPORTED RACK



ELEVATION



TYPICAL DETAIL OF TRAY FIXING



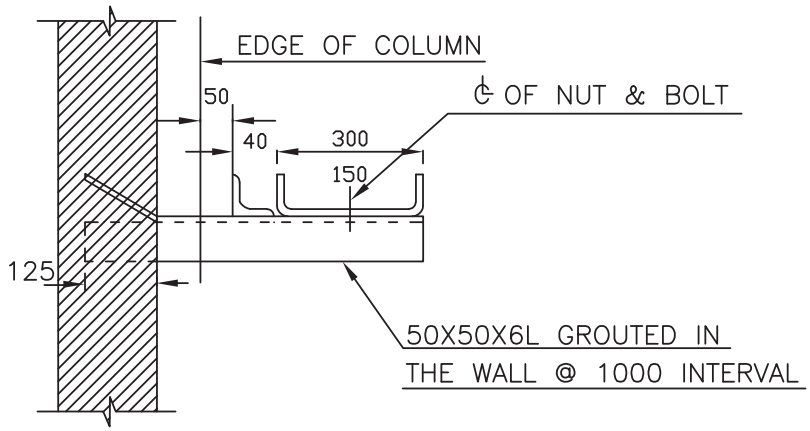
P L A N

NOTE:—

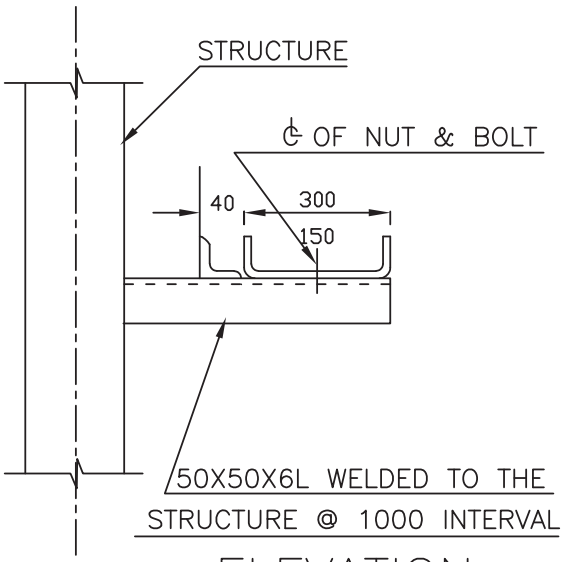
1. THE TRAY SHALL BE FIXED AT 1000 INTEREVAL BY 6 ø X 20 LONG ROOFING BOLT AND SHALL BE USED ONE NO. FOR 150 WIDE TRAYS & TWO NOS. FOR 300 WIDE TRAYS.
2. FOR MULTI TIERS RACK MINIMUM CLEARANCE BETWEEN THE TIER TO BE KEPT 300.
3. ALL DIMENSIONS ARE IN mm.

	FIXING ARRANGEMENT OF PERFORATED CABLE TRAY (HORIZONTAL FORMATION WALL / STRUCTURE SUPPORTED)	PDS: E 526	1
पी डी आई एल PDIL		DOCUMENT NO.	REV
		SHEET 1 OF 1	

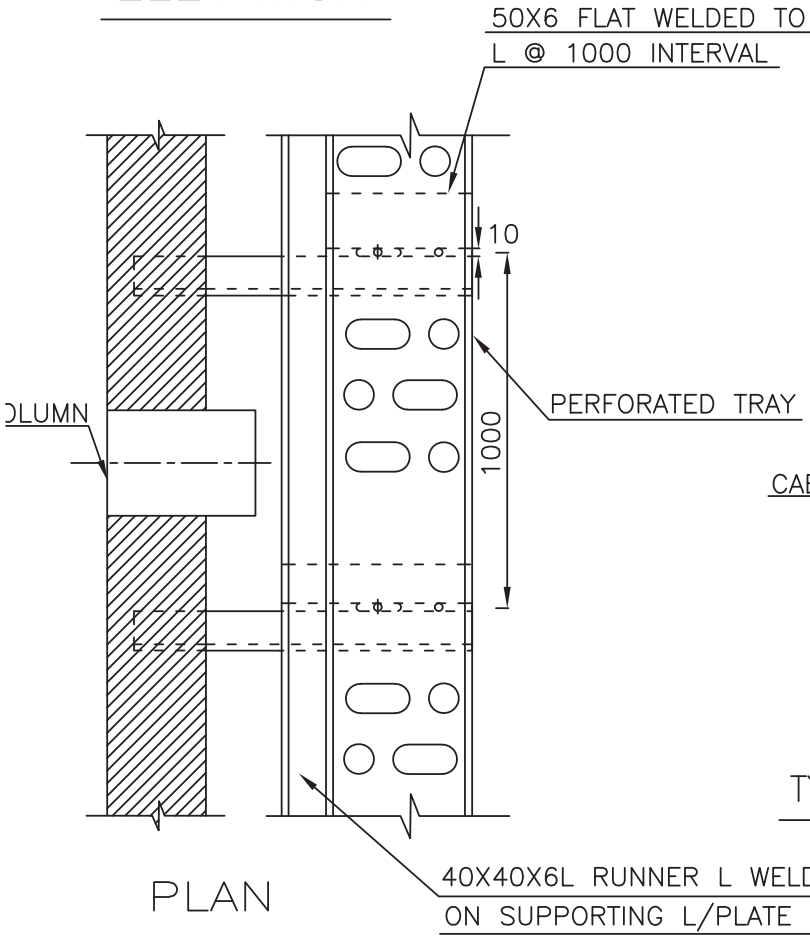
WALL / STRUCTURE SUPPORTED RACK



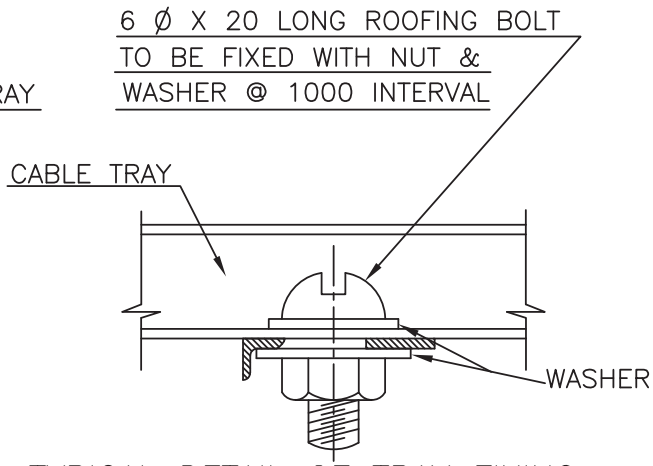
ELEVATION



ELEVATION



PLAN

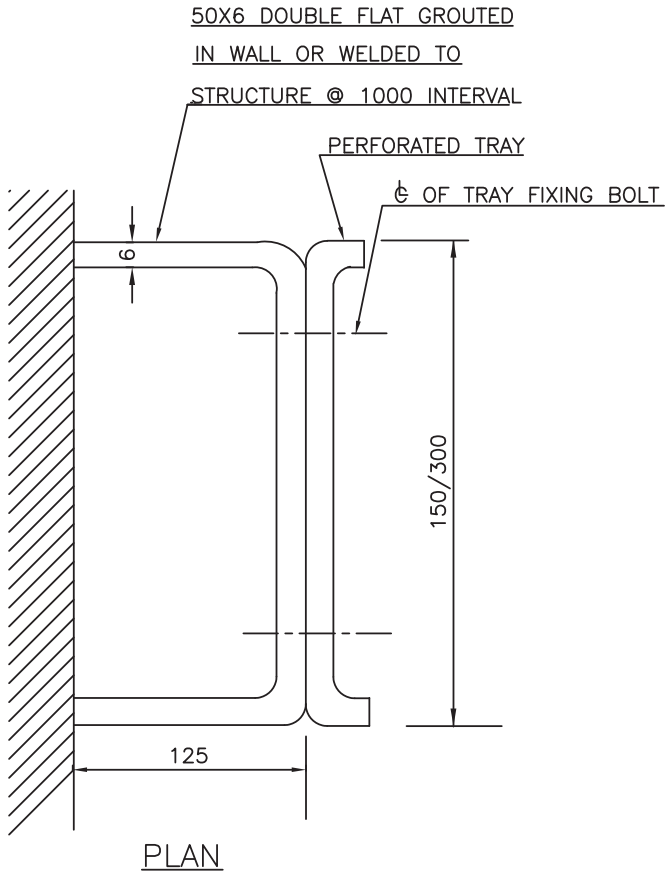


TYPICAL DETAIL OF TRAY FIXING

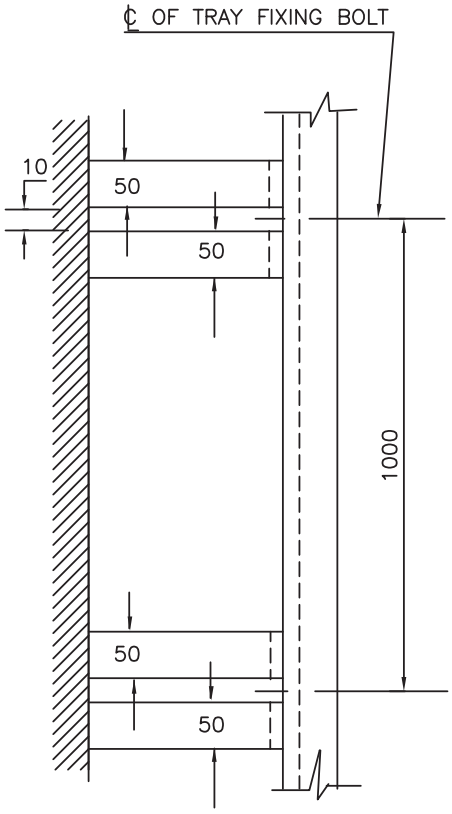
NOTES:–

1. THE TRAY SHALL BE FIXED AT 1000 INTERVAL BY 6 Ø X 20 LONG ROOFING BOLT. (ONE NO. FOR 150 & TWO NOS. FOR 300 WIDE TRAYS.)
2. FOR MULTI TIERS RACK MINIMUM CLEARANCE BETWEEN THE TIER TO BE KEPT 300.
3. ALL DIMENSION ARE IN mm.

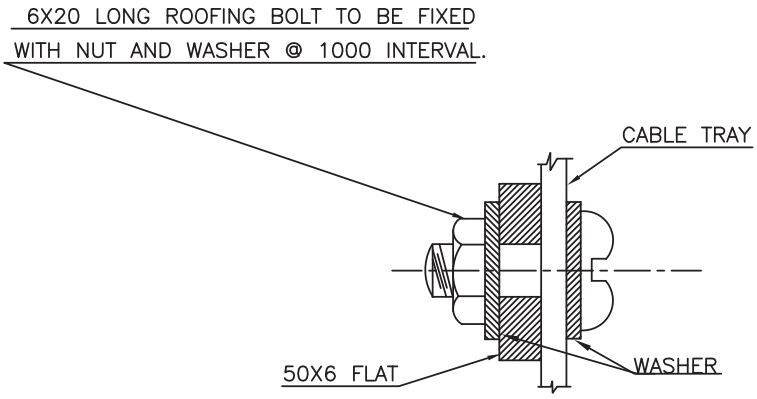
पी डी आई एल PDIL	FIXING ARRANGEMENT OF PERFORATED CABLE TRAY (VERTICAL FORMATION)	PDS: E 527	1
		DOCUMENT NO.	REV
		SHEET 1 OF 1	



PLAN



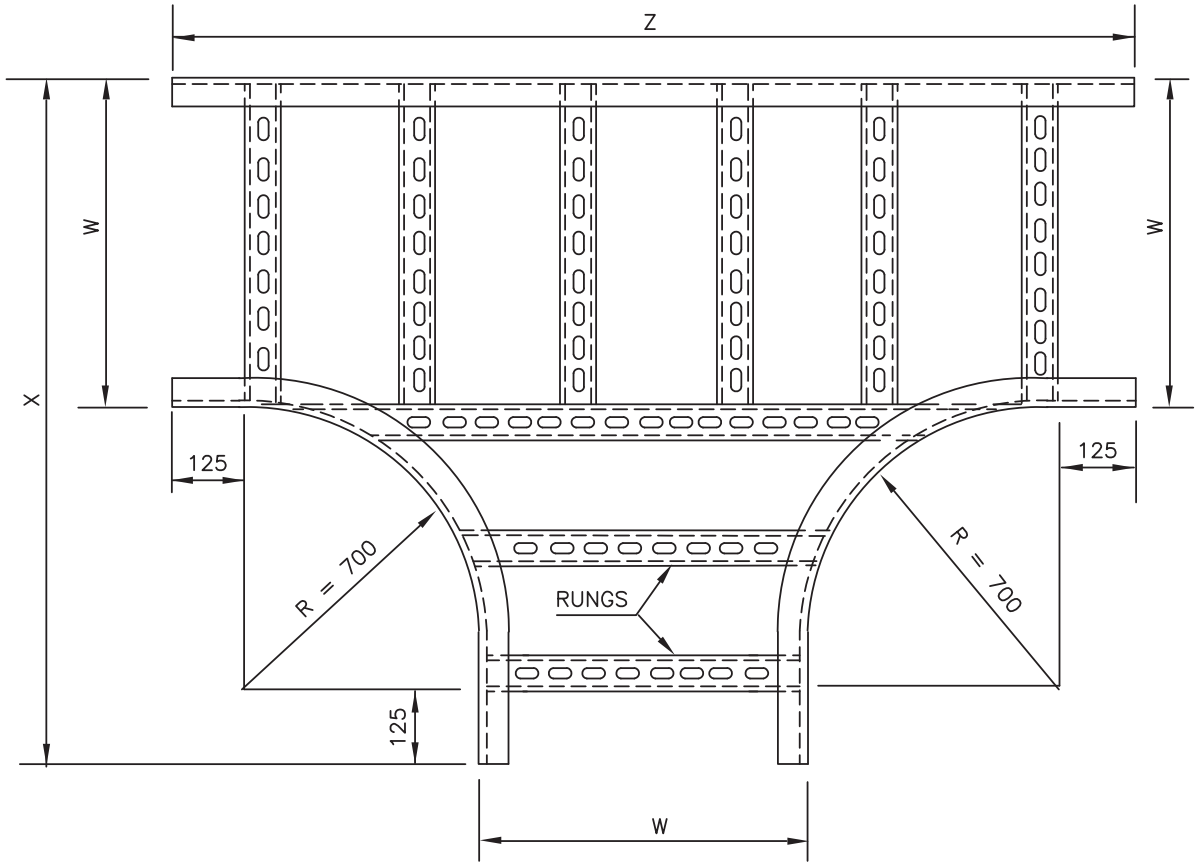
ELEVATION



TYPICAL DETAIL OF
TRAY FIXING

ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY HORIZONTAL TEE	PDS: E 531	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



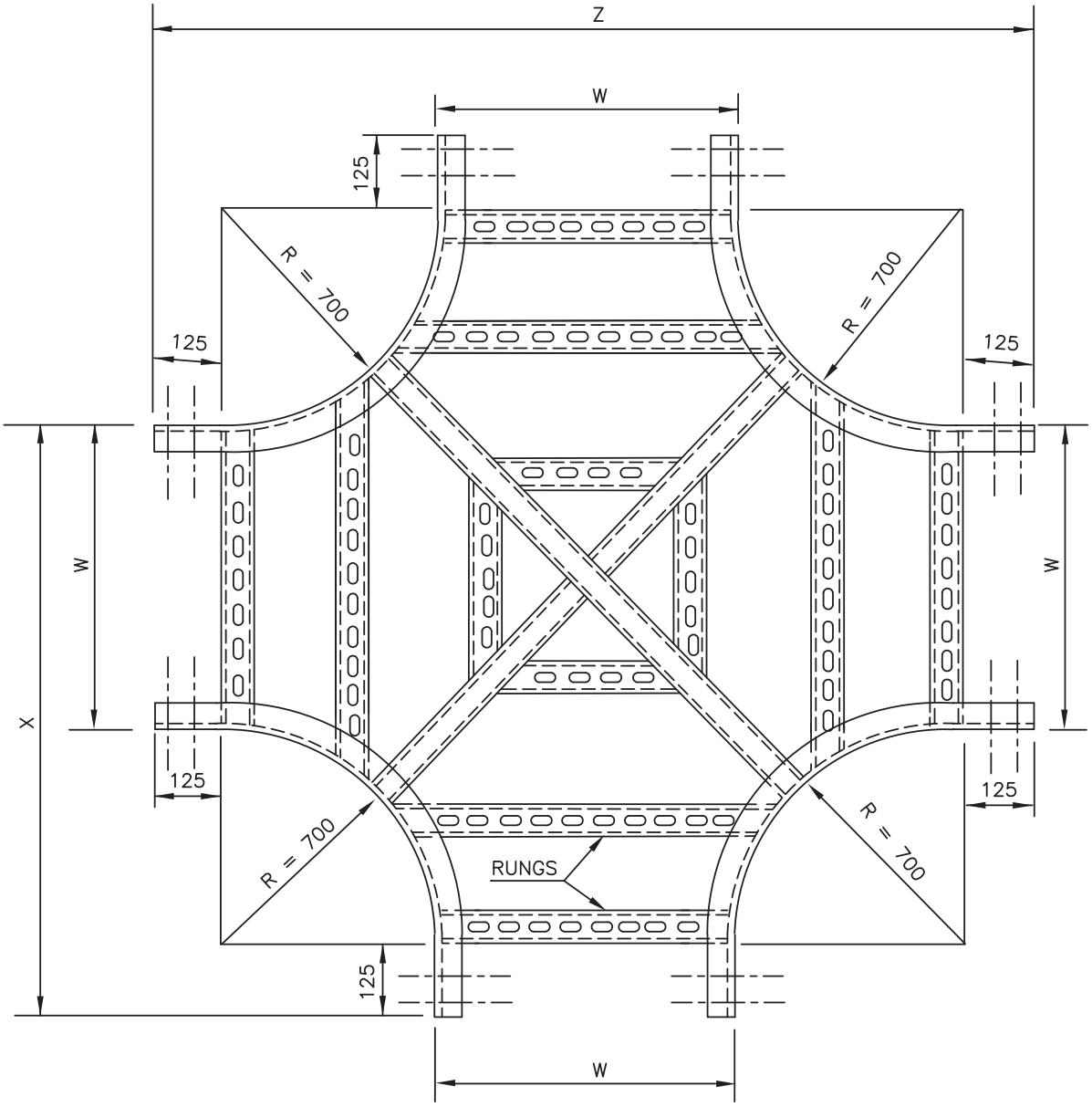
PLAN

DESIGN TYPE	W	X=R+W+125	Z=2R+W+250
HT 900	900	1725	2550
HT 600	600	1425	2250
HT 450	450	1275	2100
HT 300	300	1125	1950

NOTES :–

1. DISTANCE BETWEEN TWO RUNGS SHOULD BE APPROX. 300mm.
2. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY HORIZONTAL CROSS	PDS: E 532	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



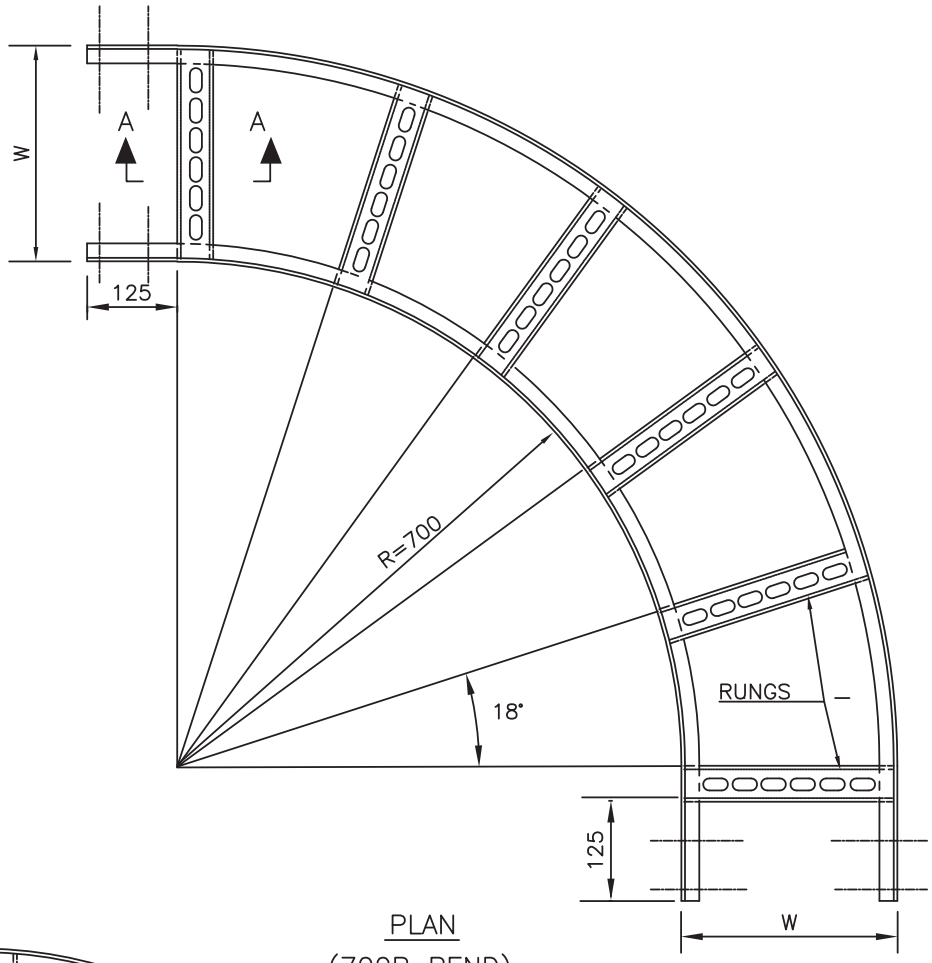
PLAN

DESIGN TYPE	W	X=R+W+125	Z=2R+W+250
HC 900	900	1725	2550
HC 600	600	1425	2250
HC 450	450	1275	2100
HC 300	300	1125	1950

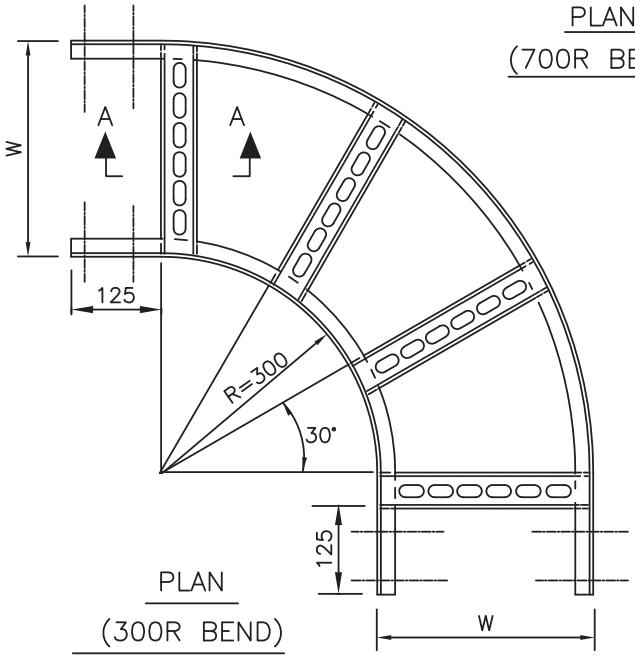
NOTES :–

1. DISTANCE BETWEEN TWO RUNGS SHOULD BE APPROX. 300mm.
2. ALL DIMENSIONS ARE IN mm.

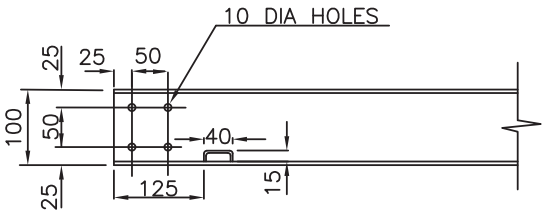
पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY 90° HORIZONTAL BENDS	PDS: E 533	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



PLAN
(700R BEND)



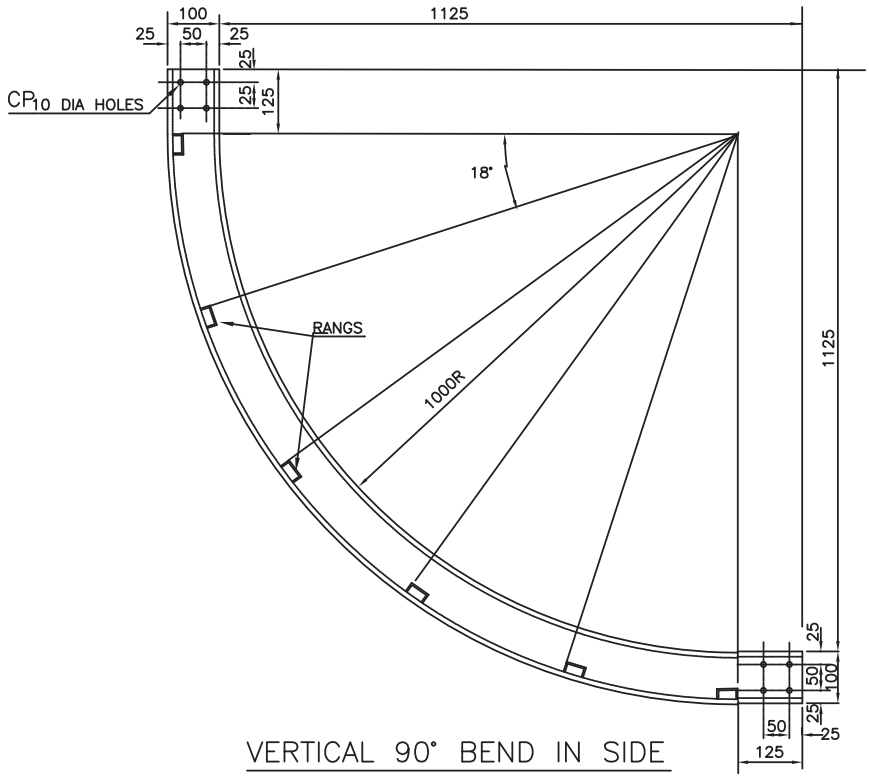
PLAN
(300R BEND)



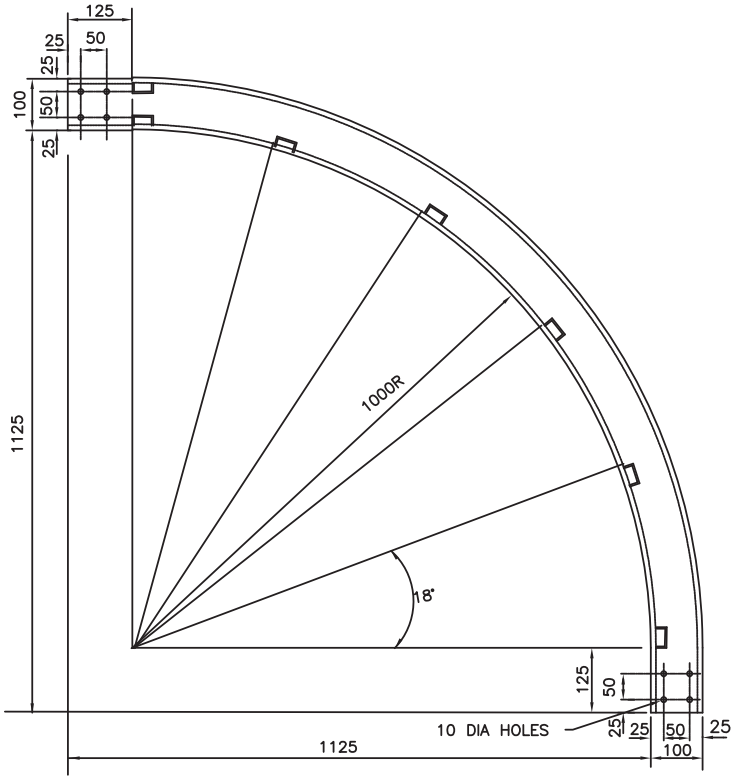
SECTION A–A

ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY 90° VERTICAL BEND BENDING RADIUS 1000 mm	PDS: E 534	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



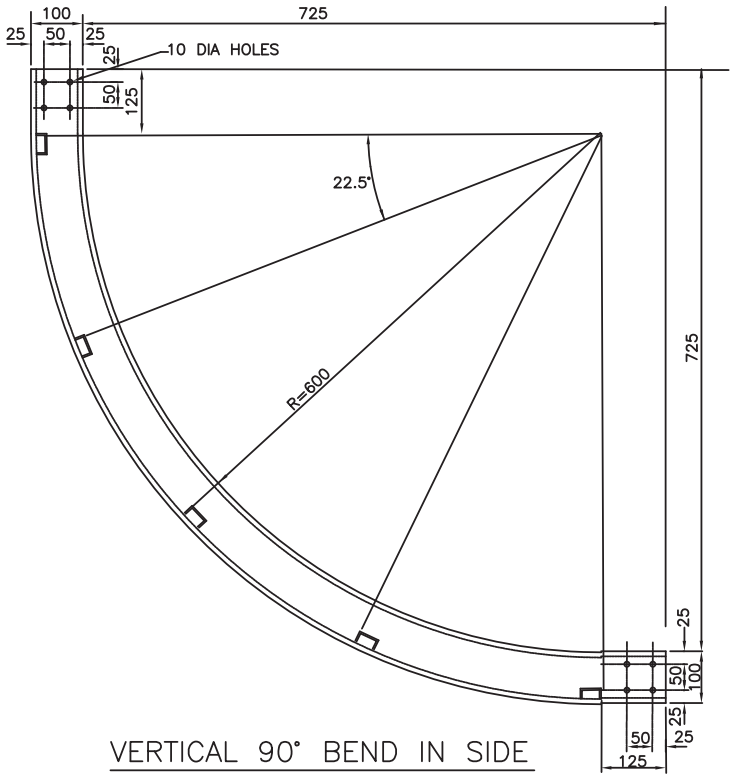
VERTICAL 90° BEND IN SIDE



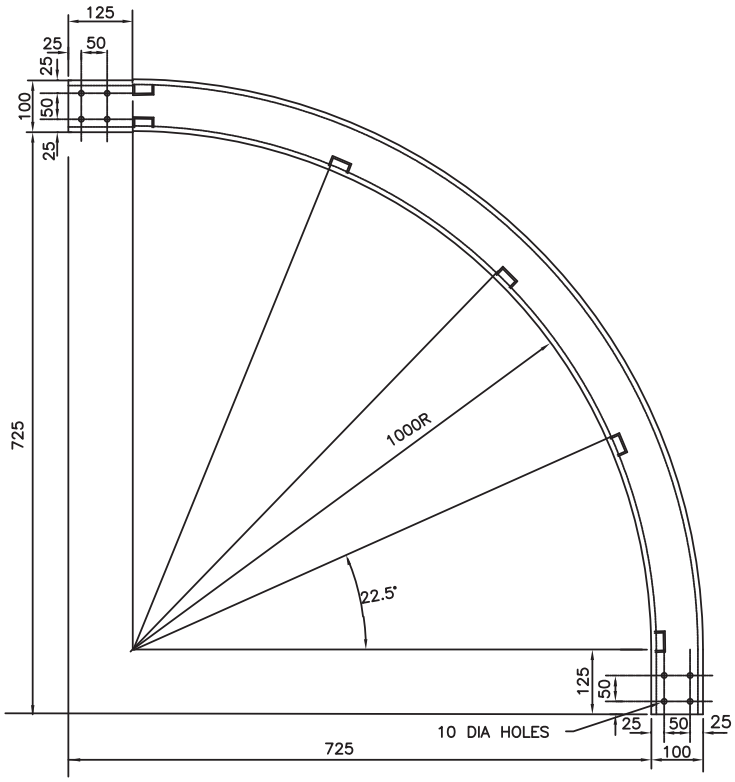
VERTICAL 90° BEND OUT SIDE

DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY 90° VERTICAL BENDS BENDING RADIUS 600 mm	PDS: E 535	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



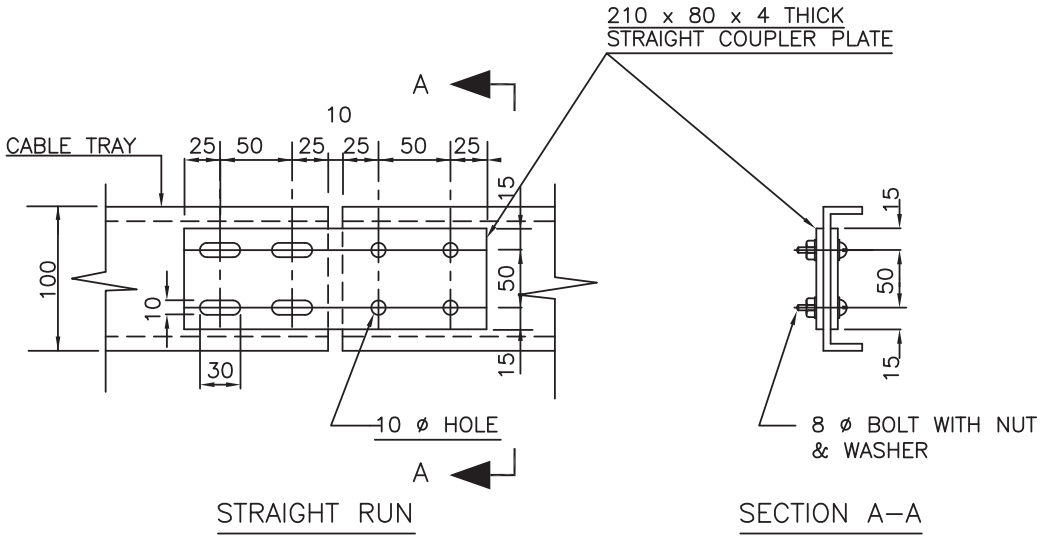
VERTICAL 90° BEND IN SIDE



VERTICAL 90° BEND OUT SIDE

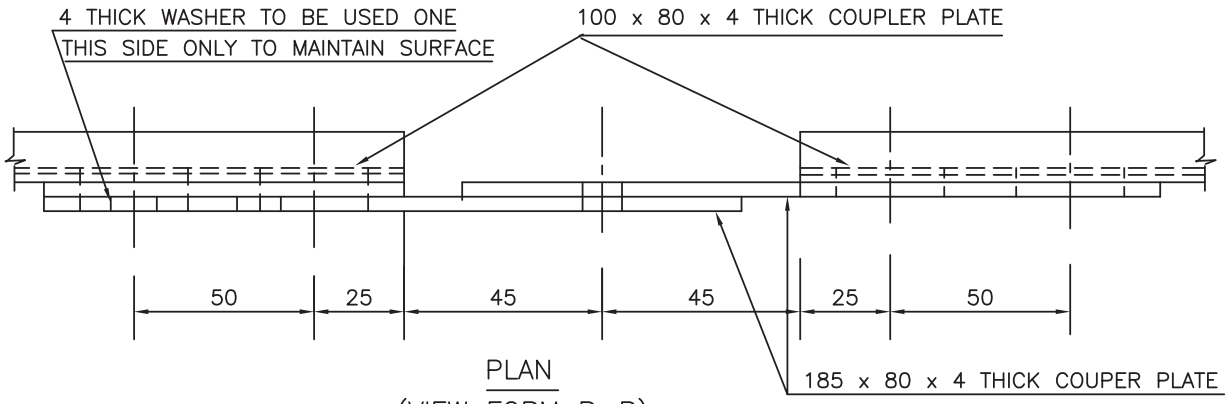
ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY COUPLING ARRANGEMENT	PDS: E 536	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	

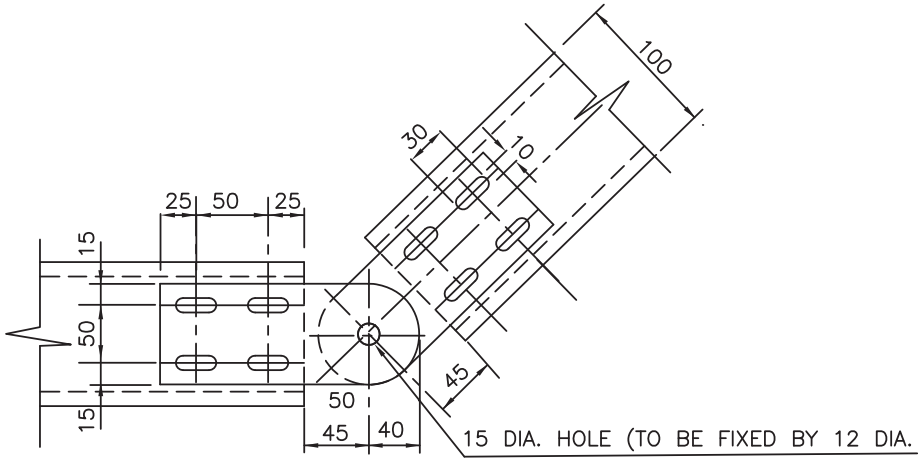


STRAIGHT RUN

SECTION A–A



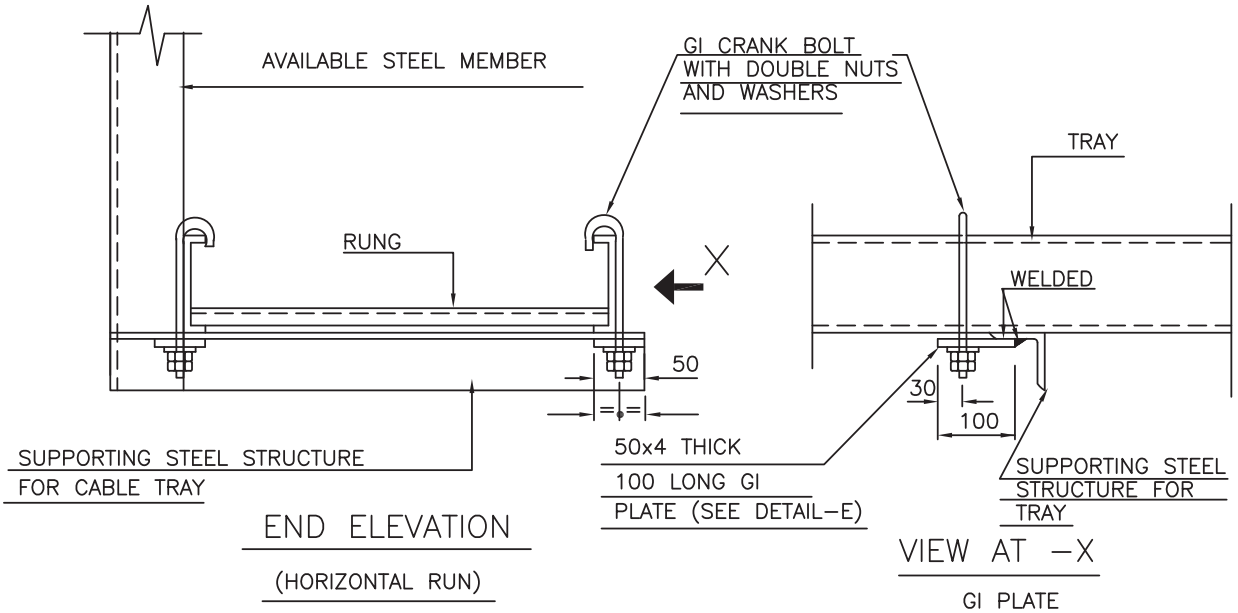
PLAN
(VIEW FORM B–B)



ELEVATION
(ADJUSTABLE BEND)

ALL DIMENSIONS ARE IN mm.

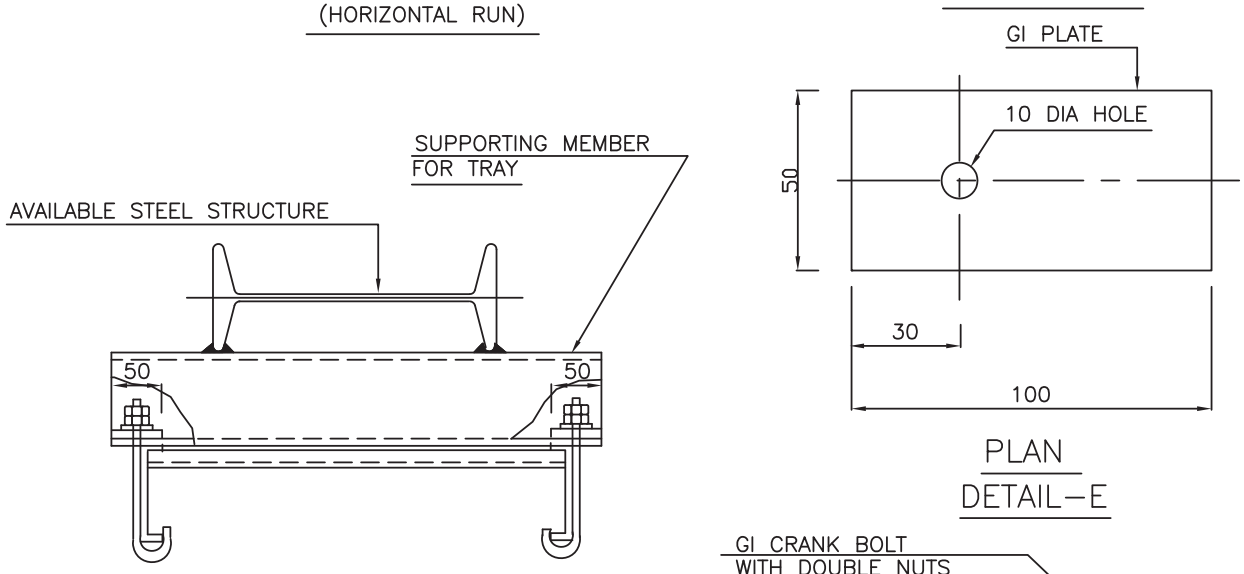
पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY FIXING ARRANGEMENT	PDS: E 537	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



END ELEVATION

(HORIZONTAL RUN)

VIEW AT –X

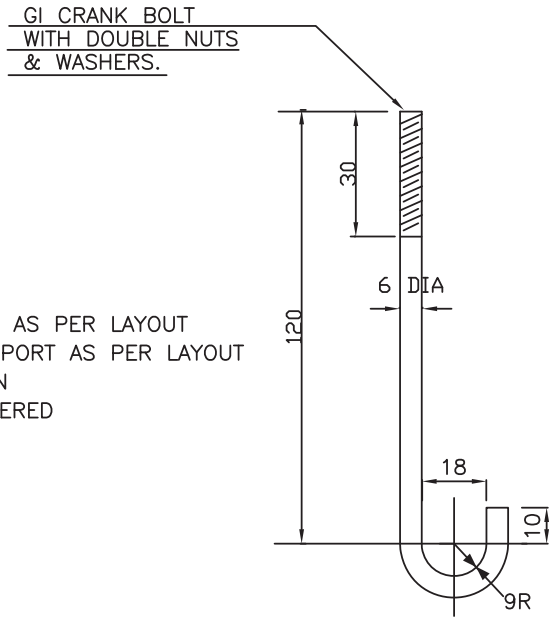


PLAN

DETAIL–E

PLAN

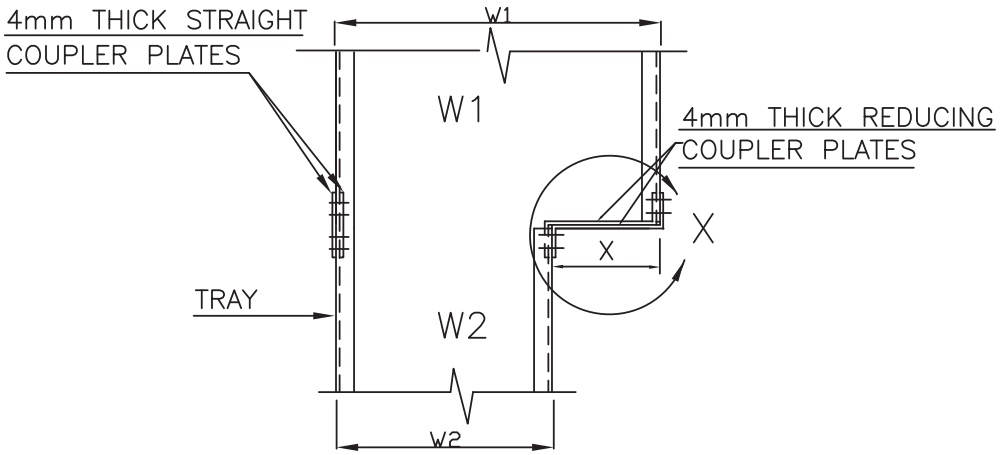
VERTICAL RUN (RISER)



NOTES:–

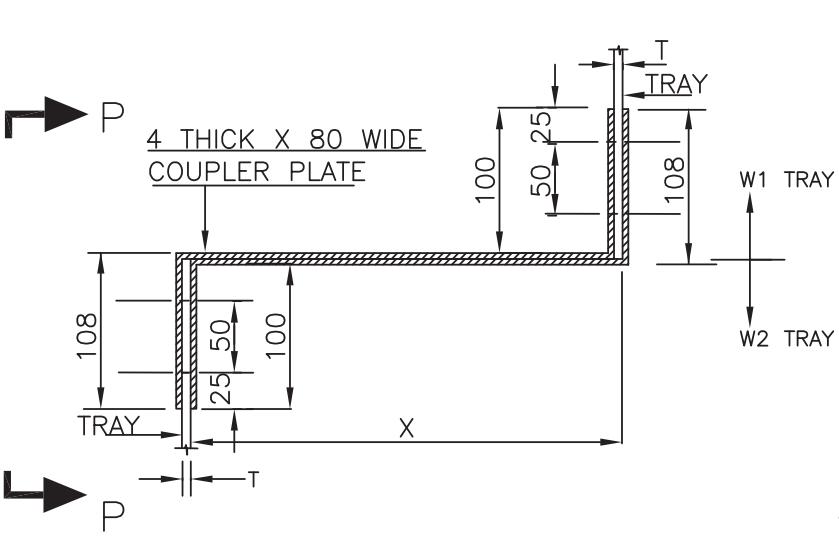
1. HORIZONTAL RUN TO BE CLAMPED WITH EVERY SUPPORT AS PER LAYOUT
2. VERTICAL RUN/ RISER TO BE CLAMPED WITH EVERY SUPPORT AS PER LAYOUT
3. EACH CRANK HOOK SHALL BE SUPPLIED WITH ONE PLAIN WASHER, ONE SPRING WASHER AND TWO DOUBLE CHAMFERED HEX NUTS. THESE SHAL BE GALVANISED ITEMS.
4. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	PRE–FABRICATED CABLE TRAY REDUCING COUPLER PLATE	PDS: E 538	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



PLAN

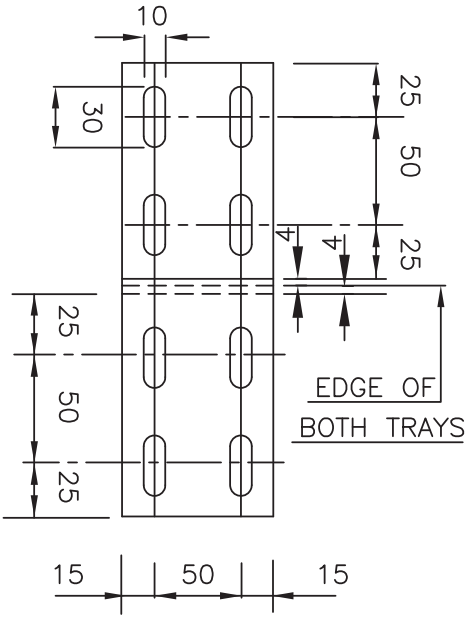
(REDUCING TRAY JOINT)



DETAIL– X

DETAIL OF REDUCING

COUPLER PLATE (4 THICK)



VIEW – P–P

ALL DIMENSIONS ARE IN mm.

SL. NO.	W1	W2	X
1	900	600 450 300	300 450 600
2	600	450 300	150 300
3	450	300 150	150 300

SL. No.	EQUIPMENT TO BE EARTHED	FAULT LEVEL (MVA)	G.I.STRIPS/WIRES			ALUMINIUM					REMARKS
			MIN.SIZE (mm^2)	SIZE TO BE USED (mm^2)	SYMBOL	MIN.SIZE (mm^2)	STRIPS/WIRES SIZE TO BE USED (mm^2)	STRIPS/WIRES SYMBOL	1.1kv PVC SINGLE CORE CABLE SIZE (mm^2)	1.1kv PVC SINGLE CORE CABLE SYMBOL	
1A.	FOR PLANTS HAVING SWITCHYARDS/ GENERATING STATION										
I.	SWITCH YARD EQUIPMENT,GENERATORS,H.T.SWITCH BOARDS,TRANSFORMERS,MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	750 AT 11KV	706	2–50x8	2 (2)	491	2–38.1x6.35=484	2 (12)	500	21	AS PER CLAUSE 17.3.2 OF IS:3043
II.	SWITCH YARD EQUIPMENT,GENERATORS,H.T.SWITCH BOARDS,TRANSFORMERS,MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	500 AT 11KV 300 AT 6.6KV 150 AT 3.3KV	471	60x8	1	328	50.8x6.35=323	11	400	22	–DO–
III.	SWITCH YARD EQUIPMENT,GENERATORS,H.T.SWITCH BOARDS,TRANSFORMERS,MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	250 AT 6.6KV 125 AT 3.3KV	392	50x8	2	272	50.8x6.35=323	11	300	23	–DO–
IV.	SWITCH YARD EQUIPMENT,GENERATORS,H.T.SWITCH BOARDS,TRANSFORMERS,MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	350 AT 11KV 200 AT 6.6KV 100 AT 3.3KV	330 314 314	50x8	2	229 218 218	38.1x6.35=242	12	240	24	–DO–
V.	SWITCH YARD EQUIPMENT,GENERATORS,H.T.SWITCH BOARDS,TRANSFORMERS,MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	250 AT 11KV 150 AT 6.6KV 75 AT 3.3KV	235	50x6	3	163	31.75x4.78=152	13	185	25	–DO–
1B	FOR PLANTS WITHOUT SW.YARD/GENERATING STN. H.T.SWITCH BOARDS,TRANSFORMERS,MAIN EARTHING GRID, CONNECTION FROM EARTH BUS TO EARTHING GRID.	ANY FAULT LEVEL AT ANY VOLTAGE	210	50x6	3	120	38.1x3.18=121	14	120	27	AS PER CLAUSE 12.3.2 OF IS:3043
1C	ALL M.V.SWITCH BOARDS		210	50x6	3	120	38.1x3.18=121	14	120	27	AS PER CLAUSE 12.3.2 OF IS:3043
2	H.V. MOTORS		210	50x6	3	120	38.1x3.18=121	14	120	27	–DO–
3	TRANSFOMER NEUTRALS		–	–	–	120	–		150	26	–
4	M.V. MOTORS RATED 75KW & ABOVE		210	50x6	3	120	38.1x3.18=121	14	120	27	AS PER CLAUSE 12.3.2 OF IS:3043
5	M.V. MOTORS ABOVE 30KW &LESS THAN 75KW		175	35x6	4	93	31.75x3.18=101	15	95	28	–DO–

पी डी आई एल
PDIL

EARTHING CONDUCTOR DETAILS

PDS: E 602

DOCUMENT NO.

REV. 0

SHEET 1 OF 2

SL. No.	EQUIPMENT TO BE EARTHED	FAULT LEVEL (MVA)	G.I.STRIPS/WIRES			ALUMINIUM					REMARKS
			MIN.SIZE (mm^2)	SIZE TO BE USED (mm^2)	SYMBOL	MIN.SIZE (mm^2)	STRIPS/WIRES SIZE TO BE USED (mm^2)	STRIPS/WIRES SYMBOL	1.1kv PVC SINGLE CORE CABLE SIZE (mm^2)	1.1kv PVC SINGLE CORE CABLE SYMBOL	
6	M.V.MOTORS ABOVE 5.5KW & LESS THAN 30KW 63A SW.SOCKETS,BATTERY CHARGERS,LIGHTING SUB–DIST.BDS.,D.C.BDS.		44	25x6	5	25	2 SWG=38.6	17	25	29	AS PER CLAUSE 12.3.2 OF IS:3043
7	M.V.MOTORS RATED 5.5KW & BELOW		7	8 SWG=13	6	5	10 SWG=8.3	18	6	30	–DO–
8	ALL MINOR EQUIPMENT RATED FOR 250V & BELOW		–	10 SWG=8.3	7	–	10 SWG=8.3	18	6	30	
9	NON ELECTRICAL EQUIPMENT,SUCH AS VESSELS STRUCTURES IN HAZARDOUS AREA & LIGHTNING PROTECTION CONDUCTORS		32x6	35x6	4	–	25.4x3.18=81	16	–	–	AS PER IS:2309

NOTE :–EARTHING CODUCTOR SIZES FOR ITEMS AT SL.No.4,5,6 & 7 SHOULD BE CHOSEN AS HALF THE POWER CABLE SIZES ACTUALLY USED.

पी डी आई एल PDIL

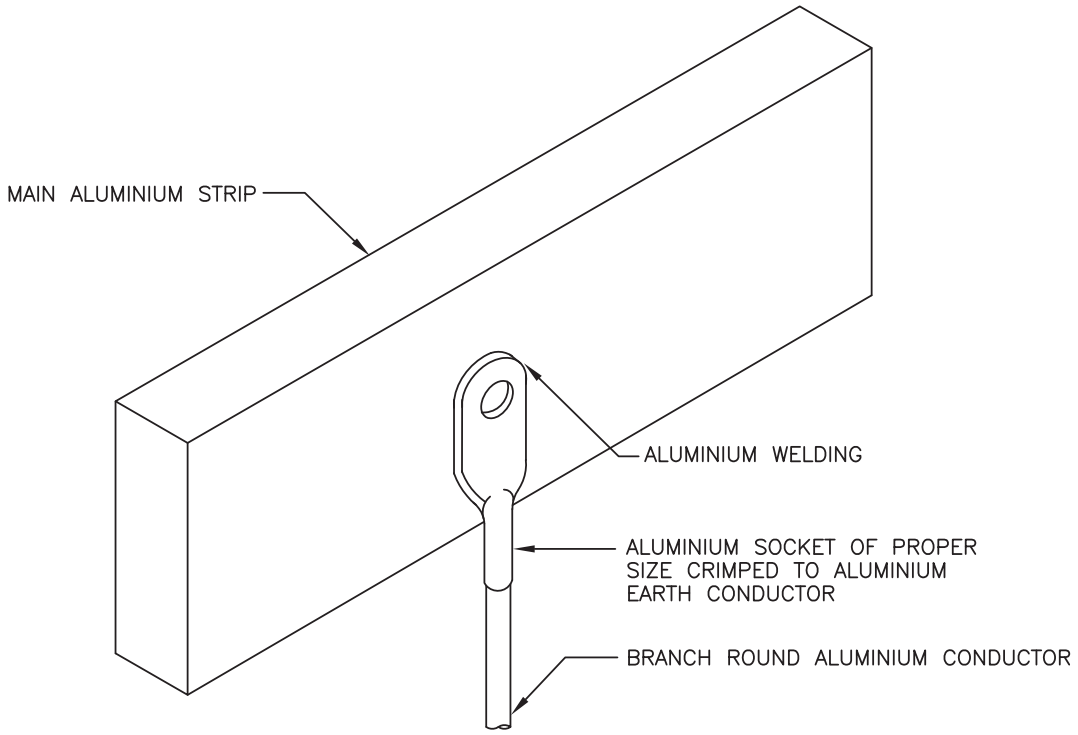
EARTHING CONDUCTOR DETAILS

PDS: E 602

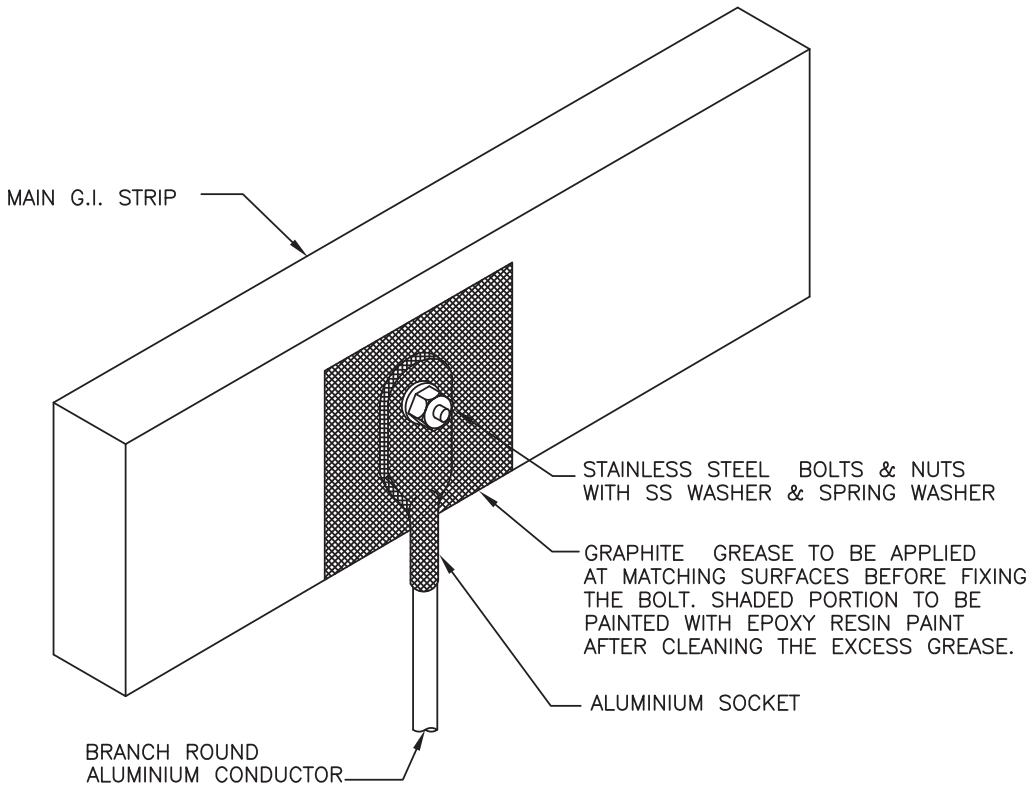
DOCUMENT NO.

REV. 0

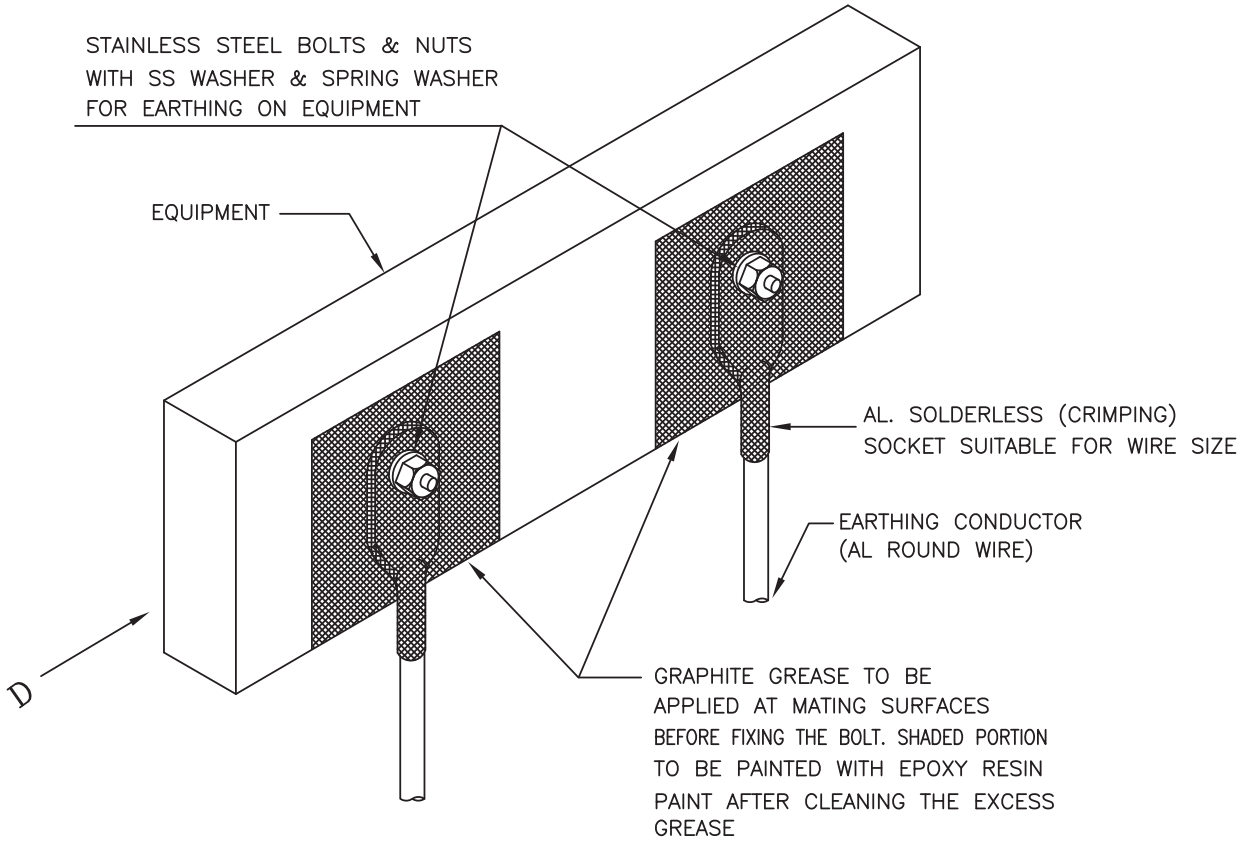
SHEET 2 OF 2



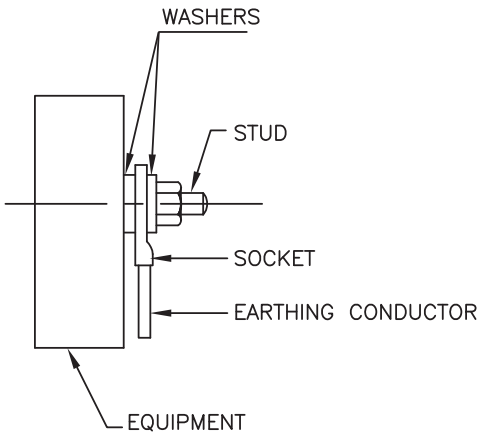
' T ' JOINT ALUMINIUM STRIP TO ROUND ALUMINIUM CONDUCTOR



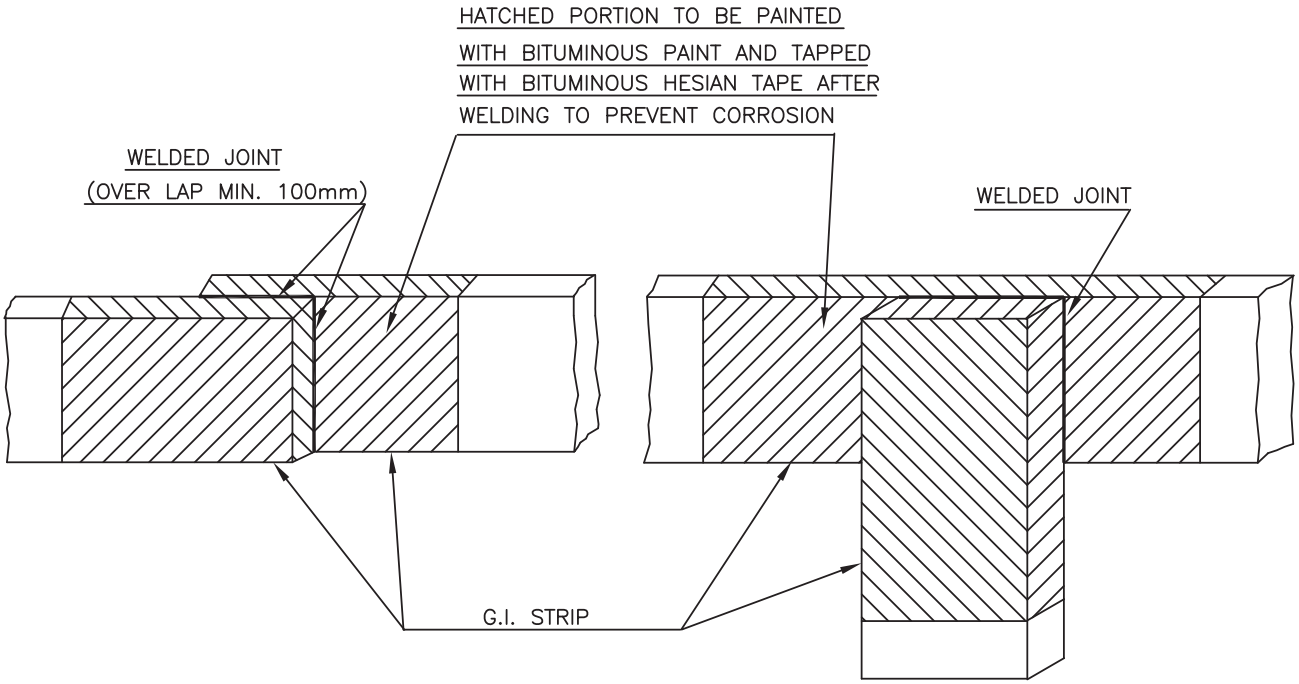
' T ' JOINT G.I. STRIP TO ROUND ALUMINIUM CONDUCTOR



ARRANGEMENT OF DOUBLE EARTH CONNECTIONS TO EQUIPMENT

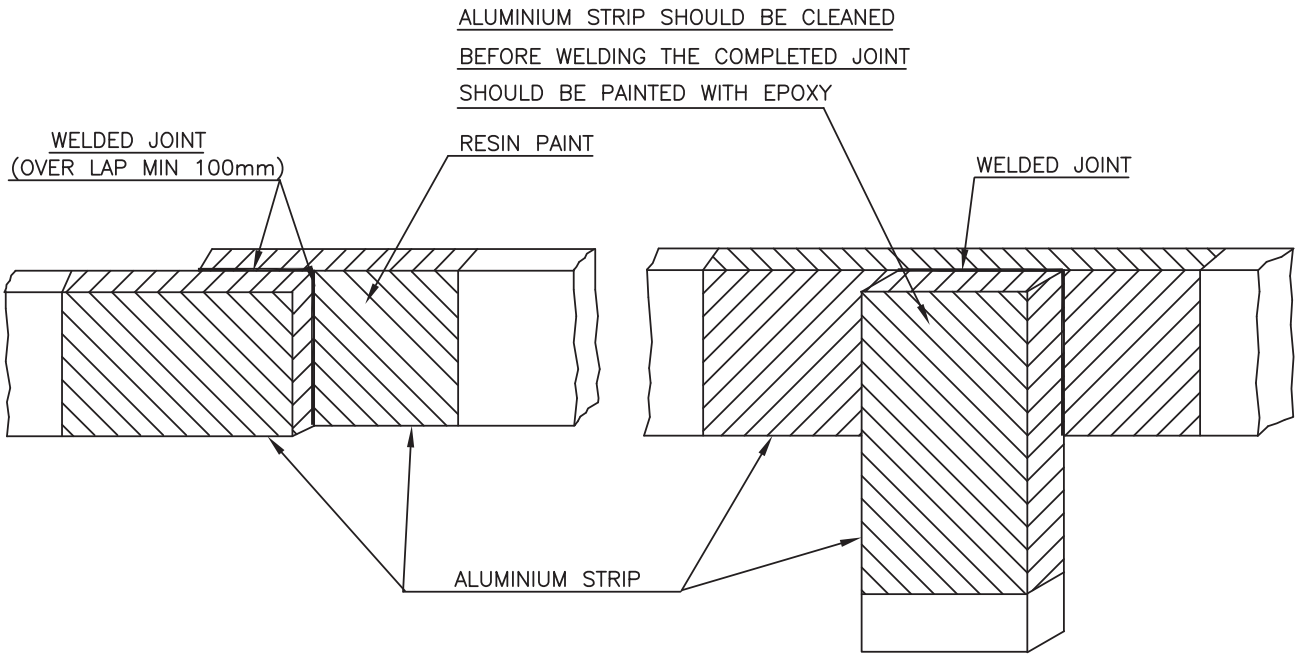


V I E W F R O M – D



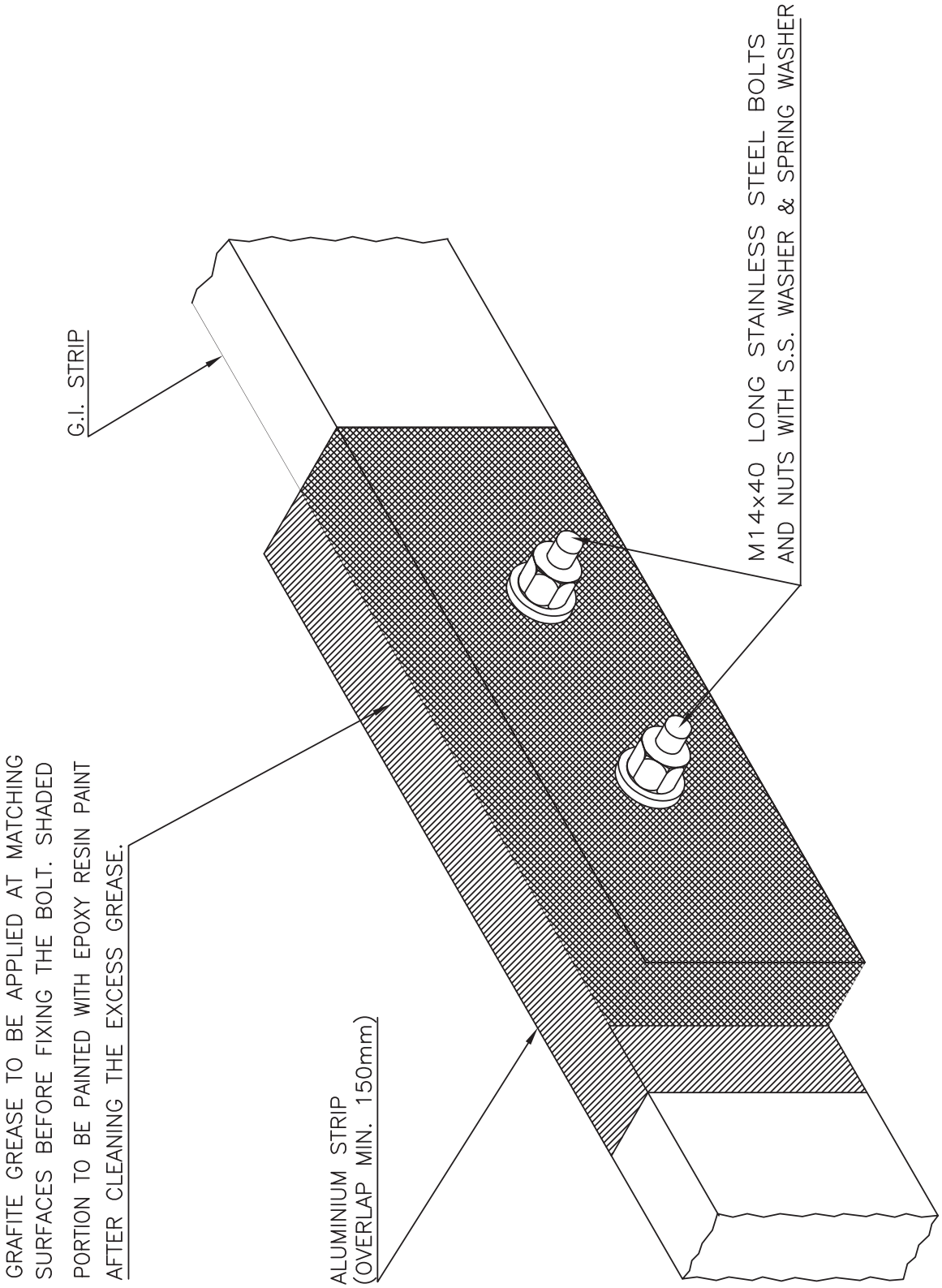
STRAIGHT JOINT G.I TO G.I. STRIP

" T " JOINT G.I. TO G.I. STRIP



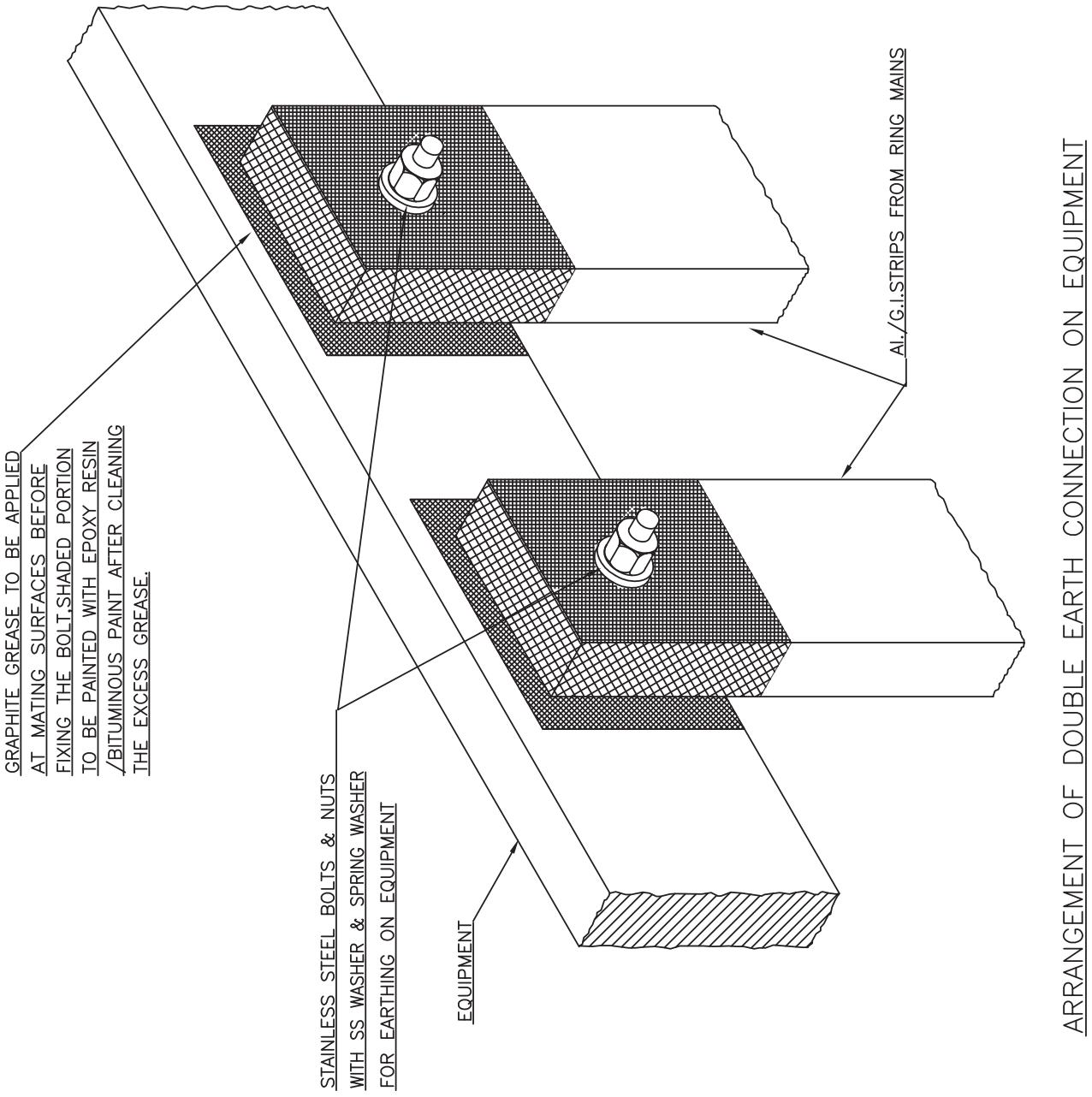
STRAIGHT JOINT AL. TO AL. STRIP

" T " JOINT AL TO AL STRIP



ARRANGEMENT OF LAP JOINT BETWEEN

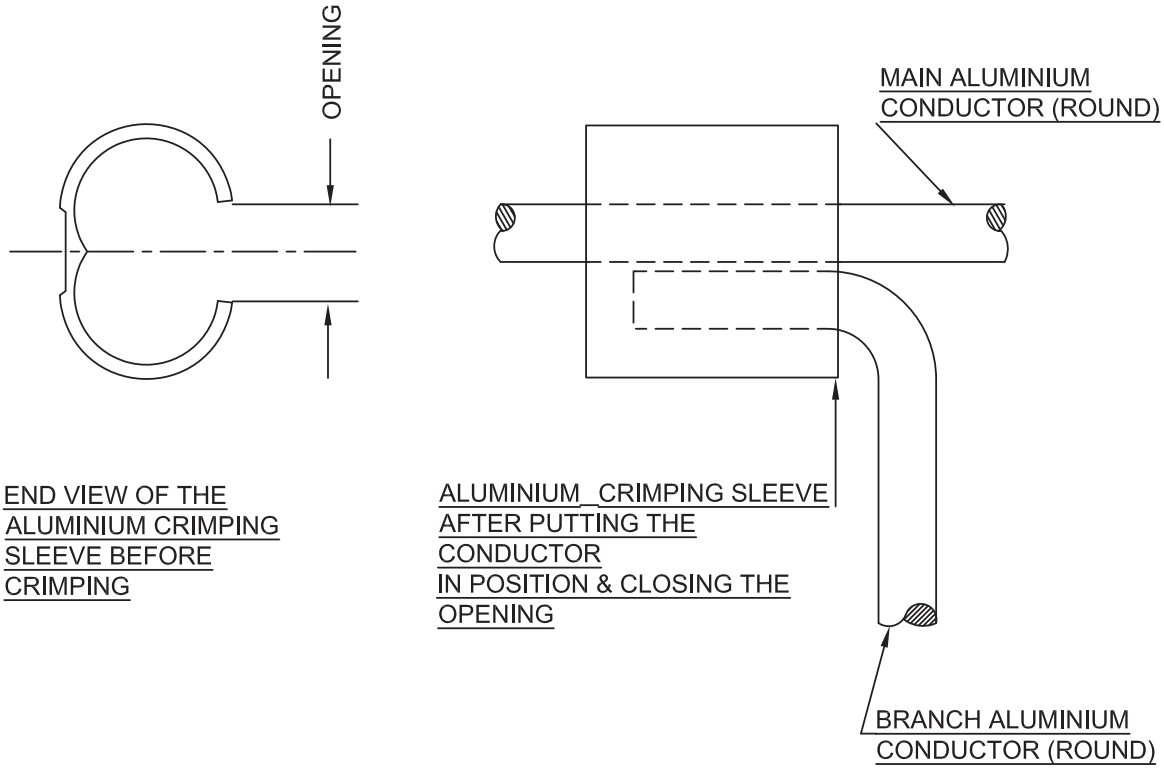
AI. EARTH STRIP TO G.I. EARTH STRIP



ARRANGEMENT OF DOUBLE EARTH CONNECTION ON EQUIPMENT

NOTE:–

EPOXY RESIN PAINT SHALL BE USED FOR AL STRIP AND BITUMINOUS PAINT FOR G.I.STRIP.

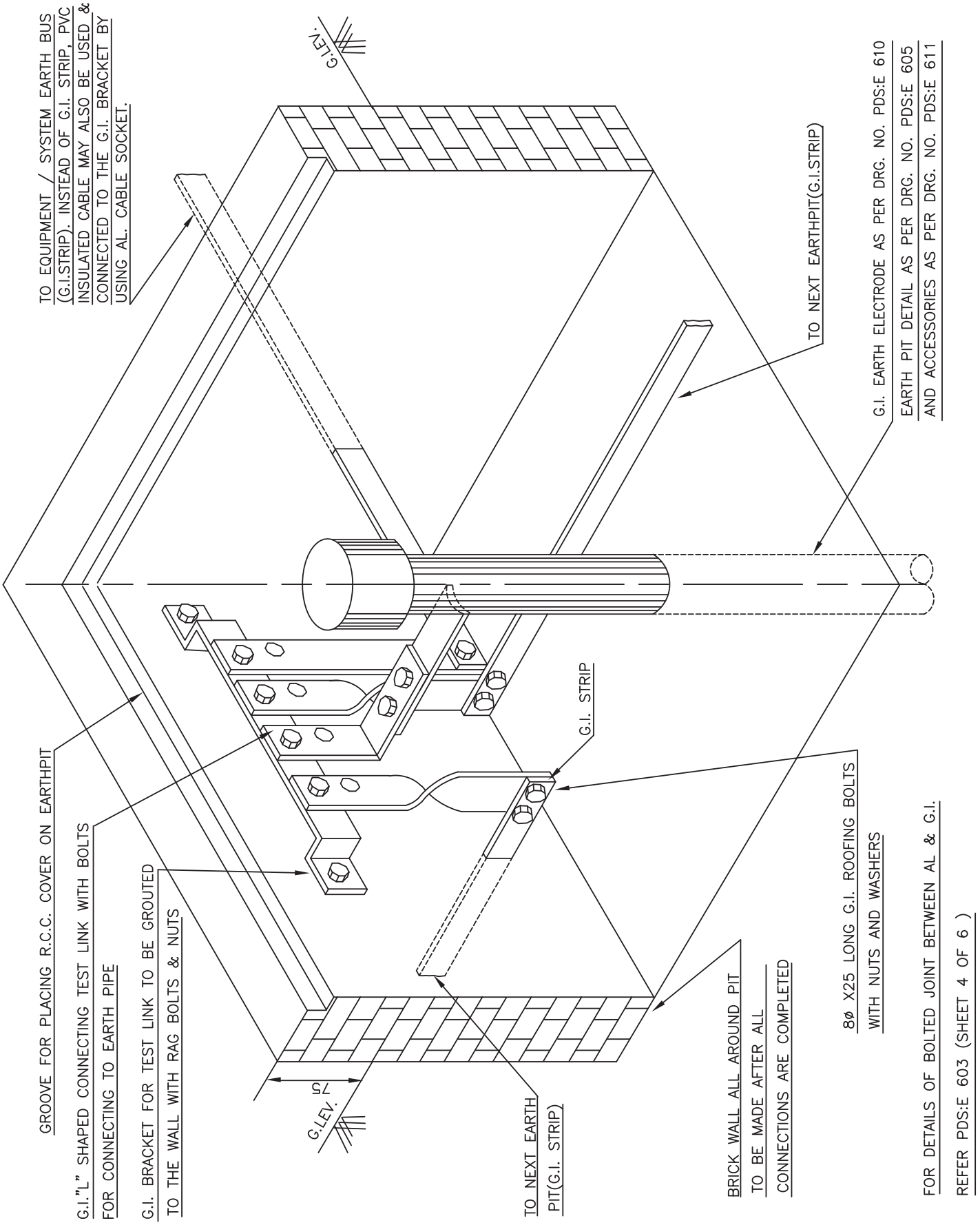


"T" JOINT ROUND ALUMINIUM CONDUCTOR TO ROUND ALUMINIUM CONDUCTOR (CRIMPING TYPE)

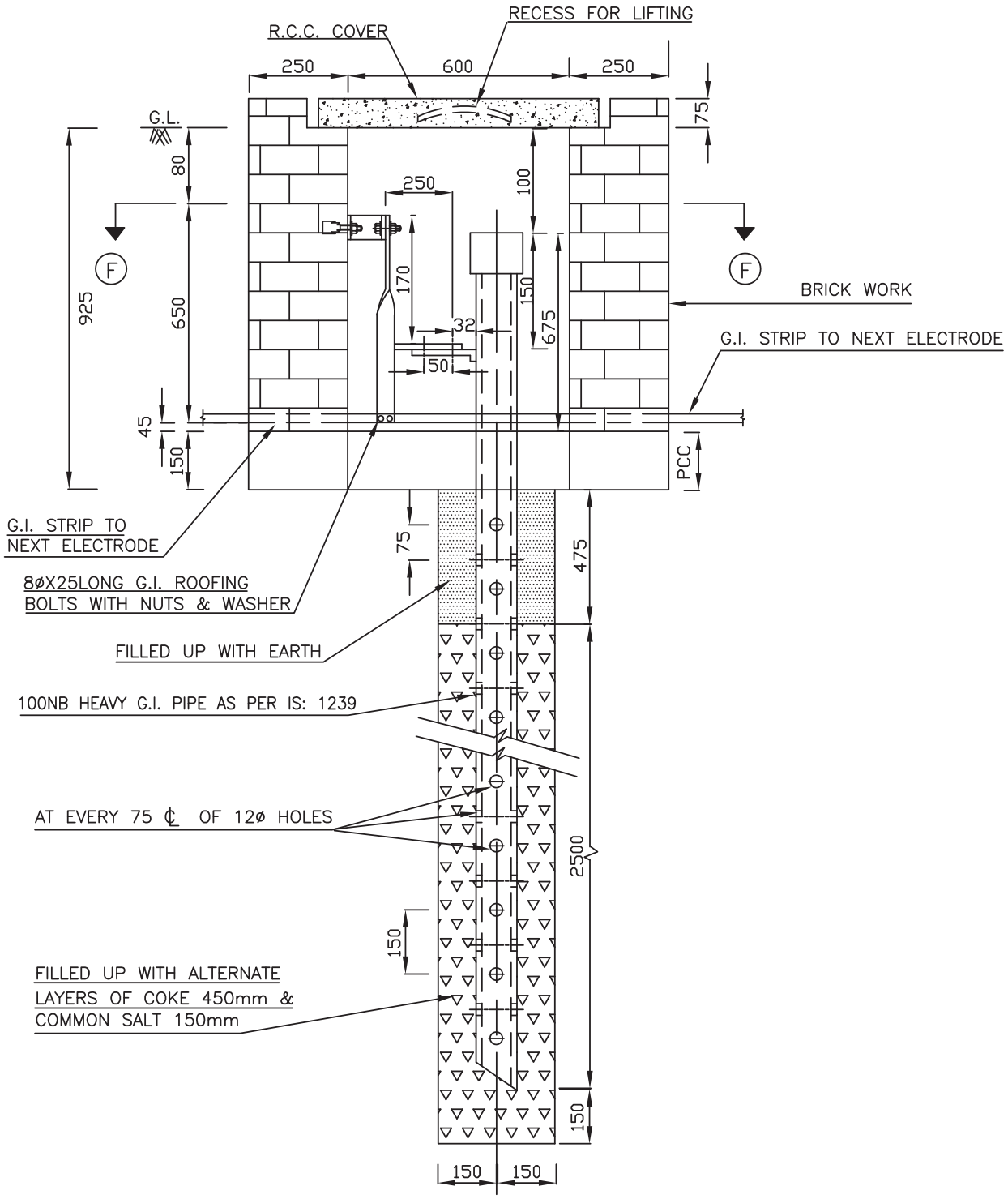
NOTE :–

USE CORRECT SIZE OF COMPRESSION DIES.

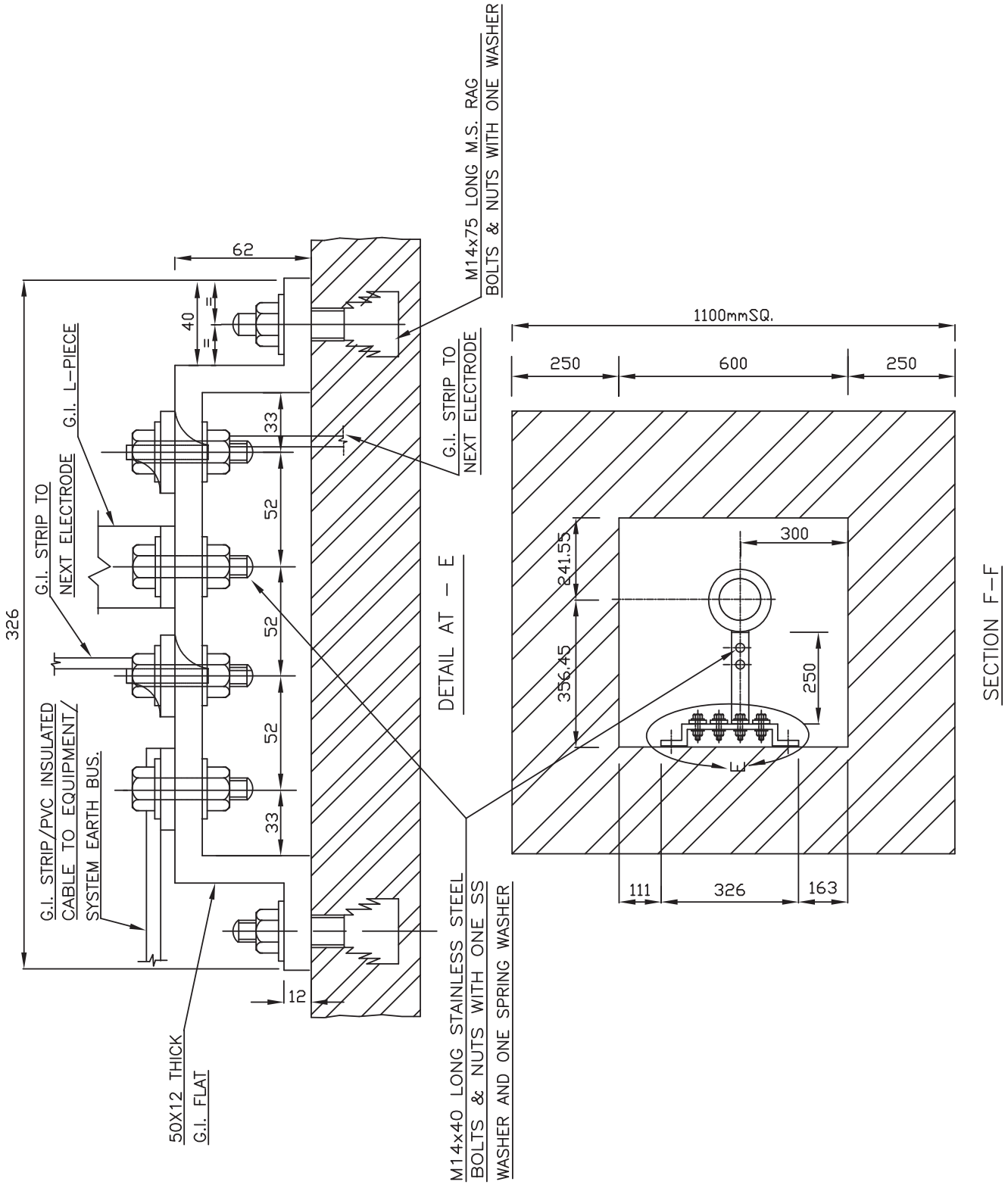
पी डी आई एल PDIL	TYPICAL DETAILS OF CONNECTIONS IN EARTH PIT	PDS: E 604 / 0 DOCUMENT NO. / REV. SHEET 1 OF 1



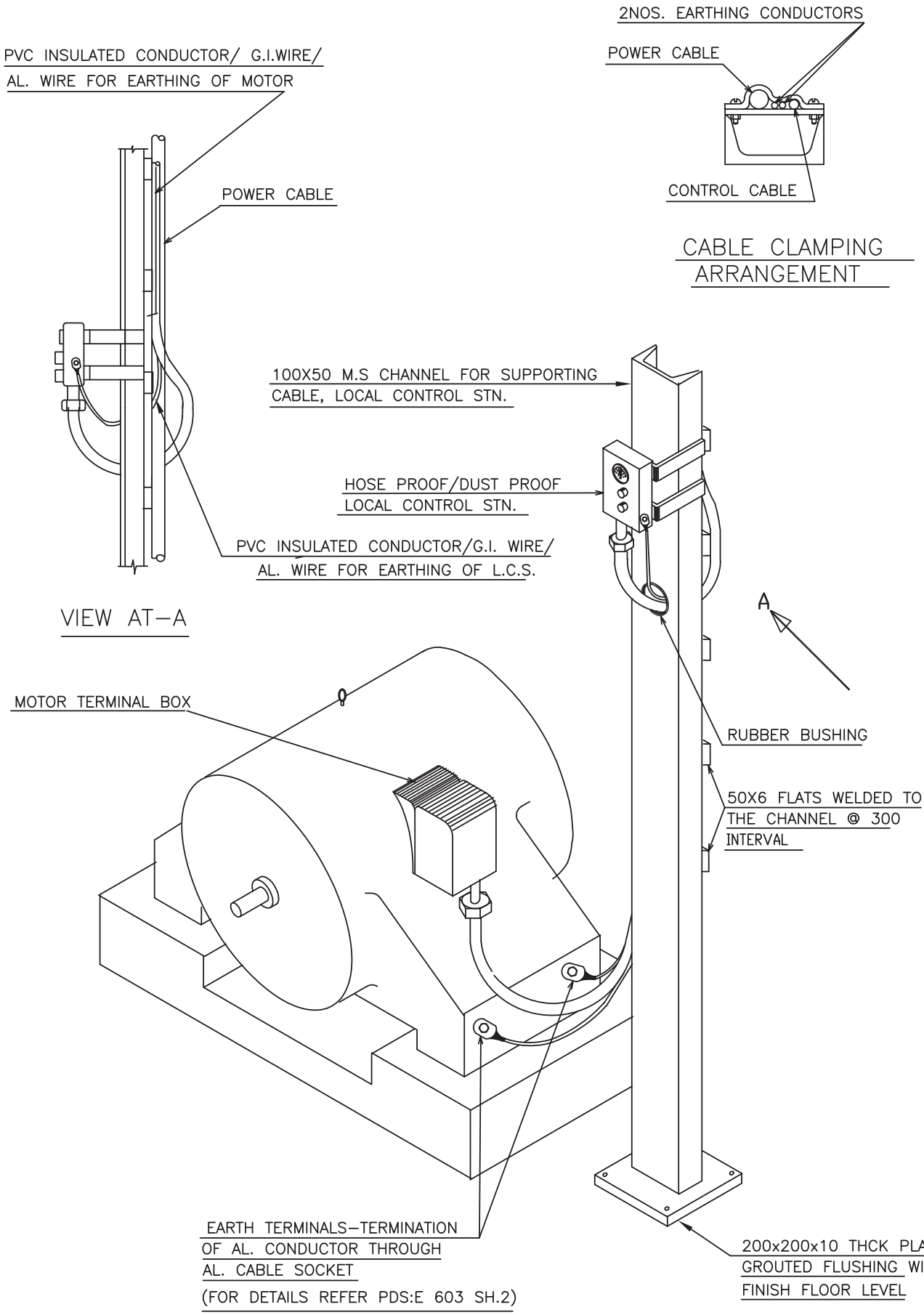
पी डी आई एल PDIL	EARTH PIT DETAILS	PDS: E 605	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 2	

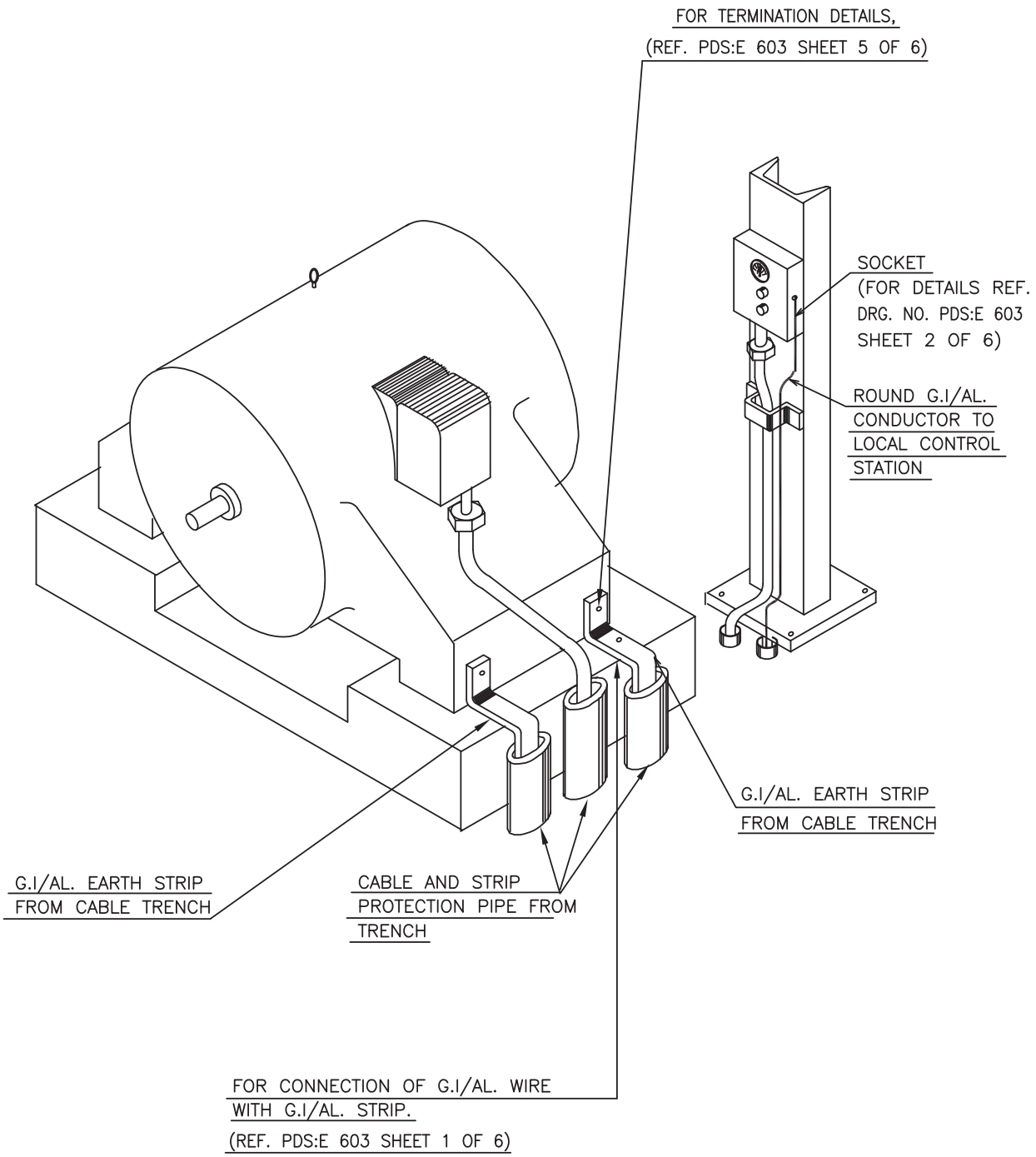


SECTIONAL ELEVATION OF EARTH PIT

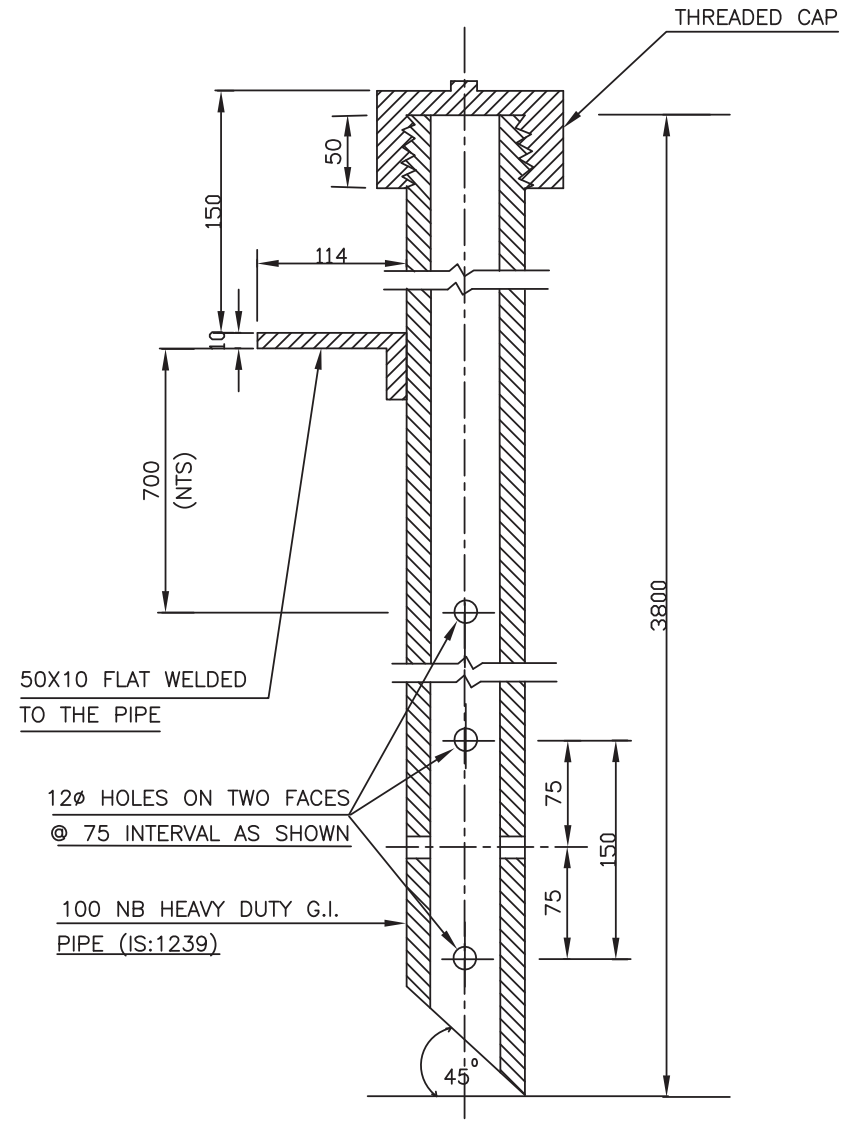

M14x75 LONG M.S. RAG BOLTS & NUTS WITH ONE WASHER
62
40
40
G.I. L-PIECE
G.I. STRIP TO NEXT ELECTRODE
33
52
52
52
33
326
G.I. STRIP/PVC INSULATED CABLE TO EQUIPMENT/ SYSTEM EARTH BUS.
G.I. STRIP TO NEXT ELECTRODE
12
50X12 THICK G.I. FLAT
M14x40 LONG STAINLESS STEEL BOLTS & NUTS WITH ONE SS WASHER AND ONE SPRING WASHER
DETAIL AT - E
1100mmSQ.
250
600
250
300
241.55
356.45
250
E
111
326
163
SECTION F-F

पी डी आई एल PDIL	TYPICAL ARRANGEMENT OF EARTHING FOR MOTOR AND START STOP PUSH BUTTON STATION	PDS: E 606	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 2	

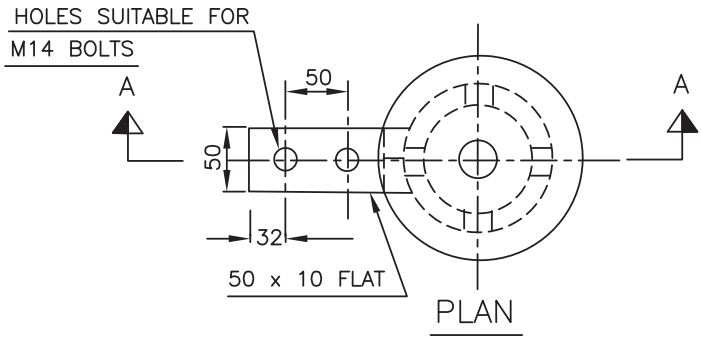



FOR TERMINATION DETAILS,
(REF. PDS:E 603 SHEET 5 OF 6)
SOCKET
(FOR DETAILS REF. DRG. NO. PDS:E 603 SHEET 2 OF 6)
ROUND G.I/AL. CONDUCTOR TO LOCAL CONTROL STATION
G.I/AL. EARTH STRIP FROM CABLE TRENCH
G.I/AL. EARTH STRIP FROM CABLE TRENCH
CABLE AND STRIP PROTECTION PIPE FROM TRENCH
FOR CONNECTION OF G.I/AL. WIRE WITH G.I/AL. STRIP.
(REF. PDS:E 603 SHEET 1 OF 6)

पी डी आई एल PDIL	3.8M G.I. ELECTRODE FOR EARTHING	PDS: E 610	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



SECTION A–A

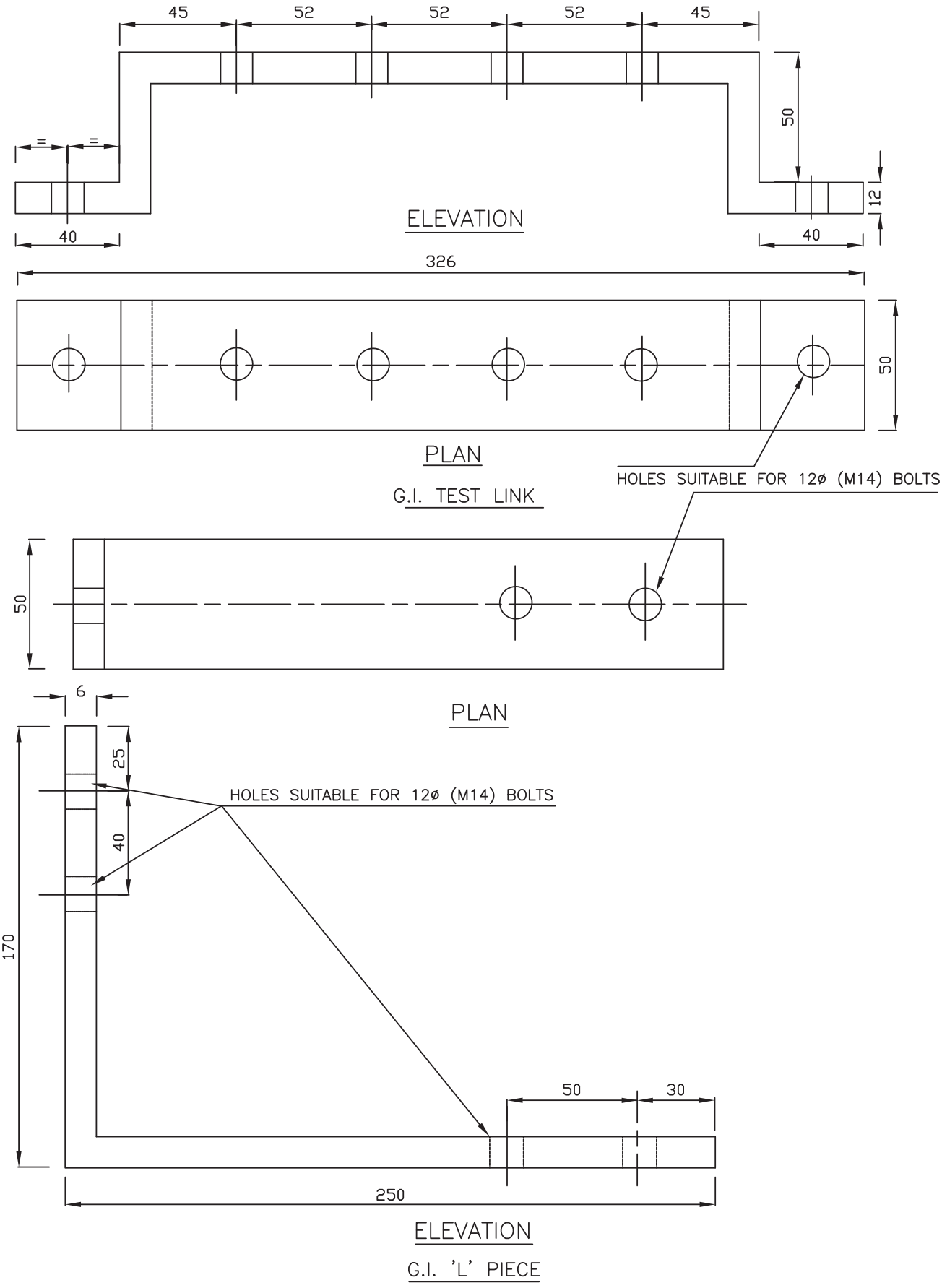


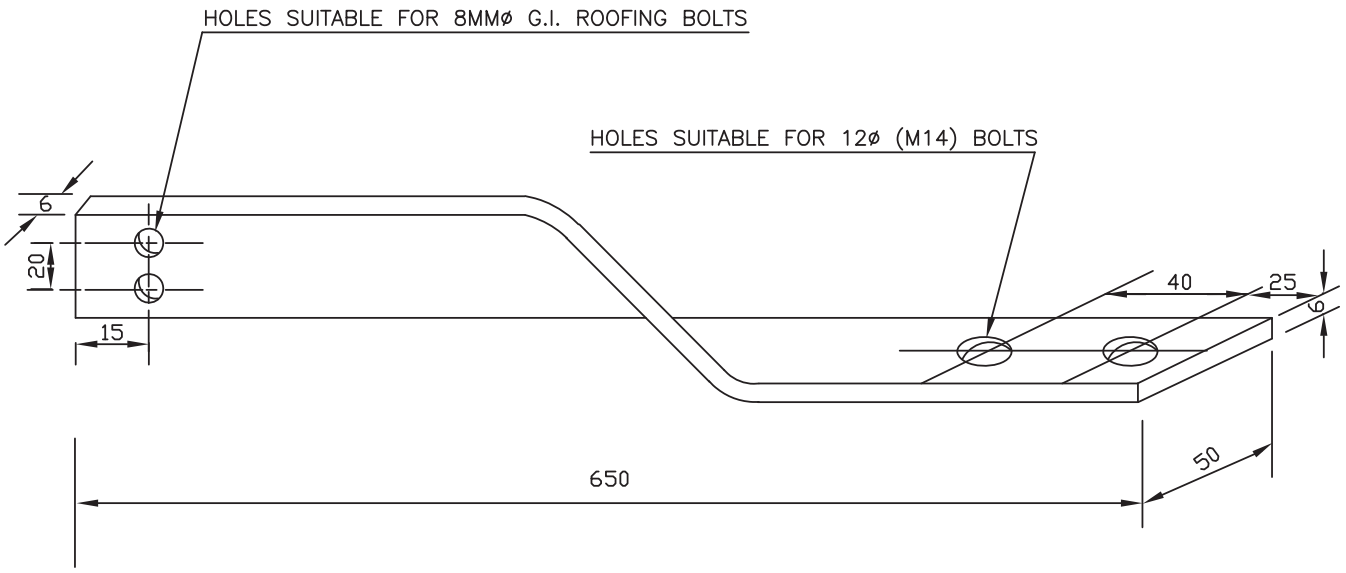
PLAN

NOTE:–

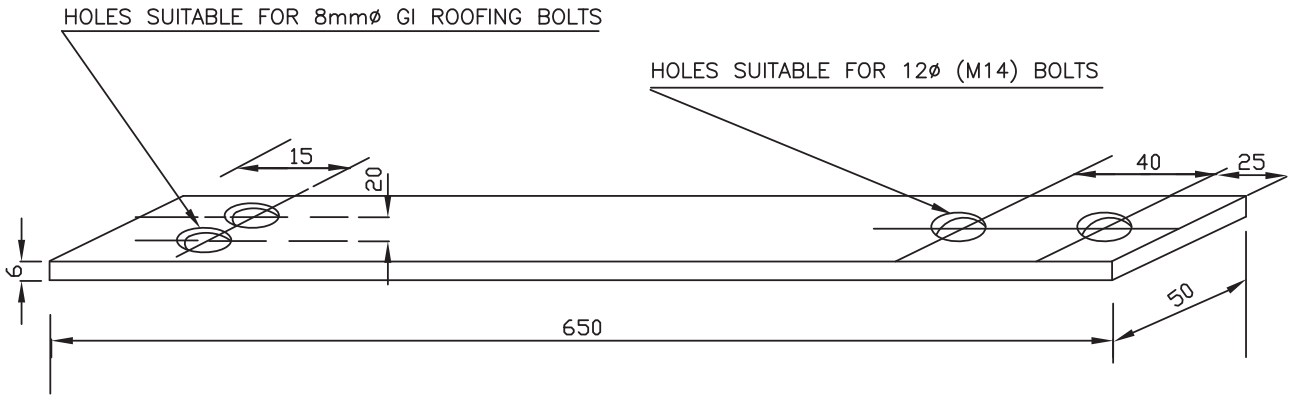
1. 12ø HOLES WILL BE PROVIDED AT 75mm INTERVAL ON TWO FACES THROUGHOUT THE LENGTH OF PIPE. THE FIRST ONE SHALL START 700mm BELOW THE WELDED FLAT.
2. ALL DIMENSIONS ARE IN mm.

पी डी आई एल PDIL	GI / AL ACCESSORIES FOR EARTH PIT	PDS: E 611	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 2	



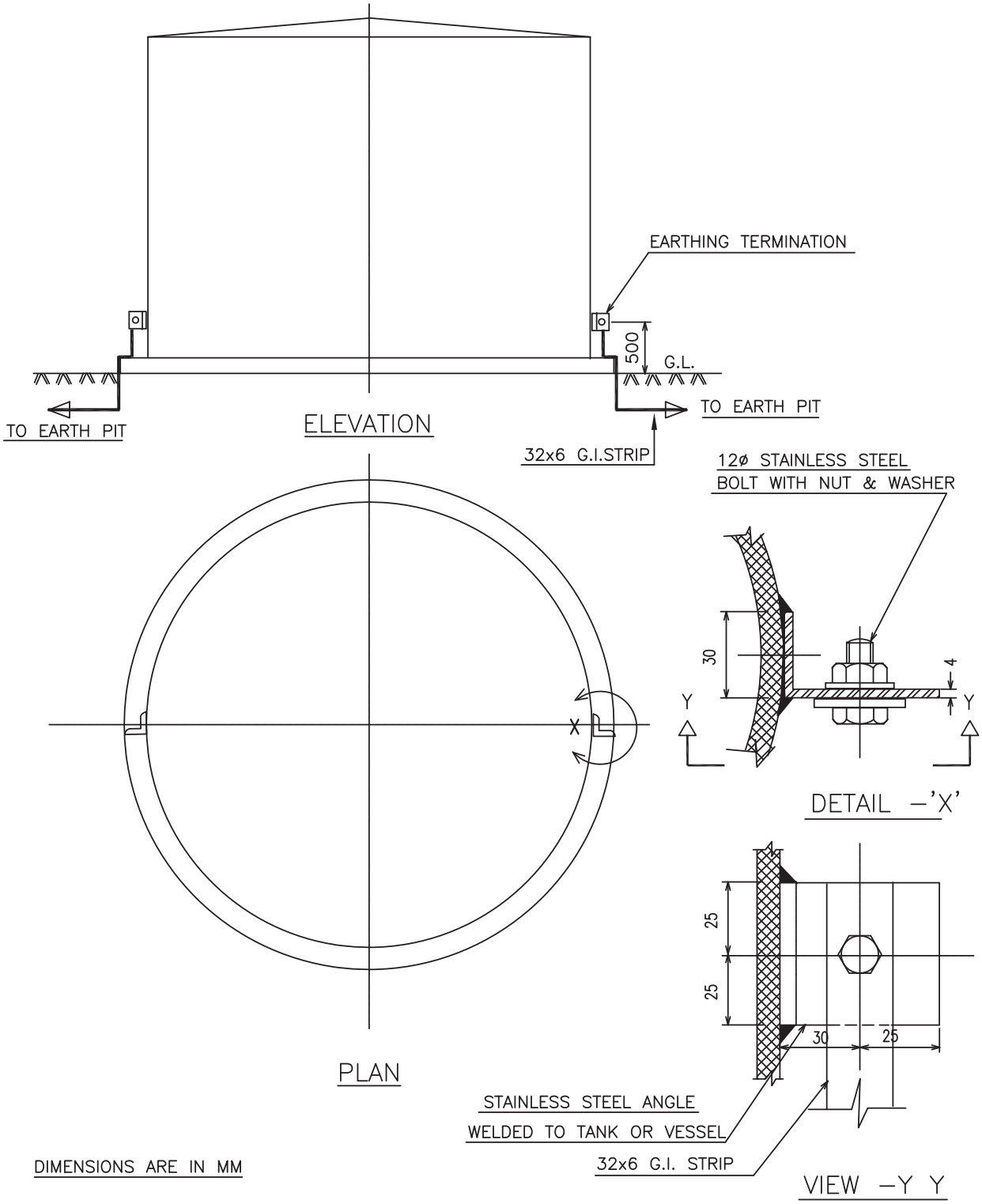


CONNECTING TWISTED ALUMINIUM FLAT PIECE



CONNECTING ALUMINIUM / G.I. FLAT PIECE

पी डी आई एल PDIL	EARTHING OF STORAGE TANK & VESSEL	PDS: E 613	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	

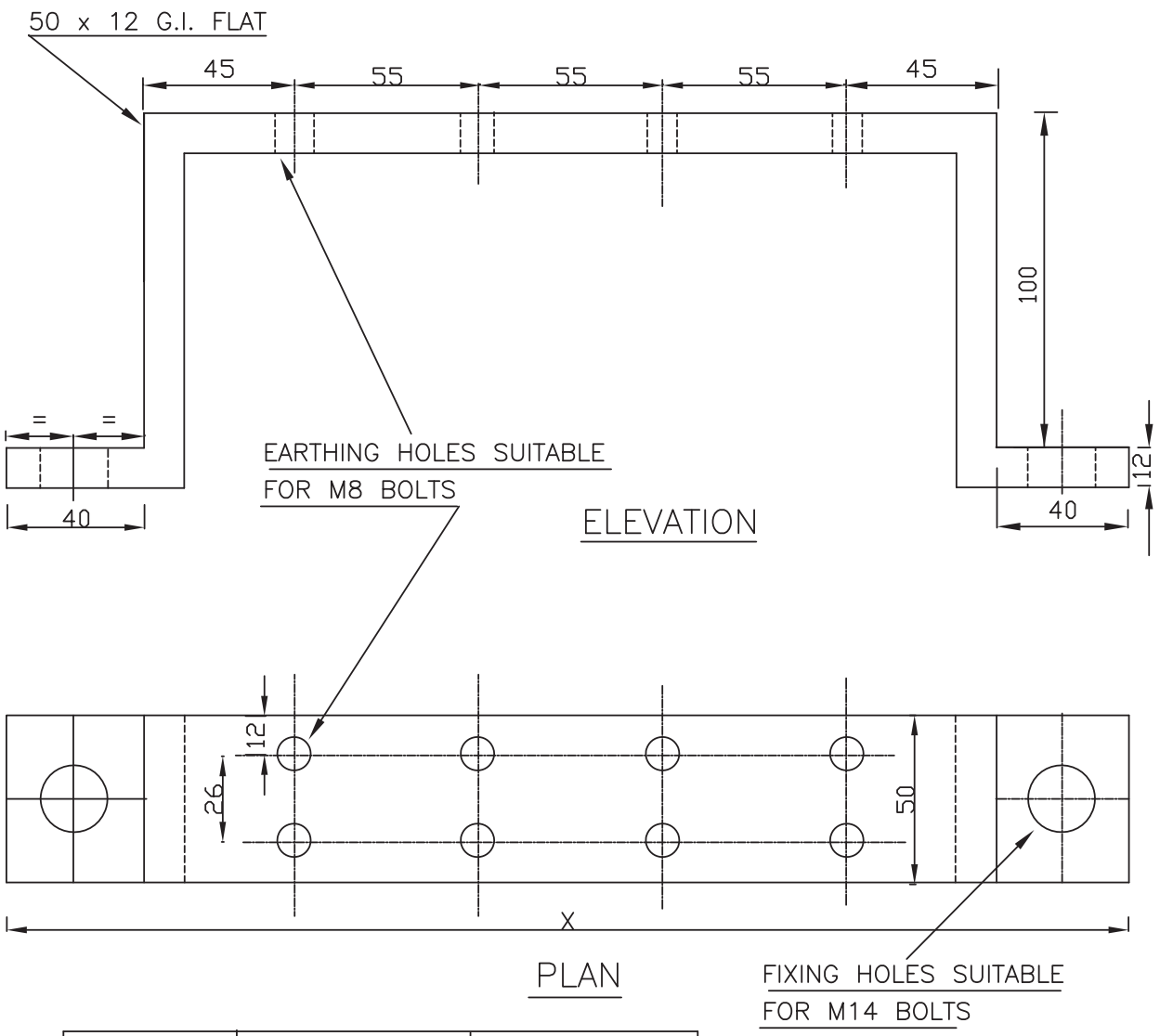


DIMENSIONS ARE IN MM

THE NO. OF EARTH CONDUCTOR SHALL BE AS FOLLOWS

EQUIPMENT WITH ANY DIMENSION	HAZARDOUS AREA	NON–HAZARDOUS AREA
≤ 3 Mts.	1	1
> 3 Mts. ≤ 30 Mts.	2	1
> 30 Mts.	3	2

पी डी आई एल PDIL	G.I. EARTH BUS	PDS: E 615	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	

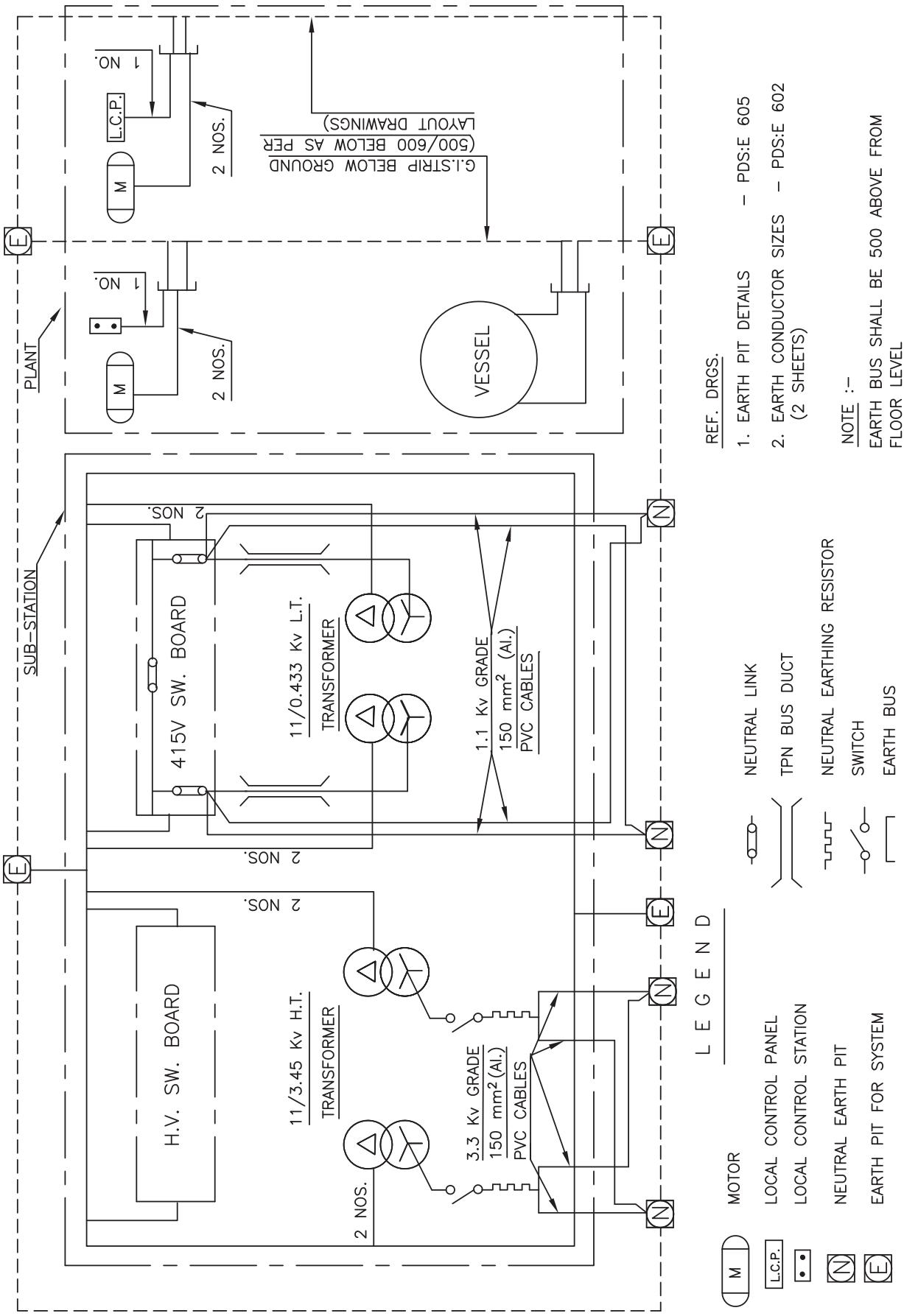


TYPE OF EARTH BUS	NO.OF EARTHING HOLES	OVERALL LENGTH x (mm)
1	8	335
2	10	390

NOTES:–

1. LOCATION OF EARTH BUS TO BE DECIDED AS PER EQUIPMENT POSITION AT SITE.
2. EARTH BUSES SHALL BE LOCATED ON STRUCTURES/COLUMNS WALLS/EQUIPMENT FOUNDATION ETC.
3. MOUNTING HEIGHT OF EARTH BUS SHALL NOT BE LESS THAN 500mm FROM FINISHED FLOOR LEVEL
4. ALL DIMENSIONS ARE IN mm

पी डी आई एल PDIL	TYPICAL ARRANGEMENT FOR NEUTRAL AND EQUIPMENT EARTHING	PDS: E 617	0
		DOCUMENT NO.	REV.
		SHEET 1 OF 1	



PART-II: TECHNICAL

SECTION – 11

DESIGN PHILOSOPHY - INSTRUMENTATION

PLANT: NEW AMMONIUM NITRATE MELT PLANT, AT RCF TROMBAY (INDIA)

0	14.01.2021	14.01.2021	Issued for Review(COMMENTS INCORPORATED)	KM	SKT	SKT
P	26.10.2020	26.10.2020	Issued for Review	KM	SKT	SKT
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Instrumentation And Controls
2.0	Scope
3.0	Control Philosophy (General)
4.0	Basis Of Design
5.0	Instrumentation Code And Practices
6.0	Hazardous Area Classification & Electrical Execution
7.0	Electrical Supply
8.0	Field Instruments
9.0	Primary Differential Producers
10.0	Other Flow Meters
11.0	Level Instruments
12.0	Level Gauge Glass
13.0	Pressure Instruments
14.0	Temperature Instruments
15.0	Control Valves
16.0	Pressure Relieving Devices
17.0	Switches And Solenoid Valves
18.0	Control And Shutdown System
19.0	Emergency Shutdown System (ESD)
20.0	Control Room
21.0	Package Unit Instruments
22.0	Noise Immunity Of Electronic Instruments
23.0	Specification For Contacts
24.0	Local Control Panels
25.0	Pneumatic Transmission
26.0	Installation
27.0	Fire And Gas Detection System
28.0	Factory Acceptance Test (FAT)
29.0	Site Acceptance Test (SAT)
30.0	CCTV
31.0	Telephone Exchange
32.0	Local Area Network (LAN) for CR
33.0	Instrument Workshop

LIST OF ATTACHMENTS

ANNEXURE NUMBER	DESCRIPTION	NUMBER OF SHEETS
1	Instrument Accuracies	
2	Instrument Process Connections	
3	System Configuration	
4	Indicative Sample format for PTR	

General Specifications

GSTD-0001 GENERAL SPECFICATION FOR ANALYSER SHELTER
GSTD-0002 REQUIREMENTS FOR ANALYSER SYSTEMS
GSTD-0003 GENERAL SPECIFICATION FOR STACK ANALYSER
GSTD-0004 GENERAL SPECIFICATIONS FOR ANALYSER SYSTEM
GSTD-0005 PROCESS STEAM ANALYSER
GSTD-0006 CALIBRATION GAS REQUIRMENT & UTILITY CONSUMPTION
GSTD-0007 GENERAL SPECIFICATIONS FOR MASS SPECTROMETER
GSTD-0020 GENERAL SPECIFICATION FOR MASS FLOW METER
GSTD-0100 GENERAL SPECIFICATION FOR INSTRUMENT TUBE FITTING
GSTD-0101 GENERAL SPECIFICATION FOR INSTRUMENT TUBING
GSTD-0102 GENERAL SPECIFICATION FOR INSTRUMENT VALVES AND MANIFOLD
GSTD-0103 GENERAL SPECIFICATION FOR JUNCTION BOXES AND CABLE GLAND
GSTD-0120 GENERAL SPECIFICATION MOTORISED ACTUATOR
GSTD-0122 GENERAL SPECFICATION FOR GAS DETECTORS
GSTD-0201 GENERAL SPECIFICATION FOR DCS & PLC SYSTEM
GSTD-0202 GENERAL SPECIFICATION FOR PLC SYSTEM
GSTD-0210 GENERAL SPECFICATION FOR MACHINE MONITORING SYSTEM
GSTD-0400 GENERAL SPECIFICATION SAFETY RELIEV VALVE
GSTD-0401 GENERAL SPECIFICATION RUPTURE DISC
GSTD-0900 SPECIFICATION FOR CCTV
GSTD-9998 INSPECTION AND TEST REQUIREMENTS

DRAWINGS:

DRG-0035 Thermowell
DRG-0036 Thermocouple RTD Assembly with Thermowell
DRG-0041 Orifice Plate
DRG-0101 Inst, JB Tray & Air Dist Support

1.0 INSTRUMENTATION AND CONTROLS

2.0 SCOPE

2.1 This section outlines the general requirements and specifications for Instrumentation and Control System for the project. The Instrumentation and Control System shall consist of but not limited to the following:

a) Electronic micro-processor based Distributed Control System located in Control Room for AN melt Plant. SAFETY SIL-3 PLC (TMR/QMR) based Emergency Shutdown System

b) Separate Control, shutdown, Vibration monitoring systems shall be considered for different units.

c) DCS/ESD/PLC shall be provided with latest version at the time of supply of the system. Further patch update on this version will be provided till warranty expires

d) All Field Instruments including control valves and safety valves.

e) Analyser Systems with Analyser shelter (SS). Minimum one Analyser Shelter for AN melt plant, depending on allowable transportation time and other factors. Mass-spectrometer if recommended by Licensor can be used with its proven track record in India. All Gas analysers including Gas Chromatograph shall be located in Analyser Shelter. Vortex cooling is not acceptable.

f) CCTV system at vulnerable strategic location of AN melt Plant (minimum 15 Nos. Camera to be considered). Bidder shall submit CCTV layout for the plants. No. of cameras shall be sufficient for surveillance of all the units of the plant. This shall be discussed during detail engineering with Owner/PMC.

g) Suitable Clean Agent System as per NFPA 2001 shall be provided for Control Rooms.

h) Gas Detectors

i) EPABX system including handsets.

j) LOCAL AREA NETWORK (LAN) for Main Control Room

Selected Instrument shall be latest & proven model with minimum one year proven track record (PTR) in hydrocarbon industries like Fertilizer, Refinery, Petrochemical and Gas Processing Plant under similar process conditions for at least 4000 hrs. from the bid opening date.

All equipments / instruments / system oriented items (with all its sub-systems) shall be of field proven quality both with respect to design and materials. Prototype instruments or instruments of an experimental nature shall not be offered or supplied. In general, all the supplied items by supplier shall have a well proven performance record of operating satisfactorily in an Fertilizer, hydrocarbon industry like Refinery, Petrochemical or Gas Processing Plant for at least 4000 hrs (as collaborated by user certificate). No instruments requiring special maintenance or operating facilities shall be offered or supplied as far as possible. PTR for field instruments shall be considered min for 4000 hours. And PTR for System oriented items like Bently Nevada, DCS, PLC, MMS, Mass Spectrometer, analyser shall be one year.

Fire and Gas Detection system (FGS system), EPABX exchange, PA system exchange, and LAN switch shall be housed in Control Room (CR).

Vendor to provide PTR for all the critical items like Control valves, Safety valves, Control System, Analysers, Gas detectors, CCTV, cables, custody transfer flowmeters, coriolis meter, transmitters, solid flow measurement devices. Vendor has to provide PTR for all the above critical items even if they have been listed in the attached Project vendor list. Vendor to provide PTR as per attached Annexure-5.

2.2 The Contractor's scope for all the above facilities shall cover design, engineering, procurement, installation, testing, calibration and commissioning etc. as detailed below:

a) Preparation of general specification for Instruments.

b) Sizing of flow instruments, control valves, pressure relief valves etc., and preparation of Technical data sheets for all Instruments.

c) Invitation of offers, technical and commercial evaluation of offers and placement of orders on final approval from the OWNER.

d) Preparation of engineering and construction documents like Functional schematics, I/O list for both DCS and ESD System, Logic diagrams for interlocks as per ISA 5.2 with functional descriptions, Configuration diagram, Control room layout, Electrical load list, Cable schedule, Cable tray/trench

layout, Instrument air requirement, Instrument air header, Air header piping, piping layout, Nameplate schedule, JB schedule, Instrument location layout, Electrical instrument signal interface, Instrument index, Layout drawings, Loop diagrams, Primary and secondary sketches and Bill of materials. Co-ordination with all instrumentation vendors and Package vendors for obtaining sufficient information in the form of documents, drawings for engineering and approval from OWNER.

e) Preparation of all engineering documents for DCS like Graphic schemes, Instrument loop data base, Log formats and any other documents necessary to carry out the system engineering of DCS and ESD. For all package PLC's, all interlock graphics shall be made available with first out feature in main Plant DCS. Co-ordination with DCS and ESD vendor for system engineering, implementation, software testing, supply and final commissioning and site acceptance tests. FAT and SAT is included in the scope.

f) Preparation of specification for erection materials like cables, cable trays, pipe & pipe fittings, air tubing, junction boxes, air distribution pots etc.

g) Site supervision of construction, erection, testing and commissioning activities of field instrumentation and control room instrumentation activities.

h) Preparation of instrument scope for all package items like, pumps etc.

In case of contradiction/conflict among documents, Bidder shall refer to Owner for clarification. However, most stringent specification shall be followed with Owner's approval. Owner decision shall be considered as final.

2.3 Operating Staff Training

Operating courses include all aspects involved in operating the Control System from operator interface. This shall include operation under normal and abnormal conditions as may result from minor or major system malfunctions such that the trainee can take the appropriate remedial actions. The training shall include but not be limited to the following:

- Overview of the system
- Control philosophy
- User interfaces
- Messages and alarms
- Operator commands
- Generation of reports

- Predictable events and expected operator action

2.4 **Engineering staff training**

Software Design courses shall be provided which would train the Employer's Maintenance and Design staff to be able to identify and remedy software faults, upgrade and implement data and software changes, generate/develop new software for the purpose of improving the system and production of revised or new displays. The training shall include but not be limited to the following:

- Overview of the system architecture, hardware and software
- Software design and organisation
- Database structure, generation and modification
- Generation and modification of the VDU screen
- Customisation of report/chart/graph format
- Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules.

3.0 CONTROL PHILOSOPHY (GENERAL)

3.1 Design and installation of instrumentation shall comply with codes and recommendations listed in item 5.0.

3.2 The Instrumentation shall be designed to provide stable and accurate plant control ensure safe plant operation and to facilitate plant maintenance, Control and Monitoring. The operating interface to the process shall be colour 22” LED (Minimum) display units with touch facility, presenting overview, group and point displays as well as process graphics with live data 2 monitors one above the other to facilitate larger view. The operator will manipulate all facilities through dedicated operator’s keyboard and using the touch panel. All operating consoles for DCS and ESD shall be located inside the control room but their I/O units, marshalling cabinets, power distribution cabinets and engineering station shall be housed in a adjacent room.

3.3 All elements of the Control function (DCS) and Interlock function (ESD) are to be completely separate and segregated. All Control functions are to be implemented in DCS and all logic and interlock functions are to be implemented in ESD.

The emergency shutdown system shall be implemented in a dedicated PLC and the regulatory control / monitoring in the controller sub-system of DCS.

Loops for indication/ control and interlock/shutdown shall be completely independent of each other including the field sensor / transmitter as well as control valve.

3.4 Symbols of DCS, ESD system shall be totally separate.

3.5 All Start function shall be local. Stop function shall be from local/DCS. Trip functions of Rotating equipments are to be from ESD. Interlock functions are not to be initiated from DCS. Interlock initiation shall be from ESD.

3.6 Each of the trip parameters shall have individual Process Override switch, which will be used as Process Override Switch (POS) as well Maintenance Override Switch (MOS). These shall be realized as soft touch target with confirmation dialogue box in the DCS graphic and from DCS via DCS-ESD software communication link. The status of the POS/MOS from the ESD, as read by ESD, may be communicated to Operator on DCS Operator station via DCS-ESD software communication link. Irrespective of process licensor's recommendation, these override switches shall be provided for all trip input parameters of ESD. This is applicable to each of the trip input parameter

Maintenance override switches (MOS) shall be hard wired. One hardkey with three independent switching elements for 2oo3 voting logic shall be provided in Auxiliary console for the Activation of the MOS. Individual sensor hardwiring is not required.

Process override switches (POS) shall be soft type.

3.7 All system/marshalling cabinets for DCS/PLC/MMS and their PCs shall be housed in Control Room only.

3.8 Appropriate furniture (Godrej Make) as per specifications for Control Room and other places shall be provided by the bidder.

3.9 A separate highly reliable TMR/QMR based Emergency ShutDown System (ESD) shall be specified, using PLC technology and incorporating 2 out of 3 voting systems to ensure freedom from spurious trips. Single point failure shall not be provided in the plant. ESD shall be SIL-3 certified as per standard IEC 61508. All sensors / software switches for 2 out of 3 voting system shall be triplicated for critical trips. If necessary, annunciator/mosaic panels for trip groups shall be provided for monitoring. All trips shall be manipulated via software switches with inputs field transmitters for trip purposes and utilities packages. This same philosophy is applicable for all package units also irrespective of any proprietary/dedicated/special systems provided by OEM or there package units .

All DCS and ESD/PLC/Package PLC must be supplied from same vendor/make to avoid any communication and interfacing issue.

3.10 New Control room has been envisaged for AN melt Plant in ground floor only. Redundant HVAC shall be provided for control room building. The Control Room building shall house DCS/ESD, UPS power and distribution room, HVAC room, Process, Instrument engineer/operator's room and Toilet as a minimum. Control & monitoring facilities of AN melt plant shall be provided by LSTK bidder.

All cable entries in Control Room, Marshalling cabinets, Analyser Shelter etc. shall be through MCT blocks/frames only. Material of MCT blocks/frames shall be SS316.

Bidder to indicate the control room, Analyser shelter sizes. The tentative placement of all cabinets, panels, consoles etc shall be made for ascertaining the size of the control rooms

3.11 Bentley Nevada 3500 series probes and proximeters, along with Transient Data Manger and System-1 monitor for all plants shall be used for vibration monitoring of Pumps and important machines, with LED displays inclusive orbital analysis, key phasor output etc. in the control room. Each machine shall have separate racks and each rack shall have dual power supply alongwith dual redundant serial communication with DCS. All radial and thrust bearings shall have RTD, temperature monitors of Bentley Nevada make with 2oo2/2oo3 trip facility. All monitors shall be located in CR. All vibration, axial displacement and speed signals are connected with DCS through 4-20 mA loop also. All radial and thrust bearings temperature monitoring signals (RTD) shall be connected to DCS with temperature transmitters only. Wherever RTD is being used for tripping, the same shall be connected to VMS and trip initiated from VMS.

3.12 There shall be System-1 monitor enterprise license with minimum 2 user/client license.

3.13 The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.

3.14 DCS-PLC communication is to be used only for transferring Status and Alarm signals from PLC to DCS.

No tripping parameters shall be interfaced through serial communication and soft links.

Transfer of data through serial link from DCS to PLC and vice versa shall be used only for monitoring purpose and not for control & trip except POS and MOS.

3.15 Fire and Gas (FGS) PLC: TMR/QMR SIL-3 PLC for FGS of the same type as the ESD system as per ITB. This shall include smoke (ISD type) detectors and all points of ISD/UV/ Manual call points shall be fully addressable. VESDA not required. Fire and Gas system shall be independent stand alone system.

3.16 MMS/VMS: Two X-Y probes at each radial bearing and three axial displacement probes at each thrust bearing (TMR implementation in the module for tripping/shutdown) along with System-1 software and hardware shall be required along with RTD, temperature element at Radial and thrust bearing with temperature monitors with tripping facility.

3.17 HVAC in CR: Two separate DUCTS for console room and Cabinet Room should be there with flow regulators to maintain different temperatures. 1 ladies + 1 gents toilet in CR.

3.18 BPS for 24V DC shall be provided for each process controllers separately as per segregation philosophy having redundant bus bar.

3.19 DIs/DOs from MCC to DCS/ESD shall be with relays only also IRC's Separate for DI's & DO's and IFC's Separate for AI's / AO's. IRC/IRP shall be located in Control room.

3.20 Alarm and Annunciation System:

Annunciation system is used to indicate and sound alarm for any process abnormality, trip/status change of Electric drive. Annunciation system shall be of modular design & programmable type. Electrical circuit is designed to read the change of state of discrete signal and generate the output to illuminate the window and give the alarm. The alarm can be silenced by acknowledge switch. Window light can be reset automatically or manually as desired, when the state of signal returns to the prior alarm state. Annunciation system can be configured for any of sequences of ISA standard. There shall be a provision in circuit design to change the state of signal required to generate alarm (from Open to Close or vice versa) simply by changing the jumper position on circuit board. LED Lamps shall be used.

Hooter in general, shall be solid state type with audibility of the order of 100 dB at the distance of 3 meters. An interruption of power supply up to 20 msec shall not affect the functioning of unit.

A hard-wired mosaic/annunciator panel that clearly displays status of trip alarms, bypasses, trip-groups, etc. with a first-up alarm shall be incorporated near the DCS operator work stations. The operator shall also be informed of trip conditions by

means of a warning sound that differs from the audible signal from the DCS alarm system. However operation of override switch to be included in operator action log.

3.21 All Printers shall be Laser type

3.22 There shall be panel segregation for various I/Os meant for DCS and ESD system.

3.23 All Monitors supplied in this project shall be minimum 22" COLOR, LED type with Touch Facility.

3.24 All Servers in the complete Plant shall have Raid-5 architecture as a minimum.

3.25 IAMS (Asset management) System shall be considered and provided by contractor for all (SMART) for all analog signals to DCS and PLC as per standard specification. All signals to DCS and PLC shall be SMART type with HART protocol. The I/O cards for DCS shall be HART protocol compatible. Wherever HART pass through cards are considered AMS shall be intrigued. However if cards are not considered separate. HART MUX shall be provided

3.26 The minimum instrument accuracy shall be as defined in Annexure-1.

3.27 The MMS vendor/LSTK shall submit clause wise compliance of API 670 latest edition.

3.28 All field Instruments and control system throughout the complete plant to be designed so as to maintain fewer inventories and have interchangeability at any time. Bidder to submit detailed chart for spare parts interchangeability for instruments/control system.

3.29 Alarms from FGS system shall also be available on DCS Operator Consoles.

3.30 **Interfacing with DCS and Other systems at CR**

All DCS, Control Systems, ESD/PLC system like, , All Analyser PLC, Any Analyser system like Mass Spectrometer, CCTV, Fire and Gas System PLC, Any Package PLC etc. shall be connected to Main DCS and Other systems at CR with suitable redundant interface using Optical Fibre Cables. If OPC and Firewall is required for any of the interface the same shall be provided by the LSTK Bidder.

Suitable graphics pages shall be built in main DCS for viewing these data.

Suitable hardware and software required for interface of these shall be provided by the LSTK bidder.

4.0 BASIS OF DESIGN

General

Instrumentation for the proposed AN melt Plant is to provide a highly reliable and comprehensive control and monitoring system. To facilitate these well proven techniques shall be adopted for measurement and control.

In the event of any conflict between this specification, related standards and codes, any other attachment to this package or process packages supplied by process licensors, the contractor shall follow the following documents in the order of their priority:

Design Philosophy Section 11

General Standard specification attached

Licensor's recommendation

Statutory requirements and codes & standards

This document is prepared to cover the requirement that is not identified elsewhere. Hence this document shall be considered in addition to other documents and shall be read in conjunction.

In case of contradiction among documents, LSTK Contractor shall refer to PMC for clarification. However most stringent specification shall be followed with PMC/Owner's approval. Owner/PMC's decision shall be considered as final.

The following philosophy is to be adopted:

1. The input transmitters and the Final control elements being used for Control functions (DCS) and Interlock functions (ESD) are to be completely separate.

2. Same valve cannot be used for both Control and ON-OFF actions. Separate Control valve and ON-OFF valve to be provided with the Control valve wired to DCS and the ON-OFF valve wired to ESD.

3. All control valves shall be provided with SMART valve positioner with valve position signal feedback connected to DCS system by 4 to 20 mA analog signal. It shall be HART compatible.

4. Universal HART Protocol with Latest Revision shall be used in all cases.

5. Wago/Weidmuller/Phoniex/Klippon make Panel Access. (Relay, Switch, Lamp, Push Button), screwless terminals shall be used with single tier only.

6. P&F/MTL/Stahl Barrier make Isolator, Trip Amplifier shall be used for the entire Plant.

7. Swagelok/Parker/Hoke make compression fittings shall be used for the entire Plant.

8. Fibre Optic cables shall be armoured, multicore type. All Fibre Optic cables must be laid through HDPE conduit. Make of these OFC cables shall be Belden/Leoni.

9. Card mounted Relays are acceptable.

10. For all gas services flow meters, either being used as custody transfers, Guarantee flow measurement purposes or for mass balance purpose, shall be 5–path including one diagnostic path, non-insertion probe type Ultrasonic flow meters based on Time-to-Flight measuring principle, having total RMS accuracy of +/- 0.1 % of reading, wet calibration Ultrasonic Flow meter shall be also used for very high turn down and where pressure drop is not allowed.

11. For Cooling Water, Ultrasonic Flowmeter (Clamp-On) dual path type to be used. Accuracy 0.5% of reading or better to be used. Make Flexim/GE/E&H/Krohne/Siemens shall be considered For all steam and BFW service bidder to ensure submission of IBR Form IIIC certificate in original.

12. All limit switches shall be proximity sensor type.

13. Bidder shall provide minimum 8+8x6 MCT frame of SS316 material alongwith multi-dia blocks with peeling of arrangement and centre plug, with wedge, lubricant, stay plate. Bidder shall provide at least 20% installed spares with multi-dia blocks with peeling of arrangement and centre plug.

14. Each Main cable rack shall have 20% spare space for future use.

15. No head mounted temperature transmitters are to be used.

16. UPS shall have minimum 60 minutes backup.

17. General Earthing & Instrument Earthing shall be provided separately.

18. Turbine flowmeter shall not be used.

19. All Contacts shall be Gold Plated to SPDT wherever possible.

20. No Process Switches (Pressure/Level/ Flow/Temp.) shall be used in the plant including package units.

21. Execution type for all field transmitters in hazardous/safe area shall be intrinsic safe. Flame/ex. proof enclosures shall be provided where intrinsic certifications are not available.

22. All field transmitters for pressure, d/p, level, temperature and flow shall be microprocessor based (dual compartment) metallic partition Type, SMART transmitters with “UNIVERSAL HART” protocol with latest revision. The transmitter selection shall be such that the operating maximum upper limit shall be around 70% of the total measurement range of the transmitter.

23. All catalyst vessels’ dP measurement shall be with ERS (electronic remote seal).

24. All equipment/materials supply shall include spares required for Commissioning and Mandatory/Insurance spares (as per List enclosed elsewhere in the tender).

25. Bidder’s to recommend 2 years Operational Spares and submit Itemised List with validity of 2 Years.

26. Redundant Bulk Power supply with diode ‘O-ring’ arrangements shall be provided for field instruments. Individual power supply Loading 50% only.

27. Irrespective of licensor recommendation and Area classification, SIL Study (SIL assessment study, validation/verification) has to be done for all plants and recommendations to be implemented. HAZOP Study recommendation to be implemented in PID.

28. Local / Remote Selection Switch

    a. For start/stop of all electrical equipments, local/remote selector switch shall be located in MCC.

    b. Local stop push button on LCS (local control station) shall be always effective.

c. In remote mode motor can be stopped from DCS

d. In LOCAL mode, both START and STOP shall be possible only from LOCAL. In REMOTE mode, stopping is possible from DCS

e. Auto/manual selection shall be in DCS/local.

29. Local indicators, start/stop switches, emergency stop switches shall also be provided near package units/rotating machines where local start up of the equipment is advisable.

30. For all motors current indication shall be provided in DCS for rating more than 2 KW.

31. All trip solenoids shall be dual redundant, and configured and hooked up properly in such a way that failure of one solenoid doesn't initiate a false trip. Trip solenoids shall be normally in energised condition and shall be de-energised to initiate trip.

32. Air fail to open, Close or Hold of any control valve shall be as per Licensors document, to take care of process, plant and human safety. For Piston actuators necessary air volume chambers and lock up relay shall be provided to achieve the fail safe condition.

33. Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shut downs and vice versa for low. A passive alarms shall warn about the burn-out.

34. Minimum 2 Nos of hand held communicator or HHT shall be provided. This shall be loaded with latest HART software. Each HHT shall be provided with minimum of 1 GB removable, plug in type memory bank, which can store a minimum of 1000 transmitters configuration data.

35. Control room Floor level shall be 1.5 meter from the Finished floor Level.

36. All Analysers, GCs, Mass-Spectrometer shall be EEx'ia'. If Intrinsic safe could not be provided the same shall be Ex-proof irrespective of area of installation.

37. Internals of All Control Globe / Ball / Butterfly valves, On-off valves, MOV Ball, MOV gate, MOV butterfly valves, MOV Check Valves, Pressure relief valves, Thermal relief valves shall be minimum SS316 or service specific subject to OWNER approval.

38. All control valves / On–Off Valves / MOVs shall be flanged type.

39. Control valve/On-Off valve, pneumatic valve shall be designed for minimum 4 Kg/cm2 air pressure.

40. Full body Steam Jacketing for all inline instruments shall be provided wherever instrument is in line with steam traced /steam jacketed pipe.

41. All Safety Valves / Thermal relief valves shall be flanged type only.

42. All Thermocouples shall be duplex type.

43. Thermowell flange rating shall be 1 1/2” 300# SS316 minimum.

44. Temperature transmitter shall be used for both open loops & Closed loops.

45. Guided wave radar type instruments (SMART) shall normally be used for level measurement up to 1219 mm. Differential pressure transmitter (Capillary type) shall be used for level measurement above 1219 mm and for services requiring purge or where liquid might boil in external portion. Capillary type DPTs shall not be used in vacuum services. Internal displacer type of level transmitters shall be not be used. Remote Seal PT/DPT shall be with min 5 mtrs Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball (MOC SS316) type Isolation Valve. For Vessel/Equipment requiring more than 5 m capillary electronic remote seal shall be provided.

46. Air distribution pots shall be of Stainless Steel (Min SS304). Inst. Impulse pipes for process parameters shall be in accordance with piping specifications

47. Hot dip galvanised Perforated aluminium Cable trays to be used in whole plant Main instrument air header and Branch header material : Minimum SS304

48. Main instrument air header shall be at least 2” (SS304) minimum depending on requirement. It shall have 1” minimum takeoff (SS304) with Gate type isolation valve (SS) & further distribution for each instrument through separate ½” SS line with ½” SS Ball valve single piece design with SS handle (Bidder to provide sizes of tubing and tube fittings in inches)OD SS316 tubing.

49. Inst. Air isolation valve for each instrument.: SS304 minimum

50. All the instruments shall be as follows: (for DCS/ESD i.e. complete plant including all package units):-

- All Smart Positioners SIL 2
- All Partial Stroke Testing (PST) shall be implemented by SIL3 mechanism.
- All Transmitters - SIL2
- All Solenoids – SIL 3
- All Gas Detectors – SIL2
- All Relay – SIL 3
- All Barriers – SIL 3

All the instruments in the SIL loop shall be SIL certified as per the SIL study if the SIL study indicates higher SIL rating than the above mentioned table then instrument shall be SIL certified as per higher rating.

51. HART Compatible gas-detectors shall be provided.

52. All line mounted instruments like in-line SOVs, Magnetic flow meter, Rotameter, Mass flow meters control valves ,MOV's ,vortex flowmeters ,ultrasonic flowmeters etc shall be provided with block & bypass arrangement. Bypass for on/off valves shall be subject to OWNER discretion.

53. Separate Tapping shall be used for each instrument coming for trip, control & monitoring, local display.

54. Separate Sample handing system shall be used for each analyzer. Multi Channel with stream selector can be used, provided the total system including sample handling system shall be imported. Necessary sequence shall be inbuilt in the analyzer for draining the condensate.

55. Double acting actuators shall not be provided anywhere.

56. FRP Canopies, 2" Pipe mountable , are required for Transmitter, JBs, LCPs, Control Valve positioner, Temp Elements, Proximity switch, remote mounted electronics, Mass flowmeter, Ultrasonic flowmeter, Solenoid Valves etc.Canopy accessories shall be SS 316

57. Temperature, Pressure & Flow instruments provided in buried vessel shall be located above ground level. IP 67 shall be provided if instruments are under water.

58. System / Marshalling/ CCTV cabinet size shall be 2100 (H) X 1200 / 800 (W) X 800 (D). All Cabinets shall be Rittal make only.

59. All field transmitters shall be dual Compartment with metallic partition Type.

60. Conventional SMART type Transmitter shall be provided for all closed loops & critical open loops.

61. For Monitoring & Control, separate nozzles/takeoff shall be taken for all loops. No More than 3 set of taps are allowed.

62. In case of PLC, all I/Os through interposing relays.

63. SMART positioner shall be considered for all Control Valves and the same shall be connected to HART Maintenance system. For high temperature services (Above 200 Deg C) remote feedback shall be used for the smart positioner.

64. Valve signature software shall be provided for all Control Valves.

65. For all Local panels rain cover to be provided.

66. For Analysers separate feeders to be directly taken from UPS. No sub-branching allowed at any place.

67. No Switches to be used. If in pump seal plan, if level is not available, GWR to be used,

68. In general separate junction boxes shall be used for the following:

a) 4-20 mA DC signals (IS) for input signal and output signal separately
b) 4-20 mA DC signals (non-IS) for input signal and output signal separately
c) Thermocouples
d) RTDs
e) Contact signals (Field switches, push buttons etc.)
f) Interlock and shutdown signals (Solenoid valves)
g) Power supply to various instruments.
h) Gas Detectors
i) Vibration signals
k) Telephone System
l) PA System

69. Separate junction boxes shall be used for signals connected to ESD/PLC and to DCS. No signal shall be shared between them in the field junction boxes.

70. Only metal tube Rotameter with transmitter shall be considered. Glass tube Rotameter shall not be used for process applications. Whereas for instrument sample flow of analysers, Glass tube Rotameters are permitted for sizes ½" & ¼" only.

71. DCS / PLC SYSTEM configuration description is attached.

72. All Instrument Hookups shall be approved by owner/PMC. Prefab Hook-up shall be used (details will be provided detail engineering).

73. All Transmitters shall have backlit type LCD Display.

74. Partial stoke testing shall be provided for all ESD/PLC valves. For ESD valves, Proximity type limit switches shall be provided for open & close status in addition to Smart positioners.

    Partial Stroke testing shall be provided for ON/OFF valves using Smart Positioners for fail close valves. DCS AO (open loop) shall be used for realizing this partial stroke testing.

75. All Components in 2oo3 Trip Loop in ESD shutdown loop (Final control element, logic solver, primary element) shall be SIL-3 compliant.

76. Mid value selector philosophy derived from 2oo3 transmitters to be employed for critical closed loops.

5.0 INSTRUMENTATION CODE AND PRACTICES

IEC 13	Diagrams, Charts and Tables, Preparation of Logic Diagrams
IEC 534	Industrial - Process Control Valves
IEC 584	Thermocouples
IEC 605	Equipment Reliability Testing elements
IEC 611-12	Part 12 Graphical Symbols for Diagrams. Binary Logic
IEC 654	Measurement and Control equipment
IEC 751	Industrial Platinum Resistance Thermometer Sensor
IEC 801	Electromagnetic Compatibility for Industrial Process measurement and Control Eqpt.
IEC 848	Preparation of Function Charts for Control Systems

IEC 902	Industrial Measurement and Control Terms and Definitions
ISA S-5 .1	Instrumentation Symbols and Identification
ISA S-5.2	Binary Logic Diagrams for Process Operation
ISA S-5 3	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Symbols
ISA-S20	Instrumentation specification formats
ANSI/ISA S 5.1	Process Instrumentation Terminology
ANSI/ ISA S71.04	Environmental conditions
ANSI/ ISA S75.01	Control Valve Equations
ANSI/ ISA S75.02	Control Valve Procedure Capacity Test
ANSI/ ISA S75.03	Face-to-Face Dimensions for Flanged Globe Style Control Valve Bodies
ANSI/	Quality Control Standard for Control Valve Seat
FCI 70.02	Leakage
API 598	Leakage class for On/Off Valves
BS 6020	Instruments for the Detection of Combustible Gases
DIN 3582	Screwed Plugs, Tapped Holes, with Whitworth Part-2 Pipe Threads: General Outlay of Types
DIN 43760	Measurement Standard for RTD.
DIN 19243	Measurement and Control Electrical Sensors, Electrical Position Sensors and Signal Converters used for Intrinsically safe two-wire DC System.
EN-50-014/020	Electrical Apparatus for Potentially Explosive Atmospheres
EN 54 Part I	Components of Automatic Fire Detection System Introduction.
EN 54 Part 5	Heat sensitive Detectors-Point Detectors containing a Static Element.
ISO 3511.1	Process Measurement Control Functions and Instrumentation Representation Part I: Basic requirements.
ISO 3511.2	Process Measurement Control Functions and Instrumentation Representation Part 2: Extension of Basic Requirements.
ISO 3511.4	Process Measurement Control Functions and Instrumentation Representation Part 4: BasicSymbol for Process Computer, Interface and shared Display/Control Systems.

ISO 4200	Plain End Steel Tubes, Welded and Seamless - General Table of Dimensions and Masses per Unit Length.
ISO 5167	Measurement of Fluid by Means of Orifice Plates, Nozzles and Venturi Tubes Inserted in Circular cross-section Conduits Running Full.
API RP 520	Sizing, selection and Installation of Pressure relieving devices
API RP 521	Guide for Pressure Relieving and Depressuring System
API RP 2000	Venting Atmospheric and low pressure storage tanks
API- Chapter 5.4	Accessory equipment for liquid meters Manual of
Chapter 6.2	Loading rack and tank truck metering system
Chapter 6.6:	Pipeline Metering Systems Measurement
Chapter 12:	Calculation of Standards Petroleum Quantities
2.1 & 12.2	Part 1 and 2
API-RP-550	Manual on Installation of refinery Instruments Part I and Control System
ANSI - B 16.104	Control Valve seat leakage
ISA-S 75.01	Control Valve sizing
ISA S 18.1	Specifications and guides for the use of general Annunciators.
IEC 529	Environmental Protection of equipment
ANSI B 2.1	Pipe threads
ANSI B 16.5	Steel pipe flanges, flanged valves and fittings
IEC 79.11/	Intrinsic safety code and practice
IEC-79.14	International Boiler Regulation
IS 2148	Flameproof enclosure of electrical apparatus
NACE MR0175 (95)	Standard Material Requirements - Sulfide Stress Cracking-resistant Metallic Materials for Oil field Equipment.
NFPA	National Fire Protection Association
NFPA-496	Purged and pressurized enclosures for electrical equipment.

NFPA 852007 Ed. Firing system

NFPA 70-1984 Art 500 Vol.6 Classification of hazardous area.

OSHA Occupational Safety and Health Authority.

6.0 HAZARDOUUS AREA CLASSIFICATION & ELECTRICAL EXECUTION

6.1 Irrespective of area classification, the execution of instrumentation shall be minimum as per area Zone 1, group IIC, T4, EExia and Protection:

Electrical / Electronic instruments	IP 67
Sensors; RTD, T/C, etc.	IP 65
Local Gauges; PG, etc.	IP 65
Pneumatic instruments	IP 54
Solenoid valves	IP 67
Local Panel / Skid Mounted Panels	IP 55

EMC compatibility and electrical safety as per latest IEC standard.

6.2 Electrical instrument equipment shall be designed for and supplied as intrinsic safe certified. Analysers, solenoid valves and other equipment that cannot be classified intrinsic safe shall be ex-proof in accordance with the above mentioned electrical specification.

Certification for installation in hazardous areas in accordance with IEC 60079 series is shown below:

Transmitters, positioners, I/P converters, etc.:	EEx ia IIC T4
Switches:	EEx de IIC T4
Analysers and Panels:	EEx ia IIC T4 for analyser Exp for panels
Solenoid Valves:	EEx ia IIC T4 (Ex md not allowed)
Cable Glands:	EEd IIC T4
Junction Boxes:	EExe IIC T4

7.0 ELECTRICAL SUPPLY

The electrical supply will be as follows:

Distributed Control System, trip system, and Control Room Instruments	: 115V AC
Solenoid Valves	: 115V AC/ 24V D.C
Local Panels	: 115V AC/24 V D.C
Local Illumination, equipment for air conditioning, space heaters, ventilation of	

Local panels and similar purposes	: 240V AC
Field-mounted Transmitters and switches	: 24V D.C. intrinsic safe
Safety Circuits	: 115 V AC

The 115V AC supply will be an uninterrupted power supply (UPS) of 115V +/- 10%, 50Hz +/- 3%.

Where 24V DC is needed, it will be generated by local rectifier units, which are part of the instrumentation supply. The power supply to these units shall be taken from the UPS.

Where 24V DC are used for Safety Circuits, the rectifier units shall be duplicated and with high reliability and form a part of ESD vendor. Redundant 24V D.C. power supply shall be powered from two different sources of UPS with Diode O R ring.

A separate instrument earthing system apart from the power supply protective earthing system is foreseen.

There shall be minimum 4 separate earth pits for System, Panel /power and Intrinsic safe signals with different cable colour codes. All earth shall be less than 2 Ohm or OEM specific, if better. The size of Earthing Cable shall be 50 sq.mm minimum and should be routed in proper HDPE conduit, outside the control room building. All above instrument earth pits shall be separate from Electrical earth pits and must have separate colour identification from electrical earths.

Two separate AC distribution board (Dual ACDB) fed from parallel redundant UPS are essential for Instrumentation power distribution system for the improved reliability. Each DCS/ESD ACDB shall be fed from redundant UPS feeders & shall have with static switch for change over automatically without power interruption in case of any incomer failure.

UPS supplies shall not be used for utilities supplies cooling fans, panel/cabinet lighting etc. A separate non-UPS supply shall be used for the same.

A summary of all critical UPS alarms shall necessarily provided in DCS and hardwired annunciation in control room or any manned location.

Only copper cables & tin-plated copper lugs shall be considered for instrumentation power distribution system.

Protection coordination with respect to fuse/MCB ratings from the supply source ACDB/DCDB to downstream distribution panels shall be thoroughly studied by the system designers/OEM and documented as a part of the system documentation and be implemented accordingly.

8.0 FIELD INSTRUMENTS

8.1 Analyser

The Analysers used for analysing the components in the process stream in the Plant will mainly be:

Infrared analysers : CH4, NH3, CO, CO2, NOx non destructive dispersive type

Thermal conductivity : H2

Zirconium Oxide+ Catalytic : O2+Combustibles in flue gas

Chemiluminiscence /NDIR : Nox in flue gas

UV pulse flourescent/NDIR/NDUV: SO2 in flue gas

Paramagnetic/ Zirconium oxide: O2 in air

UV Fluorescense : Sulphur analyser

All gas Analysers shall be intrinsically safe type suitable for execution class specified for the area. All gas analysers shall be housed in pressurised shelter(s) conforming to Namur recommendations. Purge type mass spectrometer for all flammable gases shall be specifically certified for execution class of hazardous area besides the purge unit. Purging medium shall be nitrogen. LEL gas detectors shall be provided to detect leakage of gases in the purge line in each shelter. The shelters shall be pressurised through cooled air in summer and steam coil shall be provided in the duct to have warm air during winter through HVAC unit. All electrical apparatus related to the analyser shelter shall be flame proof conforming to the area classification. The gas sample conditioning unit shall be installed outside the shelter.

All liquid analysers shall be of intrinsic safe design suitable for execution class specified for the area. Liquid Analyser, sampling conditioning unit and other accessories shall be mounted on a rack suitable for field mounting. pH, conductivity shall be installed preferably in a bypass line to facilitate maintenance of the analyser.

All liquid Analysers shall be smart with HART protocol and shall be configurable with HART hand held configurator.

Sox and Nox analyser cabinets shall be located just below the stack. If the area is unsafe purging with nitrogen /air shall be provided and shall conform to the hazardous area classifications. This is applicable in case of fired heater type start-up heater.

All Analysers shall be micro-processor based in general and shall be capable of providing detail diagnostic alarms, messages to help maintenance personnel. Analysers shall have manual/auto calibration facility.

Self diagnostic routines and calibration functions shall be provided as standard. The Bidder shall supply details of self diagnostic routines and calibration functions including calibration intervals. Auto calibration facility is required for Analyser. Calibration gas cylinder supplied during FAT. The Analysers shall use tried and field tested analysis technology.

Analysers shall generally be single stream. Multi stream Analyser applications shall be supplied where process requirements specify.

The Analyser range shall be as detailed on the relevant data sheet, the operating point will normally be at the midpoint of the span. The Analyser range shall be changeable without having alteration in the field hardware.

For each Analyser the Bidder shall specify the time required for the sample analysis. In general, the Analyser accuracy shall be ±1% of the reading over the expected temperature range and sensitivity shall be ±0.5% of the reading unless otherwise specified in data sheet.

Additionally, Analysers should have provision of Ethernet (preferred) or Modbus RS485, 2 way communication ports If a particular Analyser is not having Ethernet/Modbus communication facility then shall have dual analog output (4-20 mA) for each component being measured. All parameters of the Analyser shall be available through the serial port.

Each Analyser shall have local configuration and indication facilities. Local panel display shall be provided where the individual indication is not available on the Analyser. The configuration facilities shall be accessible without removing Analyser covers etc.

Each Analyser shall have as a minimum following alarm outputs wherever possible:

- Sample flow low
- Carrier Gas flow low
- Loss of purge or purge failure
- Analyser Fault

This shall be in the form of volt free contacts, gold plated, rated as a minimum 24 V DC 500mA and suitable for IS use.

Bidder shall ensure that if an unsafe condition occurs e.g. loss of carrier gas, the Analyser shall, if required, “trip” to a safe state and an appropriate alarm be initiated.

Bidder shall detail all equipment that cannot be field mounted. The detail shall include full drawings giving as a minimum, size, weight, mounting details, termination details, power supplies required and allowable environmental conditions.

In general, the sample analysis cycle time shall be limited to three(3) minutes for control applications and five(5) minutes for monitoring applications.

All consumables including buffers, calibration gases, reagents, (as per their stability and validity) filters, probes, tapes, desiccants etc. shall be supplied for 2 year period.

For all IR / NDIR/ UV based analysers, Calibration Cuvettes shall be used in place of calibration gas cylinders.

All Analysers including stack analysers, SOx and NOx shall be placed in the analyser shelter only.

ADSU shall be provided, and it shall be as per GSTD-0003. It shall have latest Console PCs with 22”–COLOR, LED, one in shelter and one located in control room as per GSTD-0003.

Analyzers for all stacks if applicable (SOx, NOx, CO, SPM etc.) shall be supplied as per latest CPCB guidelines and shall comply with CPCB/STATE POLLUTION BOARD requirement (whichever is more stringent to be followed parameter wise). Connectivity of these analyzers with CPCB/ STATE POLLUTION BOARD portal shall be in bidder’s scope. Bidder shall supply required hardware and software for connecting these analyzer to the CPCB/PPCB portal with min. 20% spare points for future use.

Sample extraction for stack analyser shall be hot extraction technique/dilution technique only.

Remote calibration feature shall be provided for Stack analysers as per latest CPCB /SPCB guidelines.

Analyzers for fugitive emission of Hydrocarbon (HC) / VOC & Benzene at periodicity as per the Fugitive emission standards shall be in bidder's scope.

Silica analyser shall be of HACH make only.

Service, Accuracy, repeatability, Span & Zero drift speed of response Analyser's performance quality shall be in line with the following as a minimum:

Servi	**Accuracy**	**repeatability**	**Span & Zero drift**	**speed of response**
CH4	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for infrared 63% of reading
NH3	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for infrared 63% of reading
CO2	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for infrared 63% of reading
O2	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 10 S for zirconia 63% of reading
O2	+/- 2% F.S	+/- 2% F.S.	+/- 1% F.S	+/-<than 20 S for paramagnetic 63% of reading
H2	+/- 2% F.S	+/- 2% F.S.	+/- 1% F.S	+/-<than 20 S for thermal conductivity 63% of reading
SO2	+/- 2% F.S	+/- 2% F.S.	+/- 2% F.S	+/-<than 20 S for ultraviolet 63% of reading
Nox	+/- 2% F.S	+/- 2% F.S.	+/- 1% F.S	+/-<than 20 S for chemiluminecent 63% of reading
S.G	+/- 2% F.S	+/- 1% F.S.	+/- 0.5% F.S	+/-<than 5 S for 90% of reading

If Mass spectrometer is considered as per licensor recommendation, then a dedicated laptop for programming of Mass-spectrometer shall be provided along with required software/cable. The laptop shall be with latest Intel hardware, Licensed OS and MS office software at the time of supply. Mass spectrometer must be redundant. In case GC is used, it shall be one (non redundant) for each stream. Multi component analysis is acceptable upto 4 component.

Online Process Analyser

On-Line Process Analyser shall be designed and constructed according to data sheets listed in the requisition.

Supplier shall specify all materials used in the construction of the Analyser. Aluminum and Copper shall not be used.

Process pressure and temperature conditions shall be mentioned in individual data sheet of Analyser. All wetted parts shall be suitable to process condition and in general, be SS316 or better

Hastelloy or Inconel shall be used where required.

Any windows on Analyser housing / shelter / Enclosure shall be shatter proof safety glass.

Mounting: The Bidder shall submit full data on the weights of all equipments that he proposes to supply and provide detailed mounting drawing. These drawings shall also define any specific requirements for the location and elevation of the Analyser with reference to its sample inlet and outlet points at Analyser.

Bidder shall use NACE certified tubes and fitting for sour services.

SAMPLE TAKE OFF, TRANSPORTATION AND CONDITIONING SYSTEM

For each type of Analyser, bidder shall supply the following data with respect to the sample. Each parameter shall be quoted as Minimum, Normal and Maximum.

• Flow Rate

• Inlet Pressure

• Inlet Temperature

• Outlet Pressure

• Outlet Temperature

• Sample Transport time

For each Analyser, bidder shall supply a recommended procedure for sample preconditioning, transportation and conditioning. This shall include complete drawing

indicating the sampling system from sample take off point to Analyser and connections for carrier and calibration gases etc. The sampling system drawing has to be approved by original equipment manufacturer (OEM). Quantity and types of components shall be shown in the drawing including any pumps or compressors that may be required to achieve correct Analyser inlet conditions and reduce sample transport lags.

The process stream sampling shall be continuous and sample system shall have provision for a test sample to be taken without disturbance to the Analyser.

Insulation and or heat tracing is necessary for the sample transport line when

• The dew point of the sample is equal to or above the minimum ambient temperature. A vaporized sample has to be maintained in the vapor phase.

• The pour point of the sample is above minimum ambient temperature of the sample.

• The sample viscosity is too high to obtain short time-lags (for liquid samples).

Sample transport calculations shall be prepared in accordance with EEMUA publication 138.

To ensure correct natural turbulence for proper sampling, a line velocity of about 2 – 3 m/s should be required for liquid and about 8-10 m/s for gas samples.

The bidder shall specify slope of sample tubing.

For remote mounted Analysers the Bidder shall indicate the expected sample lag considering transportation and sample conditioning system, for each Analyser, for tubing length of 25m, 50m and 100m approximately. The calculations for these lags shall be supplied and be broken down in to pre-conditioning, transport and conditioning times.

Bidder shall consider the safety of Analyser in the event of loss of sample flow if the sample isolation valves are closed on emergency.

SAMPLE PROBE

Sample probe is only recommended for single phase process sampling in line size greater than or equal to 2”.

The probe shall be in direct contact with the process fluid hence special consideration shall be given to ensure that all material, flange type, pipe fittings, valves, gaskets, bolts, class rating, branch connection details, instrument connection, welding and heat treatment shall comply with the piping material.

For Liquid service, Sample shall be taken from the side of horizontal process lines via a sample probe. When liquid sample is to be vaporized, narrow and extra strong pipes and reduced bore valves shall be used to keep the liquid volume to a minimum. The vaporizing regulator shall be installed adjacent to the process sample take off point in order to reduce the transportation time lag. The sampling system shall be designed in such a way that the pressure at any part of the sampling system shall always be higher than the vapor pressure of the sample to prevent flashing.

For Gas service, sample shall be taken from top of the process lines.

For the samples, which are vaporized at the take-off point, impact tube assemblies shall be used. The vaporizing pressure regulator shall be mounted directly on to the impact tube probe assembly.

The location of the sample take off point shall be such that temperature, pressure or other conditions are as close as possible to the required specifications for the Analyser in order to minimize use of additional components.

The contained volume of the probe shall be kept to minimum by limiting the dimensions. Double valves shall be provided if required.

SAMPLE PRE-CONDITIONING

Sample systems for Analysers installed remote from the take-off point, normally in the Analyser house or shelter, often require pre-conditioning system. The reason can be :• For too high pressure, pressure reducing system shall be used,

a) When the process pressure is higher than the designed pressure of any downstream component used in sampling system.

b) To reduce the sample flow to minimize waste of sample.

• For too low pressure, booster pump / compressor shall be used,

a) When the process pressure is too low to create an acceptable time-lag or if a liquid

sample might flash in the sample system.

b) When the distance to the Analyser location is too long to obtain sufficient velocity in the sample line.

The sample pre-conditioning system can be divided into three major parts

• Pressure Reducing System

• Sample Booster Pump

• Temperature Control

Pressure Reducing System – When the process pressure exceeds 15.3 kg/cm2(g), a

pressure reducing system including relief valve (set at 15.3kg/cm2(g)) shall be installed at the sample take-off point. The bubble point of the sample shall be considered while designing the sample system for a given operating pressure. Relief valve discharge shall be connected to closed drain / plant flare system or back to the process. Bidder shall supply properly sized regulating and/or relief valve with all accessories, if required.

Sample Booster pump / Compressor – When the pressure drop between sample take off and sample return point is too low, then a pump or compressor with necessary safety or relief valve shall be installed near the sample take off point. The pump shall be installed at ground level and suitable for the area classification.

Sample pump, if required shall be installed outside the Analyser housing and within a cabinet and protected by a volume filter. Pumps with double seals shall be supplied where the sample is hazardous.

The sample booster pumps shall be electrically isolated in the event of sample isolation valves are closed on emergency.

Temperature Control – Bidder shall specify any requirement for heating, cooling or winterization of the sample from the sample take off to the Analyser including the sample temperature requirements from sample take off assembly to the Analyser inlet, if any. Any break point for the application of heating or cooling including insulation requirement shall be indicated. Heat tracing shall be provided to the sample conditioning system as required, to prevent condensation of the sample or to compensate for heat loss at a higher pressure drop. Where sample may contain condensable components, a steam or electrical heated pressure reducing regulators

shall be used. Electrical heater thus used shall be suitable for the area classification. Power for electrical heaters shall be 240VAC, 50Hz.

SAMPLE TRANSPORTATION

For sample transport systems following has to be considered :

• The length & size of the sample line, accessories used and volume shall be kept to a minimum.

• The sample velocity in the sample line shall be as high as possible.

• The sample transport response as per licensor requirement.

The sample transport system can either be single loop or fast loop. The choice is depending up on the allowable lag time of the Analyser system and type of sample.

Fast Loop – it is the circulating loop connected across an equipment like Pump, Control valve, Process Equipment, etc. which develops a differential pressure. The return point for fast loop of the liquefied gas samples shall be selected such that the pressure at return point is always 2Kg/cm2 higher than the sample vapor pressure to prevent flashing.

Where a single line to Analyser is installed, the system shall have a bypass stream branched off close to the Analyser to maintain high sample transport velocity, resulting in a short transportation time lag.

In general, fast loop sample line shall be ½" OD SS 316 tubing and single loops shall be with ¼" OD SS 316 tubing depending on transport time delay and process fluid condition. Tubing shall be in continuous runs without intermediate joints between sample preconditioning and sample conditioning system and from sample conditioning system to sample return point.

Bidder shall provide facility for flushing, venting and/or draining with vent and/or drain valve(s) for sample transportation and conditioning system.

SAMPLE CONDITIONING SYSTEM (SCS)

The sample conditioning system (SCS) shall be designed to withstand all possible normal or abnormal operating condition and to supply a representative sample at the required Analyser inlet conditions. This holds for extreme pressure and temperature

as well as for critical chemical conditions which might lead to corrosion or chemical reaction with applied materials.

The sample conditioning system shall be designed by the Analyser Bidder and approved by the client. The Bidder shall provide sample line and return line sizing, lag time calculations and install all components, tubing, equipments, etc. required to achieve the design conditions.

Bidder shall use SS316 as minimum for all wetted parts of sample conditioning system in accordance with ANSI/ASME B31.3. The make and type of components and tubing shall be approved by the client at the enquiry stage. All compression fittings shall be double compression ferrule type (Swagelok/Parker/Hoke). All tubing shall meet the requirements of ASTM A269. All compression fitting and tubing shall be installed strictly in accordance with the manufacturer instructions.

All sample conditioning and fast loop systems shall be installed in a steel enclosure outside the Analyser house.

A local temperature and pressure gauges shall be supplied at the inlet and outlet point of the sample conditioning system. The pressure gauges shall be supplied with ½" NPT male connection and gauge adapter, complete with isolation and vent valves.

Bidder shall supply instrument air and nitrogen supply lines with a filter regulator complete with pressure gauge and back flow protection. The nitrogen reducer shall of the non-bleeding type Regulator shall be provided with ½" NPT(F) inlet and outlet ports. Pressure gauge for regulator shall have 50mm dial and ¼" NPT connection.

Compression fittings shall be provided with parallel threaded connections. Compression fittings shall be locked to the body of a relevant component with a locking pin. NPT threaded compression type elbows shall not be used. Where NPT threaded connections are used, thread tape or equivalent shall be applied by placing tape on male threads. PTFE tape shall not be used.

The tubing shall be arranged such that the removal of one component will not require the dismantling of other parts. The components shall also be installed in different planes to avoid the need for bends when crossings have to be made. The tubing shall be cut dead square with a tube cutter and the tube edges shall be burr free. The tubing shall be bent with a high quality tube bender to at least the minimum bending radius as specified by the tubing manufacturer.

Steel tube type rotameters shall be used. Glass tube rotameters shall be considered for air, nitrogen and water application at low pressure. Where the design flow range does not permit the use of metal tube flow meters then glass tube flow metes may be used with client"s approval. Level gauges and sight glasses must have borosilicate toughened glass components to BS3463.

Any component or part made of glass shall not be applied for flammable and toxic fluids. When the metal components for particular range are not commercially available, the Bidder shall obtain written approval from client. When glass or glass containing components are used, they shall be suitable for 1.5 times the maximum operating pressure of the related system and shall be protected by a pressure relief valve mounted in an appropriate part of the system. The glass part shall be provided with a 5 mm thick polycarbonate screen for personnel protection.

The flow rate of flammable fluids to the Analysers shall be limited by an Excess Flow valve. For flammable gases, the flow rate shall not exceed 20 Normal Litres / Hr. to the Analyser. The liquid flow rate shall not exceed the maximum required flow rate as specified by the Analyser manufacturer. The excess flow valves shall be self closing type.

The Analyser Bidder shall install heating or cooling components inside the sample conditioning system to meet the Analyser inlet sample temperature within specified limit. Copper or its alloy shall not be used. For cooling requirement, water from closed cooling system shall be used. If the cooling water temperature is too high, cooling by means of cold air from a vortex tube or refrigerator shall be considered.

Where heating is required to lower the viscosity or to prevent freezing of liquid sample, a stainless steel steam heating coil shall be provided around the sample vessel. Where steam is not available, electrical heating shall be applied, suitably certified. In case of heated samples, temperature gauge or RTD shall be provided at sample point for temperature indication and provision for temperature adjustment shall be provided externally.

Bidder shall install all components of SCS on stainless steel mounting plates with flat countersunk headed stainless steel bolts. Special attention shall be paid to the position of the components in relation to the connections to be made. All components shall be suitably supported. Non-metallic spacer material shall be applied to isolate tubing from the supports.

Bidder shall mount each sample conditioning system in boxes / cabinets. The box/cabinet shall be designed for total weight of all components including weights of sample fluid(s). The cabinet shall be designed such that any spillage is easily cleaned and the base is slightly sloped towards a drain point. The drain shall be provided with suitable plug or connected to the closed drain system.

Each cabinet shall be a welded construction in stainless steel sheet, approximately 2mm thick, complete with access doors at the front, fitted with laminated safety windows (minimum 6mm thick) with a suitable gasket. Each door to be hung on three recessed stainless steel butt hinges, two hinges may be used on enclosures less than 750mm high and are to seal on a suitable gasket, keeping the cabinets to IP65. The doors of all sample system cabinets shall be lockable. All cabinet locks shall have a single master key (three sets of keys to be supplied by Bidder).

All equipments or components inside the sample conditioning system shall be installed to facilitate easy removal for maintenance.

Each sample conditioning system shall be supplied with the engraved name plates for each component. The name pates shall be fixed directly to the mounting plate with stainless steel screws. All incoming and outgoing connections shall be identified with a name plate. Components such as relief valves, excess flow valves, flow meters, pressure regulators, temperature controller, etc. shall be provided with name plates showing their settings.

Bidder shall provide low flow detection within the sample conditioning system and an alarm on low sample flow to Analyser for each stream of sample.

Bidder shall make separate provision for “zero” & “span” calibration gas. Where same calibration gas is used by more than one Analyser, individual isolation valve shall be provided for each Analyser. The conditioning system shall be designed in such a way that each Analyser can be calibrated without affecting other Analyser performance.

Where significant pressure variation in sample is expected, the “block and bleed” arrangement shall be provided to equalize the sample pressure to atmospheric pressure prior to injection or measurement.

Bidder shall supply a standby filter in the bypass loop connected via a block valve

arrangement so that the Analyser remains in operation during filter replacement or cleaning.

Each sampling system shall be provided with a lab sample take-off point. The lab sample shall be connected through a SS316 Sample Bomb. The sample bomb shall be connected through quick connect fittings and flexible hoses. The Bidder shall ensure that the sample bomb can be flushed with the sample by connecting either to the closed drain system or flare header as applicable. In the event of lab sample is being collected a suitable alarm shall be generated in the DCS, which is detected via a low flow switch or valve position proximity switch.

For the Analysers requiring Nitrogen/Hydrogen as carrier gas a field rack shall be provided with provision of two banks of cylinders (4 cylinders in a bank) and connection autochangeover regulators with pressure gauges for each bank and header pressure. The outlets of the regulators shall be connected to the utility header via a purifier system and excess flow check valve. The rack shall have a pressure switch to indicate “Low Carrier Pressure”. Each cylinder shall be have individual isolation valves for ease of replacement.

FLUE GAS ANALYSERS

The On-line flue gas Analysers are required for continuous monitoring of SOx/NOx emission from the furnace, heater or boiler stack to environment. The SOx/NOx stack monitoring system is to be based on stack dilution method for measurement of SOx/NOx emission at stack and with facility for future diversification for other gas components. Bidder shall be responsible for design, supply and commissioning of complete SOx/NOx Analyser system suitable for continuous SOx/NOx emission monitoring of stack flue gases along with sampling system

Flue gas Analysers shall be housed in an Analyser room located in field.

The SOx Analyser shall be based on continuous measurement of SOx by UV fluorescent absorption method and consists of microprocessor controlled Analyser Zinc UV lamp, stabilized UV lamp power supply, continuous UV energy monitoring with compensation of variation for measurement at constant UV energy level.

The NOx Analyser shall be based on chemiluminescence"s principle and consist of ozone generator, reaction cell, photomultiplier tube, etc.

DILUTION SYSTEM FOR SOx/NOx ANALYSERS

A continuous sample of gas in the stack is extracted by a dilution probe by means of critical orifice and pneumatic ejector is fed by pressurized dry dilution air. There shall

be a very low sampling rate, avoiding any clogging problem, and immediate dilution at the sampling point. Calibration and zeroing shall be carried out at stack temperature and flow condition. The unit shall have pressure indication of instrument air supply, calibration gas and vacuum and also flow regulators for calibration gas and sample.

Dilution control unit shall be suitable for use of multiple probes (min. of 2). The unit shall be of manufacturer"s standard design and shall be mounted along with the Analyser in the shelter. The control unit shall perform all functions required for pressure control, air vacuum, back flush and all manual and automatic operation along with Analyser unit. The control unit shall have facility for switching in for two probes.

O2 ANALYSER

O2 Analyser shall consist of in-situ probe assembly and grade mounted control unit. The probe shall be Zirconia Oxide Cell. The probe material shall be of Inconel-600 material as a minimum. The enclosure shall be weather proof to IP65 and Ex-proof as per area classification.

The control unit shall be microprocessor based smart type with temperature controller, auto blow back facility, auto calibration and zeroing facility, self diagnostic facility, with local indication and alarm for operating parameters etc. The control unit shall be explosion proof and shall be suitable for hazardous area mounting. The electronic shall also provide analog output signal for remote transmission over relatively long distances (to DCS) and provide power supply to the probe assembly. The response time shall be less than 20 Sec.

It shall be possible to view the parameters like cell temperature, cell mili-volt, oxygen concentration, thermocouple milli volt, etc in the display unit and make configuration changes by an inbuilt keypad.

The sensor, thermocouple, heater etc should be field serviceable on line. Temperature controller shall have fail-safe circuitry to protect the temperature element burnout.

Bidder shall provide one number of Portable Oxygen Analyser along with its sample probe (suitable for same range and with the same accuracy as all the online Analysers) in addition to the online Oxygen Analysers. This portable Analyser shall be used for cross checking the reading of online oxygen Analyser.

The probe shall have inbuilt pressure and temperature sensors. Portable Analyser shall be intrinsically safe. Portable oxygen Analyser shall be supplied with rechargeable battery pack with charger unit. Portable Analyser shall also be suitable for 240VAC 50Hz power operation.

MOISTURE ANALYSER

Fixed type Moisture Analyser and probe.

The moisture Analyser shall be wall mounting type on C-Channel

The moisture Analyser electronics shall be installed inside the Analyser house. The moisture Analyser electronics shall multi channel type. However, separate sampling systems shall be used for each sample gas. The sampling shall be fixed type preferably as close to the sample take off point as possible.

The moisture sensor (probe) shall be equipped with in-built pressure and temperature sensor along with the provision of connecting an external pressure transmitter with 4..20mA output.

Probe shall be intrinsically safe and shall be digitally self compensating for long term electronic stability. Probe shall be aluminum oxide type or equivalent.

Bidder shall provide one number of Portable Moisture Analyser along with its sample probe (suitable for same range and with the same accuracy as all the online Analysers) in addition to the online moisture Analysers. This portable Analyser shall be used for cross checking the reading of online moisture Analyser.

The probe shall have inbuilt pressure and temperature sensors.

Portable Analyser shall be intrinsically safe portable hygrometer with internal sample system and probe.

Portable moisture Analyser shall be supplied with rechargeable battery pack with charger unit. Portable Analyser shall also be suitable for 240VAC 50Hz power operation.

DEW POINT ANALYZER

Dew point analyzer shall be online, continuous monitoring type. Sensor should be unaffected by fluid flow rate. The moisture probe shall operate accurately under

dynamic as well as static fluid flow conditions. Sensors shall withstand exposure to contaminants like water spikes, ambient humidity, compressor oil and chemical impurities. Minimal drift in readings that allow long calibration intervals of at least 12 months. Sensor shall be 316 stainless steel or PTFE. NIST traceable calibration certificate.

Transmitter shall be 2-wire loop powered connection, Measurement range -60 to +20°C dp Accuracy ±2°Cdp, IP66 Protection, Automatic Calibration function, Long term stability, Fast response.

Dewpoint measurement device shall be used to control the regeneration cycle. Integrating a dewpoint sensor with the dryer control system, the towers will not switch until the dewpoint transmitter senses a degrading dewpoint temperature, thus ensuring full utilization of each desiccant tower and minimizing wasted purge air.

It shall comply to relevant EN standards.

Analyser Shelter

Number of analyser shelter, location of analyzer shelters and number of analyser along with no. of analyzers installed in each of these shelters shall be decided based upon:

i) Allowable transportation time for each sample.

ii) Available space requirement for analyzer shelter room.

iii) Accessibility with respect to approaches & obstructions.

iv) Space required for equipment maintenance and calibration.

v) Proving the analyzers as per process requirements specified by process licensor.

Bidder to provide details of the analyser shelter size and detailed list of Analysers provided in Analyser shelters.

In no case, the transportation time should exceed the recommended figures indicated by licensor in the Process package. In case no value is indicated the transportation time should be considered less than one minute.

Outside Area Classification –EX. PROOF ZONE-2 GR IIC T4

Inside Area Classification EX. PROOF ZONE-1 GR IIC T4

The LSTK contractor shall house the process analyzers and other analyzers (Control units) in analyser shelter. The construction of each analyzer shelter shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A.

HVAC system shall be dual type without any shared components. One shall be working and other standby.

Analyser shelter shall have complete redundant air conditioning, venting, heating and/or house pressurization system.

The analyzer house size shall take into consideration the size of each analyzer plus an allowance for 20% spare on both inside and outside walls for future analyzer and sample conditioning systems.

Shelters shall be equipped with all safety measures like panic bar at the doors, Emergency alarm push buttons, LEL gas (hydrocarbon) detectors, Fire detection system, warning panels, Fire extinguishers, wash basin etc.

A PLC shall be provided to execute safety logics for analyzer shelter. PLC shall have redundant CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated

Each analyzer shelter shall have common fresh air intake via a stack mounted on the analyzer shelter roof. These stacks shall be provided with a rain hood and a mesh to prevent entry of birds etc. also adds tie bars for support of stack. The air shall be drawn from a non-hazardous area and the air intake location shall be at least 1 meter outside the hazardous area. The design of the intake tray and the diameter and length shall be sized by Seller so as to limit the air velocity inside the traying to a maximum of 8m/second. The intake stack shall have filters 5 microns down to 99% efficiency, fire dampers and louvers

All Analyser shelter temperature indication must be provided in DCS.

Cable Entry into Analyser shelter shall be through MCT blocks (MOC SS316).

One Analyser PLC for each Analyser shelter shall be provided with redundant connectivity to CR.

8.2 Flow Instruments

8.2.1 Flow Transmitters

D/P cells shall have measuring method on the floating differential capacitance/ Silicon Resonator technology or OEM standard. The signal transmitter shall normally be a 2-wire system and shall be capable of delivering rated current into external load of at least 600 ohms when powered with 24V D.C. Protection against short circuit and reverse voltage shall be provided. Bodies shall normally be in stainless steel with SS316L internals. Integral 3- valve manifold shall be used for mounting transmitters on manifold for ease of maintenance. Material of manifold in general shall be SS316L can be upgrade depending upon service. Digital output indication shall be preferable on the integral output meter with the transmitter. All flow transmitters shall have sq. root extraction function.

The transmitter shall be furnished with an output meter or gauge with a sqrt scale. Smart type transmitters will be used with Hart V protocol. Overall accuracy for SMART transmitters shall be +/- 0.050% or better. Any additional component/option added shall not be used to achieve the required accuracy. Stability of all transmitters shall be 0.1% over 10 years. Process connection size shall be 1/2” NPT through oval flanges. All field transmitters shall be dual Compartment with metallic partition Type.

All field transmitters shall be 2 wire type, 24 Volt DC, SMART with HART protocol, and shall be equipped with Local LCD type digital indicator. 2” pipe mounting, SS304 MOC brackets & Stud/Nuts, Rangeability 1:100, Local Display configurable, Double Compression SS316 cable glands (Exd), EExia IIC/T4, IP67, Wetted MOC SS316L, SS316L MOC Manifold, Housing Die-Cast Aluminium .Epoxy Painted, Universal Hart Protocol with Latest Revision is required.

8.2.2 Rotameter

Rotameters or variable area meters may be used in pipe sizes from 1 1/2” and smaller. The meter shall be selected for normal flow at 50 to 60% of the span. In applications with toxic or inflammable fluids, glass tubes must not be used except for low pressure analyser sample flows. They may be used for severe corrosive services and of fluid of high viscosity. The metal tube meters shall be of stainless steel SS316, PTFE lined or any other suitable lining for the service. The Indicator assembly shall be magnetically coupled and mounted with Rotameter body. Transmitters or Indicators on float extension are not recommended except for cryogenic services. The

switch assembly shall be of proximity type. All Rotameters shall be metal tube type with rotameter transmitter except for low pressure analyser sample flows.

The tube and flange be SS316 as a minimum. Flange connections shall be as per piping specifications. Irrespective of pressure, the minimum flange rating shall be ANSI 300#.

The rotameter transmitters shall have 4-20 mA output at 24V D.C. power on two wire system.

9.0 PRIMARY DIFFERENTIAL PRODUCERS

9.1 Orifice Plates

Orifice plates of the square edged concentric type shall be specified except where unsatisfactory for the application. Materials of orifice plate shall be minimum SS316 unless special materials are required for the service. The maximum ratio of orifice to inside pipe diameter of 0.70 and minimum ratio of 0.25.

Orifice plates dimensions and calculations shall be in accordance with ISO 5167-1980.

The flow range shall be selected such that normal flow rates are between 50% and 70% of the flow upper range value.

Material of construction of orifice plate shall be 316 SS except where this material is unsuitable for the service because of corrosion or erosion considerations, in which case an alloy shall be chosen whose corrosion allowance is equal to or better than line material. Orifice plates dimensions, finishing, flatness, tolerances for dimensions and identification information shall be in accordance with ISO standard. Orifice plate shall be provided with tab handle, which is welded on the orifice plate and engraved with following information on the upstream of the tab handle:

- UPSTREAM or UP
- Instrument tag number
- Orifice diameter
- NPS (Nominal Pipe Size) and ANSI flange class
- Material of the orifice plate
- DP range & Meter (Flow) range

The tab shall also be in line with the Drain or Vent hole and shall indicate the direction of flow.

BIDDER shall submit the sizing calculations for orifice plates for review.

Pressure drop for orifice sizing shall generally be selected among the following values: 125, 250, 500, 625, 1250, 2500, 5000 and 10000 mm H2O with standard selection at 2500 mmH2O.

Orifice plates shall be installed on horizontal lines when practical. Vertical meter runs may be used for down flow of vapour and up flow of liquids.

Differential ranges for all liquid flow meters shall not exceed 5000 mm water. Typical ranges for gas, steam or vapor meters are as follows:

Static Pressure (in Kg/Cm2g)	Diff. Range (in mmwc)
0.35 to 2.5	500-1200
2.6 to 6	1250-2500
Above 6	2500-5000

Orifice bore with diameter less than 0.125” shall be avoided.

9.1.1 Flange taps orifice shall generally be used for line sizes 2” to and including 18”. Above 18”line size, D and D/2 taps shall be used. Integral Orifice assembly with transmitter shall be used for line size 1 1/2 “or below (as per standard BS-1042/ ASME MFC-14M). Integral orifice assembly shall be with corner tapings and H Type manifolds. Honed pipe runs for integral meter shall be provided.

Orifice assembly shall be provided with two sets of “Flange Taps” located in accordance with latest AGA standards. The orifice assembly shall be provided with jack screw for removal of orifice plate. In case of 2 out of 3 logic requirement, three transmitters shall be used. In such case six set of taps shall be provided in orifice assembly. Instrument tapping connections shall be 1/2”NPT (F).

9.1.2 Orifice flanges shall be in accordance with the ANSI B16.36, ANSI B16.36a and applicable piping specification and shall generally be of weld-neck type only. The minimum pressure rating of flanges shall be ANSI 300 lbs (irrespective to pipe class rating).

Flanges larger than 3" shall have a pair of jack-screws. The mating flanged shall be aligned in such a way that jack-screws will be diametrically opposite.

9.2 Nozzles

ISA 1932 Nozzles may be used in high and medium pressure steam and BFW piping.

Materials for nozzle element shall be minimum SS316 steel unless special materials are required for the service. Dimensions and calculations shall be in accordance with ISO 5167-1980. Generally branch pipe is required with the nozzle the same shall be machined from higher schedule pipe than the one used for the service or forged branch pipe shall be used if higher schedule pipe is not available. The branch pipe bore shall be same as that of nozzle ID and shall have mirror finish.

9.3 Venturi Tubes

Venturi Tubes or nozzles as per ISO 5167-1980 or similar type elements may be used to measure the flow of low pressure gases or liquids where loss of pressure is an important consideration.

9.4 Pitot Elements

Pitot Elements of the averaging type may be used where high accuracy is not required or the pipe diameter is too large for acceptable orifice plate design. Use of annubars shall be limited to combustion air, flue gas raw water and fresh water services unless specifically indicated. The annubars shall be extraction type with ball valves(SS316) and pipe fittings required for installation. The connection size shall be 1 1/2” NPT. For rating 1500# and above the process connection size shall be 2” flanged.

9.5 Local Flow Indicator

Motion balance (Barton cell type) type differential pressure indicator shall be used for local flow indication. Body and internals shall be of SS316 . Process connection shall be 1/2” NPT(F). 3-valve manifold(SS316) with 1/2” NPT connection shall be used with the meter.

10.0 OTHER FLOW METERS

10.1 Mass Flowmeter

Coriolis type mass flow meter with local digital display of flow shall be used to measure the process flow where high accuracy is required. Normal accuracy for mass flowmeters shall be 0.15% of mass flow rate. The sensing element shall be straight/U-tube, matl. SS316 minimum. Material of wetted parts shall be minimum SS 316 or superior material as demanded by the process conditions.

10.2 **Vortex Meter**

Vortex shedding meters may be used for wide range of flows for gases and liquids. The measured flow shall be temperature compensated.

Insertion type vortex meter may be used in utility services for line size more than 6" inplace of Pitot /Annubar/ Venturi tubes.

The metering tube and shedding bar material shall be SS 316 as a minimum and higher grade material like high chromium Austenitic or Duplex SS shall be provided as required by the fluid and service condition.

Flanged end meter shall be used unless otherwise specified. Flange and body material shall be SS316 min

Accuracy shall be, in general ±0.7% of reading. Accuracy figures shall include linearity, hysteresis, repeatability, static pressure and temperature effects.

In case of dual sensor flow meter, the flow meter shall consist of two independent flow sensors with their dedicated electronics under one body design (welded type construction) with process end connection for the meter as flanged.

10.3 **Ultrasonic Flowmeter**

Ultrasonic flow meters (non- insertion probes preferred) based on the "time-of-flight" method shall be used. Meters based on the "Doppler" principle are less accurate and shall not be used. Ultrasonic flow meters shall be considered for large turn downs and where pressure drop is not permitted. Upstream and downstream straight lengths shall be as per vendor standard.

10.4 **Electro-Magnetic Flowmeter**

Electromagnetic flowmeter with ceramic lining shall be used for the measurement of flow with high accuracy for highly viscous and corrosive services.

Grounding rings shall be provided. Material of grounding rings shall be SS 316Lmin.

Electrode material shall be selected based on process requirement. The meter tube shall be lined with a material suitable for the application.

Flanges provided shall be Weld Neck. Accuracy shall be ±0.5 % of flow rate.

11.0 LEVEL INSTRUMENTS

11.1 External Displacement

Displacer type level instrument shall be avoided and guided wave radar type or remote diaphragm seal DP shall be used in their place if suitable to process condition.

If unavoidable External displacement type instruments shall generally be used for small spans only, in specific cases it may be used upto a range of 84". The cage material shall normally be forged material conforming to the service requirements. Where the vessels are of alloy steel construction, the body material shall be equivalent or of a better material. The displacer shall be in stainless steel and the torque tube in inconel. If LVDT type transmitter in place of torque tube is selected then the range spring of such transmitters shall be Inconel and cannot be used for temp. more than 330 degree C. Process connections shall normally be 2" flanged with side-side connections.

For high temperature as well as low temperature and cryogenic services, torque tube heat insulation extension or torque tube extensions shall be applied. Radiation fins or extensions shall be used for temperature above 200 degree C or below zero degree Centigrade.

11.2 Guided Wave Radar/Non Contact Type Radar

Ultrasonic / Radar type Instrument shall be used for large liquid storage tanks. Guided Wave Radar type level instruments, where used, shall be external type with side / side connections and rotatable transmitter head. Vent and drain valves (Ball Valves) with SS316 trim and body material shall be provided. Radar Level Transmitter shall be based on "Time Domain Reflectometry (TDR)".

Guided Wave Radar Level transmitter shall be applicable for liquids or slurries, hydrocarbons too water- based media. In absence of dielectric constant for the process fluid, Bidder shall confirm the suitability of Guided Wave radar Level Transmitter for such applications and Bidder shall suggest the suitable model for the same. Bidder shall suggest the suitable model for Interface applications like oil on water, Hydrocarbon on water, etc. Electronics shall be capable of measuring upper liquid and interface level simultaneously. Selection shall be available for analog output signal from level transmitter corresponding to upper liquid or Interface. Process connections shall normally be 2" flanged with side-side connections. Process connection for top mounted Radar shall be 4" flanged.Still well shall be provided for

all GWR's . Still well size shall be one size higher than the nozzle size for top mounted Radars.

Material of wetted parts shall be SS 316L min or better as demanded by the process conditions. Chamber material shall be SS316 min.

To avoid touching of probe to still well inside wall, centering disc or weight shall be provided at probe end. Material of centring disc or weight shall be SS 316L as a minimum or superior material.

Grade level indicators shall be provided wherever Radar LT Display is not readable from grade.

The transmitter shall have overfill protection as per WHG-19 standard.

Bolt/nut /gasket material shall be as per vessel drawing min.

12.0 LEVEL GAUGE GLASS

12.1 Gauge Glasses/ Magnetic Type

Glass gauges shall be avoided and **Magnetic type** level gauges shall be used for all suitable process condition. If magnetic type could not be used due to process condition, Gauge Glasses may be used and the same shall normally be reflex type for all process services, except for boiler drums bicolour/magnetic types shall be used, and in corrosive services. Where transparent gauges with glass protection and illuminators shall be used, Illuminators shall be explosion-proof in hazardous areas. Gauge glass columns will not exceed 1500 mm.

For magnetic level gauge ,flapper shall be white (Vapour) / red (Fluid) colour for design temperature below 400°C and black (Vapour) / silver (Fluid) colour for design temperature 400°C and above.

The magnetic level gauge chamber material shall be SS316 minimum. The liquid chamber shall be one piece construction with a minimum internal diameter of 2" Sch 40S. Level gauges operating at sub-zero temperatures shall be provided with larger chamber size.

The level gauge chamber shall be provided along with complete assembly including drain & vent, bottom flanges for removal of the float, etc. Drain and vent connection type and size shall be ball and ½" 800# min (Body MOC SS316 and trim shall be SS316L).Level gauges shall be provided with 1/2" NPT drain valve & vent plug. Gland

packing for the check/drain/vent valves shall be Teflon/ Grafoil.

Float material shall be Titanium irrespective of pipe class.

Scale shall have marking in mm unit only. Scale shall be rotatable. The indicating system shall be hermetically sealed and filled with inert gas in order to avoid the fading of flapper colors.

Transparent type gauge glasses (double glass) will be used for services in which a level may not be distinguishable, such as interface services, between different liquids, where mica shields are required and fluids of high viscosity or high solid content.

Level gauges shall be supplied with a pair of off-set shut off valves with ball check. (Body MOC SS316 and trim shall be SS316L).

For cold services where temperature is below 0 deg C a non-frosting gauge will be used. Defrost block shall be considered in such a way that it does not not effect the visibility of level gauge , specifically in case where cold insulation has been provided on level gauge.

Bolt/nut /gasket material shall be as per vessel drawing min.

Glass tube level gauges shall be avoided.

13.0 PRESSURE INSTRUMENTS

13.1 Pressure Transmitters

Pressure Transmitters and differential pressure transmitters shall be modern inherent motion-free type of the floating capacitance / Silicon Resonator principle or OEM standard. Bodies shall normally be in stainless steel with pressure elements in SS316L. Two valve integral manifold of SS316L material in general shall be used with pressure transmitters.

The signal transmission should normally be a 2-wire system and shall be capable of delivering rated current into external load of atleast 600 ohms when powered with 24 V D.C. Protection against short circuit and reverse voltage shall be provided. The transmitter shall be furnished with an digital output meter or gauge with a sq.rt. scale. Smart type transmitters will be used with latest Hart protocol. Overall accuracy for SMART transmitters shall be +/- 0.050% or better. Any additional component/option added shall not be used to achieve the required accuracy. Stability of all transmitters shall be 0.1% over 10 years. Process connection size shall be 1/2” NPT. All field

transmitters shall be dual Compartment with metallic partition Type. Transmitter shall have over-range protection : 1.5 times of design pressure. All transmitters shall be supplied with adjustable zero and span.

All field transmitters shall be 2 wire type, 24 Volt DC, SMART with HART protocol, and shall be equipped with Local LED type digital indicator. 2" pipe mounting, SS304 MOC brackets & stud-nuts, Rangeability 1:100, Local Display configurable, SS316 MOC, Double Compression SS316 cable glands(Exd), EExia IIC/T4, IP67, Wetted MOC SS316L, SS316L MOC Manifold, Housing Die-Cast Aluminium Epoxy Painted, Universal Hart Protocol with Latest Revision is required.

13.2 **Pressure Gauges**

Gauges for process and utility services shall be industrial SS316 Bourdon gauge/diaphragm or spring bellows type as per process requirement with the case in SS316. The gauge for 60 kg/cm2 above pressure shall preferably be a safety type with solid front where pointer and glass are partitioned off from the sensor by a solid disc. Pulsation dampeners shall be installed with the gauges where pulsating pressure occurs. Process connection shall be 1/2" NPT (M) bottom in general. SS Bezel rings shall be screw on pattern. Dial Size minimum 150mm.

Blow-out discs are required for all pressure gauges except for instrument air services.

Vibration proof gauges or remote seal type shall be used if the surrounding environment is subject to vibration.

Minimum accuracy for pressure gauges shall be +/- 1% of reading.

Wherever Gauge saver/Snubber/Syphon etc is required the same shall be of minimum SS316 MOC.

13.4 **Diaphragm seal**

Diaphragm seals of the filled or mechanically type shall be furnished where plugging of the element may occur due to congealing and high viscous fluids or where suitable sensor material is not available in highly corrosive services.

Remote Seal PT/DPT shall be with min 5 mtr Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball type Isolation Valve (SS316). For Vessel/Equipment requiring more than 5 mtr capillary electronic remote seal shall be provided.

DP transmitters with diaphragm seals are envisaged, where condensing leg required to be filled in normal DP transmitters, at all those locations, remote seal type DP transmitters are to be used.

All catalyst vessel's dP measurement shall be with ERS (electronic remote seal).

Also, wherever there is a control and interlock on level measurement, one transmitter shall be remote diaphragm seal type and one will be guided radar type with Material : Minimum SS316L. Guided Wave radar may be used for non-critical applications.

In general Remote seal DP transmitters shall be used for all tank levels, KO drum levels and all tower level applications.

Material of diaphragm seal shall be SS316L min. For differential pressure application, the two capillary tubes shall be of the same length.

Fill fluid for diaphragm seal shall be suitable for process conditions (including maximum and minimum design temperature and pressure). Diaphragm seals shall be suitable to maximum design pressure / differential pressure as a minimum.

Accuracy shall be 0.050% or better .Accuracy shall be provided after installation of diaphragm seal

Nozzle size for DP seal instrument shall be minimum 3".

14.0 TEMPERATURE INSTRUMENTS

14.1 Thermocouples

Thermocouples shall normally be the sheathed type with high purity magnesium oxide insulation. The hot junction shall be isolated from ground. Sheath diameter shall normally be 6mm (1/4") Inconel 600 sheath material shall be used for design temperatures above 400 degree C, whereas SS316 material shall be used below 400 degree C. The nominal wire diameter shall be approximately 20AWG. For thermocouples installed in vessels/equipments, sheath and thermowell material shall be SS316 min or better as per internal MOC of TE nozzle as per approved vessel drawing .

In general type K thermocouples shall be used according to IEC 584 class-1. However, Element colour code shall be as per ANSI MC 96.1 standard. All temperature elements shall be duplex type, one connected and the second one shall be used as spares.

Skin thermocouples/RTD's as well as multipoint thermocouples/RTD's shall be used for equipment shell temperature measurement as per requirement. Skin thermocouples for heater shall be extraction type with sheath material of Inconel wherever feasible, unless specified otherwise in the data sheets. All extraction type skin thermocouples shall be provided with Heat shield assembly.

All multipoint temperature elements shall be provided with still well/guide pipe Multipoint temperature elements shall be provided with bimetallic arrangement of sensors to keep the sensor tip pressed against the thermowell.

The type of thermocouple shall be selected based on the following guidelines as minimum:

Copper-Constantan (ISA-Type-T)	(-) 200 to 200°C
Chromel-Constantan (ISA-Type-E)	(-) 200 to 600°C
Iron-Constantan (ISA-Type-J)	(-) 40 to 750°C
Chromel-Alumel (ISA-Type-K)	(-) 180 to 800 °C
NiCrSil - NiSil (ISA-Type-N)	0 to 1200 °C
Platinum Rhodium-Platinum (ISA-Type-S or B)	600 to 1600°C

14.2 Resistance Temperature Probes

Resistance Temperature Probes shall be considered for applications where very narrow spans and high accuracy are required as well as low temperature service.

They shall be 6mm (1.4") stainless steel sheath type similar to the thermocouples and with a Pt 100 ohms (0 degree C) element. The sensors shall be duplex type and shall be spring loaded for vibration proof. The elements shall conform to DIN 43760 or IEC 751.

For RTD's installed in vessels/equipments, sheath and thermowell material shall be SS316 min or better as per internal MOC of TE nozzle as per approved vessel drawing .

The nominal wire diameter shall be approximately 20AWG. Sensors shall be MgO packed metal sheathed mineral insulated whose thermoelectric properties and limits of errors for all temperature elements shall conform to ASME MC 96.1 or IEC584.

Class 'A' / Class '1' tolerance as per IEC 751 / 584-2 shall be specified for all RTD and thermocouple sensors in complete temperature measurements for all open/closed loops and interlocks/Logic.

The sensors shall be duplex type and shall be spring loaded to minimise vibration & to keep the sensor tip pressed against the thermowell.

Thermocouple & RTD heads

RTD & Thermocouple shall normally be provided as an assembly consisting of sheathed elements, connection head and connection head extension (Nipple-Union-Nipple) assembly. The connection head extension (Nipple-Union-Nipple) assembly shall be of SS 316 material & length shall normally be 150 mm as minimum.

The Connection Head enclosure shall be Flameproof to EEx “d” suitable for Zone 1, IIC and T6 hazardous area & shall be IP-67 certified. Head cover shall be screwed type, with SS retaining chain fixed to body. Ceramic Terminal block with SS terminals shall be provided.

14.3 Temperature Transmitters

All Temperature transmitters shall be Remote mounted type (on 2” Pipe), Smart with latest HART protocol and integral digital output meter dual compartment type with metallic partition.

Head mounted transmitters shall not be used anywhere.

Conventional transmitter shall have universal input for thermocouple / RTD and output 4-20mA DC for 2 wire system.

Transmitter output signal shall be linear and directly proportional to the measured temperature with overall accuracy of +/- 0.1% reading.

Transmitter shall have automatic cold junction compensation for thermocouples.

Burnout protection (selectable Up Scale / Down Scale) must be provided for all temperature transmitters.

No temperature switches are to be used. The same is to be achieved through temperature element and transmitters which shall be directly connected as analog input to DCS / PLC.

Temperature transmitters are to be provided for all temperature measurement (closed/open/interlock) loops. All process temperature measurements shall be done through Temp. Transmitters. No temp. Input shall be connected directly to DCS/ESD/PACKAGE UNITS. MUX is not allowed. For Bearing and winding temperature connected to VMS, RTD can be directly used.

14.4 Thermometers

Thermometers shall normally be bi-metallic, heavy duty, weatherproof (IP 65), adjustable angle connected type with 150 mm dial as a minimum, dials of smaller size may be used for auxiliary services on machinery.

Liquid filled indicators will be used only where indication is required to be remote. Case and stem shall be in stainless steel. Dials shall be of white, non-rusting metal with black figures.

For local temperature control upto a maximum scale range of 530 deg C, liquid filled sensors with capillary extension shall be used.

Filled system instruments when used shall be fully compensated for ambient temperature variations.

Capillary shall be SS armoured and length of which will not generally exceed 3 mtrs.

14.5 Thermowells

All thermowells shall be flanged, fabricated from bar stock and tapered. Thermowell and flange material shall be same.

Flanged thermowells shall be of 1 1/2” size with minimum 300# rating irrespective of piping specification. screwed thermowells shall be of 1” NPT(M). Flanges facing and material shall be in accordance with the equipment or piping standard.

Thermowell and flange material shall be minimum SS316 and Inconel 600 Thermowell shall be provided for temp >400Deg C. For temperature above 800Deg C, Incoloy 800HT/Incoloy 800 min or better as per TE nozzle drawing shall be provided.

Special thermowell with purged termination box shall be provided for multipoint thermocouples.

Immersion length of thermowells for different line sizes shall be as follows:-

Line Size	Immersion length (U)
4" to 6"	280 mm
8" and above	320 mm
Vessels/Ducts	400 mm

Min thermowell immersion length shall be 80mm.

Immersion length is based on 200 mm length between flange face and inner well of pipe and approx. 60% insertion in the pipeline. In vessels, where fouling with vessel internals is expected, the immersion length shall be suitably modified. Other sizes and immersion lengths may be considered based on special condition/actual requirements.

The design of the wells shall be verified by means of stress analysis, resulting from stream velocity condition. The wake frequency shall not exceed 66% of the thermowell natural frequency. Wake frequency calculation is required for all thermowells. Bidder has to submit Wake frequency calculations for all thermowells as per latest PTC 19.3. Velocity collars shall not be used.

Cases wherein thermowell fails stress and WFC, modifications as mentioned below in order to pass thermowell in their order of preference shall be followed:

a) Material: Alternative material with increased mechanical properties shall be considered.

b) Insertion Length : Reduce immersion length into pipe or standoff height gradually to reduce unsupported stem length (Follow min 80mm insertion length in this case as well)and increase Thermowell thickness accordingly.(Response time shall not be affected by increasing T/W thickness)

c) Tip Dia: Increase tip diameter of thermowell (Same shall be within limits as per latest PTC 19.3 standard)

d) Root Dia : Increase root diameter of thermowell (Same shall be within limits as per latest PTC 19.3 standard)

e) Fillet Radius : Increase fillet radius to improve strength .

Only when, after making the above modifications, if T/W fails stress and WFC, T/W with Scruton/hellical design with following specifications shall be provided :

- Construction of Thermowell shall be flanged ,drilled bar stock (Solid

machined)and tapered .

Welding design of helicals on Scruton Thermowell is unacceptable.

- Design and Calculation of Scruton thermowell shall be based on latest ASME PTC 19.3 .

Straight thermowells shall not be provided in any case.

15.0 CONTROL VALVES

Valve types shall be selected, pneumatic diaphragm/piston operated globe, ball or butterfly shall be selected taking into account such factors as piping, operating and design conditions, fluid being handled, tangibility required, allowable leakage, noise and other special requirements.

Control/On-Off valves bodies used in steam/BFW services shall be A182 F22/ A216 WC9/better/equivalent. All on/off valves shall be bidirectional.

The valves shall have SMART electropneumatic positioners with latest HART protocol.

Seat Leakage shall be chosen in accordance with process demands and safe operation of the plant and in accordance with FCI-70.02/API -598. However all control valves shall be minimum class IV leakage class as per FCI-70.02. Metal seated valves shall be used instead of soft seated valves. Soft seat requirement shall be evaluated by PMC/Owner on case to case basis. For Vent services, the leakage class shall be minimum class V or VI depending upon process requirement. For high performance all ball valve seat leakage shall be TSO (tight shut off), metal seated, as per API-598.

Safety shutoff valves must not be used in throttling service during normal operation.

Noise abating devices shall be provided with valves where noise level at the outlet of valve at a distance of 1 metre all around is more than 85 DBA for valve which have operating times of 5 minutes or more in general and which are only working during start up and in upset conditions. For continuous operation the allowable sound level shall be 85 dBA. All noise abating plates, expanders, flanges, gaskets, studs & nuts shall be in the scope of valve manufacturer. The noise abating plates shall be of wafer design for easy removal for maintenance. Source treatment for noise shall be

preferred over path treatment and for high noise vent applications “DRAG” type trim shall be specified.

All valve bodies shall be cast or forged.

Flanged bolted type gland packing boxes shall be used, unless other specified. Gland packing shall normally be self-lubricating type. Packing shall be PTFE type up to 200”C. For temperature above 200 “C, grafoil is to be used. Usage of asbestos is not allowed in any part.

Bellows seals shall be used wherever gland leakage is not permissible like toxic / hazardous product like carbon monoxide gas, etc.

As a minimum, trim MOC shall for all control/on-off valves shall be SS316. By default, all Guide stem MOC shall be hardened stainless steel like 440 C, 17.4 PH, or better. For erosion service, high pressure drop, cavitating service hard surfacing of plug and seat material. Special cases valve may require 17.4PH seat and 440C solid plugs or other material like Hastelloy, Monel, Zirconia, duplex steel, 2 RE69, etc. for severe services like steam, acid, etc.For all Control and On-off valves HRC value of trim shall be minimum 46 HRC

Mechanical stopper shall be provided as per process recommendations for min. Flow condition.

On line replaceable trims shall be considered for all high pressure valves of butt-weld or socket weld connections.

Where tight shutoff is required, fire safe type soft seat trims shall be used, provided pressure/temperature of service permits the use of this. For temperature above 300°C stellited facing shall be used for guide and guide bushing shall always be harder by a minimum of 125 Brinnel than that of the guide.

Trim characteristics shall be equal percentage, unless otherwise specified. For high erosion service or in steam service where, the delta P is higher than 5 Kg/Cm2, hardened trim with stelliting shall be used. When this alone is not sufficient, in such cases, special Anti-cavitating trim or shall be selected. In general, hardened, full stelliting shall be used, as a minimum.

All on-off valves shall be ball type on-off valves only. The ball valves of up to 2” size shall be floating ball design with full bore design, unless otherwise specified. Other ball valves with higher size shall be trunnion supported ball type design type.

All Ball valve shall be as per API 608.

All On-Off Ball valves shall be metal seated with minimum leakage class V, moreover if class VI leakage is required, soft seated ball valve may be used with Client/PMC approval only.

Split body design for ball valves acceptable where top entry ball design has not been considered. Mufflers shall be provided on ball valve vent air lines for noise suppression. Spring loaded seat and hard chrome plated ball shall be a standard feature for ball valves, in general.

All valve actuators shall be selected for a minimum operating air pressure of 4.0 kg/cm2g. The actuators shall be diaphragm or piston actuators in general. Diaphragm actuators with single or concentric multi-springs shall be used. volume tank with airlock relay, booster relays shall be avoided as far as possible.

Rotary rack and pinion pneumatic actuators may be used with ball and butterfly valves for on-off services.

In general, if otherwise not specified in the valve data sheet the time for full travel shall not exceed 10 seconds.

Wherever handwheel is required with a valve the same shall be side mounted type.

All split range functions for valve operations shall be carried out in DCS and split range provision in valve positioners shall not be necessary.

Butterfly valve bodies shall be of wafer design. Lug type body shall be considered for size above 12”. Face to face dimensions shall conform to ANSI B 16.10 and ANSI B 16.47 wherever applicable. Double flanged butterfly design shall be provided for size above 18”and above.

Butterfly valves shall be used for high flow, low pressure drop below 10 kg/cm2g.

All instrumentation control and on/off butterfly valves shall be triple offset type only.

Non destructive test like radiography, ultrasonic, die penetration and magnetic particle shall be carried out for cast and forged bodies conforming to procedures laid down in ANSI B16.34. Radiography or ultrasonic test, if not specifically mentioned in the data sheet, shall be carried out for cast or forged bodied of rating 900 lb. and above.

Valve bonnets shall be in general of bolted bonnet design as per ASME B 13.3 par 307.2 with minimum four bolts.

Smart E/P positioners with position transmitter along with valve signature software to be provided for all control valves. The software shall be provided for remote configuration and diagnostic analysis too.

Actuator sizing shall be done at 4 Kg/cm^2.

Valve actuators shall be designed with 1.5 times factor of safety.

Handwheel (Side-mounted) for all regulating control valves to be provided.

By-pass valve provision shall be as per process licensor requirement.

The control valve % opening shall be at minimum flow 10-20%, for normal flow 50 to 70%, for maximum flow 75 to 85%.

In general, the minimum valve body size selected shall not be less than two (2) line sizes below the line size. Reduced trim should be used instead.

Control valve size shall not be greater than line size.

All on – off application valve shall be fixed with necessary limit switches.

Valve Sizing shall be used on a maximum flow rate of approx. 1.5 time normal flow or 1.3 times the max. flow, whichever is greater, and the process conditions that exist at the increased flow (Pressure and differential pressure). Valve lift shall be approximately 70 % for equal percentage and 60 % for linear characteristic plug design at normal flow. It shall be checked that the calculated and the selected valve also covers start-up and stop conditions. In cases where over sizing shall not apply, it will be specifically mentioned in the Instrument Data Sheets.

The fluid velocity at outlet flange shall not exceed 6 m/sec for liquids whereas the velocity of gas or vapor shall not normally exceed 0.3 Mach under operating conditions. To meet this, valves shall be selected having reduced trim, labyrinth plug or cage trim as manufacturer standards.

Bidder shall submit the sizing calculations for all control valves.

Face to face dimensions of the control valves shall be as per ANSI/ISA-S75.03.

Direction of flow indication shall be engraved or embossed on the body.

DCS MOV's shall have minimum indication as follows:-

a) Open Indication

b) Close Indication

c) Motor Tripped on Torque

d) Position Indication

e) Local/Remote

f) Fault Alarm

g) Actuator being opened by Handwheel Status

Commands:-

a) Open Command

b) Close Command

c) MOV Maintain

ESD MOV's shall have minimum indication as follows:-

a) Open Indication

b) Close Indication

c) Motor Tripped on Torque

d) Position Indication

e) Local/Remote

f) Fault Alarm

g) Actuator being opened by Handwheel Status

Commands:-

a) Open Command

b) Close Command

c) Trip Command

d) MOV Maintain

15.1.1 Control Valve Test and Inspections

Valves shall be tested in accordance to individual specification which shall cover but not limited to:

- Visual Inspection and dimensional check
- Liquid Penetrants examination on stellite coating as per ASME B16.34 ann D.
- Radiographic, ultrasonic, magnetic particle as per ASME B16.34
- Hydrostatic Body Test - Duration 3 min. (including all parts in assembled condition like body, gland, all joints)
- Impact test
- Seat leakage test as per FCI 70.2
- Performance tests and Functional tests
- Leakage test from actuators and seals and packings
- Diaphragm head test
- Complete actuator leak test
- Helium leak test for control valve with bellow seals
- Stroke calibration
- Stroke speed test

15.2 Limit switches / Position Switches:

15.2.1 All type of limit switches shall be 2 wire, proximity type, intrinsically safe certified. Limit switches shall be provided both for close and open positions for all shutdown valves.

15.2.2 The make shall be P+F only. The sensor shall be generally cylindrical NAMUR sensor type proximity switch. The diameter and sensing range shall be selected based on application.

15.2.3 The MOC of sensor shall be SS316. Krastin type probes shall not be used, unless surrounding atmosphere heat permits the use of the same under worst condition.

15.2.4 All limit switches sensor shall be adjustable with the threaded length and check nut arrangement.

15.2.5 Flying lead type loose connections for NAMUR sensors are not acceptable. All these

NAMUR sensors installed on any instruments to sense the position shall be housed in a closed box certified for weatherproof to IP65. The gland size shall be ½" NPT(F).

15.2.6 All ON-OFF type application valves taking in part in interlock/shutdown shall be provided with Open and Close type NAMUR sensor as limit switches. The sensors along with enclosure shall be installed in control valve in such a way that it can be removed with ease for maintenance.

15.2.7 Limit switches shall not be used for Control Valves.

15.3 Actuators

15.3.1 Generally, control valve actuator shall be of the spring and diaphragm, pneumatically actuated type. Standard air control signal to positioner shall be 0.2 to 1.0 kg/cm2g. For larger dP shut offs, higher spring range/higher areas shall be considered.

15.3.2 Actuators shall be single acting type for all Control/On-Off valves.

15.3.3 All valve actuators shall be designed with 1.5 times factor of safety.

15.3.4 Piston type actuators (spring return type) with or without fail-safe capacity tanks (minimum of 2 strokes to be possible in case of air failure) shall be considered for high-pressure drop services or if actuator force requirements fall beyond the normal range of diaphragm actuators. All actuators shall be adequate to fully stroke the valve under the maximum differential pressure specified by the process requirements.

15.3.5 Air filter Regulator filter to be 5 micron with SS filter and gauges. Miniature type, plastic body, filter & drain assembly etc as parts of air filter regulator are not acceptable. AFR MOC shall be SS316.

16.0 PRESSURE RELIEVING DEVICES

16.1 **Pressure Relieving Devices**

All Pressure Relieving Devices shall be sized in accordance with applicable local and national code requirements. Formulas shall be in accordance with API RP 520, 1990 and ASME Codes section I and VIII.
Percent Overpressure and Accumulation used in calculation of sizes of relieving devices shall be:

Overpressure
3% - Steam services where ASME Power Boiler Code applies.

10% - Gas or Vapour service.

15% - For liquids and pump discharge lines with 6% system accumulation (Power Boiler Code) and with 10% system accumulation (Pressure Vessel Code)

21% - Fire exposure on unfired pressure vessels.

10% - Liquids for thermal relief of pipelines or vessels Accumulation

10% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies

16% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies and the system is protected by means of multiple valves.

16.2 Nomenclature

Nomenclature used shall be in accordance with API RP 520.

16.3 Safety and Relief Valves

Safety and Relief Valves shall normally be direct spring loaded type.

Balanced bellows valves shall normally be furnished for relief into closed flare and slowdown systems, if the developed back-pressure exceeds 10% of the set pressure. Bellows shall also be specified where leakage of gas from the seals are not permitted during normal plant operation.

Full body Steam jacketing shall be provided to keep some valves and lines warm at all the times to avoid the solidification of the lading fluid.

Full nozzle types of valves shall be specified for sizes 1” or above.Nozzle and disc MOC shall be SS316+stellited as a minimum requirement

Test gags shall be furnished on all safety and relief valves. Test gags shall be removed and transferred to Owners possession after testing, clearly labelled with the tag number of the valve.

Lifting levers shall be furnished for exposed spring bonnets on valves on steam and hot water services, on air valves and hot water service valves with closed bonnets.

Bonnet construction shall be plain closed bonnet for toxic and inflammable gases as well as vapour and liquids. Exposed bonnet shall be specified for steam service and in Boiler feed water service above 200°C. Bonnet extension shall be used above 400°C.

Springs shall be of carbon steel with Cd plating for normal process operating temperature of (-) 25°C to 200°C and tungsten alloy or high temp. alloy steel above 200°C. Stainless steel spring may be used for services below (-) 25°C. Carbon steel with Cd plating is permitted above 200°C for open bonnets. Springs shall be rustproof.

Blowdown shall be between 5% to 7% for gas servie and 10% for liquid service. For steam services under Power Boiler Code as per ASME the blowdown shall be 3% - 4%.

All connections shall be flanged in general with facing and rating in accordance with the piping specification or API 526 whichever is higher.

Centre to Centre dimensions shall be in accordance with API 526.

The manufacturer must specify Cold Differential Set Pressure (CDSP) for each pressure relieving devices at 25 deg. C.

All valves shall have the facility of blow down adjustment except thermal relief valves. Safety valve sizing calculations shall be submitted for review.

16.4 **Rupture Discs**

Rupture discs may be used in lieu of or in combination with safety and relief valves, where applicable or required. MOC shall be min. SS316. For disc rupture trip or alarm disc shall be with bursting sensors.

Rupture disks shall be sized and specified in accordance with API RP 520 or ASME sec. I & VIII. Any restriction in the discharge area caused by the disc holder assembly shall be considered in the calculations. Orifice calculations and corresponding selected body sizes shall be submitted for review.

Rupture discs shall be reverse buckling and non-fragmenting type, in general and shall be supplied in pre-torque holder assembly which shall fit inside the inner diameter of the bolt circle of standard flanges. Disc and holder material shall be SS316 min or better and shall be compatible with the process fluid & bursting requirements.

Rupture disc devices shall be supplied as a complete unit i.e. disc holder and the required number of discs. The scope shall also include pre-assembly screws, jackscrews, companion flanges, studs, nuts & gasket.

For vacuum service, vacuum supports shall be provided. Retainer ring shall also be provided to hold the vacuum support & rupture disc in place.

16.5 **Pressure and Vacuum Relief Valves**

Pressure and Vacuum Relief valves for storage tanks shall normally be of the weight loaded or pilot operated type, and sized in accordance with API RP-2000 Tank Venting Code, or Local Codes if they govern.

16.6 **Thermal Relief Valves**

Thermal Relief Valves Safety / relief valves for thermal expansion (on liquids) shall be flanged type. Thermal relief valves shall be flanged with Inlet 1" and outlet 2" with typical "D" designation and typically 0.38 cm2 orifice size

16.7 **Centre-to-Face**

Centre-to-face dimensions shall be in accordance with API 526.

17.0 SOLENOID VALVES

Solenoid valves shall normally be used to actuate other instruments/valves connected directly to the process. The SOVs shall be direct acting type. Protective enclosure shall be IP 67 and the coil insulation suitable for continuous operation in 85 degree C ambient temperature (max. surface temperature in sun) for outdoor service. Body materials shall normally be stainless steel SS316. Solenoid valves will be powered by 24V DC plus 10% on continuous basis, insulation class 'H' and orifice size 9 mm. The D.C. solenoids shall not have in built rectifier to operate with A.C voltage. The d.c. solenoids shall be used as an alternative to A/C solenoids only for low current intrinsic safe operations.

All solenoid valves shall be fitted with 1/2" NPT (F) SS316 double compression ,IP-65 ,EExd cable gland connection.

All SOV's body, trim, coil housing and spool piece MOC shall be SS316L only. All SOV spool valves shall be provided with manual override (MOS) facility wherever possible to check the SOV operation locally without energizing the coils.

18.0 CONTROL AND SHUTDOWN SYSTEM

CONTROL AND SAFEGUARDING DESIGN CRITERIA

EXPANDABILITY

Systems shall be designed with minimum 30% installed pre-wired spare capacity for

all I/O type cards of each category for project development. The sparing supplied shall be for “complete loop”; i.e. corresponding marshalling, power supply, terminals/barriers, interposing relays, pre-fab cables other accessories, etc. and its space, and panel cut outs where appropriate, etc.

To allow for future expansion 30% spare capacity shall be allowed & terminated in multi core cables, junction boxes, marshalling racks, etc.

Communication networks and cables shall have a spare load capacity of 50% as a minimum.

Plant wide networks shall have a node connection spare allowance of 50 % as a minimum.

Local networks shall have a node connection spare allowance of 30 % as a minimum**.**

Approx 20% empty space (For Cabinets and Consoles) shall be considered in Rack Room and Console Area for future project expansion. LSTK to consider the same.

The control system shall be a modern Digital Distributed Control System (DCS) located in the Control Room. The system shall be reliable, fault tolerant and build up in modules from the suppliers’ standard components and software. The system shall have facilities for plant control monitoring and alarm handling. It shall be self-diagnostic, self documenting and contain all the functions necessary for advanced regulatory control.

The control system shall comprise racks with I/O devices, control cards, CPU cards, hard disk, system buses, and a sufficient number of operator stations with colour video display units (VDU) with dynamic graphic generation capabilities to ensure complete access to the process during normal operation, start-up, and upset conditions. The operator shall use dedicated operator keyboards to manipulate the DCS.

Various colours used in Graphics should be as follows

- Red: Stop, Valve close, Alarm points
- Green :Pump running, Valve opening
- Flashing Yellow: intermediate state
- DCS graphics background shall be grey

The DCS shall have the following main components. Detailed specifications of each of them are given in subsequent sections. The system shall be 100% fault tolerant and dual redundant. This means, all central control processors, all communication processors and all other central rack and individual node's common cards, all the communication cards, networks and cables, all power supply modules, all I/O modules for closed loops and interlock I/Os etc. shall be 100% fault tolerant and dual redundant, except individual IO cards of the system. All the system hardware of DCS shall have ISA G3 level corrosion protection (including all packages and offsite & Utility plants). Since redundancy at I/O card level is not envisaged, the failure of a single card from complete system shall not affect more than the I/Os supported by that particular I/O card. Redundancy for critical closed loops and ESD I/O is required. It means all the hardware except I/O cards shall be 100% fault tolerant. All the hardware including control/communication processors, networks, cables, all type of system cards, all type of I/O cards, all power supply modules shall be hot replaceable.

The DCS will be housed in a control room designed strictly in compliance with the requirements for electronic instrumentation.

The DCS will monitor and control the following main units:

1. AN melt plant

Each section in above unit, shall have independent and redundant DCS controllers. No cross-wiring shall be acceptable. However trip interlock shall be incorporated in one single SIL-3 TMR/QMR ESD system.

18.2 DCS Functions

The DCS will perform, as a minimum the following functions:

Data Display
Process Control
Process and system alarms
Logging
Real Time trends & Historical trend
Dynamic Graphics
Report Generation (shift, daily, weekly, monthly and on demand)
System diagnostics

18.3 Data Storage and Retrieval

Data storage and retrieval will be provided on hard disc and on DVD or DAT. The trend shall be recorded as follows:

Analogue signals

Last hour	Every 1 second.
Last 24 hours	Every 1 minute.
Last 30 days	Every 1 hour
Last 1 year	Shift averages
Last 2 years	Daily averages

Alarms Last 48 hours (Minimum)

18.4 **DCS Operator Interface**

For Details of OS/ES please refer Annexure -3 System configuration.

1 Nos. auxiliary bay for housing instruments, push buttons, alarm panels etc.

1 Nos. (75") LVS

Other Devices

1 Nos. Set of emergency push buttons to be engineered and wired to Emergency Shutdown System

1 No. Interface for ESD (redundant)

1 No. Interface for machine monitoring system (redundant) if applicable

1 Nos. Ethernet connectivity (spare)

1 Nos. Modbus connectivity (spare)

18.5 **Process Controller Cabinets**

The process controllers will contain the microprocessor based system capable of combining continuous, sequential and discrete functions in order to the requisition of analog and discrete signals, sequential and continuous control.

The process controller cabinets shall/may have incoming and outgoing cable marshalling facility. All field cables shall be terminated in marshalling cabinets in

single tier Wago make cage clamp type terminals. Isolators shall be provided for all intrinsic safe input and outputs. All thermocouple signal wiring from terminal to respective isolator/input card shall be through field mounted temperature transmitter. Head mounted temperature transmitter shall not be used.

The signal I/O cards may also be installed in Process Controller Cabinets.

No I/O racks shall be installed in MCC room. For interfacing with MCC, Marshalling panel shall be installed in Control Room only.

18.6 DCS Redundancy Philosophy

In order to increase the system availability and then the continuity of plant operation, redundancy shall be provided as follows:

100% fault tolerance and dual redundancy in DCS shall be for Controller cards, all communication cards and buses, all control buses, all type of common cards in the system, all power supply modules, all I/O modules for closed loops and interlock I/Os, buses, Ethernet modules. The failure of any single I/O module for open loop shall not affect more than the channels being catered by that particular I/O card. Dual redundant power supply modules for each dual redundant controller shall be dedicated.

18.7 Multiloop Controllers and Input/Output Cards

All multi loop shared controllers will be redundant with 1:1 redundancy. The control processors shall be of fault tolerant type and both shall be active with cyclic changeovers. All I/O cards for close loop applications shall be capable of holding the last value in case of open condition of input. Input cards for specific open loop inputs used for calculation functions must also be capable for holding the last value. As otherwise the same function shall be built up in DCS software.

18.7.1 I/O Segregation:

The I/O card segregation for DCS shall be as per above physical units of the plant. Additionally, if there is more than 1 machine in one section/unit of the plant, all type of I/Os for diff. machines shall be segregated at I/O module level. This means one I/O module shall not cater to I/Os of more than one machine, within same section also.

18.7.2 Controller Loading

Each Controller loading shall not exceed more than 50% (hardware and software load

of each controller) in any case, after implementation of complete project and running at peak load. In case more controllers are required to meet 50% loading criteria, CONTRACTOR to include additional controllers without any cost implication.

18.7.3 **DCS/ESD requirements**

a) All DCS/ESD/PLC (irrespective of plant/unit) systems' all cards shall be supplied with ISA G3 level or equivalent coating for environmental protections.

b) All digital output from DCS and ESD shall drive interposing relays of OMRON/paramount make, 4 Change over (4 NO/NC) with socket mounted relays with LED indicators and built in surge suppressor. The contact rating shall be minimum 230 V AC/ 5 amps. Any DO Channel from DCS/ESD shall not be directly connected to any devices without interposing relays. DIs coming from electrical side, should be connected to card through interposing relays.

c) DCS shall be a large and expandable type system available with the vendor. The system cabinet and marshalling cabinet should be separate. Further segregation shall be made on voltage level basis.

d) Vendor to provide unit performance monitoring for DCS and the following functions are required:

- Material and Utility Balances
- Unit production and utility (steam, fuel, and electricity) balance calculations and (periodic) reporting.
- Process Performance Monitoring
- Energy consumption related to production. Monitoring and reporting of final product Qualities.

e) The system architecture shall be compliant to IEEE 802.XXX with dual redundant and 100% fault tolerant BUS/RING topology. System shall be fully open with DDE/OPC&ODBC compliant. DCS System availability shall be better than 99.995%.

f) One OPC server shall be provided with DCS/PLC system with OPC connectivity to ERP/MIS system/data exchange for 2 nos. of systems. Tags shall be based for these 2 nos. of systems. Vendor shall also provide necessary software / hardware (OPC server & software) and manpower support / assistance for establishing connectivity of the system with ERP & other systems. OPC server tag license must be for minimum

5000 tags.

g) DCS and ESD I/O cards channel density shall be as per following:

I/O cards' Channel density shall not exceed the following limits

Analog Input	16 Channels
Analog Output	16 Channels
RTD/T/C Inputs	16 channels
Digital Input	32 Channels
Digital Output	DCS-32 Channels /ESD-16 Channels

h) All I/O cards in individual category shall be of same type/model/revision only. No diff bulk I/O cards or I/O cards with degraded features shall be accepted in any of the category in a mix mode supply.

i) ISOLATIONS

Analog I/Os to Field : Galvanic Isolation through safety barriers

Analog I/Os Module : Channel to Channel Galvanic Isolation

If individual channel to channel isolation is not available with DCS/ESD vendor, then only Isolation shall be provided in a group of 4 channels as per DCS/ESD vendor design.

Digital Input to Field: barriers + optical isolators on cards.

Digital Output to Field: Interposing relays + smart barriers for monitoring purpose.

j) PANELS:

All panels shall be either 1200 mm (wide) x 800 mm (depth) x 2100 mm (height) or as a special case 600 mm(wide) x 800 mm (depth) x 2100 mm (height), RITTAL make only, with 100 mm black powder coated metal base frame and with colour shedding of RAL7032 (Siemens Grey) and removable gland plates at bottom only. This applies to all types of instrument panels to be used in the whole project like various PDB, Electrical / Instrument panels, Third party device panels like wood word digital governors, Bentley Nevada system hardware panels, etc.

k) PLC (ESD) and DCS marshalling panels shall be separate. PLC (ESD) and DCS system hardware cabinets shall also be separate.

l) All A/D converters of system I/O cards shall have resolution of min. 13 bits and all D/A converters of system I/O cards shall have resolution of min. 10 bits

m) There shall be 20% installed spares minimum 1 no., installed and wired capacity for I/O cards of each category in DCS, including all peripheral termination modules, prefab cables, Relays, Safety barriers, etc

n) All marshalling and system panels shall have minimum 20% wired spare capacity for future expansion (should be possible with the same wiring philosophy).

o) There shall be time synchronization facility available in DCS for diff. other sub-systems like ESD, SCADA, etc. In this case DCS clock shall remain a MASTER clock and it will synchronize all other sub systems of the plant.

DCS System Redundancy

Following system redundancy shall be available as a minimum.

a.	Controller (CPU for control, I/O communication, network communication)	1:1
b.	Input / output cards closed loops	redundant
c.	Communication Bus	1:1
d.	I/O communication modules with CPU (I/O bus between CPU and I/O with all necessary hardware)	1:1
e.	Main data highway	1:1
f.	Communication Cards	1:1
g.	System Device	1:1
h.	Power supply (Power supply for all CPUs, I/O power supply modules)	1:1
i.	Serial (RS-485) Modbus (For Interlock PLC)	1:1
j.	In case of client-server system, server shall be redundant (Raid-6 Configuration)	1:1

I/O bus and I/O interface card at controller rack shall be redundant

Connectivity from Upstream redundant device to downstream redundant device shall be through redundant device or cable.

Loading philosophy (with 20% installed spares and 20% future expansion)

Control Processor	50%
Communication Processor	50%
Communication Bus	50%

18.8 Scanning Time

200 msec. for flow and pressure control loops.
500 msec. for all other control loops
1 sec. for temperature acquisition loops
1 sec. for all other acquisition loops

18.9 System Communication

All communication devices such as bus and cards shall be redundant with 1: 1 redundancy

The system will be interfaced with the following foreign devices:

ESD System
Machine monitoring system
FGS

Analyser system

Any other PLC system
Any other system where data has to be sent to control system.
Customer LAN through hardware firewall

Other Interfacing shall be as per project requirement.

At least 1 Nos. redundant foreign device interface shall be provided as spare in both for future use.

18.10 DCS System Power Supply

The system shall be powered from uninterrupted power supply at 115 V A.C. The system shall further provide redundant D.C. power for all the control stations, communication devices, I/O cards etc., however the LED units shall operate on A.C. only.

18.11 Other requirements

There shall be minimum 2 nos. of dual redundant/fault tolerant controllers in the proposed DCS system with control area segregation. However, the detail segregation

shall be carried out during detail engineering of the plant and after studying inter-relation of various units/sections of the plant as per OWNER's requirement from operation philosophy point of view.

Operators' Keyboard

This shall be used by plant operators along with each Operator station display unit for operation of the plant. It will have multiple assignable keys to directly open pre-programmed display as well as few other system typical templates for selected tags including controller group display, trend, configuration display, alarm summary pages, etc. There shall be both numeric and alphabet keys and dedicated function keys on membrane type operator keyboard each of which must be freely programmable. There shall be one no. of operator keyboard with each of the operator stations.

This shall be membrane type fully dust proof and spill proof & corrosion proof.

Key lock switch / password switch shall be provided for operator/supervisor/engineer security levels

Dummy Consoles/Filler Panels shall be provided to maintain aesthetic and mounting instruments like indicators, annunciators etc. as well as for push buttons, lamps, key switches, paging system hardware.

Entry into the Marshalling Panels shall be through bottom mounted MCT blocks (SS316 MOC).

18.12 **Consumables**

One No. Spares printer cartridges with each printer to be provided.

19.0 EMERGENCY SHUTDOWN SYSTEM (ESD)

19.1 **General**

The ESD shall be a system with a very high degree of reliability, SIL-3, TUV certified. The system shall be microprocessor based programmable logic control (PLC) with fault tolerant redundant processors based on TMR/QMR technology.

The emergency Shut Down System shall perform any of the following functions for safety of the plant from control room.

- Total Shut Down
- Unit Shut Down

- System Draining and Depressurisation

- Start-up interlocks shall be included in ESD.

ESD system shall be a standalone fail safe system independent of other areas of the plant. ESD system instruments, junction boxes and marshalling cabinets shall be independent of other systems.

The following shall be adhered to while selecting the TMR/QMR system

a) TMR/QMR CPU's shall be applied.

b) If a CPU fails, the other(s) shall continue to operate. Single CPU operation system to be certified to operate without any time limitation of faulty CPU repair.

c) TMR/QMR buses shall be applied.

d) TMR/QMR analogue inputs and outputs shall be applied.

e) TMR/QMR digital inputs shall be applied.

f) TMR/QMR digital outputs shall be applied.

g) Redundant communication interfaces shall be supplied.

h) Redundant Power supplies shall be supplied.

i) In the event of a failure of a fault tolerant component, power supply or other function, of the system shall change over to "single mode" operation without causing nuisance trips and also generate alarm on DCS Operator and Engineering console, also on ESD Engineering Station.

k) In case of failure of complete processor system, i.e., system outputs shall take fail safe state automatically unless otherwise specified.

Operator interface for critical trips shall be mosaic display with illuminated push button for trip, reset, inactivation etc. and LED indication for each element of trip & actions.

The operator will be informed about a trip situation by a warning sound (to be different from the audible signal from the alarm system), and a LED display will clearly inform about the alarms in trip position. The first up alarm will flash.

Scan time shall be maximum 250 msec. CPU shall be TMR/QMR. CPU loading shall not exceed 50%, Bus Communication modules, Power Supply and I/O cards shall

have 100% redundancy and fail safe certification.

System Redundancy

Following system redundancy shall be available as a minimum.

1.	Controller (CPU for control, I/O communication, network communication)	1:1
2.	Communication Bus	1:1
3.	I/O communication modules with CPU (I/O bus between CPU and I/O with all necessary hardware)	1:1
4.	Main data highway	1:1
5.	Communication Cards	1:1
6.	System Device	1:1
7.	Power supply (Power supply for all CPUs, I/O power supply modules)	1:1

However, lamp drive cards, supporting mosaic need not be redundant also. Active isolator / barriers (MTL / P&F make only.) need not be certified for fail safe operation.

The operator can bypass trip alarm inputs, which may be necessary in abnormal situations. A lamp shall indicate that the trip alarm is inactivated. The operator will be warned by sound and fast flash if the inactivated circuit goes in alarm status.

Alarms generated from the DCS will be provided for most trip-alarms as pre warnings. Separation in nomenclature of alarms clearly identified the origin of alarms i.e. from DCS or from ESD.

The system shall include an event recording system, and it shall be considered to store about 100 ESD events. Sequence event recorder of 1 msec, resolution to be envisaged.

Display colours shall be in accordance with the following:

Alarm and Trip (safety operations) : Red
Pre-alarm for trip (safety operations) : Orange
Indication for by pass of trip (safety operations) : Blue
Equipment in operation (alarms and pilot lights) : White
Ready (standby of equipment) : Green

The critical trip shall be displayed on mosaic tiles of 18x18 mm size.
The mosaic panels and event recorder shall be mounted on auxiliary consoles of DCS operating console.
Consumables like printer paper, cartridges, fuses etc shall be supplied along with the ESD system for a minimum period of one year duration.

19.1.1 ESD requirements

Some of the ESD requirements have been covered in DCS sections also.

a) ESD system shall be fail safe, TMR/QMR TUV certified for all hardware and software, SIL-3 compliant and more than 99.99% availability.

b) Fuse terminal blocks with blown fuse indicator is required for DO's.

c) All interlocks shall be realized in ESD only. This ESD shall be Safety Class-6 (as per DIN19250/VDE801) and SIL-3 as a minimum, as per IEC61508, irrespective of plant's safety integrity level. This shall be either TMR safety ESD system. The crippled mode running for unlimited time period, without degradation in safety class is a mandatory feature of safety ESD.

d) The redundancy shall be implemented at Processor level, for all common hardware of central racks, all communication cards, highway and all type communication and control buses, power supply modules, all type of I/Os. All I/O cards shall be of fail safe and testable modules in the whole system. The complete interlock shall be realized for whole plant in this centralized Safety Class-6 ESD only, irrespective of process safety integrity level of the plant.

e) The ESD shall have scan time of 250 msec and SER with 1 msec resolution for time stamping with minimum 512 inputs

f) I/O segregation and channel density as specified in DCS section.

g) Maintenance override switches (MOS) shall be soft type. One hardkey shall be provided in Auxiliary console for the Activation of the MOS.

Process override switches (POS) shall be soft type.

POS & MOS philosophy shall be implemented in soft in DCS with its actuation feedback from ESD system for all individual sensors. Further One hardkey with three independent switching elements for 2oo3 voting logic shall be provided in Auxiliary console for the Activation of the MOS. Individual sensor hardwiring is not required

h) Auxiliary Hardwired console

Auxiliary consoles shall be provided for high priority discrete hardwired safety functions, which shall be manually operated. The console shall be installed adjacent the operator station console, near 22" LCD color monitors in the control room. The console shall be equipped with, Mushroom top Emergency push buttons for emergency shut-down action only. All Emergency stop and manual start push buttons shall drive an interposing relay located at IRC and one contact of this relay shall be wired to MCC for manual start/stop of pump/motor and another contact shall be wired to ESD for feedback in SOE as pot-free DI.

All trip parameters shall have override switches and their output status lamp on console.

Indication for trip by-pass shall be through LED on DCS auxiliary console.

i) Repeat output from ESD (with separate channel and separate relays) shall be hardwired to DCS for all closed loop control valves to put them in manual mode and switch output to safe value in case of interlock actuation.

j) Information exchange between DCS/ESD shall be one way (From ESD to DCS) only and shall be used only for information purpose. No control/decision making shall be realized based on this information on either side. For this purpose, all necessary signals shall be hardwired between ESD and DCS. Each ESD shall have its own dual redundant link with DCS.

k) All interlock and control transmitters shall be separate right from field junction box to ESD/DCS marshalling panels.

l) Those parameters, which are directly or indirectly tripping the plant or may cause production loss, shall be wired with 2 out of 3 transmitter trip voting interlock in ESD. There shall be three separate analog input channels in three diff. AI cards shall be used for this purpose in ESD. Same thing is applicable to Digital inputs also.

m) All critical control valves, which are covered under SIL-3 requirement shall be equipped with double solenoid valves with two separate output channels from ESD from two diff. DO cards, via two separate interposing relays, MCB's & fuses.

n) All shutdown related On-Off valves, for which the position switches are used in interlocks shall be with 2 out of 3 philosophy right from the position sensor, field junction box and wired to three diff. Digital input cards three diff. channels in ESD.

o) All MCC DI/DOs and all Process DI/DOs (SOV, Lamps, interface with DCS, etc.) shall be wired in separate DI/DO panels. All MCC DI/DOs shall be wired in Digital Interface panel for electrical/instrument interface IRC.

p) Centralized DCS and Centralized ESD marshalling panels shall be separate.

q) Centralized DCS and Centralized ESD system hardware panels shall be separate.

r) All major machines Emergency trip push buttons on Field local panels and those located on Dummy Operator console at Control room shall be triplicated with 2 out of 3 philosophy with one actuating device with three element push buttons and switches connected to three separate digital input channels of three separate input cards of ESD.

s) ESD shall be TUV certified TMR/QMR and 100% fault tolerant at all levels.

t) No field switches shall be used for ESD inputs. All trips/interlocks shall be realized through 2 wire, 4-20 mA DC SMART transmitters only. .

u) Smart barriers with line monitoring features shall be used.

v) OEM commissioning engineers shall be present for all the commissioning activities for specialized instrumentation systems like, Bentley Nevada Systems, Gas Chromatographs Gas Analyser, DCS, ESD etc. The OEM engineer for DCS, ESD shall be present for 1 month after successful commissioning of the plant or as per ITB time whichever is more.

w) In addition to the specified training, CONTRACTOR is responsible to impart DCS/PLC configuration/operation and maintenance training to OWNER's personals at sub vendor's works as per ITB. Also training for specialized instrumentation systems like Bentley Nevada Systems, Gas Chromatographs shall also be imparted to OWNER's personals at sub vendor's works for minimum 7 man days (1 week for 2 persons) on each system, by CONTRACTOR.

19.2 System Cabinets

19.2.1 Interlock Marshalling Cabinet

Marshalling cabinet(s) are foreseen for both incoming to Interlock system and outgoing from Inter ('from' and 'to' field) termination. The interlock marshalling cabinet(s) shall also accommodate the repeater power supplies for the field transmitters, galvanic isolators for all inputs, trip amplifiers, output relays etc.

The termination strips shall be arranged or grouped for inputs/outputs 24VDC, 115VAC, etc. both for inputs as well as outputs.

The terminals shall be of the WAGO/WEIDMULLE/PHOENIX make cage clamp type single tier design (double tier design shall be avoided). Terminal stack for each unit shall be supplied with approx. 30% extra terminal points as spare/future provision in addition to the existing inputs and outputs.

Physical separation between the terminal stacks/points shall be maintained for the intrinsically safe and normal termination. Also the termination area shall be physically separated from the electronics area there by sealing the latter from dust ingress.

19.2.2 Interlock System Cabinet

An interlock system cabinet is foreseen, containing the interlock and trip system PLC, circuitry for the interlock display/operator stations, connectors for the display/operator stations and event recording system.

Cards of identical/similar functions shall be grouped together in the racks.

The system design including layout shall take into account the following factors.

- Ease of testing and simulation
- Ease of maintenance and operability
- Ease of modification and expansion

19.2.3 Interconnection Cables

All interconnection cables beyond termination strips in the Interlock marshalling cabinet shall be part of interlock system and would include cables between:

- Interlock marshalling cabinet and interlock system cabinet.
- Interlock system cabinet and panel mounted display/operator stations.
- Interlock system cabinet and event recording system
- Event recording system printer and video display
- Any other cables required within the IMC and ISC not covered above.

About 30% additional I/O cards (each type) shall be pre-wired into the system over and the total number of inputs/outputs indicated. This will include galvanic isolators, trip amplifier, isolating power supplies for transmitter etc. alongwith different type of

logic cards.

The Interlock system shall also include following test diagnostic tools:

- Logic tester
- Test adapter
- Test signal generator

19.2.4 **Event Recording System**

The Event Recording System shall be a microprocessor based system for recording the change of state of all inputs, and operator actions in chronological order on a high speed digital printer.

Apart from total inputs of the plant with a scanning period of 10 millisecond, 50% spare inputs to be provided shall be in the scope of the bidder. A buffer memory shall be included in the system for holding at least 100 events on a continuous basis.

The reporting in general shall contain:

- Date : Year Month Date
- Time:
- Input No:
- Text : 32 characters Alpha-Numeric
- Status : Failure/OK

Programming/changing of already loaded programme shall be possible through the keyboard.

- Programming text and status
- Changes in existing test/modification in text
- Disabling or enabling a group or a particular input for scanning

In case any EPROMs are provided for storage of input text, necessary EPROM programming facility/unit shall be included.

If volatile memories are used, back-up (Lithium Oxide cells) of min. 72 hours shall be included in the scope of supply.

19.2.5 **System Clock**

The basic frequency signal shall not be derived from the mains frequency. A crystal oscillator shall be provided for the purpose. The resolution of the clock shall be adequate. The system clock shall have facility for synchronising with a DCS shall be

provided with battery back-up of sufficient time with Lithium Oxide cells.

19.2.6 **System Terminal/Printer**

A system Terminal cum printer shall be provided.
- As an output terminal for the event recorder system.
- As an operator communication interface with event recorder system.

The event recorder shall print the power outages, power returns along with date and time.

19.2.7 **Video Display Station**

A coloured VDU shall be provided for display of the latest status of the Interlock and trip input/output information.

The inputs/outputs shall be divided into convenient groups and subgroups and allocated to a number of pages in the display.

Inputs and outputs in alarm conditions / trip condition shall be conspicuous on the display either by bold characters or reverse video.

The following information shall be displayed on a page as a minimum.
- Year Month Date
- Hr. Mt. Sec (Time)
- Groups/Sub groups : Name and Text
- I/O Tag No.

It shall be possible to affect any program changes in the event recording system memories through the video display unit.

19.2.8 **Power Supply**

An uninterrupted Power Supply to ESD shall be provided to the power distribution cabinet of ESD at 115VAC +/- 10%, 50Hz +/- 3%.

In case rectification to DC is involved, rectifiers shall be dual redundant and both shall be 'hot' (on line) so that failure of one rectifier will not cause a system trip. Provision shall be included in the system to annunciate the rectifier/D.C. power supply failure.

Philosophy of power isolation and over load protection (switch fuse units) or only over load protection shall be extended upto individual card level, while designing the

system, so that, minor card failures can be localised for easy rectification. Also this will avoid major down time on the system. Provision for online replacement of faulty power supply cards without adversely affecting power supply to DCS, is required.

Earthing /Grounding bus bars for terminating shields of the cables shall be provided on the cabinet.

19.2.9 **Annunciator**

The Annunciator display stations will consists of:

- LED Lamps

- Split type architecture with lamps and electronics separate.

- All connections with interlock system cabinet and interlock marshalling cabinet shall be through plug in connectors.

- About 20% spare capacity shall be there.

- All switches and status lights indicated below shall be an integral part of Display Modules.

- Supply shall include mounting accessories and about 20% of unassembled extra LED lamps.

19.2.10 **Precision & Accuracy**

The isolator, repeater modules/trip amplifiers for analog inputs shall have a total accuracy of less than 0.2% of full span for the measurement circuit.The accuracy and stability for thermocouple trip amplifiers shall be +/- 0.5%.

19.2.11 **DCS & PLC, Spare Philosophy:**

Installed Spares	I/O Level	30%
	Marshalling	30%
Spare Space	I/O Level	30%
	Processor	50%
	Marshalling	30%
	Rack	

20.0 CONTROL ROOM

Control room (CR) shall be completely blast proof building. All doors of CR shall also be blast proof. In front of all the doors blast proof walls shall also be provided.

Control Room shall be suitably furnished with Tables / chairs of Godrej makes.

There shall be single control room for whole plant

Besides housing of control panel/operator's consoles, rack area for marshalling cabinets, separate cable termination room for field cables, Engineering console room, process operator's room, HVAC/ Air handling room(s), UPS and UPS battery room, toilets, rest rooms etc. shall be accommodated in the control room building in general. Tentative placement of all cabinets, panels, consoles, etc. shall be made by the bidder for ascertaining the sizes of the control rooms.

The instrumentation cable entry and all other cable entries (UPS room, HVAC etc) to the control room shall be through MCT (multi-cable transit) SS 316. Cable way in control room shall be below access level through cable trays as per ITB.

The overground cable trays shall terminate just below the cable entry opening in the control room to have a natural slope for cable laying at the entry. The electrical power and control cables terminating in the UPS room shall have separate entry.

The operator's console area, rack area and engineering console room area shall have false flooring above 1.5 mtr from ground level for cable laying. The control room operator's area shall have two entry /exit but one should preferably away from the plant area as a safe passage.

The Operating console room, the rack area, engineering console room, operator's room(s), UPS room (not battery room), shall essentially be air conditioned as a minimum. All other rooms in the same building shall also be air conditioned.

1 No's of corrosion monitoring (copper & silver) PURAFIL make must be mounted in rack room of each control room. The location of the monitors must be near the duct and cable entry.

The false ceiling for air conditioning shall be at a height of 3 metres. The false flooring should be capable of withstanding a loading of 1200 Kg/m2. All false ceiling in the building shall be of plain/perforated panels, square edge type of 84 mm x 12 mm (min.) deep having 23 mm recessed flange rolled and formed out of 0.5 mm thick

aluminium magnesium alloy stove enamelled on both sides. 25 mm thick resin bonded mineral wool insulation of density 48 kg/cm3 as per international standard shall also laid over panels.

Wherever cavity flooring is provided in the control room the floor panels shall be of 35 mm thick super phenol formaldehyde bonded particle board having fine termite/moisture resistant quality with 2 mm thick topping “MICOLAM” or equivalent high pressure laminated rough textured malt finished. These panels shall be supported on adjustable height M.S. Jack pedestal made of 25 mm dia MS rod. The cavity floorings shall be designed to withstand a load of 1200 kg/m2.

The internal walls of the operator’s control room/rack area shall be “Vineratex” or its equivalent decorative texture coat of synthetic plaster of light shade.

a) International Norms/Certifications followed for Designing Control Room & Control Desk

i) International Design Norms:

- ISO 11064 – Ergonomically Designed Control Room & Control Desk

ii) Quality Certifications for Control Desk:

- Greenguard by Underwriter’s Laboratory
- Greenguard Gold by Underwriter’s Laboratory
- BIFMA X5.5
- FSC (Forest Stewardship Council) for Control Desks
- ASTM e-84 for Surface Burning Characteristics.
- RoHS (Metal & Electrical Components)
- Seismically Tested Console (For Zone 5)

iii) Quality Certifications for Control Room (Wall Paneling/ Partition & Ceiling)

- ASTM e-84 for Surface Burning Characteristics for Wall Paneling & Partition.
- Sound transmission class (STC) value of 35db for Wall Paneling & Partition. (according to IS: 9901 (Part III) – 1981, DIN 52210 Part IV-1984, ISO:140(Part III) -1995
- Noise Reduction Coefficient (NRC) value is 0.30 for Ceiling – Sound Absorption Coefficient by diffuse field method; IS: 8225-1987 “Measurement of Sound Absorption Coefficient in Reverberation Room” (Equivalent to ISO: 354- 1985 and ASTM 423-90 Sub-Div#5.07/A/Doc.3/TP#14)

b) Instrument Calibration Work Bench and Test Equipments

Apart from a central cabinet room (size: as required), control room (size, as required) and a central engineering room, one room for shift Technicians and one room for Instrument calibration shall be considered in the same building with central air conditioning.

The room shall be designed/sized and constructed based on various following requirement:

i. It shall accommodate a full-fledged test/calibration work bench of approximately 4 meter x 1 meter size.

ii. It shall allow storage of various documents cupboards/test catalog/manuals, and file racks for various calibration report.

iii. It shall include a wash basin.

iv. It shall have instrument air taping inside the room at work bench.

v. The test/calibration room shall be preferably in the vicinity of adjoining instrument technician's maintenance and rest room.

Licensed Configuration software of all the smart instruments (PT, DPTs, RADAR, Ultrasonic meters, specific gravity analysers, mass flow meters, positioners etc), isolators (temperature isolators etc) with suitable connectors having USB connectivity with laptop shall be provided.

c) Instrument Maintenance Room

The maintenance room will be located in the control room. The minimum requirement of instrument maintenance room shall be as follows:

i. It shall be equipped with file racks/cupboard and pigeon hall lockers for storing various instrument tools/tackles.

ii. It shall be equipped with wash basin and instrument air supply.

iii. It shall be without air conditioners.

iv. It shall be provided with 110V AC /230V AC (non-critical) for testing/calibrating control valves/solenoid valves and will be used to perform these type of heavy jobs like dis-assembling, washing, cleaning of various flow meters, tubes,

sensors, etc. It shall also be provided with Instrument air header with sufficient tappings.

v. It shall be provided with lockable doors.

vi. It shall be furnished for minimum 4 technicians and two working tables.

vii. It shall also have two nos. heavy but small metallic stools, vice and grinding machine, etc.

21.0 PACKAGE UNIT INSTRUMENTS

21.1 The use of field instruments, control systems/panels for typical equipment packages will be defined as follows as typical.Contractor/Vendor to select any one of the package type (whichever is applicable)

Package Type 1

Package Vendor shall design and supply all instruments as detailed on the Vendor PID's, wiring materials to junction boxes and piping/tubing materials for impulse line and air line inside Vendor's battery limit. Control and/or interlock shall be carried out via Purchaser's own system (DCS and/or ESD system). Vendor shall be responsible for providing all drawings and informationnecessary for Purchaser to correctly configure his DCS and/or ESD system. Vendor shall design for control/logic and indication to be implemented in Purchaser's system.

Package Type 2

Package Vendor shall design and supply all instruments as detailed on the Vendor PID's, wiring materials to junction boxes and piping/tubing materials for impulse line and air line inside Supplier's battery limit.Package Vendor shall also design and supply its own stand alone control system located within a Vendor supplied local equipment. The control system shall preferably be PLC type. The control system will communicate with Purchaser's own control system (DCS) via Redundant Modbus TCP/IP or Modbus RTU for monitoring. Control and interlock signals shall be hardwired. The Vendor shall supply all data and function (including logic, control and sequence narratives, wiring details etc).

21.2 Vendor's scope supply includes:

21.2.1 All instruments for safe and efficient running of the machine. The supply shall include control valves, suction and discharge auto block valves, relief valves, shut off valves,

solenoids, speed indicators, transmitters, electronic governors, pressure and temperature gauges, switches, sensors etc.

21.2.3 Gauge Board to be located near each machine with local gauges mounted on it.

21.2.4 All instrument erection materials such as cables, pipes, pipe fittings, supports, trays, conduits, junction boxes etc.

21.2.5 Tools for service calibration and maintenance

21.2.6 Spares parts for Commissioning

21.2.7 Engineering documentation

21.2.8 Spares, wherever applicable, shall be supplied along with the main item.

21.2.9 Mandatary/Insurance

21.3 Process Alarm, Motor Alarm and Shut Down System

21.3.1 General

Critical alarms and shut downs must be derived from direct process sensors and shall be entirely separated from any other system (including process connection). All trip alarms shall always be preceded by a passive alarm from an independent primary measurement. However, the same primary element can be used for measurement of vibrations and displacement. Critical alarm sensors shall also be independent of shut down sensors, but may be common with sensors used for control or indication. Filled temperature elements shall not be used. Alarm signals from analogue loops shall be derived via a trip amplifier. Inputs from thermocouples shall be provided with cold junction compensation and downscale burns out feature for high temperature shut downs and vice versa. A passive alarm shall warn about the burn-out.

The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.

The logic for alarms (process and motor) and the logic for shut down system shall be independent.

A common output contact for the process alarm and motor alarm system for remote indication shall be provided.

The following additional hardwired Motor signals to be considered:

- Ready to start (for standby pumps)
- Auto/Manual (wherever applicable in emergency services in addition to the above)

For all motors current indication shall be provided in DCS for rating more than 5 KW.

The contact shall be potential free and suitable for low level signals, i.e. gold plated.

21.3.2 Physical Description

The process alarm and motor alarm systems shall be supplied with displays, logic and power supply as an integrated package for flush mounting on the main panel front. Alarm facias may be separated from the electronics by prefabricated cables.

The shut-down system shall be shown in a logic graphic display on 22" LED. panel front as well as on operator console containing the various trip alarms, by-pass lamps and switches, including open and closed positions of any automatic block valves. The logic and duplicated power supplied shall be located inside the panel.

21.3.3 Power Supply

The internal power packs shall have an output of 24V DC, full wave rectified, generated from the 115V AC supply with 50% loading.

21.3.4 Alarm Sequence

The annunciator sequence for process alarms shall be ANSI/ISA-SI8.1, Type "A-14". The sequence required is automatic reset: "The sequence returns to normal state automatically after acknowledgement when process condition returns to normal". The display for motor alarms would consist of two windows per motor, one for running indication and one for "ready-to-start" indication. The annunciator sequence for motor alarms shall be as mentioned above, but with steady light for running and "ready-to-start" respectively and light off by acknowledgement and motor stopped.

21.3.5 **Shutdown System**

The shutdown system for the unit consists of an alarm annunciator and related Interlocking that stops the unit. The unit cannot be restarted before the failure is cleared.

The various shut-down groups shall be sub-divided in such a manner that a trip alarm shall be connected to one interlock group only and any subsequent action shall take place from one shut-down group to another.

The shut-down system shall provide access for contact inputs and outputs from/to outside the process unit, and a common output contact identical to the one for the alarm system shall be provided.

Speed control and over-speed systems shall be independent. There shall be separate TMR over speed trip system for the rotating machines as per the relevant API Code

21.3.6 **Shut-down Presentation**

The annunciator sequence shall be type ANSI/ISA S18.1, Type F1M-14.

The sequence required is “First out” with subsequent alarms to appear in the acknowledgestate - no flashing device operates when subsequent trips occur. On acknowledge first cause of trip continues to flash.

“Manual Reset”	The sequence returns to normal state after acknowledgement when the process has returned to normal and the reset push button is operated.
“Manual Restart”	The interlock module returns to normal state after Manual Reset of the alarm modules and the restart push button is operated.
“Lamp Test”	Operation of the test push button lights the visual display lamps only.
“Manual Stop”	Operates the interlock modules, but not the annunciator, to stop the unit.

21.3.7 **Display and Colour Coding**

The shutdown display shall be arranged as a logic graphic display in the panel front built up out of windows back lighted by two lamps of a colour as defined in General Specification for Instrumentation of this Annexure and with identifying name plates.

The lamps such as the alarm annunciator lamps shall be under rated for extended life. MTBF shall not be less than 7000 hrs. Switches and push buttons shall be logically arranged in the graphic display also.

The maximum execution time for an alarm signal input shall be 50m sec.

21.3.8 Interlocking Module

The interlock logic is locked in by any shutdown alarm. The logic can be reset only when all shut down alarms are back in normal process condition and are reset, the logic is reset manually by operating the “restart” push button.

The output relay for shutdown shall be with normally open contacts (open in shut down state and power less state), contact rating: 220V AC, 2A.

Extra contacts, wired up to terminal strips, are required for signalling shut down status to control room, contact rating: 24VDC, 10mA.

21.3.9 Checking of the Shut-down System

The shut down system shall have provision for on-stream testing without affecting the output relay. Push buttons for test purposes may be placed inside the panel.

By-pass switches shall be provided for each trip inlet.

An alarm display shall indicate which one of the inputs is inoperative and a special sound and flashing light shall warn the operator if the trip circuit goes into alarm status during the by-pass states.

21.3.10 Monitoring and Protection

For the purpose of monitoring the “health” of the machine and for automatic shut-down in case of emergency, a highly reliable continuous monitoring system shall be supplied wherever applicable.

The monitoring system comprises machine mounted sensors and transducers and the monitoring instruments installed in the auxiliary panel the control room.

The monitoring system shall have built in computer interface unit(s) for connection to an overall monitoring and diagnostic computer system.

21.3.11 **Sensors**

The complete system shall be from the same instrument manufacturer, Bentley Nevada 3500 series, in order to have single source system responsibility.

Below is listed the minimum number of sensors required. The list is indicative and should not preclude the vendor from including other parameters which in his judgement are necessary for the safe and reliable operation of the train.

Temperature sensors shall be mineral insulated duplex RTD elements. In all sliding surface babbitt bearings, the temperature sensor should normally be between 0.75 mm to 1.5 mm under the surface of the babbitt to ensure that the wall thickness is sufficient to prevent the oil pressure from penetrating the babbitt.

No common trip DO output of two different parameters from Machine protection system is acceptable (for e.g. Axial/Vibration trip clubbed into one DO is not allowed).

Two sensors per radial bearing (one for redundancy) at the calculated maximum load deflecting bearing under abnormal conditions.

One sensor in each two shoes for thrust bearing on both the active and inactive side.

Sensors on the machine case at various locations in accordance with the machine vendor's recommendation.

Vibration and Thrust position sensors shall be Eddy current proximity sensors in accordance with API 670 latest edition. To allow adjustment and replacement during operation, external probes with no connectors or probe lead wires inside the machine is preferred. If internal probes are provided, they should be mounted on rigid brackets that will not vibrate and the armoured lead wires shall be sufficiently long to terminate in weatherproof connectors outside the bearing housing. Necessary supports, strain anchors and suitable feed shall be used where required inside the machine.

Two sensors at or near radial bearing, 90 degrees apart and normally 45 degree from each side of the vertical centre. Installation at the nodal points shall be avoided under any circumstances. The X-Y probes shall be in the same radial plane through out the machine train. It is desirable that one of the mid turbine probes is a dual probe consisting of a seismic velocity transducer and a proximity probe. The seismic transducer may be un-monitored and used for connection to diagnostic instruments.

Two axially oriented sensors at each thrust bearings with at least one of them observing a surface i.e., integral to the rotor. It is preferred that none of the probes are monitoring the thrust collar, as the thrust collar may get loose and the axial probe monitoring the thrust collar no longer measure true rotor movement.

One key-phasor radian on the driver of the machine train with a corresponding one event per revolution marking groove under the probe. It must be ensured that thrust float and differential expansion do not move the mark out from under the key-phasor probe.

21.3.12 Monitors shall be of Bently Nevada make series 3500 or equivalent. The monitors for the machinery protection system shall be installed on the panel in the control room. Installation and area classification shall be in accordance with the plant requirement. All instruments shall be highly reliable and shall conform to API 670 latest edition. The machine supplier must ensure that the potential free contacts are available from the system for all alarm and trip signals. The monitoring system shall comprise of the following instruments:

Power supply for provision of the DC voltage necessary for the system but with a separate power source for the key-phasor.

Digital shaft speed indicator operated from the signal supplied by the key-phasor probe. The indicator shall have provision for repeating the speed signal to the control room. The repeater signal shall be a pulse signal. Local indication of speed shall also be available near the machine.

Dual voting thrust position monitor for each casing, designed to prevent false trips due to transducer or collar failure. The monitor shall have built in adjustable time delay of 0 - 3 secs.

Sensor output panel for termination of unmonitored transducers used for periodic checks and diagnostics.

Temperature indicators with high alarm relays form radial and thrust bearings.

All information from the backplane electronics of monitoring instruments in the local control room shall be available in the control room. The transmission shall be through serial communication. However all vibration, axial displacement and speed signals are connected with DCS through 4-20 MA loop. All interfaces, bus cables and PC shall be supplied by the vendor. The computer for transient data management system shall be located in the control room.

Two plane radial vibration monitors for each casing for continuous monitoring of the outputs of the two radial probes mounted 90 degrees apart at the same bearing. The installation shall be such that either of the transducer pairs from the same casing can be connected to the monitor. The monitor shall be designed to prevent false trips due to transducer failure and shall be provided with built in time delay.

VMS/MMS I/O modules shall be within built Barriers. 4-20mA for DCS. MMS to be provided with System-1 monitor. Rule Packs also to be provided.

Interlock, shutdown and trip signal shall be hardwired to PLC (Contact signal from machine monitoring**).** All analog signal from VMS to DCS shall be hardwired. RS232C/485 Communication shall be given as an additional provision. Also Ethernet port shall be provided for connecting the VMS to configuration & diagnostic station (PC based).

21.3.13 Lubrication, Shaft Sealing and Control Oil System

Everything possible shall be done to design the oil systems to provide a continuous, cool, clean supply of oil at the required constant pressure to suit the need of the user. Generally, the instrumentation for the oil system shall comply with API standard 614.

It is not the intention with this chapter of the specification to cover the complete instrumentation for the oil system, but only to highlight a few important parameters. As such it is not described which events that shall shut down the train. The complete system proposed by the machinery vendor shall be subject to the approval of the OWNER/PMC.

All local pressure gauges and temperature indicators shall be mounted on gauge boards.

No pneumatic system shall be used for lube oil and seal oil tanks.

21.3.14 Lube Oil System

The reservoir which shall be steam heated for start up purpose by means of a manual operated control valve shall be provided with a local level gauge, level transmitter with indication, with low level alarm at the main panel.

The lube oil system shall be furnished with two identical lube oil pumps, both electric driven. Either one shall be selectable for normal operation, while the remaining one automatically becomes stand by with auto start, if the normal one fails.

"Running", "ready to start" and "On Auto" lights shall be provided for the lube oil pumps in the main panel. A low lube oil pressure switch in the pump discharge lines shall start the spare pump and alarm the condition in the main panel. A low lube oil pressure switch in the lube oil header after the coolers and the filters shall give alarm. The oil coolers shall be controlled by a temperature control loop with separate high and low alarms in the main panel. The cooling water control valve shall be provided with handwheel. The dual filter units with manual switching shall have main panel mounted indication of the differential pressure across the filter and a high alarm to warn the need for switching and filter element replacement. A pressure control loop on the system shall be provided to ensure the required constant oil pressure for the turbine lube oil and compressor lube oil. Each of the system pressures for lube and control shall be recorded in the main panel.

All drain lines shall be provided with sight glasses and local temperature indicators.

21.3.15 **Seal Oil System**

The instrumentation of the seal oil system shall basically be similar to the lube oil system. The main difference is in the control at the delivery end. To ensure the correct pressure to the elevated seal oil tanks, the pressure shall be controlled by recycling the oil to the reservoir before filtration. The pressure control valve in the spill back line shall, because of the high pressure drop, be with solid stellite trim.

The oil rate to each seal is maintained by the tank indicating level controller which manipulate the valve in the supply line. The tanks shall be provided with high and low level switches for alarm on the main panel. In addition, the low switch shall start the spare pump.

Operation at 115V AC and certified for the hazardous area as per general specification for instrumentation of this annexure. Further, the valves shall be designed for the operating under tropical conditions with a relative humidity upto 100% and with a shade temperature upto 46°C.The solenoids shall be with MOC SS316, class "H" high temperature insulation.The valves for instrument air shall be designed for 10 kg/cm2g at 70°C and the operating differential shall be from 0 to 10 kg/cm2.

"Running" "ready to start" and "On Auto" lights shall be provided for the Seal oil pumps in the main panel.

22.0 NOISE IMMUNITY OF ELECTRONIC INSTRUMENTS

The electronic Instruments shall have a susceptibility of less than 0.5% of span for a frequency range of 20 - 200 Mhz in a field strength of 20 Volts/metre.

23.0 SPECIFICATION FOR CONTACTS

All contacts used for IS/low current applications shall have gold plating as per the following specifications:

Fixed part of the contact - min. 20 m 24 carat gold over silver
Moving part of the contact - min. 40 m 24 carat gold over silver

24.0 LOCAL CONTROL PANELS

All local panels under the scope of package vendor if applicable shall follow the minimum specifications listed below:

24.1 Panels shall be free standing close cabinets, constructed in sections of min. 1000 mm wide. The panel construction shall be welded or bolted frame construction with upright and and additional framing in modular construction. The panel front sheet thickness shall be min. 3 mm. The front of panel shall be stiffened where necessary with profiles tack welded to the rear. Top, sides and doors can be made out of 1.6 mm thick plate.

24.2 The panels shall have environmental protection conforming to IP 55 min.

24.3 Instrument air shall be provided for purging of local panels.

24.4 Panel face, sides and doors shall be sand blasted and cleaned before primer and two coats of paints are applied. The colour of paint shall be bright grey. The final surface shall be semi mat, free from blemishes and paint runs.

24.5 115V A.C. +/- 10%, +/- 3% Hz power at one point to the local panel shall be provided by the client. Any other voltage level if required preferably 24 V, DC, the same shall be arranged by the vendor. Redundant rectifier units shall be provided for the generation of d.c.by the vendor.

24.6 Earthing lugs for both power and system earthing shall be provided by the vendor.

24.7 The wiring shall preferably contained in polymer ducts. Instrument safe wiring shall be laid separately from others. The colour of IS wiring shall be light blue.

24.8 WAGO type cage clamp type terminals shall be used for cable termination and wiring. 20% terminals shall be kept as spares in each terminal strip and box.

24.9 Gland plates shall be provided alongwith cable glands(ex. proof wherever required) in each panel for cable termination.

24.10 A miniature circuit breaker shall be provided for each power supply.

24.11 All panels shall be provided with vibration dampening pads.

24.12 Each panel section shall be provided with illumination level of 300 Lux min.

24.13 Name plate/labels (SS MOC) shall be provided for each panel mounted instruments, equipments and accessories mounted in the front or rear of the panel.

24.14 Purged panels shall be provided with purge fail alarm. Purge fail trip shall be provided with a bypass switch.

25.0 PNEUMATIC TRANSMISSION

25.1 Output Signal

Output signal from all pneumatic transmitters shall be 0.2-1 kg/cm2g.

25.2 Pneumatic Receiver Instruments

Pneumatic receiver instruments shall have receiver elements design for 0.2-1 kg/cm2g input signal.

25.3 Pneumatic Transmission Tubing

Pneumatic transmission tubing for local transmission shall be 6 mm OD stainless steel tubing(SS316) with stainless fittings(SS316).

25.4 Instrument Air

Instrument air required is available at 6 kg/cm2g and max. 70 degree C. However, the air pressure can be down to 4.5 kg/cm2g for remote consumers. Design pressure is 10 kg/cm2g.

Air Distribution Headers shall be as SS 304.

26.0 INSTALLATION

26.1 INSTRUMENT LOCATION

26.1.1 The location of instruments, control valves. Including junction boxes shall permit easy access from grade, permanent platforms or stairways for operation, inspection and maintenance.

26.1.2 The use of portable ladder or mobile platform shall be limited to access root valves, thermowells and line mounted flowmeters.

26.1.3 Locations shall be decided to minimize the possibility of damage from passing or falling objects and the possibility of tripping hazard or obstruct on walkway.

26.2 INSTRUMENT CABLE

26.2.1 Overhead Runs

Instrument main cable tray from field junction boxes to main control building shall generally be laid in aboveground cable tray with protection cover. Tray protection cover shall be provided only for the tray on top of tray layer.

Instrument branched cable runs from junction box or local panel to each instrument in the field shall also be routed aboveground and supported with trays, steel angles and channels.

Only aluminium perforated cable trays with adequate supports shall generally be used for instrument signals/main cable trays. Single pair cables from instrument to junction box and branch cable tray shall be through perforated aluminium cable trays.

For Signal 900mm/ 600mm tray and for power 600mm/ 300 mm tray to be considered.

Cable trays, Elbows, junctions and brackets, channels, special pieces and secondary cable support shall be made of galvanised steel/suitable material.

Main metal conduits or raceways shall generally be anchored along piperacks and/or structures of the plant.

Cable tray segregation shall be based on the voltage level. Cable tray shall be supported at every 3M. 20% spare to be considered in the cable tray filling.

Instrumentation cables that form part of intrinsic safe (IS) circuits, if any, shall be segregated from other instrument signal cables.

Instrument power supply (AC) cables shall not run in the same tray of instrument signal cables. Cable tray shall be dedicated for laying instrument power cables separately from the signal cable tray.

Cable ducts shall not be considered.

26.3 CABLES

The primary insulation material shall be XLPE (cross linked polyethylene) for all types of multi pair cables. The voltage grade shall be min. 600 V for all signal and control cables and 1100 V for all 110 V AC/24 V DC power cable.

All cables shall be FRLS as per standard IEC 332-3 Part 3 Cat. A. Fire resistance cables whenever specified shall be as per me 331 Cat. A.

The insulation grade shall be 600 V/1000 V as a minimum arid shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-2.

All cables shall be armoured. Armour over inner jacket shall be of galvanised steel wire/flat as per IS-1554 part I / IEC 502. All the cores of single pair or multi-pair shall be twisted and numbers of twist shall not be less than 10 per metre.

For signal and control cables, inner jacket colour shall be black. Outer jacket colour shall be light blue, for intrinsically safe application and black for others. For thermocouple extension cables the inner and outer jacket colour shall be as per IS-8784.

L/R ratio of adjacent cores shall not exceed 40 □H / 0 for cables with 1.5 mm2 conductor and 0.25 pH / 0 for cables with 0.5 mm2 conductor.

Contractor shall ensure a minimum of 20% of quantity of each type of cables supplied as spare including any special cable and in each multipair cables 20% pairs shall be kept as spare.

26.3.1 Instrument Signal Cable

a) Single pair shielded signal/alarm cables shall be used between field instruments switches and junction boxes/local control panels.

b) Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room.

c) The single pair/triad cables shall be 1.5 mm2 conductor size made of annealed electrolytic copper conductor of 7 strands with each strand of 0.53 mm diameter. Multipair cables with 0.75 conductor size shall have 7 strands of annealed electrolytic grade copper conductor with each strand of 0.3 mm diameter. Multi triad cable or multi pair cable with 1.5 mm2 conductor shall have 7 strands with each strand of 0.53 mm diameter. Colour of core insulation shall be black blue in pair and black, blue and brown in a triad.

d) Shield shall be aluminium backed mylar/polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair/triad and 0.075 mm in case of multipair/triad cable.

e) Drain wire shall be provided for individual pair and overall shield which shall be 0.5mm2 multi stranded bare tinned annealed copper conductor. The drain wire shall be in continuous contact with aluminium side of the shield.

f) All multi pair cables shall have 6 pair/12 pairs only while multitriad cable shall have 6 triads/8 triads only.

g) All single and multipair cables for vibration monitoring system shall be instrument cables with copper braided shielding for individual pair and overall.

26.3.2 Cables and Multicore Cables for Solenoids etc.

Cables and multicore cables for such items as Gas detectors, flame detectors shall normally have a conductor size of 2.5 mm2. Cables for solenoid valves shall be direct run and shall normally have a conductor size of 2.5 mm2. However, conductor sizes for power cables shall be co-ordinated with the Electrical Group to avoid too many different cable types.

Signals (4-20 mA or switch 'contact): 6/12 pair individually and over all shielded (screened) and armoured, twisted, 0.75 mm2 conductor.

26.3.3 Thermocouple Extension Wires

a) Single pair shielded thermocouple extension cables shall be used between thermocouple head and junction boxes transmitters/ local control panel mounted instruments.

b) Multipair individually and overall shielded thermocouple extension cables shall be used between junction boxes and main control room mounted devices.

c) The type of thermocouple extension cables shall be compatible with thermocouple used. In addition the colour coding of the primary insulation shall be as per ANSI.

d) The cable shall have 16 AWG and 18 AWG solid conductors for single and multipairs respectively.

e) All thermocouple extension cable shall be matched and calibrated in accordance with MC-96.1.

f) Shield shall be aluminium backed by mylar/polyester tape bonded together helically applied with the metallic side down with either side having 25% overlap and100 % surface. Minimum shield thickness shall be 0.05 mm for single pair and0.075 mm for multipair cable. Drain wire shall be 0.5-mm2 multi-strand bare tinned annealed copper conductor. The drain wire shall be in continuous contact with the aluminium side of the shield.

g) Inductance shall not exceed 4mH/Km.

h) All multi-pair cables shall have 6 pairs/12 pairs only.

26.3.4 Power supply Cables

All power supply cables shall be as per IS-1554 Part I and shall have copper conductors. Minimum conductor size shall be 2.5 mm2. The cables shall be PVC insulated and armoured. The higher size conductors shall be used incase of long distance power cable where voltage drops more than 3 volts than required supply.

Any other special cable required for instruments that should also be supplied as per requirements. CONTRACTOR shall ensure that these cables are armoured type and shall meet all other requirements.

26.4 JUNCTION BOX

a) All Junction box shall be of SS304. Junction boxes shall be certified for weather proof with IP 65 certification for IS signal. For non IS signals, Junction boxes shall be flame proof for IEC Zone 1 & Gas group IIC EExe. Junction box shall have screwed covers. Silicon gasket shall be provided. All entries to junction box shall be from bottom.

b) In general a junction box shall contain only signal of same class. The signal class is categorized as following type:

i) Signal Level

- Analog Input
- Analog Output
- Digital Input
- Digital Output
- Instrument Power

ii) System

- DCS
- ESD
- F&G

iii) Type of protection

- Non IS, EExe
- IS

c) The multi-cable entry for 6/12-pair& 8 Triad JB shall be 1” & 1 1/ 2” NPT (F). Each junction box shall be provided with 2 multi-cable entries from the bottom of the junction box with one plugged with weather proof SS316 plugs. All Cable entry shall be at the bottom only, and not from side or top.

d) All spare cable cores shall be terminated in the Junction box, at the marshalling panel end and wired through spare barriers / isolators or relays (as the case may be) right upto the corresponding spare channel of I/O module.

e) All spares hole of JBs, T/C head etc to be plugged with metallic SS plugs. The metallic SS plugs, Junction box hinges, Handle, DIN rail, Allen screws shall be SS316 material of construction.

f) Cable glands shall be provided with Cables shrouds. 20% spare terminals shall be supplied in each junction box.

g) To the extent possible the Field Instrument Signal Distribution Junction-Box wise should be such that the signals terminated from individual Junction Box shall be terminated in the same DCS I/O module, i.e., signals from one junction box shall not be terminated in different I/O modules.

h) There shall be a separate panel in the MCC for terminating signals (DI/DO with proper segregation) to/from DCS/ESD.

26.5 CABLE GLANDS

a) Contractor shall supply all cable glands required for glanding the above mentioned cables both at field instrument and local control panel side, junction boxes side and at control room side.

b) Cable glands shall be Ex-proof, SS316 double compression type IP65. suitable for armoured cables. Extra entries shall be plugged with SS316 plug.

c) Flame proof glands wherever required 'shall be supplied with EX'd' certification.

26.6 INSTRUMENT VALVES AND MANIFOLDS

a) Contractor shall supply instrument valves (miniature type) and valve manifolds wherever required.

b) Body rating shall be as per piping class or better. All valves and manifolds shall be forged type only.

c) Valve body and trim material shall be minimum SS 316 unless otherwise specified. Superior trim material shall be selected as requirement by process conditions. Packing material in general shall be of PTFE.

26.7 INSTRUMENT IMPULSE LINES

a) In general ½" OD annealed seamless SS 316 tubing shall be used in preference to piping.

b) Tubing standard shall be used upto 600# only where the same is required as per job specification. For rating above 600# and hydrogen/lethal service, only

piping standard shall be used. The tubing shall be 1/2" OD tube with all fittings suitable for the same. Valves used shall be threaded. At the first isolation / root valve end suitable pipe tag to tubing conversion fittings shall be used. For remote installation suitable unions / couplings shall be used.

c) Piping standard shall be used for all installation where specified in job specification. For rating upto 600 #, the connection to the transmitters shall be with a male connector and tubing 1/2" OD. For rating higher than 600 #, no tubing shall be used. The connection to the transmitters shall be with 1/2" piping with flanges in between piping standard, all pipes shall be 1/2" NB unless higher sizes required to meet the "requirements, with all fittings suitable for the piping. All the joints shall be welded or flanged as required. For instrument end connection i.e root valve of orifices and other items, level gauges vent and "drain connection, seal welding shall be provided. For non diaphragm seal instruments and instruments where provided with threaded connection, no welding is required at instrument end.

d) Steam, tracing of all instruments shall be considered on steam traced Process lines as per P&ID and other documents. For steam tracing of instruments SS316 tube & SS316 fittings shall be used, Tube fittings shall be double ferrule type. For each instruments steam trace bore shall be provided with steam trap duly connected to plant.

e) All instruments shall be provided with isolation, drain and/ or vent valves with vent/drain end duly capped. This isolation valve shall be in addition to the first isolation /root valve provided on the pipe or vessel at instrument take off.

f) For diaphragm seal type instruments, spacer ring with vent and drain connection along with vent / drain valve with end capped.

g) Contractor shall supply flareless compression type of tube fitting and of three piece construction with design similar to Swagelok/Parker Hannifen etc.

h) Socket-weld type forged pipe fittings of suitable material and rating shall be supplied for pipe fittings. The minimum rating shall be 3000 #. Weld neck fittings shall be used where socket weld type are not allowed by piping class.

i) All pipe fittings shall be according to piping material specification as per piping class of the pipe on which instrument is connected. In case of vessel/equipment/reactor, PMS of equivalent piping class shall be considered.

26.8 INSTRUMENT AIR SUPPLY DISTRIBUTION

Instrument air headers, pipes and distributors shall be of SS 304. Instrument air manifold shall be used for supplying instrument air to control valves and other instruments. These shall be with 10 nos. of tappings and be with ½" NPT (F), SS 304 valves. From the nearby air manifold, instrument air shall be supplied to the control valves. For the purpose, all tubing shall be used shall be of SS316, 6mm, 10mm, 1/2" OD, seamless tubes, laid in perforated aluminium trays. All intermediate fittings shall be double compression, SS316 MOC, Swaglok/Parker/Hoke make only. Solenoid valve operated condensate auto draining points to be provided on the header at regular intervals.

27.0 FIRE AND GAS DETECTION SYSTEM (FGS)

GENERAL:

The FGS shall be a distributed system covering all process unit and comprising the following components. Integration with factory wide FGS system is also in contactor scope:

Fire and Gas (FGS) PLC : QMR/TMR PLC for FGS of the same type & make as the ESD system as per ITB. This shall include smoke (ISD type) detectors and all points of ISD/UV/ Manual call points shall be fully addressable. VESDA not required.

Fire Alarm system and Fire Gas system shall be separate independent system.

- Field and building mounted sensors and call points.
- CR controller stations, including input/output interface.
- Fire station and control building located operator monitoring stations.
- Fire station located graphic mimic panels.
- Field and building located alarm horns and beacons and activation devices.
- Field MCP shall be housed in Ex-proof type housing.

The FGS shall provide fire and gas detection and alarming functions. Output functions shall also be provided to initiate fire protection systems. (Fire water pumps start, extinguishant release, deluge, etc.).

In general, however, only a limited range of automatic actions shall be implemented and fire- fighting systems will be initiated by the FGS operator and/or fire-fighting crews.

Automatic process shutdown shall not be implemented, but the FGS shall include this capability by both direct and hardwired communication to the ESD system.

SYSTEM STRUCTURE:

The fire and gas detectors and hardwired alarm outputs of the process units shall be connected (via connection cabinets and I/O modules) to the FGS controllers located in the Control Room (CR). The FGS controllers shall be connected on the ESD/FGS redundant (fibre optic) communication network. Connections between buildings shall be made via this network, i.e. there shall be no hardwired inter building cabling. FGS operator stations with alarm printer shall also be provided in the fire station and all control buildings. These stations shall be connected on the ESD/FGS communication network to provide access to FGS data for monitoring of FGS I/O status via a series of graphic and alarm displays.

A graphic mimic panel shall be provided in the Central fire station, showing a geographic layout of the with key common alarms, group alarms, system status information and fire water pump status indication (including jockey pump) and start facility. The alarms shall be connected as hardwired outputs from an FGS controller located in the fire station for this purpose. Mimic panels shall also be provided in the Control buildings. In the CR common alarms for each process unit or fire zone shall be provided on the respective operator console. These shall be generated as hardwired outputs from an FGS controller located in the CR for this purpose. FGS alarm data will be logged on the common ESD/FGS Sequence of Event Recording (SER) facility located in the CR and provided as part of the ESD requisition.

EXTERNAL CONNECTIONS:

The FGS shall have the following interfaces to external systems:

- Redundant serial connection to DCS for process operator monitoring of fire and gas alarms.
- Hardwired interface to heating, ventilation and air-conditioning systems.
- Hardwired interface to fire protection systems (deluge systems, building extinguishant systems).

- Hardwired or serial link connection to non-process related fire protection systems.

FGS ALARM PHILOSOPHY:

FGS alarms are provided for three (3) purposes:

- Alert personnel to hazard to allow safe evacuation or other action as appropriate.
- Alert the FGS operator and/or fire-fighting crew to allow appropriate action to be initiated to deal with the hazard.
- Alert the process operator to allow appropriate process operation to be initiated to minimize the hazard.

Alarming shall be based on fire zones defined (by others) with consideration of geographic layout, potential sources of hazard, unit operations and applicable regulations. Alarming shall be provided by means of the following:

- Hardwired audible and visual alarms located in the field and in buildings.
- FGS operator consoles located in the fire station and control rooms.
- Mimic panel located in the fire station, and all control buildings.
- DCS operator consoles located in control buildings.
- Hardwired alarm lamps located on DCS operator consoles.

Clean Agent System

Automatic fire detection and suppression system for control room & cabinets room shall be of clean agent type extinguishing media.

Suitable Clean Agent System as per NFPA 2001 shall be provided for All Control Rooms.

27.1 Gas Detector

Gas Detector of Hydrocarbon/IR type, CO/Electrochemical Type, Hydrogen/Catalytic type will be required.

Hooters/Electric Type and Beacons/Rotating Type are required.

Bidder to list out sufficient Gas Detectors (each type), Hooters, Beacons.

28.0 FACTORY ACCEPTANCE TEST (FAT)

FAT is inspection for verification that all equipment and devices function properly with integrity.

Prior to notification of FAT to Client/Purchaser, all the involved contractual documentation shall be completed and all the cabinets, equipment and components of DCS/ESD shall be assembled and installed in one area at one time.

Seller shall demonstrate all the function of DCS/ESD working properly in FAT. Each test shall be carried out on the procedure reviewed and accepted by Client/DEC/Purchaser after submitting Manufacturing Internal Test Certificate.

FAT certificate shall be issued by seller at the successful end of the test activities. All the hardware and software failures and problems shall be documented. All the failures and problems shall be resolved before shipment to site, All series of actions shall be taken in accordance with the FAT procedure.

FAT will start with Visual Inspection including the following activities as minimum;

- Quantity of all the cabinets, equipment and components.
- Installation of all the cabinets, equipment and components.
- Tagging of all the cabinets, equipment and components.
- Wiring of all the cabinets, equipment and components.

Once Visual Inspection has been successfully completed, Hardware Testing shall start including the following activities as minimum;

Power-On

- Redundancy of Power Supply on failure
- Diagnostics of the main equipment
- Redundancy of the main equipment on failure
- Redundancy of network on failure

- 100% I/O Accuracy Check at 5 point (0%, 50%,100%,50% and 0%) for all the hardwired points (sample check may be allowed if 100% I/O Accuracy has been checked Manufacturer Internal Test)

Once Hardware Testing has been successfully completed, Software Testing shall start including the following activities as minimum;

- I/O Database implementation
- Graphic implementation
- Control implementation
- Logic and sequence implementation
- Historian implementation
- SER implementation

29.0 SITE ACCEPTANCE TEST (SAT)

SAT is inspection for checking that all the conditions are good after installation at site.

Prior to notice of SAT to Client/Purchaser, seller shall submit all the "As-Shipped" documentation incorporating all the FAT correction.

Prior to start SAT, all the cabinets, equipment and components of DCS/ESD shall be installed in proper location as designed.

Seller shall demonstrate all the function of DCS/ESD working properly in SAT. Each test shall be carried out on the procedure and its criteria reviewed and accepted by Client/Purchaser.

Test certificate shall be issued by seller at the successful end of the test activities. All the hardware and software failures and problems shall be documented.

SAT shall be identical to FAT but at reduced amount to check hardware without any damage, installations completed properly and interface working properly. Seller shall provide special tools and test equipments.

30.0 CCTV

CCTV System IP based (minimum 15 Nos. Camera to be considered).

All Cameras shall be installed in outdoor and PTZ type.

Raid-6 configuration shall be used for CCTV.

Bidder shall submit CCTV layout for both the plants. No. of cameras shall be sufficient for surveillance of all the units of the plant.

Bidder shall give a CCTV system which shall have complete provision of connecting total 10 Nos. of cameras.

Closed Circuit Television system for the PLANT units shall consist of the following elements:

30.1 DESIGN CRITERIA

The Closed Circuit Television (CCTV) system shall consist of the following units as a minimum:

a) IP based Colour electronics Digital Video Camera Unit. With day and night viewing under very low light conditions.

b) Video management software, Video analysis system along with LED monitors

c) Server with video management software (for minimum 32 No. camera) recording, storing and playing, Colour Video Monitors, Mouse-Keyboard, PC for System Administration / Management / Maintenance etc.

d) Enterprise Level Server and Storage to handle minimum 32 cameras and having 20 TB minimum storage.

e) CCTV System cabinet

f) Power supply distribution board

g) Coaxial cables, control cables, optical cables, connector etc. of required type & size, cable glands, connectors and other accessories

h) Network switches (Layer-2 Managed)

i) Ceiling hung CCTV monitors (LED type) minimum 55" size or Stand mounted CCTV monitors minimum 55" size such that these can be suitably matched with control room aesthetics by dimensions, appearance etc.

j) Network Video Recorder (NVR), will be located in main Control Room

k) Automatic computer based switching device

l) Media convertors (shall be IP 65 or better)

m) System should be expandable system with provision addition of more NVRs and more cameras (More than 32 cameras)

30.2 CAMERA UNIT

Camera unit shall consist of High resolution IP Based Digital Video Camera with inbuilt IR, camera unit enclosure, remote controlled pan and tilt unit, remote controlled washer and wiper assembly, sun shield -and thermostatically controlled heaters, receiver units, junction boxes etc.

30.3 Video Camera

a) The video camera shall be colour type comprising of ½.8" CMOS sensor with wide dynamic range and resolution 2 Mpx as a minimum with Full HD 2MP minimum resolution 30x Optical Zoom.

b) The camera shall have Automatic Gain Control (AGC) facility with gain adjustment of typically up to 18dBA. The video amplifier shall ensure a signal to noise ratio of 50.

c) The camera shall be able to operate satisfactorily under varied light intensity levels. The light sensitivity of the CCTV camera shall be 0.65 lux low light sensitivity in color/Normal mode, and 0.2 lux low light sensitivity in "night" mode and shall be able to view objects in illumination level of 45 lux at the distance of 50 m as a minimum.

d) Automatic lens iris control facility shall also be provided as per the background light levels.

e) The focal length of the camera shall be based on the distance of the objects from the camera. The lens adjustment for focus control and zoom control shall be motorized and remote controllable. F=4.3 to 129 mm.

f) The camera shall have feature of backlight compensation.

30.4 Camera unit enclosure

Camera unit enclosures in safe areas shall be weather proof to IP-65 as per IS-13947. Camera unit enclosures in hazardous areas shall meet the following requirements, as a minimum:

Weather-proof : IP-66 Type NEMA 4X

Camera unit enclosure shall be suitable for the area classification indicated in the datasheets. Camera unit enclosure shall have factory fitted SS enclosure. Camera shall have 316 billet stainless steel construction.

30.5 Pan and Tilt Unit

The factory integrated pan and tilt arrangement shall be able to adjust camera within an angle of 0° to 360° horizontally (i.e. pan range) and a minimum of 180° (±90) vertical (i.e. Tilt range). The movement of the device shall be smooth. Pan speed shall be 6 degrees /sec and tilt speed shall be 3 degree/second as a minimum. Pan and tilt action shall be operable from video management system in control room. Pan and tilt unit shall be suitable for area classification as indicated in the datasheets. Pan and tilt units shall also be weatherproof to IP66 Type NEMA 4X. 30x Optical Zoom shall be there.

30.6 Space Heater

For outdoor applications and where there is a possibility of condensation on the glass window, the camera unit shall be provided with a thermostatically controlled anti-condensation heater.

30.7 Junction Box

The junction boxes for housing the accessories shall be suitable for outdoor installation with minimum IP-65 weatherproof protection and shall be certified for the specified area classification as per datasheets.

30.8 Camera Mounting

Cameras shall be provided with suitable mounting accessories for mounting on structures, roofs, poles. If mounted on the pole, the pole shall have ladder for camera maintenance.

30.9 Video Management System/Video Recording/Video Analysis

The system shall support the virtual matrix capability (i.e., software based matrix) to allow the operator to assign any camera to any local or remote monitor on the network. Also it shall be possible to Control and monitor any camera on the network.

The video management system shall be able to permit online selection of:

a) Camera Units
b) Monitors
c) No. of views on one monitor
d) Recording Commands
e) Pan-tile Control
f) Sequential Switching of image on monitors
g) Focus, wiper, wash and zoom operating for each camera unit.

The monitors shall be 55" colour LED monitors with necessary controls like colour brightness, contrast adjustment and monitor ON/OFF control. These functions shall be possible from the monitor front.

The camera views on the monitor shall be populated based on the operator request. The operator shall be able to view 1/4/9/16 views per monitor. The operator shall be able to enlarge the views.

The operator shall be able to view cameras through simple drag and drop commands.

The system shall be equipped with the web based client software to allow users to view the cameras on the Microsoft explorer browser from any PC on the network, provided if they are given the permission and password.

The user interface shall present the operator with a camera tree that shall show the list of all the cameras and camera sequences that are available to the operator. The Vendor shall present the hierarchy of the camera tree together with the grouping of cameras and the way in which the user! operator shall interact with it.

The NVMS user interface shall have a map to allow viewing the graphical representation of the area together with allowing the operator to place camera icons on the map. The Vendor shall present the full features and operations of the map and shall present the way in which the user/ operator shall interact with the map.

The operator shall be able to perform pan/ tilt zoom/ washer and wiper unit control for PTZ cameras.

The operator shall be able to enable/ disable Motion detection for cameras.

The operator shall be able to write macros/scripts for the cameras to do the following as a minimum:

(i) To define the sequence of cameras to be viewed on a given monitor

(ii) To define the period and start/ stop time for viewing a camera on a monitor

The viewing and control of cameras shall be controlled by use of passwords. Two levels of password shall be provided:

a) The operator level in which the operator shall be able to perform PTZ controls, viewing, recording and playback.

b) The supervisor level in which the supervisor shall be able to make configuration changes in addition to the PTZ controls, viewing, recording and playback.

30.10 Video Recorder

a) Whenever specified the system shall also supplied with video recorder to record video images automatically or on manual demand. The recorder shall meet the following requirements as a minimum.

b) The video recorder shall have disk space to store on-line video storage for duration as specified in the datasheets and access to high capacity archiving mechanisms for removal of stored video to off-line storage media.

c) The vendor shall size the video recorder hard disc space based on the number of cameras, number of days (minimum 30 days) for which the recording has been done, the resolution of recording and the number of frames per second to be recorded, as indicated in the datasheets. Vendor shall submit calculations/ equations for storage requirements. Use of software without supporting calculations shall not be acceptable.

d) The system shall mark the events with time and date stamping during monitoring and recording. The system shall allow the operator to view stored information with respect to time and date of recording with scan and search of the marked events/ timing.

e) The operator shall be able to playback the recorded events in slow and fast motion with variable speed.

f) It shall be possible for the operator to schedule recordings for each individual camera taking place in the future. The operator shall be able to configure the Start and Stop time for the scheduled recording.

g) The operator shall be able to exports previously stored video to DVD or latest storage option as specified in the datasheets.

h) The exported video shall be able to retrieve archived video from DVD or the latest storage option as specified in the datasheets.

i) Captured images or videos shall be easily distributed to any remote locations through the LAN/WAN environment, if required. The operator shall be able to export previously stored video from a recorder to any other network storage devices including a network drive. An exported file must be in MPEG-4/ MJPEG format and, as such, should be readable using any MPEG-4/MJPEG compliant decoding software.

j) Each video recorder shall be of 19" rack mountable type.

k) Video recorder shall support RAID 6 as a minimum.

30.11 Video Analysis

a) System shall generate alarm on motion detection in areas where no motion is expected.

b) System shall generate alarm on no motion detection in areas where motion is expected.

c) System shall generate alarm on flare flame failure.

d) System shall generate alarm in case fire is detected.

e) System shall generate alarm when toxic cloud is observed.

30.12 Alarms & Events

a) The operator in the control room shall be able to get an indication of the faults occurring in any of the devices connected over the network. This includes faults occurring in the cameras, video encoders, computers, and video

recorders. Faults occurring in each of these devices shall generate an alarm in the operator console.

b) The operator shall be able to view the chronology of events by device, date, time and description.

c) The system shall support logging of events for reviewing and analysis in the future.

d) Upon detecting a fault, the system shall be able to automatically send an E-mail alert.

30.13 Configuration

The following facilities shall be provided for configuration of the CCTV system as a minimum:

a) Assign an ID or name to each camera.

b) Add/delete cameras.

c) Change the camera details (e.g. Camera location, Camera ID, Camera number, etc)

d) Configure the camera encoding parameters in terms of number of frames per second.

e) Configure the camera encoding resolution in terms of setting it to CIF, 2CIF, or 4CIF.

f) Creation of schedules for recordings.

g) Configure recording either on demand, continuous recording or based on motion detection.

h) Add/ delete monitors to the system.

i) Add/ delete computers to the system.

j) Creation of a camera group, view a camera group, view a camera sequence, and view a multiple view screen.

k) For an IP based system, assign IP addresses to video encoders, computers of video management system, video recorders, video wall controllers as applicable.

l) Program external outputs based on certain events.

30.14 Interfacing with DCS

Interfacing with DCS shall be done to allow DCS operators to view live video along with DCS graphics on the DCS operator consoles. Hardware required for the same shall be provided by vendor. Software required in video management system and DCS shall be provided by vendor.

30.15 CCTV CABINETS

The CCTV cabinet(s), Rittal make shall house the following components: (i) Computer(s) (ii) video encoder(s), (iii) video recorder(s), (iv) control unit (v)network switches (vi) Transceiver modules, if any (vii) indoor fibre patch panel, if any (viii) VGA boosters, if any(ix) Line drivers, if any (x) Miniature circuit breakers etc. as applicable.

The cabinet(s) shall be fitted with lockable doors and shall have front and rear access. All system cabinets shall be completely wired.

The cabinet shall be free standing, enclosed type and shall be designed for bottom cable entry. Cabinet structure shall be rigid and shall be provided with removable lifting lugs to permit lifting of the cabinets.

Cabinets shall be fabricated from cold rolled sheet steel of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum of 1.6 mm thickness. Cabinets shall be thoroughly de-burred and all sharp edges shall be grounded smoothened after fabrication.

Each cabinet shall be of maximum 2100 mm height x 1200 mm width. Construction shall be modular preferably to accommodate 19" standard electrical racks. Maximum swing out for Pivot card racks, doors and drawers shall be limited to 600 mm. Doors of the cabinet shall be equipped with lockable handles and concealed hinges with pull-pins for each door removal.

In order to effectively remove dissipated heat from the cabinets, vent louvers backed by wire-ply screen shall be provided on the cabinet doors. Ventilation fans shall be provided in each cabinet along with fan failure alarm contact.

Fluorescent lamps shall be provided in each cabinet for each cabinet for internal illumination along with door operated micro switches. All lighting shall be on 230V AC 50Hz normal power supply.

All wiring within the cabinet shall be neatly laid and shall be accessible. Clamping rails shall be provided for incoming cables to present excessive stress on the individual terminals. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with common grounding lug.

The color of the CCTV cabinets shall be matched with the existing cabinets at control room.

Cable glands shall be provided for cable entry into the CCTV cabinet. Spare cable entries shall be plugged.

30.16 OPTICAL FIBER CABLE

The Optical Fiber Cable (OFC) used for the CCTV system shall conform to the following specification as a minimum:

a) The OFC shall be CSTA (corrugated steel tape armored, electrolytically chrome plated low carbon steel) armored cable.

b) The OFC shall have FRP strength member, loose tubes for single mode optical fibers filled with moisture resistant jelly, moisture barrier of polymer coated Aluminum tape or water swellable tape, inner sheath of HOPE and outer sheath of PVC.

c) Optical fibers shall be single mode fibers compliant to ITV-T G 652 and fibers colours shall correspond to IEC 793-2 and 304. Optical fibers shall be coated with UV cured double acrylic resin. It should not have any reaction with cladding or core material. The coating should provide maximum resistance to micro-bending & abrasion and ensure mechanical & optical strength. The coating shall be easily stripped with mechanical tools.

d) The number of fibers in the OFC shall be decided depending upon the requirement with 8 fibers as a minimum.

e) The cabled fiber attenuation shall be -S 0.37 dB/km for 13] 0 nm wavelength range and 0.22 dB/km for 1550 nm wavelength range.

f) The tensile performance shall be as per IEC-794-IEI and with tensile load of9.81 W Newton with attenuation change -S 0.05 dB/km at 1310 nm. W is weight of OFC/km.

30.17 Network Switch

The network switch used for the CCTV system shall conform to the following specification as a minimum:

The network Switch shall be configured to provide communication paths and provide the facility for adaptive packet and message routing through any available communication link. The network Switch shall provide the facility of multiple protocol router and bridge that provides high bandwidth connections into backbone networks for remote sites.

The hardware design shall be based on distributed processing architecture with packets forwarding to be performed on the network interface modules. It shall be based on the modular design and architecture and shall allow new network interface cards to be added in the racks without powering down the unit and ensuring no disruption of service to the network users.

The network Switch shall support both intra-area and inter-area routing for transporting messages between nodes and shall support the network routing! bridging services for OSI, TCP/ IP, X.25, LAT and other industry standard wide area networks/ protocols. The network switch shall be adaptive 10/100/1000 Mbps interface port, supporting pass through Crossover adaptation of port. The network switch shall be provided with optical fiber module interface suitable for long distance transmission.

30.18 POWER SUPPLY

The system shall operate on 110 VAC/ 230VAC (as required) with the following specifications:

Voltage variation	± 10%
Frequency	50 Hz± 3 Hz

Any other power supply required shall be derived from this power supply by the vendor.

Power Supply distribution for all items related to closed circuit television system shall be carried out from the system cabinet itself. Vendor shall supply any hardware required for conversion/distribution. Power supply for each item shall be provided with a separate switch and fuse for isolation and protection of the system.

The CCTV camera unit shall be capable of withstanding plant vibration level of 2. 1 G (within the frequency range of 5 Hz to 200 Hz) and sudden shocks of level 5 G (with frequency of 2 Hz).Any vibration pads required to meet this requirement shall be in vendor's scope of supply.

The CCTV system shall have the capability for future expansion to add cameras and additional storage in video recorders.

All cable glands, as required, for camera enclosure, pan, tilt unit, junction boxes, CCTV cabinet etc. shall be SS316, dual compression type, suitable for area classification specified in datasheets.

31.0 TELEPHONE EXCHANGE AND ASSOCIATED ACCESSORIES

31.1 BASIS OF DESIGN

The system and all the equipment shall conform with all relevant and the latest edition of Indian, International, OISD and CCITT/ ITU standards as applicable. As a minimum, the following standards shall apply:

a. IS: 2148 Flameproof enclosures for electrical apparatus.

b. IS:13346 General requirements for electrical apparatus for explosive gas atmospheres.

c. IS:5572 Classification of hazardous areas (other than mines) for electrical installation areas having flammable gases & vapors.

d. IEC:79 (Applicable parts) Electrical apparatus for explosive gas atmosphere.

e. IS:13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.

f. IS:13408 Code of practice for the selection, installation & maintenance of electrical apparatus for use in potentially explosive atmospheres.

g. IS:5571 Selection of equipment for Hazardous areas.

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention.

The telephony system shall also be connected to the Public Switched Telephone Network (PSTN) through the EPABX, and shall comply with all the telecommunication carrier's requirements; technical compatibility between the public and private networks shall be ensured.

LAN and Telephone shall be independent and have different network.

31.2 Service Conditions

All the equipment shall be suitable for the site conditions as specified in design basis. Indoor equipment shall be installed in a HVAC controlled environment.

31.3 AREA CLASSIFICATION

All the out-door equipments shall be suitable for installation in hazardous area and shall be EEx'ia' IIC T4 and weatherproof to IP67 as per IEC529, irrespective of plant's hazardous area classification. Where intrinsic safe is not possible Ex-proof shall be provided.

All the outdoor equipments shall have certification (as minimum) for use in Zone-2 IIC T4 irrespective of plant's hazardous area classifications and by the recognized testing and certification authorities such as 'CMRI' Dhanbad, BASEEFA (UK), UL (USA) etc., or the relevant authorities of the country of origin.

Indigenous equipment for hazardous areas shall be approved by CCEO and all flameproof equipment shall be under a valid BIS license.

The exchange shall be fit operate on the following power supply:

a) UPS Supply voltage 115 A.C. ±10%

b) Supply frequency 50 Hz ±3%

31.4 DETAILS OF DESIGN

DESIGN SPECIFICATIONS:

The system shall comprise of fully microprocessor based digital central exchange(s) consisting of system control hardware, which shall be located at control room. It

should be an expandable system. The system shall have capacity of 50 extensions. The systems central exchange shall be extending upto 100 telephone lines. It should support IP / Digital / Analogue phones.

A redundant interface for connecting any other Telephone Exchange.

An Internet Protocol (IP) based telephony system shall be provided. The Exchange shall have facility of connection to the LAN system with POE/non-POE switches.

The Telephone Exchange shall be interfaced with FGS system via 2 wire, RS-485 serial interface over MODBUS. The Telephone Exchange system shall provide general failure alarm signals for presentation on the DCS system in the Control Room (CR).

The telephony system shall be interconnected with the PA/GA systems such that communications can be automatically established by authorized subscribers of any of the systems without operator intervention.

The EPABX and a Main Distribution Frame (MDF) shall be located at the control room.

CPU and power supply shall be provided with 100% redundancy.

Each office (or equivalent) telephone set shall dispose of two connection possibility points as a minimum. The additional connection points could be used either to change location inside the room or to add further telephone subscribers.

The cable supply and installation rules shall follow the same rules than the instrumentation cables.

The telephone JB supply and installation rules shall follow the same rules than the instrumentation items.

The system shall have automatic broad casting of alarm when a fire or gas alarm signal is initiated from the fire and gas system.

Bidder has to provide complete layout of the Telephone network in its scope of the building.

Complete supply, erection of the exchange system shall be in bidder scope.

Bidder has to provide complete system in fully working condition.

31.5 CENTRAL EXCHANGE

The central exchanges shall be fully digital, microprocessor based freely programmable exchanges, working independent of each other. Programming shall be by means of user friendly menu driven software via a dedicated lap top, which shall also be supplied by the system vendor. The specification of laptop shall be latest Intel hardware, Microsoft OS and MS Office software at the time of supply.

It shall be possible to program / re-program the exchange through external laptop PC, using text/graphic editor, via USB/RS 232 or other suitable interface. This shall enable the user to carry out the following operations without any additional software.

Complete hardware racks related to both these exchanges shall be accommodated inside control room at central cabinet room in a common panel/cabinet. The cabinet shall be fabricated out of minimum 16-gauge sheet steel, naturally ventilated, dust and vermin proof with IP-41 enclosure as a minimum. The panel shall be with swing out assembly of plug-in-card racks.. It shall be possible to locate faults by monitoring from the central cabinet.

The central exchange shall have a processor module for the control of the central exchange. The exchange shall have a completely non-blocking type switching system and associated circuitry for call recognition and acknowledgement.

The offered system shall be flexible and modular in construction with the possibility of expanding to a bigger system in the future.

The construction of the type, size and make of panel, wiring, color codes and ferruling philosophy of various signal and power cables shall be exactly same as those of DCS/ESD panel specifications as prescribed in this ITB. Panel shall be min. 1200 mm wide x 800 mm depth x 2100 mm height and of RITAL make with same color shade as those of DCS/ESD panels.

Each of the central exchanges shall have built-in fault diagnostic unit using test and monitoring modules. It shall be possible to locate faults by visual signalling and monitoring by means of test plugs from the central cabinet.

All hardware necessary for fault isolation and troubleshooting shall be supplied as a part of the cabinet along with each exchange.

The system shall have capacity of 50 extensions.

The system shall be able to connect 10 Nos PSTN lines.

The system shall have provision of 15 IP phones.

32.0 LOCAL AREA NETWORK (LAN) FOR CR

The Bidder shall lay the LAN required for Main CR area.

BASIS OF DESIGN

The system shall have as a minimum the following for CR:

1. Manageable L2- 24 port switch with 1G/10G port with 24 port Jack panel with cable manager.
2. Switch shall have with 8 redundant Fibre optic port. One redundant Fibre Optic Port shall be used for connection to main Plant LAN switch/servers.
3. Cabling shall be CAT6A cabling
4. 12 Nos 3 m/Cat 6A patch cords
5. 12 Nos 6 m/Cat6a patch cords for end user
6. UTP CAT6A cabling shall be done with one spare cable.
7. Cable and passive components shall be from AMP. I/O – 24 nos, Faceplate with cover 24 Nos.

33.0 Instrument Workshop

Instrument Workshop is not in the LSTK bidder's scope. Bidder shall provide a list and detailed specification of all the workshop equipment required for maintenance and calibration of the instruments.

ANNEXURE -1

INSTRUMENT ACCURACIES

The instrument reference accuracies shall be as per the table below. Accuracy of the Instruments shall be minimum as follows. Custody Transfer accuracies shall be as defined in the ITB in terms of rms.

Type of Instrument	Accuracy
Process Gas Analyzer – All type	+/- 2% Reading
Conductivity , pH meters	+/- 0.5 % of Reading
Belt weighers	+/- 0.5 % of Reading
Differential pressure & Pressure transmitter - SMART	± 0.050% of Reading within TD ratio of 1: 100 or better
Diaphragm seal transmitter & Pressure transmitter - SMART	± 0.050% of Reading within TD ratio of 1: 100 or better
Variable area type flow meter with transmitter	± 2.0% Reading Note (1)
Vortex flow meter	± 0.7 % Reading
Positive displacement flow meter	
- Raw material and Product	± 0.2% Reading
- Others	± 0.5% Reading
- Turbine meter or Mass flow meter	
- Raw material and Product	± 0.2% Reading
- Others	± 0.5% Reading
- Magnetic type flow meter	± 0.5% Reading
- Mass flow meter (Coriolis Type)	± 0.1% Reading
- Ultrasonic type flow meter	± 0.5% Reading
- Ultrasonic type flow meter(5 – path)	± 0.1% Reading
Orifice plate : Normal Application	+/- 2% of flow rate
Orifice plate : Special Application	+/- 1.5% of flow rate
Venturi	+/- 1 % of flow rate
- Displacement type level indicator	± 1.0% Reading
- Displacement type level transmitter	± 0.2% Reading (Smart)
- Tank gauge (Custody Transfer)	± 1 mm with +/- 1 mm resolution
- Servo type tank gauge	± 2 mm (up to 20 m height)
- Radar type tank gauge	± 1 mm or better for custody transfer ± 5 mm or better for normal application

	± 0.2% of span within TD ratio of 1: 100
- Pressure gauge	± 1.0% of span for Bourdon type , 1.5% for diaphragm
- Temperature Transmitter	± 0.15 % of calibrated span for RTD & T/C
- Filled system/Bimetallic	± 1.0% Reading
- Small size pressure gauge	± 3.0% Reading
- Draft gauge	± 3.0% Reading
- Receiver gauge	± 1.5% Reading
- Thermocouple & Resistance Bulb	Applicable Codes/Standards

Note: 1. Vendor's standard accuracy is applied to local indicator type

Remarks: 1. Accuracy of instrument and special articles except for the above mentioned instrument shall be in accordance with the applicable codes/standards.
2. FS: Full scale.
3. Overall rangeability of transmitter except for draft range shall be 1: 100. Draft range transmitter rangeability shall be 1: 30 for the accuracy indicated above.

ANNEXURE -2

Field instrument connections shall be as follows.

Instrument Type	Process / Vessel Connection	Instrumentation Connections
DP Flow Instruments	½" NPT	½" NPT
External Displacer on Vessel (Min. Rating ANSI 300#)	2" Flanged	2" Flanged
Internal Displacer (Min. Rating ANSI 300#)	4" Flanged	4" Flanged
External Ball Float on Vessel (Min. Rating ANSI 300#)	2" Flanged	2" Flanged
Internal Ball Float (Min. Rating ANSI 300#)	4" Flanged	4" flanged
Magnetic Level Gauge (Min. Rating ANSI 300#)	2" Flanged	2" Flanged
D/P Level Non-diaphragm seal (Min. Rating ANSI 300#)	2" Flanged	½" NPT
D/P Level with Remote Seal Diaphragm (Min. Rating ANSI 300#)	3" Flanged	3" Flanged
D/P Level Direct Vessel Mounted (Min. Rating ANSI 300#)	2" Flanged	2" Flanged
RADAR – Direct Mount on vessel (Min. Rating ANSI 300#)	4" flanged	4" flanged
GW RADAR – Side/Side Chamber Mounted on vessel (Min. Rating ANSI 300#)	2" flanged	2" flanged
Internal GWR on Equipment (Min. Rating ANSI 300#)	4" Flanged	4" flanged
Special Level Instrument on Equipment (Capacitance/Ultrasonic)	4" Flanged / 6" Flanged	4" Flanged / 6" Flanged
Tank Level Instruments (Servo) on Atmospheric tank/ Pressurized Equipment	6" flanged	6" flanged
Tank Level Instruments (Radar) on Atmospheric tank clean service / Pressurized Equipment	8" flanged	8" flanged
Tank Level Instruments (Radar) on Atmospheric tank viscous service / Pressurized Equipment	24" flanged	24" flanged
Tank Level Instruments (Capacitance/ Ultrasonic/R.F.Probe) on Atmospheric tank / Pressurized Equipment	2" flanged	2" flanged
Pressure Instruments	¾" NPT (M)	½" NPT
Press.Gauge	¾" NPT (M)	½" NPT
Pressure with diaphragm seal, (Min. Rating ANSI 300#)	3" Flanged	3" Flanged

Pressure Instruments on Vessel	1 ½" Flanged	½" NPT
Pressure Instruments on Standpipe	¾" SW/BW/Flanged	½" NPT
Chemical Seal pressure Instrument gauge on Vessel	1 ½" Flanged	½" NPT
Diaphragm Seal pressure Instrument gauge on Vessel	3" Flanged	3" Flanged
Thermowell (Min. Rating ANSI 300#)	1 ½" Flanged	1 ½" Flanged
Multipoint Temperature Element for Tanks	2" Flanged / 3" Flanged	2" Flanged / 3" Flanged
Standpipe	3" Flanged	-

Note:-

1) There shall be a separate tapping for each of the instruments on any pipeline/vessel. No multiple instruments from one tapping is acceptable (for example PG and PT from single pipe line tapping with single or double mechanical isolation valves are not acceptable). In case of multi-transmitter installation from a single orifice, ~~a~~ separate identical pair of tapping to be provided with ~~a~~ separate transmitter i.e. no branching from a single tapping is allowed.

a. All type of instrument tapping flange rating shall be minimum ANSI 300#, irrespective of minimum design pressure. However for pressure rating of 600# class and above, RTJ flange shall be used. At few locations, double isolation valves shall be used as per table given below.

INSTALLATION	**PRESSURE TAPPINGS**	**LEVEL TAPPINGS**	**FLOW ELEMENTS**	**CONTROL VALVE**
RATING				
300 #	SINGLE	SINGLE	SINGLE	SINGLE
600 #	DOUBLE	SINGLE	DOUBLE	SINGLE
900 # / 1500 # / 2500 #	DOUBLE	DOUBLE	DOUBLE	SINGLE

Annexure – 3

SYSTEM CONFIGURATION

The system configuration is defined as a minimum here. The Bidder has also to consider any other item defined in the Section 11 (e.g. System-1, , Mass spectrometer / Analyser system, CCTV, FGS system, etc. requirements). Any other system required has also to be provided by LSTK bidder.

Ammonia Nitrate Melt Plant

DCS

2 Nos. Operator Stations with, 22” COLOR, LED type dual monitors

1 no. of Membrane Operator’s Keyboard and 1 no. of QWERTY engineer’s keyboards with mouse with each operator station with touch screen, mouse

1 Nos. ES/OS dual personality, 22” COLOR, LED type

1 No. Supervisor Station

1 No. Annunciator with LED lamps with split type architecture

1 No Auxilary Console

ESD

1 No. ES/OS dual personality, 22” COLOR, LED type

1 No. SOE PC, 22” COLOR, LED type

Printers

1 No. A4 Heavy duty Black and white Laser printer

1 No. A3 Heavy duty Colour Laser printer

1 Nos. LVS

1 No. History Node PC with 1 Year data storage, 22” COLOR, LED type

1 No. OPC Server with interface package station, 22” COLOR, LED type

1 No. Documentation Node 22” COLOR, LED type

1 No. Fire wall / DMZ

1 No. Terminal Server, 22” COLOR, LED type

System-1 (Machine Monitoring System if applicable)

Mass-spectrometer (if applicable) with Laptop

CCTV System

FGS system: FGS operator stations with alarm printer shall also be provided in the fire station and all control buildings

1 No. Unified Gateway Service Both Way system with OPC with 22" Color LED monitor with requisite software/hardware for Remote Viewing.

1 Nos. View station for top management connected to PLANT LAN via Firewall / OPC, 22" , COLOR, LED type.

Suitable Hardware, software & support (erection, commissioning) required for the interface of the

If bidder is quoting with Client/server architecture, they should provide redundant servers kept on separate consoles. In case of Server-Client based DCS systems, all operator stations shall be direct connect type (they should not depend on Servers for data). No System Servers shall be used as Operator stations.

Analyser PLC

One Analyser PLC with laptop for each Analyser shelter shall be provided with redundant connectivity to CR.

Common Printers

1 No. A4 Heavy duty Black and white Laser printer

Annexure – 4

Indicative Sample format for PTR

Customer	Plant Location	Plant Type	Feed	Licensor	Status	Year of Supply	Model

GENERAL SPECIFICATION

FOR

ANALYSER SHELTER

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

Instruction to the Bidder

1. The Vendor shall submit complete Analyzer shelter GA drawings, BOM , HVAC details, BOM etc.

2. The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A

3. Vendor shall supply the **complete redundant air conditioning, venting, heating and/or house pressurization system**

4. ORDER OF PRIORITY

   A) Instruction to Bidder

   B) Design Philosophy

   C) SHELTER SPECIFICATION

   In case of conflict, it shall be brought to notice of PDIL / OWNER for conflict resolution.

CONTENTS

1.0 GENERAL

2.0 DESIGN AND CONSTRUCTION

3.0 NAMEPLATE

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7.0 ELECTRICAL UTILITIES

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11.0 SPARES

12.0 SHIPPING

Abbreviations:

AARH	Arithmetic Average Root Height
CMRI	Central Mining Research Institute
DCS	Distributed Control System
DPDT	Double Pole Double Throw
Deg C	Degree Centigrade
ERTL	Electronics Regional Testing Laboratory
NPT	National Pipe Threads
AMS	Analyzer Management System
ESD	Emergency Shutdown System
FAT	Factory Acceptance Test
HVAC	Heating Ventilating & Air Conditioning
PLC	Programmable Logic Controller
SAT	Site Acceptance Test
SCS	Sample Conditioning system
UPS	Uninterruptible Power Supply

1.0 GENERAL

1.1 Scope

The main purpose of an analyzer house/shelter is to ensure continuity of safe operation of analyzer systems at a specified rate of reliability by providing a suitable operating environment for analyzers which cannot otherwise operate properly. i.e. if exposed to outdoor or ambient conditions. the operating environment may be affected by requirements concerning

- Outside Area Classification **EX. PROOF ZONE-2 GR IIC T4**
- Inside Area Classification **EX. PROOF ZONE-1 GR IIC T4**
- Environmental conditions, mainly temperature and humidity
- Sample handling and conditioning
- Effective maintenance

Hazardous situation arising from the toxicity of gases and vapors which have to be handled shall be the subject of a special study, on the basis of which the appropriate measures shall be decided on and submitted by Vendor to client for approval

The following measures are necessary to ensure the safe conditions in the Analyzer house:
- The quantity of flammable materials retained in the analyzer house shall be kept at minimum.
- An efficient ventilation system shall be provided to continuously dilute any internal release of flammable gas or vapors, in order to reduce the concentration at all time below 20% of the lower explosion limit.
- The provision of safe disposal arrangement for samples.

SCOPE OF SUPPLY

WORK INCLUDED

Analyzer house vendor shall be responsible for the design, fabrication, construction and commissioning of each house. The house shall be delivered as a fully assembled analyzer house complete with all monitoring equipment, sampling systems, calibration gas supports, tubing, The electrical equipment, fire and gas detectors, alarm beacons, annunciation panel, safe guarding system and HVAC equipment in place, wired and connected.

For Field mounted analyzers, Vendor shall be responsible for the design, construction and commissioning of shelter along with the sample conditioning system, sample lines including sample probes and test or calibration gases.

The analyzer house vendor shall be responsible for the supply of all associated auxiliary equipment that will be mounted remotely from the analyzer house and for field mounted analyzers.

The analyzer house vendor shall supply all the necessary calibration gas cylinders for each analyzer.

Vendor shall be responsible for the installation and commissioning of Analyzer Management System along with all necessary hardware in analyzer house, SRR and Central Control Building (CCB).

STANDARDS

1.1.1 This specification, together with the data sheets covers the requirements for the design, materials, nameplate marking, inspection, testing and shipping of analyzer shelter with HVAC system complete with accessories, which are required for housing industrial process analyzers and their associated piping, wiring and auxiliary instruments.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry :

ANSI/ASME American National Standards *Institutel*American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads General Purpose (Inch)

ANSI/ASME B 31.3 Chemical plant & Petroleum refinery piping

B 16.5 Pipe Flanges and Flanged Fittings *NPSY2*through NPS24

B 16.20 Metallic Gaskets for Pipe Flanges, Ring Joint, Spiral wound and Jacketed.

EN 10204 Inspection Documents For Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures (IP Code).

IEC-61000-4-X Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment.

IEC-61511 Functional Safety instrumented system for the process industry sector.

IS-13947 Specification for Low Voltage Switch gears and Control gears.

IEC-61285 Industrial Process Control - Safety of Analyser Houses.

IS-2148 Electrical Apparatus for Explosive Gas Atmospheres-Flame proof Enclosures d'.

IS-5780 Intrinsically safe electrical apparatus and circuit electrical equipment with type of protection 'i'.

NFPA496 National Fire Code

API RP 540 Electrical Installations in Petroleum Processing Plants

API RP 551 Process Measurement Instrumentation

API RP 552 Transmission Systems

API TP 555 Process Analyzers

NACE MR-01-75 Sulphide Stress Cracking Resistance Metallic Materials for Oil Filled Equipments

ASTM A269 Seamless Welded Austentic Stainless Steel Tubing For

General Service

C15 Procedures for Cylinder Design Proof and Service Performance Tests

IEC 60079-016 Electrical Apparatus for Explosive Gas Atmosphere Part16
- Artificial Ventilation for the Protection of Analyzer houses

NEMA ICS6 Industrial Control and System Enclosures

NFPA Standard 90A Two hour fired rated

NFPA 496 Standard for Purged and Pressurized Enclosures for Electrical Equipment

BS 476 Test on Building Materials and Structures

BS 3463 Observation and Gauge Glasses for Pressure Vessels

IS 2147 Degree of protection provided for enclosure

IS 2148 Flameproof enclosure for electrical apparatus

IS 875 Part (3) 1987 Indian Wind Code

IS 5771 Guide for the Selection of Electrical Equipment for Hazardous Areas

IS 5572 Classification of Hazardous Areas (other then Mines) having Flammable gases and vapours for Electrical Installations

EEMUA (Engineering Equipments and Material User Association) – Design and Installation of On Line Analyzer System

IS 5572 Classification of Hazardous Areas (other then Mines) having flammable gases and vapours for Electrical Installations

UL 555 Fire and Smoke Dampers

1.1.3 In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:
a) Statutory Regulations
b) Data Sheets
c) Standard Specification
d) Codes and Standards

1.1.4 Purchaser's data sheets specify the minimum acceptable materials. Alternate superior material f construction shall also be acceptable provided vendor assumes complete responsibility for the selected materials for their compatibility with the specified operating conditions.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Whenever the requirement of detailed specification sheet for analyser shelter is specifically indicated, a detailed specification sheet for each analyser shelter shall be furnished, which shall provide all the details regarding type, material of construction as applicable. The material specifications and the units of measurement for various parts in vendor's specification sheet shall be to the same standards as those indicated in purchaser's data sheet.

c) Proven references for each offered analyser shelter inline with clause 1.2.3 of this specification.

d) General arrangement / Layout drawing of each shelter.

e) List of utilities with expected consumption of each shelter.

f) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosive Safety Organization / Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electrical and electronic equipments installed in electrically hazardous area along with:

i) Test certificate from recognized test house like CMRI/ERTL etc. for flameproof enclosure/intrinsic safety, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, BASEEFA, PTB, CSA, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

g) Deviations on technical requirements will not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.

h) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser shelter and other equipments / instruments covered in the bid.

1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those specified in the purchaser's data sheets. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 All documentation submitted by vendor including their quotation, catalogues, drawings, installation, operation and maintenance manual etc. shall be in English language only.

1.2.5 Vendor shall also quote for the following:

a) Unit rate of any special items.

b) Any special tools and tackles needed for maintenance work. In case no special tools are necessary for maintenance for the offered shelter, vendor must certify the same in their offer.

1.3 Drawings and Data

1.3. Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. submitted by vendor after placement of purchase order shall include the following, as a minimum:

a) Specification sheet for analyser shelter and its accessories.

b) Certified drawing for each analyser shelter, which shall provide following details;

i) Overall / Mounting Details of the complete shelter in millimetres
ii) Clearance space required for maintenance work.
iii) Schematic diagram for the complete assembly including utilities required for the shelter.
iv) Heat load calculations and dehumidified air flow rate calculation.
v) LEL level of gases present with calculation for safe limit dilution of inside shelter air.

c) Copy of type test certificates

d) Copy of the test certificates for all tests indicated in clause 4.0 of this specification.

e) Installation procedure for analyser shelter.

1.4 Definitions

1.4.1 Analyser Shelter

Enclosed prefabricated building or part of a building containing process / stack analysers and associated equipment where streams for analysers are brought in and which is regularly entered by authorised personnel for operation and maintenance.

1.4.2 Analyser Shed Structure with one or more sides open and free from obstruction to the natural passage of air,in which one or more analysers are installed. The maintenance of the analyser is normallyperformed in the protection ofthe shed.

1.4.3 Analyser rack
An open analyser mounting structure with / without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

1.4.4 Analyser cabinet
Small housing in which analysers are installed individually or grouped together.
Maintenance is performed from outside the cabinet with door(s) open.

1.5 LOCATION AND SIZE OF ANALYZER HOUSE

In general, Analyzer house shall be located in Non-hazardous area. Where this is not possible, the highest area classification acceptable for the location of an analyzer house shall be Zone 2.

Analyzer house and field mounted analyzers shall be located as close as practically possible to their relevant sample points in order to minimize sample transport lag and prevent sample degradation. Analyzer house location under pipe racks or other structures shall be avoided.

Additional to the requirements of IEC 61285, the location of analyzer house or shelter
• Shall be at least 15meters away from furnace / reactor.
• Shall be such that the vibration level does not exceed that specified for the equipment accommodate inside the analyzer house
• Shall be free from spills of water and process liquids

Vendor shall size each analyzer house. The analyzer house size shall take into consideration the size of each analyzer plus an allowance **for 30%** spare on both inside and outside walls for future analyzer and sample conditioning systems. Analyzers shall be installed along the longitudinal walls of each house; they may be mounted on the wall, using 'Unistrut' or equal or on free standing racks in such a way that all parts are freely accessible for maintenance. The analyzers shall bear clear identification plates stating their service. The preferred analyzer house sizes are listed below, vendor to select the best suited for the application :

• TYPE 1 – 3m(L) x 3m(W) x 2.8m(H)
• TYPE 2 – 4m(L) x 3m(W) x 2.8m(H)
• TYPE 3 – 6m(L) x 3m(W) x 2.8m(H)
• TYPE 4 – 8m(L) x 3m(W) x 2.8m(H)
• TYPE 5 – 10m(L) x 3m(W) x 2.8m(H)

The minimum walk space between fixed obstacles should be 1 meter taking into account the constraint that cabinet doors may be locked in the open position on one side. There shall be sufficient clearance between cabinets and equipments to allow for maintenance access. Sufficient space shall be provided inside the analyzer house for installation of sink, work bench and auxiliary equipment such as control units and if required recorders, signal converters, printers, computer terminals, etc.

2.0 DESIGN AND CONSTRUCTION

2.1 General requirements

• The construction of each analyzer house shall be prefabricated in press-formed stainless steel sheet. The materials of construction shall have a fire resistance of two hours minimum in accordance with UL 555 and NFPA Standard 90A. The material shall be resistant to attack from oil and chemicals and other environmental factors such as high humidity and solar radiation, etc. All fittings, supporting framework, cable trays etc. shall be compatible with the house construction to minimize corrosion. Vendor shall indicate their proposed type of construction in the offer.

• When the house structure is used for equipment support, there shall be sufficient rigidity to minimize vibrations. If required, anti-vibration pads and flexible pipe connections shall be used to isolate vibration sensitive equipments from the pipe work or structure.

• Each analyzer house shall have unobstructed internal headroom of at least 2.5mtr. Dead corners, trenches and spill or drain pits that may collect gases are not allowed inside the house.

2.1.1 The analyzer shelters are provided for housing industrial process analyzers and their associated piping, wiring and auxiliary instruments. The analyzer shelters are designed:

a) To create a space within a hazardous area (Zone-I) in which under normal operating conditions a non hazardous atmosphere exists, so that testing or calibration of analyzers and maintenance can be performed with opened casings and electrical circuits alive.

b) To create a controlled environment in which analyzers and their associated equipment are adequately protected against adverse weather conditions.

2.1.2 The analyzer shelter shall be fully prefabricated, assembled, tested and shall be supplied as ready-to-install at project site with all items including analyzers and their accessories duly mounted, wired, tubed and tested before shipment.

2.1.3 The arrangement of equipments shall be such that it provides enough access to front/back/sides of the equipments as necessary during normal operation as well as during start up and maintenance. Sufficient space shall be provided for workbench, signal and power cables entries and routing, power sockets, utility supplies, auxiliary and control equipments. Suitable arrangements shall also be made for locating devices like recorder, portable printers etc. near each equipment.

2.1.4 Shelters shall be equipped with all safety measures like panic bar at the doors, Emergency alarm push buttons, LEL gas (hydrocarbon) detectors, Fire detection system, warning panels, Fire extinguishers, wash basin etc.

2.1.5 Shelter shall be provided with ventilation and air-conditioning to maintain the temperature and humidity suitable for the analyzers stable performance, maintenance and human comfort.

2.1.6 Shelter shall be provided with both internal and external lighting for proper operation and maintenance.

2.1.7 All electrical equipments, fittings, fixtures shall be Flame proof suitable for hazardous area classification.

2.1.8 Analyzer shelter shall be sized considering 30 % additional spare space and facilities like HVAC load, power load etc. for future use.

2.1.9 The design shall be in compliance with the electromagnetic compatibility requirements as per IEC 61000-4.

2.1.1 Design Consideration

Analyzer house design calculations shall be based on the following loads:
• Dead load including weight of analyzers, analyzer house, HVAC equipments, and all other equipments forming the part of installation
• Fixtures for HVAC equipment
• Transport loads (Vertical & Horizontal)
• Live loads including furniture & analytical equipment trolley, etc.
• Roof live load and concentrated loads

• Wind & rain loads

If straightening or flattening is required, it shall be accomplished in a manner that will not damage the material or detract from its appearance

WALL

The External walls of Analyzer house shall be fabricated from 2mm thick Stainless Steel sheet. All mating joints shall be fully welded and fixed by welding to a main support frame and each section to have gussets welded in position.

The Interior walls of Analyzer house shall be of a smooth design and fabricated from 1.5mm thick Stainless Steel sheet. The inner wall panels may be riveted in place provided that the panels are suitably sealed against the framework and that the floor is continuously extended vertically at the walls to provide a continuous skirting 150mm high (not at doors).

Each analyzer house shall have mineral fiber insulation (UL Approved for fire resistant construction) sandwiched between the inner and outer walls to meet the 2 hour fire rating. The insulation shall have a minimum thickness of 75mm. Asbestos or other hazardous material for insulation shall not be used. Vendor shall consider the use of stiffeners between cavities. Vendor shall ensure that gas or liquid cannot build up within the cavity.

Additional wall supports shall be provided as required to adequately support all wall mounted equipments. Equipments shall be mounted using supports bolted to the inner wall.

ROOF

Analyzer house roofs shall be constructed of the same material as the main house (stainless steel) and be insulated. Houses shall have a centre pitch for rainwater drainage, complete with gutters and down pipes and designed to withstand uniform loadings at 0.75kMN/m2. The rainwater drainage system shall be sized to cope with the rainfall of 61mm/Hr and 522mm/24Hr.

Roof and ceiling panel shall be made of 18(1.3mm) gauge stainless steel sheet as minimum.

Roof shall be flat type with minimum practical slope of 25mm per meter.

Roof panels shall provide a net overhang of 300mm on all sides. The analyzer house shall have a canopy along each side of the house to protect external equipments. They shall be designed to withstand a wind speed of 50m/s. This canopy shall be “free venting”.

Roof panel joints shall be interlocked in such a way to provide a complete watertight fit.

DOORS

Analyzer house door shall be constructed of the same material as the main house (Stainless Steel). Each analyzer house shall have outward opening doors at both the ends. One door shall be used as main entrance and other shall be used as Emergency exit. The minimum dimensions for both the doors shall be 900mm wide and 2100mm high. It shall be possible to remove all analyzers or other equipments installed inside the house through main entrance without disassembly.

Doors shall be hung on three recessed stainless steel butt hinges and fitted with weather strips. Each door shall have suitable gasket to prevent ingress of air, rain, etc. and loss of conditioned air and heat.

Each door shall be fitted with a panic bar and self closing spring system. Two hour fire rated double glazed viewing panels shall be fitted on each door, constructed from shatterproof safety glass and installed with suitable gaskets. Each door shall have lock with a master key for main entrance.

Both the doors shall be fitted with limit switches which shall initiate an alarm if left opened for longer than 30 Seconds.

FASTENERS

Bolts, nuts, and washers for structural connections shall conform to ASTM A325, and shall be hot dipped galvanized. Prior to final bolting, all galvanized A325 bolts shall be lubricated.

All sheet metal and/or self-tapping screws, self-drilling screws shall be Class 410 stainless steel.

Fasteners which penetrate the wall or roof covering shall be installed with a neoprene washer under the head.

FOUNDATION & MOUNTING

Each analyzer house will be mounted on a concrete base which shall be impervious to hydrocarbons (supplied by Client). Vendor shall use fully welded Durbar floor plates (or equal). The floor shall be coated with a durable anti-skid, acid resistant epoxy coating on wear surfaces. The floor of the analyzer house shall slope to the door(s). The doors shall not have an entry lip. This will allow any spillages to be swept out of analyzer house.

The Supplier shall supply detailed drawing mentioning the location, alignment and size of the anchoring bolts.

There shall be no openings at the base of the Analyzer House, including around support members.

The Analyzer Shelter shall be designed with provisions for a building-to-foundation seal after installation upon the concrete slab or structure.

The base of the Analyzer Shelter shall be minimum 6 inches (150 mm) deep steel channels and/or beams, which will also serve as the skid for shipping.

The skid frame shall be designed to support the Analyzer House with all the equipment while being lifted.

The skid shall be designed so that it is flush on all sides with the outside walls of the Analyzer House. The joints between the sidewalls and the base shall be sealed.

Lifting of each analyzer house shall be by Vendor specified “eye-bolts”, mounted on each analyzer house roof, at suitable locations and sized to take load of analyzer house fully fitted with all equipments. If any special equipment such as Spreader Bar is required, they shall be supplied by House seller.

PAINTING

After primer has cured, two finish coats of epoxy resin, fire retardant paint shall be applied.
The surface preparation and painting shall not be carried out until all welding is complete, including all brackets, mounting plates, etc.
Surface finish should be applied to all external and internal surfaces including surfaces that will be enclosed with the double skin.

ALYZER SHELTER

The analyzers which are not mounted in Analyzer house shall be installed in a Shelter.

Shelter shall be provided with its own lighting and local switch mounted outside of the shelter

certified for use in the hazardous area in which it is located.

The power isolation switch for each analyzer installed inside the shelter shall be supplied by Vendor.

There shall be main power isolator switch mounted outside the shelter suitable for the area classification.

Shelter shall be so designed and constructed to allow free ventilation such that equipment contained within them can be certified the same as the area classification.

2.2 Construction

2.2.1 The shelter shall be constructed using materials capable of satisfying all the functional requirements and shall not create any safety hazards.

2.2.2 The design and construction of the shelter shall be self-supporting type and shall be sized to house required analyzers, their sample conditioning system and other accessories. Shelters shall also be provided with suitable transportation arrangement.

2.2.3 The base structure of the shelter shall be constructed using suitable size T beams, channels, and angles, welded properly and adequately. All structural members shall be sized to ensure structural rigidity and to prevent deformation during dragging, lifting, loading and unloading operations of the shelter.

2.2.4 The floor shall be fabricated from anti slip and non- corrosive Aluminium plates as a minimum, strong enough to withstand load of all equipments and at least l O-maintenance personal. It shall also be unaffected during transportation and various other obvious forces and shall be sealed to prevent any loss of ventilation pressure.

2.2.5 External sidewalls shall be ribbed interlocking stainless steel sheet of thickness 2mm and internal walls shall be stainless steel sheet of thickness 2mm. The walls of the shelter shall be strong enough to take load of the rack mounted analyzers, related sample conditioning system and associated accessories.

2.2.6 The shelter roof shall be capable of supporting the combined weight of at least 4 men without permanent deformation and shall be sealed properly to prevent loss of ventilation pressure and entry ofrain and jet water.

2.2.7 Lifting of the complete shelter along with all analyzers, sample conditioning systems and associated accessories mounted in it shall be assured by means of suitably designed lifting lugs.

2.2.8 The walls and roof shall be insulated by using glass wool of high density and low thermal coefficient, of adequate thickness commensurate with the HVAC design.

2.2.9 The shelter shall be provided with a main door and an emergency door opposite to main door. Both the doors shall be opening outwards, provided with wire reinforced safety glass window, automatic spring door closer opening hy simple push, fitted with panic har for use in case of emergency. The main door shall be provided with outside pad lock holes. Warning l ight shall be provided at both the Main door and the emergency door indicating the Hydro carbon presence within the shelter.

2.2.10 Extension roof (overhang) made of stainless steel sheet shall be provided all along the walls of the shelter and over the sampling system for protection of the sampling system and

maintenance personal from the direct weather conditions. The extension roof shall be overhung at least 1000 mm outside the analyzer shelter.

2.2.11 A nameplate with the analyzer shelter number shall be fixed near the mam door and emergency door. Tag numbers of the analyzers shall be fixed near the main door. Tag Numbers of each analyzer and sampling system shall be fixed near the respective items. All inlet & outlet tube/ pipes shall be provided with tag number & proper identification numbers engraved in the stainless steel plate. All electrical wires/ leads shall be identified inside the junction *box!* equipment by proper plastic ferrules. All cables shall be identified with stainless steel plate engraved tag nos. / identification numbers.

2.2.12 Provision shall be made for keeping all fast loop devices, distribution devices outside the shelter. A suitable restriction orifice shall be provided in each sample line to limit the sample flow not exceeding thrice the normal flow in the event of tube rupture/opening of the tube down the line.

2.2.13 All pipes which introduce flammable gases inside shelter shall have readily accessible shut off valves.

2.3 Safety considerations

2.3.1 Analyser she Iter shall be provided with pressurisation/purging with fresh air with air changes as per specs to make it safe for installation, operation and maintenance of analysers.

2.3.2 All junction boxes and electrical equipments shall be explosion proof as per area classification.

2.3.3 All analysers installed shall be suitable for working as per inside area classification even without fresh air purging / pressurisation.

2.3.4 The equipments which are not suitable for inside area shall be de-energised in case of ventilation failure and gas detection.

2.3.5 Warning panels, alarm annunciator, and repeat contacts to control room shall be provided for safety related parameters.

2.3.6 Gas detection, fire detection and oxygen deficiency detection shall be provided as per specs.

2.3.7 A PLC shall be provided to execute safety logics. PLC shall have redundant CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated.

2.4 Warning Panels

2.4.1 The following safety related local alarms / indicators shall be generated and displayed:

a. Ventilation failure

b. Flammable gas detected (> 20%)

c. Fire detected

d. Oxygen deficiency

e. Gas detection Instrument fault

f. Manual emergency (panic)

2.4.2 These alarms shall be supported at the following locations:

a. Inside shelter on annunciator panel

b. Near shelter doors on warning panels

c. Potential free repeat contacts shall be provided for connection to Purchaser's

2.5 Hazardous Area Classification

2.5.1 Hazardous area classification shall be as indicated in the job specification ~or outside the shelter. Hazardous area for inside the analyser shelter shall be considered as IEC Zone-I Gas Group IIC , temp. class T3 considering pressurization failure condition. All equipments inside the analyser shelter shall be suitable for operation in area classification under pressurization failure condition.

2.5.2 Non explosion protected equipments will be de-energised in case ofpressurisation failure and gas detection.

2.5.3 Restart of such equipments shall not be possible without appropriate authorization.

2.6 HVAC System for Analyser Shelter

VENTILATION AND AIR CONDITIONING

GENERAL

• The purpose of ventilation and air conditioning system is to provide
• A safe operating environment for equipments and personnel
• The required climatic conditions for optimal equipment performance
• A sustainable climate for the comfort of personnel in line with local regulations and/or practice
• To dilute flammable or toxic gases and/or vapors that may accidentally escape from equipment inside the analyzer house to a non-hazardous level around any potential means of ignition
• To keep house pressurized to prevent possible entry of flammable or toxic gases from the outside atmosphere into the house
• Vendor shall supply the **complete redundant air conditioning, venting, heating and/or house pressurization system.** The system shall be capable to maintain the inside house conditions as mentioned below:
 Temperature 24ºC ± 2 ºC
 Pressure 5 – 10 mmwc
 Humidity 50% RH ± 5%

Suitable temperature and pressure indicators shall be provided inside the house by Vendor. Pressure switch shall be provided to initiate an alarm on loss of house pressure.

Each analyzer house shall have common fresh air intake via a stack mounted on the analyzer house roof. These stacks shall be provided with a rain hood and a mesh to prevent entry of birds etc. also adds tie bars for support of stack. The air shall be drawn from a non-hazardous area and the air intake location shall be at least 1 meter outside the hazardous area. The design of the intake duct and the diameter and length shall be sized by Vendor so as to limit the air velocity inside the ducting to a maximum of 8m/second. The intake stack shall have filters 5 microns down to 99% efficiency, fire dampers and louvers.

All duct penetrations through fire rated walls shall include fire and gas dampers manufactured and installed in accordance with the requirements of UL 555 and NFPA Standard 90A.

The dampers Shall have a two hour fire rating and shall spring close tight when released by a fusible link or by a Fire and Gas signal. The direction of the air flow within each house shall ensure air movement throughout, and around all equipment installed inside, irrespective of wind direction and strength.

The inlet ducting shall be fabricated from hot dipped galvanized steel to BS729, the size of the ducting shall be such that air velocities inside will not create noise level which exceed 70dB(A).

The flow of air from the HVAC unit shall be sufficient to dilute escaping gas or vapors, resulting from the failure or rupture of any sample or service line, to less than 20%of LEL around any potential sources of ignition and to maintain house pressure 5mmH2O above the atmospheric pressure to prevent entry of hazardous gas.

Vendor shall ensure for each analyzer house the ventilation rate at least 10 volume changes per hour or at least 20m3 of air per installed analyzer per hour, whichever is greater, to dilute any flammable gas or vapor to a non-hazardous level.

Two pressurization fans each rated at 100% of the design duty with automatic changeover shall be provided with each analyzer house. The fan motors shall be suitable for use in Zone1 area. The fan shall be non-sparking type. The ducting to the fan inlet shall be protected from the ingress of rain water or significant blowback by wind, and shall be complete with a wire mesh screen to prevent the entry of birds, vermin or particulate matter. Neither wind speed nor direction shall have any effect on the ventilation.

Analyzer house shall be air conditioned by air handling units. The unit shall comprise of fan section, pre-filter (EU3) direct expansion cooling coil and refrigeration compressor and associated air cooled condenser. This equipment, including any controls, shall be suitable for use in a Zone 1 area.

Air shall enter the analyzer house at ceiling level from ducting via openings with adjustable flow diverters to facilitate a proper direction and flow of air throughout the analyzer house. The ventilation air shall escape from the house through vertical ducts at two opposite corners of the house, via louvers with adjustable openings.

The ducts should be installed on the outside of the short walls and connected to the interior of the analyzer house by openings in these walls which are flushed at floor and ceiling level to allow escape of gases and vapors both heavier and lighter than air.

There shall be separate power supply for the ventilating fans and shall have tripping circuit to trip the motors in case of fire.

Each fan support and casing construction shall be of adequate rigidity to prevent resonance and vibration. The fan bearing support shall be the part of fan casting.

Low flow switch shall be provided with each fan to detect air flow to the house. The switch shall be set to indicate flow failure when flow falls below 60% of design flow. A time delay of 1 min. to be provided to avoid spurious operations due to short term disturbances. Low flow alarm shall initiate visible (lamp on annunciator) and audible alarm and makes change over to the other system.

During start up of the house, both the HVACs shall run for the predefined period.

Reset buttons for both the HVAC units shall be provided on safeguarding panel. This switch shall be used to reset the latched HVAC unit alarm. The alarm latching is required to avoid the changeover to

the same HVAC unit until it is attended to.

2.6.1 Vendor shall design, engineer, procure, manufacture, inspect & test at works, shop-paint, pack & forward, transport, supply install, test and commission the HVAC System for Analyser Shelter complete with all auxiliaries required for efficient & satisfactory operation. Vendor shall carry out Performance Guarantee (PG) test at site to prove the Guaranteed Parameters. The specifications for HVAC system shall be as detailed in 2.6.2 for Analyser Shelters located in hazardous area and 2.6.3 for Analyser Shelters located in safe area.

2.6.2 HVAC System for Analyser Shelter Hazardous Area

2.6.2.1 Analyser Shelters shall be air conditioned and pressurized to prevent the entry of flammable gases & vapours and combustible dusts.

2.6.2.2 Air Conditioning and pressurization shall be achieved by providing packaged type HVAC units as per manufacturer's standard practice.

2.6.2.3 Pressurisation system shall be provided for analyser shelter with 2 nos of HVAC system (one working unit and one standby unit) each of same capacity without any common / sharing components. Fresh air shall be taken from safe area. Fresh air intake arrangement comprising of fresh air blower with drive & back draft dampers, cleanable type filter (95%, 5 micron) and bird screen etc. shall be provided. Relief dampers shall be used to exhaust room air at 5 mm WG over pressure. Shelter internal positive pressure shall be maintained at 2.5 mm WG minimum. Fresh air stack with rain cap shall be of carbon steel, welded in construction of minimum 2 mm thick. Fresh air shall be taken from nearest safe area through fresh air stack in a guy wire style or through horizontal/ vertical duct. The Ducts shall be completely leak proof while passing through hazardous area. Loss of pressurization shall initiate an audio-visual alarm. Manual HVAC selector switch to alternate between the HVAC shall be provided in the shelter. Special anti-eorrosive coating shall be provided for coolant tubes to withstand harsh refinery environment."

2.6.2.4 Fresh air make up requirements shall be calculated by the vendor based on the requirements as specified in Clause 8.3 of NFPA 496, (Latest Edition), i.e. where a release of flammable gas or vapour within an enclosure can occur either in normal operation or under abnormal conditions, protection shall be provided by diluting with air to maintain the concentration of flammable gas, vapour, or mixture to less than 25% of its lower flammable limit of any individual flammable gas or vapour entering the enclosure. However minimum 5 air changes shall be provided as per IEC 61285 for ventilation purpose. Inside temperature rise shall be limited to 5° C above ambient, by fresh air from pressurisation system, in case of failure of AC system.

2.6.2.5 Vendor shall confirm that all analysers installed inside Analyser Shelters are suitable for continuous operation in this temperature (Max. ambient +5°C). In case any analyzer being supplied is not suitable for this temperature limit, vendor shall provide high temp pre alarm inside shelter. A separate potential free contact of this alarm shall be provided in alarm J.B. for connection to control room also. The power to analyzer shall be cut off in case of high temperature.

2.6.2.6 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered while calculating the capacity of air conditioners.

2.6.2.7 All equipment shall be suitable for operation in their respective area classification. For Analyser shelters located in classified area (Zone - 2, Gr. IINIIBIIIC), HVAC unit is required to be

explosion-proof in construction. All flameproof equipments manufactured locally (within India), the testing shall be carried
out by any of the approved testing houses – CMRI/ERTL etc. The item shall, in addition, bear the valid certification from *PECB/CCE* and also the manufacturer shall hold a valid BIS license. All equipments manufactured abroad shall be certified by any approving authority like BASEEFA, FM, UL, PTB, LCIE etc. In addition certification by Indian Authorities *PECB/ CCE,* Nagpur, is mandatory.

2.6.2.8 Chemical Filters shall be provided in the fresh air intake to protect the electronic equipment installed inside the analyser shelters against corrosive gases like H,S, SO" NOx etc. as per specification clause 2.7.

2.6.3 HVAC System for Analyser Shelter Safe Area

2.6.3.1 Analyser shelters are to be air conditioned and pressurised to prevent the entry ofdust.

2.6.3.2 Air Conditioning and pressurization shall be achieved by providing packaged type HVAC units as per manufacturer's standard practice.

2.6.3.3 Pressurisation system shall be provided for analyser shelter with 2 nos of HVAC system (one working unit and one standby unit) each of same capacity without any common / sharing components. Fresh air intake arrangement comprising of fresh air blower with drive & back draft dampers, cleanable type filters (95%, 5 micron) and bird screen etc shall be provided. Minimum 5 air changes shall be provided as per IEC 61285 for ventilation purpose. Inside temperature rise shall be limited to 5° C above ambient, by fresh air from pressurization system, in case of failure of AC system. Relief dampers shall be used to exhaust room air at 5 mm WG over pressure. Shelter internal positive pressure shall be maintained at 2.5 mm WG minimum. Loss of pressurisation shall initiate an audio-visual alarm. Manual HVAC selector switch to alternate between the HVAC shall be provided in the shelter. Special anti-corrosive coating shall be provided for coolant tubes to withstand harsh refinery environment."

2.6.3.4 Vendor shall confirm that all analysers installed inside Aoalyser Shelters are suitable for continuous operation in this temperature (Max. ambient +5°C). In case any analyzer being supplied is not suitable for this temperature limit, vendor shall provide high temp pre alarm inside shelter. A separate potential free contact of this alarm shall be provided in alarm J.B. for connection to control room also.
The power to analyzer shall be cut off in case of high temperature.

2.6.3.5 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered.

2.6.3.6 Chemical Filters shall be provided in the fresh air intake to protect the electronic equipment installed inside the analyser shelters against corrosive gases like H2S, S02, NOX etc. as per specification clause 2.7.

2.6.3.7 Vendor shall submit heat load calculation for review during post order engineering. Heat load on account of fresh air shall be considered while calculating the capacity of air conditioners.

2.6.4 Inside Conditions to be maintained

Following inside conditions are to be maintained and guaranteed by vendor throughout the year:

Dry bulb temperature 26°C ± 1°C

Relative humidity 35% to 70%

2.6.5 Outdoor Design Conditions

Outdoor design conditions, as mentioned elsewhere, shall be considered for heat load calculation.

2.6.6 Spares

Spares for commissioning and start up as required shall be provided by vendor without any additional time & cost implication.

2.7 Chemical Filters

2.7.1 The design, selection, manufacture and supply of chemical air filters for the duty specified shall be in vendor's scope

2.7.2 Chemical air filters are required to be installed in fresh air circuit.

2.7.3 Selection Data for Chemical Filters

The following conditions shall be considered as a minimum for outside ambient air:

GAS	OUTSIDE (:g/m^3)		INSIDE (PPM by Vol.)
	Yearly Average	Max. (8 hr. average)	
S O_2 / SO_3	100	13000	< 0.010
NO_X	100	9500	< 0.05
H_2S	TRACES	13900	< 0.003
* Cl_2	TRACES	2900	< 0.001
* NH_3	TRACES	TRACES	< 0.5
SPM	400	15000	< 200 :g/m^3
RSPM	250	-	< 100 :g/m^3 (< 10 :)

* Normally not associated with Refinery emission.

2.7.4 Technical Specifications for Chemical Filters

2.7.4.1 Chemical air filter unit shall be selected to provide inside conditions as given above considering the outside ambient concentrations given under Max. (8 hrs. average) column.

2.7.4.2 Chemical air filter shall be selected for the chemical media life of minimum 2 years. The outside gas concentration given above shall be considered while evaluating the life. Chemical Filter supplier to furnish the calculations and nomographs etc. in support of the chemical media life, at post order stage.

2.7.4.3 Chemical air filter unit shall be skid-mounted cubicle for horizontal installation.

2.7.4.4 Three stage chemical filter shall be provided – *one/two* modules containing Puracarb or equivalent media and other metal modules containing chemisorbant or equivalent media.

2.7.4.5 Filter packs suitable for removal of specified gases shall be housed in an adequately rigid & reinforced sheet metal enclosure, with flanged inlet & outlet connections, inspection cover/manhole.

2.7.4.6 The pre-filters at inlet & fine filters at outlet shall be capable of removing dust particles of 10 microns with 90% efficiency & of 1+ microns with minimum 90% efficiency respectively.

2.7.4.7 Unit shall be suitable for outdoor installation & continuous operation. It shall be painted as per painting specifications of the Bidding document.

2.7.4.8 It should have adequate provision for easy removal & servicing of filter packs.

2.7.4.9 Unit shall be provided with indication of differential pressure across the filters.

2.8 Power Supply

2.8.1 Unless otherwise specified, the following power supplies shall be provided for each shelter at one point near the shelter by owner. Further distribution step down etc. as per requirement shall be done by the vendor:

i) 415V, 50Hz, 3 phase with neutral for the HVAC system.

ii) 11OVAC 50Hz Single phase for analyser, alarm system, horn and other related accessories.

230V 50Hz Single phase for lighting (internal and external) system of the shelter and heat tracing shall be developed by vendor.

2.8.2 The supply voltage fluctuation of ±10% and supply frequency fluctuation of±3Hz from the specified value, shall not affect the system performance.

2.8.3 The size and number of incomers shall depend on load and distance and shall be finalized during detail engineering. Vendor shall provide necessary terminal sizes and suitable cable glands.

2.8.4 Main switches for all three-power supplies shall be mounted outside the analyser shelter, which shall be weather proof to IP66 and explosion proof suitable for the specified hazardous area classification. The power supply cables will be terminated after the main switches inside the shelter in different junction boxes with terminals and switch fuse unit for power distribution to the relevant equipments/items. Individual switches shall be provided for each instrument for independent de-energisation of the items. ‘Power Supply on' indication shall be provided on the main power supply line to each analyser on PDB.

2.8.5 Two power sockets of IIOV 50Hz and nov 50Hz supply for electrical tools or test equipments shall be provided at two opposite corners of each shelter.

2.9 Other Utilities

Owner shall provide following utilities at one point near each shelter. Further distribution shall be done by vendor as per the requirement.

2.9.1 Steam

a) Pressure: 2.5 - 5.5 kg/cm'g

b) Temperature: Saturated

c) Line size connection: 1" NB NPT (M) with valve.

2.9.2 Instrument Air

a) Pressure: 4 .0– 6.0 kg/cm'g

b) Dew Point: - 40°C at atmospheric pressure

c) Line size connection: 1.0" NB NPT (M) with valve

2.9.3 Cooling water

a) Pressure: 3.5 - 5.0 kg/cm'g

b) Temperature: 33°C

c) Connection size: 1.0" NBNPT (M) with valve

2.9.4 Nitrogen

a) Temperature: Ambient

b) Pressure: 5 - 8 kg/cm'g

c) Connection size: 1.0" NBNPT (M) with valve

Vendor shall furnish the list of utilities required with expected consumption.

2.10 Lighting

2.10.1 Power supply for lighting inside and outside the shelter shall be 230 V 50 Hz.

2.10.2 Internal lighting shall be provided by fluorescent tube lamps to provide in illumination of 300-400 lux at all places on the floor.

2.10.3 External lighting shall be under overhangs to provide illumination sufficient for maintenance / repair work.

2.10.4 Lighting fixtures inside and outside the shelter shall be suitable for the hazardous area classification specified.

2.10.5 Lighting switch shall be provided outside the shelter near to the main door.

2.11 Terminal Housing

2.11.1 The terminal housing shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall comply with the following

requirements as a minimum:

Weather proof housing: IP-65 as per IEC-60529/IS-13947

Flameproof housing: Flameproof/Explosion proof i.e., Ex (d) as per IEC 60079 / IS2148 for explosion proof construction

Flameproof housing shall also be made weather proof and shall be provided with metallic enclosure.

2.11.2 All cables shall terminate on the terminal blocks in all vendor-supplied equipments, Separate terminal blocks shall be provided for power and signal cables. Unless otherwise specified, terminals shall be suitable for terminating following conductor sizes, as a minimum:

Signal cables : 1.5 /2.5 sq. mm
Power cables : 6 sq. mm

Separate terminal box shall be provided in case instrument terminals available as standard are not suitable to accommodate the specified conductor sizes.

2.12 Tubing / Piping / Wiring

Tubing and piping runs shall be installed such that they will not interfere in the maintenance or removal of any analyzer or equipment in the house or shelter nor encroach on space allotted for future instruments. All valves and instruments shall be readily accessible.

Traps shall be provided and installed by Vendor outside the house or shelter for all steam traced inlet sample lines and steam users. Each steam user shall have its own trap.

All users of instrument air shall have block valves at the take off point. All sample inlet and outlet points shall have isolation valve.

All piping and tubing shall be adequately supported. All tubing shall be protected by running it in trays or channels.

All tubing shall be annealed SS-316, 1/2 inch OD by 0.049” wall thickness or 1/4 inch OD by 0.035 wall thickness as appropriate. Fittings shall be Flare less SS-316.

Other materials for tubing and/or fittings may be considered where required by process conditions.

2.12.1 All safety valve outlets shall be terminated in a common header of 2" NB schedule 80S Stainless Steel 304 pipe and single outlet shall be provided out side the shelter with one non return valve and lock open type I" ball valve. Similarly all vents to atmosphere shall be terminated in a similar 2" NB Schedule 80S Stainless Steel 304 pipe and single outlet shall be provided . If commom header is not there then with non-return valve and Lock open type I” ball valve.

2.12.2 All atmospheric gas outlet line shall be equipped with protection from climatic condition.

2.12.3 All tubing work shall be done by using *1/2."* OD or *118"*OD SS tube aod Swagelok/ Parker/ Hamlet flare less, double compression type fittings.

2.12.4 All wiring/ tubing and all other erection work shall be done in accordance to API RP 551-5

2.12.5 All cable entries/outlets in the junction boxes/ distribution boxes etc and to the analyzer shall be provided with double compression type certified flameproof cables glands suitable for the indicated hazardous area. The material of the same shall be Nickel-plated brass.

2.12.6 All cabling/wiring works inside the shelter shall be in accordance with the international Standard / industry practice for similar application. However the cables shall be armoured as a minimum.

2.12.7 Dimensions and layout of each shelter shall be provided by contractor for Owner / PMC review before taking up for fabrication.

2.13 Hook up of Analyser Shelter

2.13.1 End Connections shall be provided for all interconnections (fast loop return, sample return, utilities, flare, vent, drain etc.) as specified in purchaser's data sheet for their hook up.

2.13.2 In case end connection for hook up of vendor's standard supply is different than that specified in the purchaser's data sheet, vendor should include the required hook up material in their scope of supply.

2.13.3 Unless otherwise specified, end connection details shall be as below:

a) Threaded end connections shall be NPT as per ANSIIASME B I. 20.1.

b) Flanged end connections shall be as per ANSIIASME B 16.5

c) Grooves of ring type joint flanges shall be octagonal as per ANSI 16.20.

d) Flange face finish shall be as per clauses 6.4.4.1, 6.4.4.2 and 6.4.4.3 of ANSIIASME B 16.5.The face fmish as specified in the data sheets, shall be as follows:

125 AARH : 125 to 200 AARH

63 AARH : 32 to 63 AARH

2.14 Foundation:

2.14.1 The analyzer shelter shall be installed on 200 mm high concrete pedestal provided on paved area in the plant by owner. The pedestal shall be extending I meter all around the footprint of analyzer shelter.

2.14.2 Analyser shelter shall be supplied with base channel of min. ISO mm height which will be bolted to the pedestal.

2.14.3 Vendor shall arrange all equipments outside the shelter including HVAC in such a manner that they are accommodated on the pedestal.

2.14.4 All civil works necessary to install the shelter on pedestal and any residual civil work to provide additional foundation for any accessory shall be in Vendor scope.

2.15 Painting

2.15.1 Non SS parts of the analyzer shelter shall be treated and painted as follows:

a) All surfaces including structures shall be sand blasted and grinded smooth and free of scale, rust etc.

b) Chemical treatment shall be done to remove rust, oil, entrapped impurities and other foreign materials.

c) Exterior and inside colour of shelter shall be finalised during detailed engineering.

3.0 NAMEPLATE

3.1 Each analyser shelter shall have a stainless steel nameplate attached firmly to it at a visible place near the main and Emergency doors, furnishing the following information:

a) Tag number as per purchaser's data sheet.

b) Manufacturer's serial number (If any).

c) Manufacturer's name/trade mark.

d) Area classification in which the shelter can be used.

e) Size of shelter.

Vendor shall fit a nameplate with the analyzer house number (e.g. AH-01) to both doors on each analyzer house.

Vendor shall also fit an appropriate warning boards like following:
• Analyser house protected by artificial ventilation
• Warning - doors shall be kept closed
• Warning - risk of H2S
• Warning - flammable material shall only be introduced into the analyser house if specifically permitted and recorded.

Vendor shall clearly identify all services with name plates, (for steam this shall also indicate maximum pressure and temperature), at entries to analyzers both internally and externally and entries to sample conditioning systems.

Vendor shall clearly identify all sample flow and return lines, carrier gas and calibration gases with name plates, at entries to analyzers both internally and externally and entries to sample conditioning systems.

All nameplates, labels and signs shall be in dual language, Hindi and English. In addition any signs for extreme caution, such as the risk of Hydrogen Sulphide shall also be in Bangla.

All parts inside and outside of the analyzer house, inside sample conditioning system, HVAC, safe guarding PLC shall have a nameplate indicating the label of that part for identification. The parts in Sample conditioning system shall also be printed with their set point or normal values in the second line of the label.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works.

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review:

a) Material test certificate as per clause 3.IB of EN 10204 for flanges, fittings and sheet steel.

b) Certificate of radiography/ X-ray for header welded joints. Dye penetration test certificate shall be provided for joints where radiography/ X-ray is not possible.

c) Dimensional verification certificate as per clause 4.3 of this specification.

d) Hydrostatic testing of all headers.

e) Leakage and continuity testing.

f) Power Distribution and wiring check

g) Functional check for HVAC

h) Type test certificates

Vendor shall carry out a complete inspection of all analyzer houses, to ensure all analyzers, analyzer sample systems, pipe and tube work, utilities, drain and vent systems, heating and ventilating system plus all analyzers which are field mounted are in manufacturer's perfect working order. The analyzer house Vendor shall permit inspection by the client at any time during the actual construction of any part or parts of the project.

Vendor shall make following facilities available for test :
• Sufficient qualified labour to carry out the test.
• Air or nitrogen at required pressure for the full duration of the test.
• Air bubbler, maximum working pressure 10kg/cm2(g).
• A gas/air leak detector
• Measuring equipment for supplies and outputs (multi-meter).
• Special measuring tools/equipment for components installed.
• Power supply units as applicable.
• Three copies of the as built drawings.
• Test and calibration gas/liquid samples for each analyzer.

Inspection and full functional testing shall then be carried out at Vendor's premises of all analyzer houses and systems and all field mounted analyzers, with the analyzer house Vendor's responsible analyzer specialist and the Client. This will include a full calibration test of each analyzer.

The analyzer house Vendor shall then ensure safe transportation of each analyzer house, complete with analyzers, sample systems and contents, plus all field mounted analyzers and their equipment, to the site, where they shall be installed by client under Vendor's supervision.

All field equipments, including field mounted analyzers sample systems and associated analytical equipment that is not mounted in each house shall be installed by Client under Vendor's supervision.

Analyzer house Vendor's responsible analyzer specialist shall then carry out a complete inspection to ensure all analyzers, their systems and all utilities are in manufacturer's perfect working order before each analyzer system and all utilities are commissioned by the analyzer house specialist. This will include a full calibration test of each analyzer.

The sample transport and return lines shall be disconnected from the preconditioning panel and sample conditioning cabinet and then flushed out with demineralised water. The system shall then be dried using clean air or nitrogen.

Analyzer house Vendor shall carry out pressure test and inspect the sample transport and sample conditioning systems before the system is offered for inspection by the client.

During the leak test, all inlets and outlets shall be capped off, with the exception of those which are provided with a valve. The isolating valve shall be closed for these connections. The analyzer shall not be included in the leak test and shall be disconnected at the inlet and outlet connection. All other valves and reducers shall be fully opened. The maximum pressure applied shall not exceed 10 kg/cm2(g). Each system shall be pressurized for at least five minutes while the bubbler is carefully observed.

Systems or parts with a design pressure upto 9kg/cm2(g) shall be isolated from the system having higher design pressure and shall be opened to atmosphere during the pressure test. Systems or parts of systems with a design pressure higher than 9kg/cm2(g) shall be pressurized at 1.5 times the design pressure via a tight shut-off valve and a high-quality pressure gauge.

4.3 Dimensional Verification

4.3.1 End connection dimensional details shall be verified for all instruments and their accessories in accordance with approved drawings. In any case, the variation shall n~t exceed ±2.0mm.

4.4 Hydrostatic Testing

All headers shall undergo hydrostatic testing at 1.5 times the header design pressure with water at ambient temperature. These shall not be any visible leakage during the testing.

4.5 Continuity Testing

a) All power cables shall be megger tested at minimum 600V. The insulation shall be as per IS-1554 Part I.

b) All signal cables / wires shall be checked for continuity, termination and identification using multi-meter.

4.6 Leakage Testing

All tubing and piping shall undergo leakage testing when pressurised with nitrogen at 100 psig. No bubbles shall appear when testing with soap solution.

4.7 Witness Inspection

4.7.1 Vendor shall offer all analyser shelters for pre-dispatch inspection at their works. Following tests/checks shall be carried out, as a minimum.

a) Physical dimensional verification and workmanship as per clause 4.3 of this specification.

b) Leakage testing of tubes and headers with nitrogen as per clause 4.5 and 4.6 of this specification.

c) Power distribution and wiring scheme check

d) Insulation resistance work

e) Functional check of HVAC

f) Review of all certificates and test reports as indicated In clause 4.2 of this

4.7.2 In the event the witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted to purchaser for scrutiny.

5.0 UTILITY SERVICES

Vendor shall provide a suitable distribution system as required. All service lines must have a minimum distance of 25mm clear between neighboring flanges. Steam and condensate lines shall have an allowance for insulation

Vendor shall provide a suitable distribution system for carrier gas, calibration gas, instrument air, etc as required for each analyzer. A means shall be provided to initiate an alarm on low pressure/volume in the header or cylinders.

All piping and tubing from headers, analyzers, cabinet drains, vents, steam users and steam tracing inside the shelter shall be brought to the outside so that, at the jobsite, all connections can be made outside the shelters.

6.0 SAFEGAURDING SYSTEM

Each analyzer house shall be protected by a safeguarding system against hazardous situations. Vendor shall supply safe guarding PLC, fire & gas detector, alarm initiating devices, annunciator etc. fully wired with respective junction box or PLC.

Vendor shall develop the “Cause & Effect Diagram”, “Functional Logic Diagram” and Input-output list for safe guarding PLC and submit the same to the client for approval. After client’s approval Vendor shall develop the logic and load into the PLC. The logic and Input-output configuration shall be uniform for the all analyzer houses supplied by Vendor.

The proposed interconnectivity among the systems like Safe guarding PLC, Annunciator, GC, AMS system, plant FGS, plant DCS, AMS PLC, etc. shall be provided. The vendor shall prepare the final interconnection diagram during detail engineering stage and submit to the client for review and/or approval.

AIR INTAKE

The presence of flammable or toxic gas at the point of fresh air intake of the ventilation system shall be monitored by Gas detectors. The Gas detectors shall be fitted in such a way that the prevailing flow profiles and air speed inside the ducting do not adversely affect either representative sampling or the accuracy of detection. The detector should easily accessible for maintenance.

INSIDE ANALYZER HOUSE

Flammable gas detectors shall be installed in the direct vicinity of the controlled outlet opening of the ventilation system inside the house.Toxic gas detectors shall be located at positions where leakage into the analyzer house is most like to occur in case of failure or mal-operation.Hydrogen gas detectors shall be installed if Hydrogen is used as carrier gas for Gas Chromatographs.Optical Smoke detector shall be installed inside the house to detect smoke/fire.Oxygen detector shall be installed inside house to alarm on oxygen deficiency.Flashing lights – RED & GREEN shall be installed inside the house. Fleshing RED light shall indicate “unsafe” condition inside the house. Steady GREEN light shall indicated “healthy (safe)” condition of the house. The lights shall be installed in such a way that the person can see through the glass window mounted on the.

OUTSIDE ANALYZER HOUSE

A Manual Call Point (MCP) shall be provided outside the analyzer house near main entrance. Actuation of MCP shall trip the analyzer house.RED & GREEN lights shall be over the roof of the house. RED light shall indicate trip condition of the house and GREEN light shall indicate healthy condition of house. These lights shall server the purpose of indication of house condition from remote.Air horn shall be installed outside the analyzer house. The horn shall blow whenever any alarm or trip is initiated by any of the device inside or outside the house. The horn shall have minimum sound amplitude of 100dBA.

ANNUNCIATOR

Indication lamps for each gas or fire detection, HVAC run/fault, house purging, house pressure,power available,etc. shall be provided on annunciator panel outside the analyzer house near main entrance.Alarm acknowledge, reset andlamp test push buttons shall be provided on the annunciator. All signals annunciator shall be wired to Safe guarding PLC. The annunciator enclosure shall be suitably certified for the area classification.

SAFE GAURDING PLC

Safe guarding PLC shall be supplied by analyzer house vendor and shall be installed in a purged enclosure inside the analyzer house along with all necessary wiring, power supply, barriers, relay, MCBs, etc.

The safe guarding system shall be independent of the main process ESD system.

The Fire & Gas System(supplied by other) of main plant will receive inputs from the fire and gas detectors of analyzer house and send output to safe guarding PLC for annunciation, beacon, alarm or trip.

In the event of an analyzer house power being isolated by the safe guarding system the power shall be restarted only by pressing the reset switch located outside the analyzer house.

• Safe guarding system for each analyzer house shall perform following actions, in the event of ventilation failure, loss of over-pressure, flammable or toxic gas detection, O2 deficiency, etc.
• Initiate an appropriate audio and visual alarm
• Isolate power to the wall sockets
• Isolate power to analyzers not certified for use in Zone1 hazardous area, isolate data highway for any analyzers connected to the Analyzer Management System and isolate any non- Intrinsically safe signals.
• In the event of fire detection or actuation of MCP outside the house, the safe guarding system shall carry out the above actions and the following:
• Isolate power to the analyzer house
• Isolate all sources of flammable material – sample, carrier gas, etc.
• Isolate the ventilation fans
• Close the fire damper at air inlet stack

Vendor shall ensure that all equipments to be isolated above with the exception of the ventilation fans, cannot be re-energized until the ventilation system is operating, the house is repressured and at least five fresh air changes have taken place. All internal panel wiring shall be within plastic trunking. There shall be separate trunking for signal types including IS and Non-IS and for Electrical supplies, with sufficient segregation to eliminateinterference.The trunking shall be sized with at least 40% spare capacity.

Between two rows of terminal there shall be plastic trunk (75mm x 75mm) minimum to receive field wiring for the panel.

7.0 ELECTRICAL UTILITIES

POWER

Following power to the analyzer house shall be supplied by client at single point on analyzer house:

220VAC ± 3%, 50 Hz ± 0.5Hz UPS power for Analyzers and Safe guarding PLC
240VAC, 50Hz Non-UPS power for lighting, maintenance socket, heater in Sample conditioning system, Sample pump, etc.

415VAC, 50Hz, 3-Phase for HVAC motors, sample pump motors, etc.Further distribution to individual device or equipment shall be supplied pre-wired by Vendor.

A manual power disconnect switch for each voltage feeder with padlock option shall be installed on the outside wall of each analyzer house / shelter.
All power distribution boards mounted on the analyzer wall shall be suitable for use in Zone1 area and classified EExd IIC T6, these shall be supplied by vendor.

Vendor shall calculate the expected load, for each supply voltage, with a 30% allowance for future expansion; these calculations shall be supplied to the client. All distribution boards shall have 30% spare capacity for future expansion.

The protection of power circuits shall be provided in both live and neutral lines and shall be either switches/fuses or MCBs. It shall be possible to “lock off” an isolated circuit. Cables entering distribution boards shall be terminated at suitably sized and rated terminals.

Bus bars and fuse blocks / switch blocks / MCBs shall be used for power distribution and shall be installed in such a way that any equipment can be disconnected from or connected to the system without interrupting power supplies to other equipments. Provision shall be made to provide a minimum of 30% spare for future requirement. Power supply wiring shall not be jumped from one instrument / device to the other.

Vendor shall provide wall sockets installed along the internal walls. These shall be provided with adequate protection for a Zone 1 area. The supply to wall sockets shall be protected in both live and neutral lines by residual current breakers and either switches/fuses or MCBs. In the event of ventilation failure or 20% LEL gas detected power to the sockets and equipment not certified forZone 1 IIC T6 use shall be isolated. The sockets shall be provided for both 240VAC UPS and 240VAC, utility supply.

Power to all electrical equipments inside the house which are not suitably protected for a zone1 hazardous area shall be isolated by Safe guarding system if a ventilation failure occurs.

CABLE

Electrical Power and Instrumentation Signal/Communication cables shall enter and leave analyzer house via separate cable transits mounted in the analyzer house walls.

Cable glands shall be used on all junction boxes or equipment entries. Glands shall be suitable for cable types and hazardous area classification.

Cable connections from chromatograph analyzers to its programmer or its computer shall not be cut. The cable shall be extended through the analyzer shelter intact, coiled, and marked by the Supplier so that connections can be made to the proper remote control section or computer.

All internal cabling shall be run on perforated galvanized cable tray. Adequate separation of signals level and voltage shall be maintained to ensure signal integrity.

The minimum size of power and lighting circuit cables shall be 2.5mm2 and also for all fire and gas detector cable size shall be 2.5mm2 and other instrument signal wiring shall be 1.0mm2 minimum.

Physical segregation of wiring for each signal type and power supply shall be maintained. Single core cables within panels shall be color coded for different signal types and power. Vendor shall supply details of his color coding system.

JUNCTION BOX

Vendor shall provide NEMA 4X (IP65) terminal boxes on the outside of each house and shall be certified for Zone1 hazardous area. Separate junction boxes shall be provided for Analog signals, Digital Signals, Fire & Gas signals and Communication signals. Vendor shall provide leads inside the shelter from these junction boxes to each analyzer, fire & gas detector or safe guarding PLC.

Further cabling from these junction boxes to Plant DCS, ESD or Fire & Gas detection system shall be carried out by Client.

The multi-core cables shall enter the junction box via bottom gland plate and all other cables shall enter via side gland plates. There shall be no top entries.

All terminal blocks shall be of the screw type, with barriers and marking strips. All wires shall have cross ferrules at each end by means of a small plastic sleeve (permanently stamped). Each terminal block shall have a minimum of 20 percent spares.

Wiring between terminals shall be continuous runs and shall not be spliced. With the exception of solid jumpers, not more than two wires shall be connected to one terminal.

The wiring shall be segregated as AC wiring, intrinsically safe DC wiring, and non-intrinsically safe DC wiring, communication wiring and power wiring.

LIGHTING

Vendor shall supply suitable and adequate lighting for each house, both internally and externally, to supply illumination level minimum of 400 Lux. All fittings shall be suitable for use in a Zone 1 area, certified EExd IIC.

Failure of any one light fitting shall not mean that any part of the house shall fall below an acceptable illumination level. Vendor shall provide minimum one light with battery backup for one hour with each house.

Both internal and external lights shall be controlled from switches placed externally at both entrance doors. Switches shall be certified for Zone 1 use.

EARTHING

Provision shall be made for three (3) independent earth connections to the safe guarding panel - plant earth, instrument earth and intrinsically safe (IS) earth.

The Plant earth - All removable doors and covers, gland plates, instrument cases, etc, shall be connected to the plant earth. Earth studs, size M10, shall be provided inside the panel, located at the bottom of the panel. All protective earths shall be connected to these studs.

Instrument Earth - an electrically isolated copper instrument earthing busbar shall be located at the bottom of the panel. Both ends shall have an earthing lug capable of accepting a 16mm2 copper earth wire. The busbar shall be positioned below terminal blocks to allow easy access for the connection of earth wires. Cable screens and electronic loops requiring earthing shall be directly connected to the earth busbar and loop-connection of screens shall not be allowed. A minimum of 30% spare connecting points shall be provided.
Intrinsically Safe Earth - An electrically isolated copper IS instrument earth busbar shall be located at the side of the panel. Both ends shall have an earthing lug capable of accepting a 16mm2 copper earth wire. This earth bar shall be used for intrinsically safe circuits. A minimum of 30% spare connecting points shall be provided.

Apart from the above earthing, Vendor shall supply a non-insulated “plant” earth bar within the analyzer house above floor level. All metal enclosures for electrical equipment, including analyzers and auxiliary equipment shall be bonded to this earth bar. The minimum size of earth conductor shall be 6mm2. Provision shall be made for site connection of two 70mm2 earth conductors to the earth bar. Earth continuity shall be ensured throughout the analyzer houses including all doors and framework.

8.0 DOCUMENTATION

Vendor shall submit to the client following design and engineering documents as minimum:
• Schedule of Vendor documents and drawing
• General arrangement in detail with all assemblies or items within the assembly including overall dimensions and location, gross weight, transporting support, lifting arrangement, earthing details, face to face dimensions, etc.
• Exploded/cross sectional View – Drawing indicating assembly details, description of component and material description and part no. against which the spares can be ordered.
• Analyzer house and panel layout drawings - clearly showing overall size, cut out details, list of instruments showing label engravings, paint finish and color, frame dimensions, etc.
• Schematic Drawing – Drawing shall indicate the electrical arrangement of all components shown in a de-energized state.
• Interconnection diagram - Block diagrams will show interconnecting cables among Instruments, analyzers, electrical equipment, junction box, safe guarding plc, annunciator, sample conditioning system, etc. indicating cables not in Vendor's scope of supply.
• Internal wiring diagram for all instrument and electrical termination details including Junction box, safe guarding plc, analyzers, etc. terminations.
• Instruments layout drawing – indicating location of each instrument with tag no. with elevation, tubing or cable layout, instrument air line layout, etc.
• Functional logic diagram – for sequence of operation and interlock logic of safe guarding plc.
• Instrumentation data sheet for each instrument installed in the house including Fire and gas detectors.
• Instrument & Electrical Cable schedule – which will list all cables with type, size, length and location.
• Installation, commissioning, operation and maintenance manual for all equipments installed in the house including, HVAC, PLC, Annunciator, Analyzers, fire and gas detectors, instrumentation items, electrical items, etc.
• Instrument loop diagrams – indicating location and termination details of each instrument with safe guarding plc or analyzer
• Sample hook up drawing – from sample take off to sample conditioning system to analyzer and return to sample line. This will indicate vent and drain lines.
• Detailed bill of materials for all items / parts with their make, model and ordering information.
• Commissioning spare list

9.0 PACKING AND SHIPPING

Each instrument and all moving parts shall be securely packed and properly packaged, boxed, or crated to prevent damage to instruments and parts while handling, during shipment, delivery, and warehousing.

All glass shall be covered with cardboard or wooden protectors and the complete instrument wrapped or packed in a container of suitable design to withstand normal shipping, handling, and indoor storage.

All openings (including tubing and pipefitting) shall be covered, plugged, or capped to prevent entrance of foreign materials and contaminants during transit and storage.

All framed openings of the shelter shall be weather sealed for shipping.

Field mounted analyzers, auxiliary equipment or other heavy items shall be provided with additional bracing to prevent them breaking loose during shipment. All supports which will be in contact with equipment in the analyzer houses shall be suitably protected.

10.0 SERVICE AND SUPPORT

Vendor shall accept full system responsibility for all supplied hardware, operating and application software, and provide the necessary training, and site support for the construction, staging, testing, installation and pre-commissioning phases per this specification until successful hand over to the contractor.

• Vendor's responsibility shall include, but is not limited to, the following items:
• System engineering support
• System hardware and operating system software
• Software for interfacing all foreign devices
• System documentation
• Recommended spare parts
• Factory acceptance testing
• Packing and shipping per the accompanying requisition
• Warranty
• Failure of this Specification, Attachments, and/or drawings to state or show materials essential to make the equipment specified complete and operable shall not relieve Vendor from the responsibilities for furnishing such materials.

The Client's review of Vendor's drawings does not relieve Vendor from the responsibility of furnishing equipment that will function as intended by this Specification.

Vendor must take full responsibility for all supplied equipment and adhere to the requirements of this specification.

11.0 SPARES

Vendor shall submit full bill of material including all items with respective manufactures part No. Commissioning spares shall be in Vendor's scope of supply.

Bill of Material shall include following
• Analysers (Chromatograph Spares)
• Sample Conditioning System Spares
• Safe Guarding PLC & it's spares
• JB spare Details
• Fire & gas Detector spares
• Instrumentation items installed inside/outside Analyzer House.
• Electrical Spares including HVAC motors, pumps, tube lights, MCBs ,emergency light, etc.
• Mechanical Spares Details
• Calibration or carrier Gas cylinder details
All above spares details will include complete ordering information for future procurement.

12.0 SHIPPING

All threaded and flanged openings shan be suitably covered to prevent entry of foreign material.

Glass windows shall be covered with thermo-coal sheet of appropriate thickness to avoid damage during transport.

Shipping breaks shall be provided in all equipment, which are supplied in installed condition inside the analyser shelter. Equipment, which is likely to damage during shipment, shall be packed separately for shipment.

REQUIREMENTS FOR ANALYSER SYSTEM

FOR

ANALYSER SHELTER

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

ANALYSER SYSTEM SPECIFICATIONS

1. GENERAL

1.1 This specification defines the minimum requirements of Analyser System / systems designed for reliable and effective analysis of various process streams.

1.2 All analysers alongwith their associated equipments shall be installed by the contractor inside the analyser shelters.

1.3 All analyser shelters shall be ventilated, pressurized and air-conditioned. However, all analysers and other associated equipments shall be so designed and selected that these will continue to operate even in case of ventilation / pressurization failure.

1.4 Contractor shall provide all installation material including consumables to install the analysers, sample conditioning systems, sample transfer lines, vent lines and all other accessories. All instruments shall be completely accessible to permit adjustments, calibration and maintenance.

1.5 The components to be furnished for each sample system will depend upon the sample stream conditions. The contractor shall select and provide all the necessary components for each of these systems accordingly.

2. SAMPLING SYSTEM

2.1 The sampling system shall consist of necessary components, including sample probes, sample filters, pressure reducers, safety relief valves, pressure and temperature gauges, moisture separators, flow regulators, flowmeters, isolation valves etc. necessary to prepare the sample for proper analysis.

2.2 All components shall be sized and coupled so as to keep the sample volume to a minimum.

2.3 Calibration zero and span gas connections shall be provided for each analyser.

2.4 The sampling system shall have various sub-assemblies as required. The minimum requirements of each sub- assembly shall be as given below.

2.5 Sample Probe Assembly

a. Sampling probe shall be designed to extract true representative sample from the process line. The design shall prevent particulates from entering into the sample system.

b. The design of probe assembly shall facilitate on line removal of the probe without shutting off the process. Suitable mounting adapters shall be provided with the probe.

c. Probes shall be of 316SS material as a minimum or better as required by process stream.

d. The length of tubing between the sample probe and the sample stream pressure reducing station shall be kept minimum by close coupling various components in between.

2.6 Sample Stream Pressure reducing stations:

a. Contractor shall design and provide sample stream pressure reducing station to minimize sample transfer time maintaining the integrity of the sample. Sample stream pressure reducing stations shall consist of pressure regulators, relief valves ,pressure gauges, temperature gauges etc as required.

b. These stations will be located at the sample process connection to minimize transport time lag from the sample point to the analyser.

2.7 Sample Transfer Line

a. The sample transfer lines hall transport the fluid sample from the sample stream pressure reducing stations to sample conditioning system located at the analyser house/shelter.

b. Contractor shall provide heat tracing for sample line wherever necessary, in order to maintain the sample integrity.

c. The routing of sample transfer lines shall be done in such away that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.8 Sample Conditioning System:

a. Sample conditioning system shall be provided by the contractor at the analyser shelter

b. Multi stream analyser system shall have a separate sample handling subassembly for each stream.

c. Sample conditioning system shall include, but not limited to, moisture separators, filters, rotameters, pressure gauges, flow switches, solenoid valves etc.as necessary for proper analysis of each sample stream. Isolating valves shall be provided as required.

d. Stream selecting valves shall be located as close as possible to the analyser to minimize connecting tubing-length and to minimize the possibility of cross contamination of samples.

e. Stream selecting valves shall be double block and bleed and shall fail closed so as to block the sample from the analyser on loss of motive power.

f. Block valves shall be provided on all process sample lines.

g. Rotameters for measuring all sample flows shall be included.

h. Special precautions may be necessary where catalyst fines and coking material, and other difficult stream conditions are present.

i. Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample ,it shall been closed in a thermally insulated, thermostatically controller heated enclosure. Enclosure heating shall be with steam heater unless specified otherwise. Sample stream flow adjustments and analyser shutoff valves shall be operable from the front of the enclosure without opening the enclosure door. Sample stream flow, pressure and temperature indication shall be visible from the front of the enclosure.

j. Sample tubing between the sample conditioning system and the analyser shall be kept as short as possible.

2.9 Sample Stream Bypass/ Fastloop:

a. Sample stream bypass/fastloop shall be provided for the sample streams to meet the required sample transport time.

b. Flowmeters shall be provided by contractor for sample bypass/fastloop flow.

space, within or otherwise hazardous area, in which under normal operating conditions a non-hazardous atmosphere exists.

4.3 The interior temperature shall be maintained at 26Ec±2E c maintained. Contractor shall provide necessary air conditioning, heating, pressurization and ventilation.

4.4 Contractor shall propose a layout of analysers and their sample conditioning system such that the length of tubing in between the sample conditioning system and the analyser shall be located in such away that it is completely accessible to permit adjustments, calibration and maintenance**.**

5. ANALYSER:

5.1 The analyser shall be furnished with all the necessary equipment to properly analyse the sample.

5.2 Material of construction for the components in contact with the sample stream shall be SS316 except where the stream composition requires other material.

5.3. The detector cells shall be of a type that will provide adequate separation of components, minimize analysis time, minimize maintenance time and meet the performance requirements of this specification.

5.4. The analyser system temperature shall be controlled by an accurate (V1EC) electric heating system to ensure the proper sample separation and minimize the analysis time.

5.5. A shutdown switch shall be provided to protect the analyser from the loss of carrier gas or loss of fuel gas.

5.6 Solenoid operated multi function valves for sample inlet and column switching shall be provided.

6. PROGRAMME / CONTROLLER

6.1 The programmer / controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to a DCS or digital computer and any require peripheral equipment.

6.2 Visual read out using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

6.3 Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

6.4. All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alter able password shall be provided to limit access to system software by unauthorized personnel.

6.5. The application program in the analyser shall be retained for a minimum of six months without external power by the use of EEPROM or Battery back-Up. An EEPROM program cartridge interface shall be provided for program loading.

6.6. Maintenance diagnostics shall be included in the software system to allow rapid trouble shooting in the event of system mal-function. Alarms in the English language shall be provided to notify the operator in the event of the mal-function. Allow carrier flow alarm shall be included.

6.7. The stream number shall be printed-out on each analysis report.

7. ELECTRIC WIRING- SIGNAL CONTROL AND POWER:

7.1. Contractor's scope of supply and work shall include all cabling and wiring inside the analyser shelter.

7.2. Contractor shall provide an explosion proof (Exd) power distribution box for power supply to various analyzers. This box shall be certified by a statutory body for use in hazardous area. The box shall have copper bus bars for distribution of power supply to various consumers.

7.3. Power supply to individual consumer shall be by dual pole, dual element circuit breakers. These circuit breakers shall be in explosion proof (Exd) construction certified by a statutory body for use in hazardous area and shall be mounted near the equipment served and shall have engraved plastic tag plates.

7.4. All cabling and wiring shall conform to API-RP-550. Signal and power cabling / wiring shall be segregated and run in separate raceways with separation distances as recommended per API-RP-550

7.5. All cables shall be armoured, flame. Retardant PVC insulated, 600 Volt grade, stranded copper conductor. Signal cables shall be twisted pair shielded.

7.6 . Conductor size for power cables shall be 2.5 sq.mm (min.) and for signal cable it shall be 1.5 sq.mm.

7.7. Colour coding for power supply wiring shall be red for phase, black for neutral and green for earth.

7.8. Contractor shall provide junction boxes for signal and control cables separately which shall serve as interfaces for cables going to remote control room. These junction boxes shall be explosion proof (Exd) certified by statutory body for use in hazardous area.

7.9 Wire termination shall be done using self insulating crimping lugs.

7.10. All cables, wires shall be provided with identification ferrule (one piece ferrule / cylindrical ferrules for proper identification.

7.11 Terminal strips shall be provided with identifying terminal numbers, as required. Terminals shall be screw and strap compression type.

7.12 20% spare terminals, cable entries with cable glands, relays and other components wired up to terminals shall be provided..

8. COMPRESSED GAS CYLINDERS AND THEIR HANDLING:

8.1 Each analyser shall be provided with the following compressed gas steel cylinders.

a. Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.

b. Calibration gas sample bottles.

8.2 Fuel gas and Carrier gas cylinders and associated manifolds shall be located on a concrete pad outside the analyser bulldinq. The gas cylinder manifold shall be arranged so that one cylinder may be replaced while the analyser remain in operation on the other cylinder.

Cylinders shall be sized 1A (225 mm diameter x 1300 mm long) and shall be supplied with auxiliaries such as fittings and two stage regulators.

8.3 Calibration gas cylinders shall be located outside the analyser shelter. Contractor shall include a drawing showing the layout of cylinders.

8.4. Racks shall be provided to support cylinders, piping, valves and pressure regulators associated with high pressure gas cylinder manifold system. Each cylinder in the system shall be secured to the rack by a separate chain or clamp.

8.5. A pressure relief valve, vented to a safe location outside the building shall be installed on the low pressure side of the pressure reducing regulator of each cylinder. Vent piping shall be installed in a manner to prevent the entry of bugs or moisture into the outlet of th event. This vent shall be in addition to the analyser vent.

8.6. All pressure regulators shall be two stage type. A sign identifying the type of gas applied to a manifold shall be placed above each cylinder rack.

8.7. The location and separation of hydrogen manifold from other flammable gas manifolds shall be in accordance with NFP A50A-1973 section 52 and 61.

8.8. All tubing between the cylinders to the analysers shall be complete and easily removable from each and either end .

8.9. Contractor's quote shall include fuel, carrier and calibration gas cylinders as necessary, as a minimum, for:

i) the field testing, commissioning and final acceptance

ii) One year from the date of acceptance.

8.10. The calibration gases shall be of high purity, at least better than the specified accuracy and precision values for analysers. It is preferable to prepare calibration gases by Gravimetric method.

8.11. The concentration of calibration gases must remain constant for a period of at least one year .

8.12. The material of construction of cylinders shall be suitable for maintaining stability of the calibration gas mixture for the specified time. Contract or may quote for the staggered' deliveries wherever calibration mixture is not stable.

8.13. The contract or must submit the following certificates from any recognized certifying agency / laboratory;

i) Accuracy / Precision of the calibration gas.

ii) Stability of sample for at least one year.

8.14. Contractor shall forward all the details including the source of supply, certifying agency, cylinder size and volume, sample pressure, dew point, regulator type and make etc.

In addition contract or must fumish calculations for number of cylinders quoted of each type. For calibration gas cylinders, consider calibration once in every 8 hours.

9.0 SAFETY REQUIREMENTS:

9.1. Hazardous Area Protection:

a The analyser shelter shall be an unclassified area. Positive pressure and ventilation from a clean air source shall be provided to achieve this classification.

b It is intended to operate the analysers even during the ventilation failure, hence it is required that all analysers shall be suitable for hazardous area.

c All the electrical fittings provided in the analyser shelter shall be explosion proof type. However, a safety system shall be provided by the contractor to switch off power supply to all electrical equipments and accessories not suitable for hazardous area in case of ventilation failure. To do this it shall be ensured that all analysers continue to work safely even under these conditions.

d All junction boxes, power distribution cabinets, LEL detectors and their panel and other safety devices shall be suitable for the hazardous area certified by a statutory body.

9.2. Grounding:

a All electrical equipment in the analyser house / shelter and outside shall be grounded properly.

b Cylinder racks, sample conditioning enclosures, analyser racks, shall also be grounded directly to the AC ground bus.

c All necessary grounding bus requirement for Equipment grounding and signal shields shall be provided by the contract or in the analyser shelter .Contractor shall also provide all earthing arrangements inside the analyser shelter.

9.3. Combustible Gas Detection System (LEL Detectors):

a Contractor's scope includes of supply and installation of combustible gas detectors with associated monitoring system for the analyser shelter .

b Combustible gas detectors shall monitor all inlet air in take points. The detectors shall be calibrated to give alarm and high alarm at 20% and 40% respectively of. The LEL of the component with the lowest LEL in the area. On the occurrence of high alarm the ventilation system shall be shut-off. Contractor shall provide potential free DPDT contacts rated at 230 V AC 5 Amp for connection to ventilation system.

c Shutoff of ventilation system shall be based on 2 out of 3 voting, which means that only if two detectors out of the three provided indicate a high LEL, trip shall provided.

d Additionally, combustible gas detectors shall monitor the analyser shelter interior and exhaust air. These detectors shall give alarm and high alarm as mentioned above, however no shut off of ventilation system shall be required.

e Contractor shall calculate total requirement of combustible gas detectors alongwith their location.

f The monitors for LEL detectors shall be provided with malfunction, warning and danger lights and a 0 to 100% indicator.

g Contractor shall provide grouped high alarm and high-high alarm SPOT contacts rated for 230 V AC 5 Amp for repeat alarms in remote control room.

h The monitors for LEL detection system shall be installed in a panel which shall be pressurized as per NFPA 496 type 'Z 'purge.

9.4 Fire / Smoke detection

a Contractor's scope shall include supply and integration of fire detectors / smoke detectors (Ionisation type) within the analyser shelter. The no .of shelters shall be decided by the contractor based on the shelter size and coverage of area with in the shelter.

b The monitors for the fire detection shall be installed in a pressurized / purged panel as per NFPA 496 type Z purge. This may be shared with LEL monitor panel.

C The signals from the fires system monitor shall be provided for :

- One contact for alarm on the waming panel.

- One contact each for repeat alarm in the control room DCS and fire panel of Electrical section.

9.5. Oxygen gas monitoring

a Contractor shall provide a maximum of two nos .of oxygen gas monitoring system for sensing deficiency of oxygen within the shelter.

b In case the monitors show low concentration of oxygen within the analyser shelter, an alarm shall be initiated on the warning panel. The repeat alarm shall also be provided for

DCS in the Main control room.

c Oxygen monitors should be located in purged panel as per NFPA 496 type Z purge. These may be located in the same panel where LEL detectors are installed.

9.6 Warning Panels:

a Contractor shall provide warning panels for audio visual alarming of hazardous conditions inside the analyser shelter. One such panel shall be installed by coniract or on each of the external walls of the analyser shelter where entrance doors are provided.

b The warning panel shall provide the following audio-visual alarms:

i Presence of combustible gases inside the analyser house / shelter.

ii Loss of analyser house / shelter pressurization

iii Ventilation system failure

iv Fire / smoke within the shelter

v Oxygen deficient within the shelter

c For alarming of analyser shelter pressurization failure contractor shall provide an explosion proof pressures switch for sensing analyser shelter inside pressure.

d These warning panels shall be of explosion proof (Exd) construction certified by a statutory body for use in hazardous area.

10.0 FACTORY TESTING AND ACCEPTANCE:

10.1. The analyser systems shall be thoroughly checked and tested prior to shipment to assure correct design, construction and proper operation.

10.2. The Owner / Consultant reserves the right to be involved and satisfy himself a teach and every stage of inspection and testing.

10.3. During the final testing vendor shall test and demonstrate to the Owner / Consultant, the functional integrity of all analysers, sampling systems and all other hardware. Repeatability test shall be performed on all analysers for a test period of 24 hours. No material or equipment shall be transported until all required tests are successfully completed and certified' Ready for shipment 'by the Owner / Consultant. Softwares, if involved, shall also be tested.

10.4. Contractor shall submit schedule of factory testing and inspection.

10.5. After placement of order vendor shall submit his factory testing and customer acceptance procedure for Owner's / Consultant approval. This document shall contain the information related to each test e.g. purpose of test, definition, test procedure, results expected and acceptance.

10.6. Owner / Consultant has every right to add or delete any test in vendor's test procedure and acceptance criteria. The system shall be tested and accepted as per the approved testing procedures and acceptance criteria. The cost of performing all tests shall be borne by the vendor.

10.7. Contractor shall notify the Owner / Consultant atleast three weeks prior to final system testing at vendor's works. In the event that representatives of Owner / Consultant arrive and the system is not ready fortesting, the contractor shall be liable for back charging for any extra time and expenses incurred by the Owner.

10.8. It shall be contractor's responsibility to modify and / or replace any hardware, equipment or analyser if the specified functions are not completely achieved satisfactorily during factory testing and acceptance.

11.0 INSTALLATION, TESTING AND COMMISSIONING:

11.1 . Contractor shall provide the services of his installation team which would install the equipment in the analyser house / shelter and in the field, lay the tubing from sample probe to analyser house / sheiter, lay the interconnecting cabling tubing inside the analyser house / shelter, perform system check outs, test and commission the entire system.

11.2. All technical personnel assigned to the site by the vendor shall be fully conversant with the system supplied and shall have capability to bring the system on-line quickly and efficiently with aminimum of interference with other concurrent construction and commissioning activities.

11.3. Contractor's responsibility at site shall include all activities necessary to be performed to complete the job including;

a Receipt of all analysers and related hardware, and checking of completeness of supply. In case of shelters, verification of all analysers and accessories duly installed tubed and wired

b Installation of all analysers, and other associated equipment including all safety equipment like LEL detectors, annunciators, panels etc., all auxiliaries like power supply distribution boxes, all interconnecting tubing / pipingetc.so as to complete the job in case of analyser room (not shelter).

c Installation of sample probes, pressure reducing stations, sample conditioning systems, interconnecting tubing, heat tracing etc.

d All analyser sample stream bypass,vent and drain tubing/piping.

e Termination of all field cables or cables to control room, ferruling} tagging of interconnecting cables in analyser house/shelter.

f Interconnection cabling inside the analyser house/shelter

g All civil works like grouting, fixing etc and patch up work where vendor is likely to remove the plaster and shall make holes in the walls, floor or ceiling.

h Checking of interconnections, hardware configuration, overall system functioning. Leakage rate test. J Liaison with vendor's home office .

k Field testing.

l Commissioning of the complete analyser system .

m Final acceptance testing .

11.4 **System Check-outs:**

a Checking of all interconnections , configuration and overall system functioning.

b Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge.

c All the check-outs shall be performed in the presence of Owner/ PMC authorized representative. All readings shall be recorded on a suitable format and shall be submitted for approval.

d After system checking is completed, contractor shall connect back any terminal or tubing or connection removed for loop checking.

e All the equipment shall be checked thoroughly after its receipt at site. The tests, as a minimum, shall include;

i Visual and mechanical testing

ii Complete system configuration loading

iii Calibration of all analysers, and other related equipment.

iv Demonstration of all system functions.

V Demonstration of all system diagnostics.

vi Checking of correct change of redundant devices.

vii Demonstration of analyser accuracies, linearities, repeatabilities, response time etc.

viii Demonstration of proper operation of system at specified voltage supply specifications.

ix A leakage test shall be conducted on entire system. Maximum permissible leakage rates shall not exceed 5%perhour of specified desiqned pressure.

12.0 TRAINING:

Contractor shall be responsible to train the Owner / Consultant personnel in the field for maintenance of hardware and software. Theoutline of each course including the course contents and the duration shall be forwarded by the vendor alongwith the offer.

13.0 DOCUMENTATION:

Contractor shall furnish all the manuals, including for maintenance and operation, necessary to test, operate and maintain etc the analysers and other related equipment, hardware and software.

14.0 ENGINEERING DRAWINGS:

14.1 . Contractor shall provide a complete set of drawings covering eachp art of supply for Owner / Consultant record. The contract or is required to include Owner's project number on each of his drawing.

14.2 . All field modifications shall be carefully recorded by the contractor's installation and commissioning personnel and changes shall be incorporated into the final drawings.

15.0 FINAL ACCEPTANCE TEST:

The Owner. Will take over the system from the contractor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks with desired accuracy and repeatability. Contractor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning.

16.0 TESTING AND CALIBRATION EQUIPMENT:

Contractor shall make available all consumables including calibration gas cylinders, instruments and equipments necessary fortesting, calibration, maintenance etc. as defined by the 'scope of work' .All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated / tested equipments and shall be certified by National Physical Laboratory or other equivalent agencies.

17.0 SPARE PARTS:

Contractor shall quote separately for spare parts required for a two year period of operation for the complete analyser system and the associated auxiliaries offered. Contractor shall enclose a list of spare parts quoted along with the offer.

18.0 MAINTENANCE CONTRACT:

Contractor shall quote separately for maintenance contract after warranty period for two years based on per day rate for each category of persorinel required. The personnel deployed shall have thorough knowledge of the system and at least two years of experience as maintenance of similar system.

19.0 PACKING AND SHIPPING INSTRUCTIONS:

19.1. All materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be recognized brands and shall conform to the best standards in the areas for the articles which are being packaged.

19.2. Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects; imperfections or omissions which would tend to impair the protection of the package as a whole.

19.3. The package shall be suitable for storing in tropicalised climate as per specified ambient conditions.

19.4 . Shipment shall be thoroughly checked for completeness before final packing and shipment. Contractor shall be fully responsible for any delay in installation or commissioning schedule because of incomplete supply of equipment.

GENERAL SPECIFICATION FOR

STACK ANALYSERS(IF applicable)

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

Abbreviations:

AARH	Arithmetic Average Root Height
CCE	Chief Controller of Explosives
CIMFR	Central Institute of Mines and Fuel Research
ERTL	Electronics Regional Testing Laboratory
DGMS	Director General of Mine safety
CRCA	Cold Rolled Cold Annealed
DC	Direct Current
DCS	Distributed Control System
HVAC	Heating Ventilation and Air conditioning
IR	Infrared
LCD	Liquid Crystal Display
LED	Light Emitting Diodes
MAWP	Maximum Allowable Working Pressure
MOC	Material of Construction
PTFE	Poly Tetra Fluoro Ethylene
NPT	National Pipe Thread
RAM	Random Access Memory
RTU	Remote Transmission Unit
SS	Stainless Steel
UV	Ultraviolet

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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirements for the complete design, materials, nameplate marking, and inspection, testing and shipping of stack gas analysers.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

ANSI/ASME American National Standards Institute/ American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads. General Purpose (Inch)

B 16.5 Steel Pipe Flanges and Flanged Fittings. NPS ½ through NPS 24.

B 16.20 Metallic Gaskets for Pipe Fittings, Ring Joints, Spiral and Gasketed.

API American Petroleum Institute

Manual on Installation of Refining Instruments and Control System

RP 551 Process Measurement Instrumentation

RP 552 Transmission System

RP 554 Process Instrumentation and Control

RP 555 Process Analysers

ASTM 693 Standard Practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environment.

EN 50020 Electrical Apparatus for potentially explosive atmospheres-Intrinsic safety 'i'

EN 10204 Inspection Documents for Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures. (IP Code)

IEC-61000-4 Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment.

IEC-61285 Industrial Process Control Safety of Analyzer Houses

IEEE 515.

IS-13947 Specification for Low Voltage Switchgear and Control gears.

IS-2148 Electrical Apparatus for Explosive Gas Atmosphere-Flameproof enclosures 'd'.

NFPA 496 National Fire Protection Association

1.1.3 In the event of any conflict between this standard specifications, job specification/data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

d) Codes and Standards

1.1.4 In addition to meeting the purchaser's specification in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheet indicates the type of analyser and the minimum sample conditioning system requirements. Vendor shall be responsible for the selection of proper analyser and design of the sample conditioning system to analyse the component of interest within the stated performance requirements.

b) Carry out complete application engineering of the stack gas analyser so as to achieve the desired analysis within stated performance requirements.

c) Provide all hardware and software, as necessary, to meet the functional requirements specified in the purchaser's specifications.

d) Provide complete data to purchaser for successfully proving serial communication with purchaser's host system i.e. DCS when specified in the job specification.

e) Purchaser's data sheets indicate the minimum requirements of material of construction for the analyser and its sample conditioning system. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for the parts of the analyser system which have the alternate material of construction for their compatibility with the analysis stream and surrounding atmosphere as specified in purchaser's data sheet.

1.1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) A detailed specification sheet for each analyser, which shall provide information regarding type, materials of construction, performance specification and accessories of analyser. The material specification and units of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.

c) A detailed drawing showing various components of sample conditioning system and their piping/tubing hook-up arrangement including sample return, vent, utilities connection and requirement of heat tracing (i.e. electrical or steam tracing), as necessary.

d) Sample transportation time calculations for the specified distance between sample point and analyser indicating sample flow rate and the recommended size of the sampling tube.

e) Calibration gas cylinder calculations considering six months of continuous operation with once in a fortnight calibration. The calculation sheet shall indicate the rate of gas consumption and specification of gases including composition, concentration, accuracy and shelf life of calibration blend.

f) Proven references for each offered model of analyser inline with clause 1.2.3 of this specification.

g) A copy of approval for intrinsically safe/flameproof enclosure, whenever specified, from local statutory authority, as applicable, such as Chief Controller of Explosives (CCE), Nagpur or Director general of Mines Safety (DGMS) in India, along with:

i) Test certificate from recognised house CMRI/ERTL etc. for flameproof enclosure as per relevant Indian Standard for all Indian manufactured equipments.

ii) Certificate of conformity from agencies like CSA, BASEEFA, PTB, LCIE, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

h) Utility requirements and their consumption i.e. instrument air, cooling water, steam etc. along with their process conditions like flow, pressure and temperature.

i) Power consumption for each analyser and its accessories.

j) HVAC requirements i.e. heat load, humidity particulate/chemical filtration etc.

k) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technicalspecifications along with the technical reasons for each of these deviations.

l) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser and accessories covered in the bid.

1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date for the analysis as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals, etc shall be in English language only.

1.2.5 Vendor shall also quote for the following: -

a) Complete calibration kit consisting of calibration gas cylinders, pressure regulators, gauges, cylinder gas piping manifolds and driers, (as required) etc. as a minimum,for

b) each analyser. In case of dual range analyser, separate calibration standards shall be provided for each range. For the purpose of calculating requirement of zero and span calibration samples/gases, consider calibration time of 30 minutes every fortnight for each analyser for a period of six (6) months of continuous operation.

c) Consumable spares for the duration of six months with list of items as per vendor recommendations for each analyser system, unless otherwise specified in job specification.

d) Start up and commissioning spare parts for each analyser/analyser system as per vendor recommendations. However this list of spare parts must include 5% or minimum one of each type of following spare parts:

- Solenoid valve
  - Pressure regulator
  - Filters
  - Temperature controller
- IR/UV Source (lamp)
  - Peristaltic pump
  - Set of fuses
  - Set of o-rings
  - Tubing and tube fittings (sizes smaller than 6 mm or ¼").

Additional spare parts, if required, during start-up and commissioning, even though not listed in the list of start-up and commissioning spares mentioned above, shall be supplied by the vendor without any implication.

d) Any special instrument or tool needed for testing, calibration and maintenance of the analyser such as spanner set (for tubes smaller than 6 mm or ¼"), non-magnetic tools, bubble rotameter etc.

e) Training at vendor works and at site as specified in job specifications.

f) Two years operational and maintenance spares for each analyser and its accessories as per vendor recommendations, which shall include spare parts like electronic modules, temperature controller, power supply module, flow meter, solenoid valve, pressure regulator, local indicator, tubes, fan assembly, sample cell, detector assembly, UV/IR source/lamps, set of o-rings, set of fuses etc.

1.3 Drawing and Data

1.3.1 Detailed drawing, data, catalogues and manuals required from the vendor are indicated by the purchaser in the vendor data requirement sheets attached with the enquiry. The required number of reproducible, prints, and soft copies shall be despatched to the address mentioned,adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for each analyser and its accessories.

b) Certified drawings for each analyser and its accessories, tag number wise, which shall provide the following information:

i) Overall dimensions in millimetres.

ii) Sampling system details identifying each component with make and model number, process connection, utility connection, calibration sample/gas connection, heat tracing requirements, sample vent and fast loop details etc. The flow, pressure and temperature at interface and other appropriate location must be shown in the sampling system drawing.

iii) Detailed interconnection drawing of each analyser identifying each component with terminal number, cable type, and cable size and cable entry details. The interface details shall be clearly identified in the drawing.

iv) Grounding details.

v) Power supply distribution details.

c) Programming/configuration data for each analyser, as applicable.

d) Serial interface specification including its configuration data (addresses) for host communication.

e) Power consumptions and utility requirements.

f) Calibration curves and calibration data for each analyser.

g) Zero and span calibration gas specification including composition, shelf life time and accuracy.

h) Copy of type test certificates.

i) Copy of the test certificates of all the tests indicated in clause 4.0 of this specification.

j) Installation procedure for each analyser and their accessories.

k) Calibration and maintenance procedures including replacement of its parts/internals wherever applicable.

1.4 Definitions

1.4.1 The following definitions shall apply for analysers and their accessories:

a) Transportation time

Transportation time is the time interval between a step change in the process fluid composition in the process line and the initial analyser response (excluding analyser response time).

b) Response Time

The time interval between the initial response of the analyser and the time required for the analyser output to reach a value of 90% of the final output value for a step change in sample quality.

c) Time Constant

The analyser response to reach a value of 63% of the final output value for a step change in sample quality is called the analyser time constant.

d) Repeatability

Repeatability of a measurement is the band of values within which an analyser repeats its measurement when the same sample is applied to it. The short termed repeatability is generally determined by multiple readings of a sample during calibration and is usually true random error over short period of time if external influences like pressure and temperature etc remain constant.

It is also defined as the difference between two successive analyser results that would be exceeded in the long run in only one (1) case in twenty (20) when a single analyser system is operated on a flowing sample of uniform quality.

e) Sensitivity

The sensitivity of an analyser is a measure of an analyser's ability to dete ct a least change in concentration of a measured component that is not masked by the background noise.

f) Accuracy

Accuracy of a measurement is the measure of how close the measured value is to the true value of the sample. For all type of analysers, accuracy is primarily a function of the accuracy of the standards used for calibration.

g) Analyser Rack

An open analyser mounting structure with/without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

h) Analyser Cabinet

Small housing, in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door (s) open.

2.0 DESIGN AND CONSTRUCTION

2.1 Analyser Requirements

2.1.1 The type of analyser and its measuring principle is specified in the purchaser's data sheet. Accessories and equipments as required to make online analysis complete are also specified in the data sheet. In general, the scope shall include the following:

a) Sample probe and sampling system, as applicable

b) Analyzer complete with all hardware and software consisting of detector, transmitter and associated equipments.

c) Fast loop and Sample return system, as applicable

d) Calibration and maintenance equipment.

e) Gas cylinders for zero and span calibration.

Unless otherwise specified the scope shall also include supply of all interconnecting tubing, piping, fittings, heat tracing equipment etc., excluding sample return piping from analyser battery limit to sample return header.

In-situ analysers when specified may not include sampling system.

2.1.2 Analysers and its related equipments directly connected to process line and In-situ analysers shall be capable of withstanding line pressure/vacuum and temperature conditions specified in the purchaser's data sheet.

2.1.3 The analyser design and design of sample handling system shall be such that components or any sub-assembly that requires removal, shall be possible without any need to disassemble any other component. Such components shall include items like stream selector valves, (when applicable) filters, pressure regulators, flow-indicator, detector, electronic modules etc.

2.1.4 Analyser shall be microprocessor based with state-of-the-art technology and shall be capable of being configured from analyser front panel locally using built-in keyboard. When specified, it shall also be possible to configure the analyser from remote through a separate terminal.

2.1.4.1 The programmer/ controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to ADSU or DCS and any require peripheral equipment.

2.1.4.2 Visual readout using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

2.1.4.3 Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

2.1.4.4 All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alterable password shall be provided to limit access to system software by unauthorized personnel.

2.1.5 The configuration related data of the analyser including set range shall be stored in a nonvolatile memory such that this data remains unaffected by power fluctuations or power off condition. In case vendor's standard product stores configuration data in battery backed RAM, analyser shall have facility to provide battery drain alarm as diagnostic maintenance message.

2.1.6 The span of the analyser shall be field adjustable from the analyser front without opening the analyser enclosure. In case, separate device is required to make such a change, the same shall be included by vendor in their scope of supply.

2.1.7 Analyser shall run diagnostic subroutines on continuous basis and shall be able to provide diagnostic alarms related to analyser optics, detector and electronics, as and when any failure/malfunction is detected.

2.1.8 Analyser shall have an integral output meter with digital readout in engineering units.

2.1.9 All interconnecting wiring shall be colour coded / numbered and terminal blocks be clearly identified.

2.1.10 The analyser shall be capable of providing the following outputs:

a) Isolated 4-20 mA DC current output for each analysed component. Smart or field bus output shall be provided when specifically indicated in the purchaser's data sheet.

b) RS485 serial output with MODBUS (RTU) protocol, whenever serial output is specifically indicated in the purchaser's data sheet. The serial output signal shall contain analyser data of component of interest and diagnostic alarms, as a minimum.

c) SPDT contact outputs for various diagnostic alarms (as applicable) such as:

i) High or low set point alarm as measurement
ii) Analyser failure
iii) Low sample flow
iv) Temperature control failure

Any other alarm contact, either specifically indicated in purchaser's data sheet or available as standard with the analyser, shall also be provided.

Unless specified otherwise, all contacts shall be normally closed type (contact open in alarm) and shall be rated for 110V AC 5 Amperes.

2.1.11 Statutory Regulatory Compliance

The design of analysers shall be incompliance to EPA, TUV or any other recognized regulations applicable in the county of sign. These analysers shall also meet the regulations of local pollution control boundary regulatory authorities applicable at the place of installation.

2.1.12 The design of analyser system shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4-X.

2.1.13 **Material of Construction**

2.1.13.1 Unless otherwise specified, the material of construction of all components wetted by the sample shall be SS 316, as a minimum. Vendor must ensure the compatibility of material of each component with the process fluid.

2.1.13.2 Material of all soft parts like diaphragms and o-rings shall be of PTFE. Other vendor standard materials can also be acceptable provided these are compatible with the specified process conditions.

2.1.13.3 The material of construction of all non-wetted parts shall be as per manufacturer's standard. However, non-metallic materials for casings, enclosures and instrument covers shall be avoided.

2.1.14 **Power Supply**

2.1.14.1 Unless indicated otherwise, the analyser including the sample handling system shall operate at 110V 50Hz power supply.

2.1.14.2 The analyser performance shall be within the specified limits when the supply voltage varies by ± 10% of specified value and supply frequency varies by ±3 Hz of specified value.

2.1.14.3 Electrical tracing when specified, shall operate at 230V 50 Hz supply. 230V 50Hz power supply shall also be used for analyser cabinet/panel lighting and air conditioning unit, when specified.

2.1.15 **End Connection**

2.1.15.1 Unless otherwise specified, the following shall govern;

a) Threaded connections shall be NPT to ANSI/ASME B 1.20.1.
b) Flanged connection shall be as per ANSI/ASME B16.5.
c) Flange face finish shall be serrated concentric to clauses 6.4.4.1, 6.4.4.2, and 6.4.4.3 of ANSI/ASME B 16.5. The face finish shall be as follows:

125 AARH : 125 to 250 AARH
63 AARH : 32 to 63 AARH

d) Ring type joint flanges shall have octagonal grooves as per ANSI/ASTM B16.20.

2.1.15.2 End connection of sizes 6 mm or below shall be suitably protected against damage.

2.1.15.3 All end connections shall be clearly identified by attaching labels or stainless steel plate of suitable size.

2.1.16 **Enclosure Type**

2.1.16.1 Analyzer enclosure and related accessories shall be suitable for the electrical area classification indicated in purchaser's data sheets. Unless otherwise specified, the enclosures shall comply with the following standards:

Weather proof housing : IP 65 as per IEC-60529 / IS-13947

Flame proof housing : Flame proof Ex (d) as per IEC-60079 / IS-2148

Purged Enclosure : NFPA 496

Flameproof and purged equipment shall also be made weatherproof.

2.1.16.2 In addition to meeting weatherproof requirements specified in clause 2.1.15.1 of this specification, intrinsically safe analysers shall meet the requirements specified in EN 50020 and shall be certified for the area classification specified in the purchaser's data sheet.

2.1.16.3 Analyser where air/nitrogen purge is provided, purge shall be as per NFPA 496 Type X. Analyser power shall cut off in case of purge failure. Purge failure alarm shall be provided for purchaser use.

2.1.16.4 Separate cable entries shall be available in the analyser/enclosure for power and signal cable.

Unless otherwise specified, following shall apply:

a) Cable entry and terminal size for power cable shall be ¾” NPT(F) cable entry other than ¾” NPT (F) shall be provided when specified.

b) Cable entry for Serial cable/signal cables (Signal output) shall be ½” NPT (F).

c) Cable entry for multi-pair signal cables (Multiple output) shall be 1½” NPT (F).

Reducer fitting may be provided when the analyzer standard cable enters are different than those specified.

2.1.16.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by attaching label or stainless steel plate of suitable size.

2.2 Sample Handling System

2.2.1 The sample handling system shall consist of primary sample conditioning near sample take off point, sample transportation line, secondary sample conditioning near the analyser, sample return, sample/analyser vent and sample drain/recovering system, as applicable.

The primary sample-conditioning unit shall be a fabricated assembly and shall be mounted on a stainless steel plate suitable for surface mounting.

Secondary sample conditioning shall also be a fabricated assembly and shall be mounted either on a stainless steel plate or within an enclosed cabinet/box with a viewing window.

2.2.2 Stream sampling shall be continuous and analyser shall be located as near as possible to the sample take-off point. Where the analyser is located away from the sample take-off point, vendor shall design the sample fast loop (bypass loop) as part of sampling system. Design shall ensure that the sample drawn is true representative of the stream to be analysed.

2.2.3 In general, sampling systems shall be designed and constructed in accordance with API-RP-555. The design of sample handling system shall consider the following factors, as a minimum:

a) The pressure/vacuum-temperature conditions required for the analyser.
b) Interfering components in the process sample.
c) Normal and abnormal sample compositions.
d) Fouling sample conditions e.g. polymer formation or presence of solids etc.
e) Transportation time requirements.
f) Utilities available and their process conditions.

2.2.4 Unless otherwise specified, material of all components wetted by sample shall be suitable for the process fluid and sample process conditions specified in the purchaser's data sheet. The material of construction for all wetted parts shall be, 316 SS, as a minimum.

2.2.5 Sampling system shall include all elements as necessitated by the process conditions indicated in the purchaser's data sheets, to make the sample suitable for the analysis. This shall include but not limited to filters (coarse and fine), pressure regulators, relief valves, flow indicators, flow controllers, temperature indicators, scrubbers, heaters, coolers, dryers, sample pumps, aspirators etc.

Each sampling system element shall be capable of being removed without disassembling the entire system.

2.2.6 Sample probe shall be provided by the vendor to obtain representative sample from the stack. The sample probe shall be inserted in the stack through an isolation valve (ball or gate valve), which shall be part of vendor's scope of supply. The probe design shall ensure the following:

a) On-line removal and insertion of the probe with non-fly-off design.
b) Unless otherwise specified, end connection for installation in the line shall be 4" flanged with type and rating as specified in purchaser's data sheet. The line isolation valve shall also be of the same size and rating as probe end connection.

c) The probe diameter shall be such that it can be easily inserted or removed through the line isolation valve when in fully open condition.

d) The length of the probe shall be selected considering its insertion upto the middle third of the stack. For the purpose of calculating probe length, consider nozzle length as 200 mm.

2.2.7 Sampling system shall include a sample block valve on all process sample line. The block valve shall be provided meeting the following requirements:

a) The block valve shall be located immediately after the sample probe.

b) Where purchaser's data sheets do not indicate the requirement of sample probe, the block valve shall be provided in the sample line as a part of primary sample conditioning unit.

c) The size of the sample block valve shall be as per the sample line size while the rating shall be as specified in the purchaser's data sheet.

2.2.8 The size of the sample tubing shall be decided by the vendor considering:

a) The distance between sample take off and analyser specified in purchaser's data sheet.

b) The specified sample transportation time.

c) Pressure at the sample take off point.

Where no transportation time is specified in the purchaser's data sheets, vendor shall consider the sample transportation time as 60 seconds.

2.2.9 Where sample is required to be transported in hot condition, sample shall be drawn using prefabricated heated tubes. The heated medium shall be either steam or electric power as specified in purchaser's data sheet.

Heating shall be controlled such that the sample temperature is maintained typically around+20C above the sample dew point.

2.2.10 When fast loop is specified or recommended by vendor, vendor shall provide flow meter for sample bypass flow. Sample return line to process shall be provided with isolation valve and check valve. Vendor shall ensure that return pressure of the sample shall be higher than the pressure of the process return point specified in purchaser's data sheet.

2.2.11 Sampling system shall include provision for connecting calibration sample/gases in auto or in manual configuration as specified in purchaser's data sheet. When no specific requirement is indicated, the provision shall be made for manual configuration only.

2.2.12 Whenever auto-calibration requirement is specified in the purchaser's data sheet, it shall be possible to initiate auto calibration cycle at preset time interval defined by user either manually via the analyser keyboard or remotely through an external contact.

The sample handling system shall be designed to include all hardware and/or software to meet this requirement. The analysed component concentration output shall remain at the last good measured value during auto calibration cycle.

2.2.13 Unless specified otherwise, analysers with common take off shall have separate sample handling system for each analyser.

2.2.14 Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser.

2.2.15 Unless specified otherwise, sample lines used for carrying samples for more than one analyser shall be provided with sample pumps in dual configuration. It shall be possible to remove or insert the pump without upsetting the sampling system.

2.2.16 A suitable restriction orifice shall be provided in each sample line to limit the sample flow exceeding thrice the normal flow in the event of tube rupture or opening of tube down the line.

2.2.17 Sample Extraction Techniques:

Sample extraction shall be any one of the following unless otherwise specified in the Data sheet.

2.2.17.1 Dilution Technique.

a) Instrument air shall be provide by the purchaser and the specification shall be as specified elsewhere. Vendor shall consider the minimum pressure condition for the system design.

b) Vendor scope shall include all items/elements like dilution probe, pneumatic control module, instrument air pressure/flow controller, pressure gauge, etc. as necessary for proper system design. Additional dew point suppression of instrument air (Beyond that is specified) shall be taken care of by vendor.

c) Vendor shall select the dilution ratio depending upon their system design. Calculations for the same shall be furnished by vendor.

d) For dilution type technique, vendor must select the range of analyzers based on the dilution ratio selected.

e) Vendor shall be fully responsible to select the dilution probe with critical orifice.The material of orifice shall be 'QUARTZ' as a minimum. Vendor's scope shall include supply of one spare orifice along with each sample probe clearly marking the dilution Ratio.

2.2.17.2 Hot Extraction Technique.

Vendor shall select heated sample lines (Prefabricated tubes with tracer and insulation) with electrical tracing. The temperature of the sample line shall be controlled at a temperature so as to avoid condensation in the sample lines. The temperature control unit shall also form part of vendor's scope of supply. The sample lines shall be prefabricated tubes with electrical traces fully insulated with overall sheath of low smoke grade PVC. All such tubes should have undergone services life performance test as per IEEE 515. The electrical tracing line with temperature controller shall be suitable for the specified area classification.

2.2.18 The sample handling system shall be designed to,

Avoid plugging of sample probe and sample line even in case of;

- Failure of electrical tracing
- Failure of instrument air
- Excessive solid particles during start up or process upset condition.

Vendor shall clearly study each of these scenario and provide automatic sample shut off and blow back facility in line with the requirements of the specified application.

2.2.19 The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.2.20 Where sample pumps are used, moisture sensor shall be provided in sample handling system to cut off pumps in case of high moisture level.

2.2.21 Analyser rack and cabinet

a) Whenever specified in the purchaser's data sheet, the analyser shall be supplied in pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. The primary sample-conditioning unit i.e. conditioning at sample tap-off point, shall be supplied separately.

b) When open rack mounted installation is specified in purchaser's data sheet, the analyser and sample handling system shall be supplied installed in an open rack with canopy to protect the analyser from direct sunlight and rain. The open rack shall be fabricated using channels/pipes of suitable size. The material of construction shall be stainless steel. The canopy shall also be fabricated out of SS plate of 1.2 mm thick.

c) Whenever closed cubical mounted installation is specifically indicated in the purchaser's data sheets, analyser and sample handling system shall be supplied preinstalled in freestanding closed analyser cabinet. The analyser cabinet shall be suitable for outdoor installation and shall be provided with a key lock.Cabinet shall be fabricated out of 2.0mm SS sheet reinforced with angles of suitable sizes. Fittings and hinges shall be of stainless steel. Anchor bolts required for installation of cabinet shall also be supplied by vendor.A power isolation switch with suitable circuit breaker or fuse shall be provided for the incoming power supply.All items including analyser installed within the cabinet shall be suitable for the maximum possible temperature likely to be attained within the cabinet (i.e. with all items fully powered-on within the cabinet) and area classification specified in the purchaser's data sheet. Heating/cooling of analyser cabinet shall be provided either when purchaser's data sheets specify the requirement of heating and/or cooling or recommended by the analyser manufacturer or found necessary by the manufacturer to meet following requirements:

i) The temperature induced measurement error exceeds ± 1% of full scale in the worst temperature conditions.

ii) The maximum allowable ambient temperature condition of any component within the cabinet exceeds its limits.

Whenever cooling is specified or found necessary, vendor may select one of the following

cooling methodology, unless specifically indicated otherwise:

a) Cabinet mounted air conditioner certified for the specified area classification.

b) Vortex cooler with compressed air system and air dryer of suitable size and capacity. No separate instrument air shall be provided by purchaser for vortex cooler.

c) Power supply cable entry and terminal size shall be as defined during detail

engineering by purchaser

.

d) The maximum height of rack/cabinet shall be limited to 2100 mm. Cabinet shall be suitable for side and bottom cable entry.

2.3 CARBON MONOXIDE, CARBON DIOXIDE ANALYSERS

2.3.1 Unless specified otherwise the CO/CO2 analysers shall be of Infra Red type

2.3.2 IR/UV analyser shall preferably be non-dispersive type.

2.3.3 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges.

2.3.4 The analyser cell material and window material shall be suitable for the specified service. Unless otherwise specified or required otherwise by pressure-temperature conditions, the oring material shall be Teflon.

2.3.5 The analyser design shall be such that it is insensitive to source fluctuations or cell window degradation/partial cloudiness.

2.3.6 The analyser shall have built-in indicator with digital display.

2.3.7 Unless otherwise specified, analyser shall meet the following performance requirements:

Repeatability	:	± 1% of full scale or better
Zero drift	:	± 1% full span/week.
Speed of response	:	less than 90 seconds for 90% of final reading.
Linearity	:	± 1% of full scale or better.

2.4 SOx ANALYSER

2.4.1 Unless specified otherwise the analyser measurement principle shall be based on UV Fluorescence. The UV source lamp shall be highly energizing, monochromatic with minimum source life of 5 years.

2.4.2 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges. The analyser cell material and window material shall be suitable for the specified service.

2.4.3 Unless otherwise specified or required otherwise by pressure-temperature conditions, the oring material shall be Teflon.

2.4.4 The analyser design shall be such that it is insensitive to source fluctuations or cell window degradation/partial cloudiness.

2.4.5 Special filters shall be offered to minimize the interference of background components, which are of least interest in process stream.

2.4.6 Where IR type analysers are specified, the same shall meet the specification as per clause 2.3 above.

2.4.7 Unless otherwise specified, analysers shall meet the following performance requirements:

Zero/span Drift	:	± 1% of full span/week

Repeatability	:	± 0.5% full scale or better.
Response time overall	:	less than 90 seconds for 90% of final reading.
Linearity	:	± 1% of full scale or better.

2.4.8 Analyzer for incinerator stack for sulphur plant (SRU)

The analyzer system design and analyzer selected for incinerator stack are suitable for the sample containing high sulphur contents. The sample handling system shall be designed for such eventuality which is likely to occur during start up or under plant upset condition.

Any one of the following techniques shall be considered meeting other requirements:

a) Dilution technique with sample handling system designed considering the worst conditions of sulphur.

b) Hot extraction technique with heated analysers.

2.5 NOx Analysers

2.5.1 Unless otherwise specified the NOx analyser measurement principle shall be Chemiluminescence type.

2.5.2 The analyser shall be complete with ozonator, mode selection chamber for NO, NO-NO2, reaction chamber and detection unit.

2.5.3 Special filters shall be offered to minimise the interference of background components, which are of least interest in process stream.

2.5.4 The analyser shall have built in indicator with digital display for measurement & instrument opacity parameters indications.

2.5.5 Unless otherwise specified the analyser shall meet the following performance requirements .

Zero/span Drift	:	± 1% of full span/week
Repeatability	:	± 0.5% full scale or better.
Response time overall	:	less than 90 seconds for 90% of final reading.
Linearity	:	± 1% of full scale or better.

2.6 HC Analyser

2.6.1 Unless specified otherwise the analyser measurement principle shall be based on the Flame Ionisation Detection (FID) for HC Analysers.

2.6.2 Probe length shall be provided such that 30% insertion in heater stack and shall be calculated

based on the nozzle projection and shall be based on the Stack ID given.

2.6.3 Probe & Filter material shall be selected to suit the stack process condition.

2.6.4 Unless otherwise specified the analyser shall meet the following performance requirements.

Zero/span Drift	:	± 1% of full span/week
Repeatability	:	± 1% full scale or better.
Response time overall	:	less than 30 seconds.

Linearity : ± 1% of full scale or better.

2.7 Analyser Data storage Unit

2.7.1 The central analyser data storage unit (ADSU) shall be provided for the storage of data and diagnostic alarms of analysers and analyser shelter/ analyser room as applicable.

2.7.2 Unless specified otherwise a common ADSU shall be provided for all the stack analysers and related analyser shelters/rooms:

2.7.2.1 Processor/Hard ware for data acquisition and communication including network switches, fibre optic cables etc.

2.7.2.2 Shelter analyser console located at each shelter.

2.7.2.3 Common stack analyser system console located at control room.

2.7.3 **ADSU Data Acquisition System**:

2.7.3.1 The Data acquisition & Communication Hard Ware of ADSU shall be located in shelter.

2.7.3.2 Each stack Analyser shall be connected to the ADSU through serial link in multi drop configuration. The serial link shall be MODBUS RTU protocol. Necessary hardware required at analyser side for protocol conversion shall be provided by vendor.

2.7.3.3 In addition to the analyser serial link, the above shall also accept all alarms from shelter equipments/items such as Detector alarms, power failure alarm, purge failure alarm etc.

2.7.3.4 Any alarm inputs from analyser sample handling system and calibration commands etc. shall also be provided at ADSU.

2.7.3.5 The ADSU data acquisition system shall be connected to shelter analyser and common stack analyser system console at control room.

2.7.3.6 The ADSU system cabinet shall be free standing cabinet and shall be located at each shelter.

The construction shall be similar to analyser cabinets as per clause with minimum dimension of 600W X 600D X 2100H.

2.7.4 **Shelter Analyser Console**:

2.7.4.1 Shelter Analyser console located at each analyser shelter shall be provided for complete analyser measurement and diagnostic data and other shelter measurement data for monitoring, calibration and maintenance.

2.7.5 Common Stack Analyser console:

2.7.5.1 The common stack analyser system console at control room shall store the complete analysis data of analysers and present this in a predefined format. The console shall be common for one or more stack analyser system in the plant and shall receive data from each ADSU data acquisition subsystem at shelter/Analyser room. The data from each shelter/ analyser room shall be provided independently and no multi dropping at field shall be considered.

2.7.5.2 The console shall be provided with stack analyser system software and shall have the following features.

a) Display of all analysis data stack wise, component wise and exception wise.
b) Alarm display & printing.
c) Report generation as per statutory requirements such as USEPA, TUV etc.
d) Freely formatted report generation.
e) Report generation as per local pollution control board requirements
f) Data storage and data compaction facilities.
g) System alarms, display & printing.
h) Predictive maintenance packages, if any.
i) Hourly shiftily, daily, weekly, monthly reports shelter wise.
j) Command for auto calibration for each analyser.
k) System shall store the analysis data and reports upto 1 year period.

2.7.5.3 The report generation as per statutory requirements shall have the following reports as minimum.

a) Data of each analyser with sample interval of 1 sec., 1 minute.
b) Performance report, period as defined by statutory regulation authority. 30 days, quarterly, biannual, and annual as minimum.
c) Magnitude of excess emission for each analyser.
d) Specific identification of periods of excess emissions , start up, shut down or other periods,cause of malfunction and corrective action.
e) Report of malfunctions or operative maintenance of each analyser along with period.
f) Summary report in case of excess emission period less than 1 % of time of reporting period,in predefined formats.

2.7.5.4 The software provided for common stack analysers shall be certified compliance to USEPA or TUV or any other statutory regulations.

2.7.6 The consoles at shelter and at control room shall access data independently from analysers. In case of failure of one console the other console shall continue to receive data. Upon resumption of failed console, the stored data from other console shall be transferred by command.

2.7.7 Each console shall have the following minimum configuration.

a) Consoles shall be PC based, Pentium latest processor with retentive memory of 512K RAM, 80GB Hard disk with 19” TFT monitor

b) No. of background colours and foreground colours for the monitor will be seven, as a minimum. These colours shall be used to distinguish parameters such as control, information, process and alarms etc.

c) No. of display characters is 80 character X 40 lines and No. of character type is min 96 ASCII characters with character construction of 5X7 dots and pattern of 7X8 dots.

d) Length of tag no is nine alpha numeric characters.

e) Length of description is fifteen alpha numeric characters.

f) Monitor data display update rate shall not be more than two (2) seconds.

g) Dynamic graphics shall be provided with control.

h) Windowing facility is required with 4 No. of windows/Display.

i) Zooming facility is required.

j) The real time clock of each operator console shall be crystal controlled one which shall be independent of line frequency.

k) A minimum of two cursor control devices must be available with monitor of console. For example cursor control could be used for monitoring the data and engineering of the complete system.

l) Key board shall preferably be touch sensitive membrane type. Each key board entry shall be registered with an audio beep. However, if press type keyboard is provided it shall be ensured that the key board is not susceptible to dust and moisture.

m) The self diagnostic message for a subsystem failure shall appear on the analyser console irrespective of display selected. The choice of the detailed self diagnostic displays shall be made by a key lock switch.

n) The offered printer shall be HP laser jet colour printer.

2.7.8 The communication between ADSU at analyser shelter and the common stack analyser console at control room shall be through fibre optic cable with necessary converters and the same shall be provided by vendor.

2.7.8.1 All fiber optical cables shall be routed through hard HDPE conduits and shall be totally enclosed within using HDPE matching fittings. The HDPE conduits shall be as per IS-4984 or equivalent IEC standard. The outer Colour of the conduit shall be orange with black fittings throughout the run. Individual fiber optic cable shall have minimum one pair of spare fiber. All fiber optical cables shall be rodent resistant and armored type only.

3.0 NAMEPLATE

3.1 Each analyser and its accessory shall have a stainless steel nameplate firmly attached to it at a visible place, furnishing the following information as applicable:

a) Tag number as per purchaser's data sheets.
b) Manufacturer's serial number and model number.

c) Manufacturer's name/trade mark.

d) Component being analysed and its range.
e) Area classification in which the equipment can be used.
f) Power supply requirements.
g) Analyser Outputs

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with the inspection test plan for process stream analysers. Vendor shall

provide necessary facilities, utilities, competent manpower and consumables required for carrying out the inspection.

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review for each of the analyser:

a) Dimensional verification certificate for each analyser.

b) Material test report as per clause 2.2 of EN10204 for all wetted parts.

c) Manufacturer's test reports as per clause 3.1B of EN 10204 for various bought out components.

d) Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.

e) Calibration report for each analyser as per clause 4.3 of this specification.

f) Repeatability test for each analyser as per clause 4.4 of this specification.

g) Power supply variation check.

h) Test certificates for zero, span, carrier and fuel gases as applicable.

i) Certificates from statutory body for flameproof/intrinsic safety and weatherproof enclosures as applicable.

4.3 Analyser Calibration

4.3.1 Analyser along with sample handling system shall be calibrated using zero and span calibration gas samples in the following sequence:

a) Check/adjust zero by connecting zero gas and span by connecting span gas.

b) Check again zero by connecting zero gas after (a) above. Also repeat span gas check.

c) If either or both zero and span are adjusted in step (b), repeat (b) again to verify the calibration until no further adjustments are made in zero and span.

4.4 Repeatability Testing

4.4.1 Repeatability of the analyser shall be checked by connecting either span gas (if it is approximately 70% of analyser span) or any other gas sample on continuous basis for the following time period.

a) 24 hours by manufacturer and report to be submitted for review.
b) 8 hours during witness inspection.

4.5 Witness Inspection

4.5.1 All the analysers shall be offered for pre-dispatch inspection by the purchaser at vendor works. Following tests/ checks shall be carried out on each analyser as a minimum:

a) Physical dimensional verification and workmanship.

b) Bill of material check for each analyser system including sample handling system.

c) Leakage testing of complete system using nitrogen or instrument air.

d) Calibration check as per clause 4.3 above.

e) Repeatability check as per clause 4.4.

f) Power supply variation check. Analyser must function satisfactorily on specified variation of power supply voltage.

g) Review of all test certificates and test reports indicated in clause 4.2 above.

4.5.2 In the event when the witness inspection is not carried out by purchaser, the tests shall any way be completed by the vendor and documents for same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.

5.2 Each major part shall be sealed in thick plastic bag. Suitable moisture absorbent shall be provided for electronic components.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.

GENERAL SPECIFICATION

FOR

ANALYSER SYSTEM

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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1.0 **GENERAL**

1.1 This specification defines the minimum requirements of Analyser System/systems designed for reliable and effective analysis of various process streams.

1.2 All analysers along with their associated equipments shall be installed by the vendor inside the analyser shelter.

1.3 All analyser shelter shall be ventilated, pressurized and air-conditioned. However, all analysers and other associated equipments shall be so designed and selected that these will continue to operate even in case of ventilation/ pressurization failure.

1.4 Vendor shall provide all installation material including consumables to install the analysers, sample conditioning systems, sample transfer lines, vent lines and all other accessories. All instruments shall be completely accessible to permit adjustments, calibration and maintenance.

1.5 The components to be furnished for each sample system will depend upon the sample stream conditions. The vendor shall select and provide all the necessary components for each of these systems accordingly.

2.0 SAMPLE HANDLING SYSTEM

2.1 The sampling system shall consist of necessary components, including sample probes, sample filters, pressure reducers, safety relief valves, pressure and temperature gauges, moisture separators, flow regulators, flow meters, isolation valves etc. necessary to prepare the sample for proper analysis.

2.2 All components shall be sized and coupled so as to keep the sample volume to a minimum.

2.3 Calibration zero and span gas connections shall be provided for each analyser.

2.4 The sampling system shall have various sub-assemblies as required. The minimum requirements of each sub-assembly shall be as given below.

2.5 Sample Probe Assembly

a) Sampling probe shall be designed to extract true representative sample from the process line. The design shall prevent particulates from entering into the sample system.

b) The design of probe assembly shall facilitate on line removal of the probe without shutting off the process. Suitable mounting adapters shall be provided with the probe.

c) Probes shall be of Inconel 600 material unless specified otherwise.

d) The length of tubing between the sample probe and the sample stream pressure reducing station shall be kept minimum by close coupling various components in between

2.6. Sample Stream Pressure reducing stations:

a) Vendor shall design and provide sample stream pressure reducing stations to minimize sample transfer time maintaining the integrity of the sample. Sample stream pressure reducing stations shall consist of pressure regulators, relief valves, pressure gauges, temperature gauges etc as required.

b) These stations will be located at the sample process connection to minimize transport time lag from the sample point to the analyser.

2.7. Sample Transfer Line

a) The sample transfer line shall transport the fluid sample from the sample stream pressure reducing stations to sample conditioning system located at the analyser shelter.

b) Vendor shall provide heat tracing for sample line wherever necessary, in order to maintain the sample integrity.

c) The routing of sample transfer lines shall be done in such a way that the total length between the sampling point and the analyser sample conditioning system is minimum. Short radius bends shall be avoided to avoid excessive pressure drop.

2.8. Sample Conditioning System:

a) Sample conditioning system shall be provided by the vendor at the analyser house/shelter.

b) Multi-stream analyser system shall have a separate sample handling sub assembly for each stream.

c) Sample conditioning system shall include, but not limited to, moisture separators, filters, rotameters, pressure gauges, flow switches, solenoid valves etc. as necessary for proper analysis of each sample stream. Isolating valves shall be provided as required.

d) Stream selecting valves shall be located as close as possible to the analyser to minimize connecting tubing length and to minimize the possibility of cross contamination of samples.

e) Stream selecting valves shall be double block and bleed and shall fail closed so as to block the sample from the analyser on loss of motive power.

f) Block valves shall be provided on all process sample lines.

g) Rotameters for measuring all sample flows shall be included.

h) Special precautions may be necessary where catalyst fines and coking material, and other difficult stream conditions are present.

i) Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample, it shall be enclosed in a thermally insulated, thermostatically controller heated enclosure. Enclosure heating shall be with steam heater unless specified otherwise. Sample stream flow adjustments and analyser shutoff valves shall be operable from the front of the enclosure without opening the enclosure door. Sample stream flow, pressure and temperature indication shall be visible from the front of the enclosure.

j) Sample tubing between the sample conditioning system and the analyser shall be kept as short as possible.

2.9. Sample Stream Bypass/Fast loop:

a) Sample stream bypass/fast loop shall be provided for the sample streams to meet the required sample transport time.

b) Flow meters shall be provided by vendor for sample bypass/fast loop flow.

2.10. Analyser Vent:

a) Analysers shall be vented to atmosphere individually or through a common vent system.

b) In case common vent header is provided, the pipe diameter shall be big enough to prevent build up of back pressure.

c) The venting of the analyser shall be done to atmosphere at a minimum height of 3 meters above the highest walkway of the structure over the analyser shelter away from any working area or any ventilation system.

d) The vent lines or header shall be provided with low point drains.

3.0 PIPING AND TUBING:

3.1. All tubing runs shall be either horizontal or vertical, with 90° tubing bends of stainless steel tubing. The tubing shall be run and arranged such that quick visual tracing is possible. All valves, gauges and flowmeters must be visible and accessible.

3.2. Sample and vent tubing, piping, fittings, valves, traps, rotameters and other components shall be of SS 316 material, unless otherwise specified.

3.3. All tube fitting used shall be of SS 316 and shall be non-flare type of `Swagelok/Parker/Hamlet make.

3.4. Sample tubing from the field shall terminate at a bulk head union plate using tube to tube bulk head fittings located at the top of the cabinet, in case sample conditioning system is enclosed in a cabinet.

3.5. Sampling line shall be arranged to be free draining without any pockets.

3.6. Vendor shall provide suitable connections for periodic flushing of sample tubing, with Nitrogen and steam, between sampling point and analyser inlet filter. Flushing connections shall be provided at both ends of each sample line.

4.0 ANALYSER

4.1 The analyser shall be furnished with all the necessary equipment to properly analyse the sample.

4.2 Material of construction for the components in contact with the sample stream shall be SS 316 except where the stream composition requires other material.

4.3 The detector cells shall be of a type that will provide adequate separation of components, minimize analysis time, minimize maintenance time and meet the performance requirements of this specification.

4.4 The analyser system temperature shall be controlled by an accurate electric heating system to ensure the proper sample separation and minimize the analysis time.

4.5 A shutdown switch shall be provided to protect the analyser from the loss of carrier gas or loss of fuel gas.

4.6 Solenoid operated multi function valves for sample inlet and column switching shall be provided.

5.0 PROGRAMMER/CONTROLLER

5.1. The programmer / controller shall be microprocessor based and shall be furnished with all the equipments necessary to properly control the analysis cycle, the automatic zero adjustment circuit, the calibration of the analyser and programmer systems and the transition of data to a DCS or digital computer and any require peripheral equipment.

5.2. Visual readout using a digital indicator shall be provided to identify each component being analysed and each step in the program as well as displaying the latest readings.

5.3. Peak peaker and long term memory circuit boards shall be provided for each component of the interest.

5.4. All program data tables shall be capable of field modification without user knowledge of higher level programming. A key lock switch or field alterable password shall be provided to limit access to system software by unauthorized personnel.

5.5. The application program in the analyser shall be retained for a minimum of six months with out external power by the use of EEPROM or Battery back-up. An EEPROM programme cartridge interface shall be provided for program loading.

5.6. Maintenance diagnostics shall be included in the software system to allow rapid trouble shooting in the event of system mal-function. Alarms in the English language shall be provided to notify the operator in the event of the mal-function. A low carrier flow alarm shall be included.

5.7. The stream number shall be printed-out on each analysis report.

6.0 ELECTRIC WIRING - SIGNAL CONTROL AND POWER:

6.1. Vendor's scope of supply and work shall include all cabling and wiring inside the analyser shelter.

6.2. Vendor shall provide an explosion proof (Exd) power distribution box for power supply to various analysers. This box shall be certified by a statutory body for use in specified hazardous area. The box shall have copper bus bars for distribution of power supply to various consumers.

6.3. Power supply to individual consumer shall be by dual pole, dual element circuit breakers. These circuit breakers shall be in explosion proof (Exd) construction certified by a statutory body for use in hazardous area and shall be mounted near the equipment served and shall have engraved plastic tag plates.

6.4. All cabling and wiring shall conform to API-RP-550. Signal and power cabling/wiring shall be segregated and run in separate raceways with separation distances as recommended per API-RP-550.

6.5. All cables shall be armoured, flame retardant PVC insulated, 600 Volt grade, stranded copper conductor. Signal cables shall be twisted pair shielded.

6.6. Conductor size for power cables shall be 2.5 sq. mm (min.) and for signal cables it shall be 1.5 sq. mm.

6.7. Colour coding for power supply wiring shall be red for phase, black for neutral and green for earth.

6.8. Vendor shall provide junction boxes for signal and control cables separately which shall serve as interfaces for cables going to remote control room. These junction boxes shall be explosion proof (Exd) certified by statutory body for use in specified hazardous area.

6.9. Wire termination shall be done using self insulating crimping lugs.

6.10. All cables, wires shall be provided with identification ferrule (one piece ferrule/ cylindrical ferrules_ for proper identification.

6.11. Terminal strips shall be provided with identifying terminal numbers, as required. Terminals shall be screw less clamp type.

6.12. 20% spare terminals, cable entries with cable glands, relays and other components wired up to terminals shall be provided.

7.0 COMPRESSED GAS CYLINDERS AND THEIR HANDLING:

7.1. Each analyser shall be provided with the following compressed gas steel cylinders.

a) Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.

b) Calibration gas sample bottles.

7.2. Fuel gas and Carrier gas cylinders and associated manifolds shall be located on a concrete pad outside the analyser building. The gas cylinder manifold shall be arranged so that one cylinder may be replaced while the analyser remains in operation on the other cylinder. Cylinders shall be sized 1A (225mm diameter x 1300mm long) and shall be supplied with auxiliaries such as fittings and two stage regulators.

7.3. Calibration gas cylinders shall be located outside the analyser shelter. Vendor shall include a drawing showing the layout of cylinders.

7.4. Racks shall be provided to support cylinders, piping, valves and pressure regulators associated with high pressure gas cylinder manifold system. Each cylinder in the system shall be secured to the rack by a separate chain or clamp.

7.5. A pressure relief valve, vented to a safe location outside the building shall be installed on the low pressure side of the pressure reducing regulator of each cylinder. Vent piping shall be installed in a manner to prevent the entry of bugs or moisture into the outlet of the vent. This vent shall be in addition to the analyser vent.

7.6. All pressure regulators shall be two stage type. A sign identifying the type of gas applied to a manifold shall be placed above each cylinder rack.

7.7. The location and separation of hydrogen manifold from other flammable gas manifolds shall be in accordance with NFPA 50A-1973 section 52 and 61.

7.8. All tubing between the cylinders to the analysers shall be complete and easily removable from each and either end.

7.9. Vendor's quote shall include fuel, carrier and calibration gas cylinders as necessary, as a minimum, for:

i) The field testing, commissioning and final acceptance
ii) Six months from the date of acceptance.

7.10. The calibration gases shall be of high purity, at least better than the specified accuracy and precision values for analysers. It is preferable to prepare calibration gases by Gravimetric method.

7.11. The concentration of calibration gases must remain constant for a period of at least one year.

7.12. The material of construction of cylinders shall be suitable for maintaining stability of the calibration gas mixture for the specified time. Vendor may quote for the staggered deliveries wherever calibration mixture is not stable.

7.13. The vendor must submit the following certificates from any recognised certifying agency/laboratory;

i) Accuracy/Precision of the calibration gas.

ii) Stability of sample for at least one year.

7.14. Vendor shall forward all the details including the source of supply, certifying agency, cylinder size and volume, sample pressure, dew point, regulator type and make etc.

In addition, vendor must furnish calculations for number of cylinders quoted of each type. For calibration gas cylinders, consider calibration frequency as once in every fortnight.

8.0 SAFETY REQUIREMENTS:

8.1. Hazardous Area Protection:

a) The analyser shelter shall be in hazardous classified area. Positive pressure and ventilation from a clean air source shall be provided to achieve this classification.

b) It is intended to operate the analysers even during the ventilation failure, hence it required that all analysers shall be suitable for hazardous area.

c) All the electrical fittings provided in the analyser shelter shall be explosion proof type. However, a safety system shall be provided by the vendor to switch off power supply to all electrical equipments and accessories not suitable for hazardous area in case of ventilation failure. To do this it shall be ensured that all analysers continue to work safely even under these conditions.

d) All junction boxes, power distribution cabinets, LEL detectors and their panel and other safety devices shall be suitable for the hazardous area certified by a statutory body.

8.2. Grounding:

a) All electrical equipment in the analyser shelter and outside shall be grounded properly.

b) Cylinder racks, sample conditioning enclosures, analyser racks, shall also be grounded directly to the AC ground bus.

c) All necessary grounding bus requirement for Equipment grounding and signal shields shall be provided by the vendor in the analyser shelter. Vendor shall also provide all earthing arrangements inside the analyser shelter.

8.3. Combustible Gas Detection System (LEL Detectors):

a) Vendor's scope includes of supply and installation of combustible gas detectors with associated monitoring system for the analyser shelter.

b) Combustible gas detectors shall monitor all inlet air intake points. The detectors shall be calibrated to give alarm and high alarm at 20% and 40% respectively of the LEL of the component with the lowest LEL in the area. On the occurrence of high alarm the ventilation system shall be shut-off. Vendor shall provide potential free DPDT contacts rated at 230 VAC 5 Amp for connection to ventilation system.

c) Shutoff of ventilation system shall be based on 2 out of 3 voting, which means that only if two detectors out of the three provided indicate a high LEL, trip shall provided.

d) Additionally, combustible gas detectors shall monitor the analyser house/shelter interior and exhaust air. These detectors shall give alarm and high alarm as mentioned above, however no shutoff of ventilation system shall be required.

e) Vendor shall calculate total requirement of combustible gas detectors along with their location.

f) The monitors for LEL detectors shall be provided with malfunction, warning and danger lights and 0 to 100% indicator.

g) Vendor shall provide grouped high alarm and high - high alarm SPDT contacts rated for 230 V AC 5 Amp for repeat alarms in remote control room.

h) The monitors for LEL detection system shall be installed in a panel which shall be pressurized as per NFPA 496 type `X' purge.

8.4. Fire/Smoke detection

a) Vendor’s scope shall include supply and integration of fire detectors/smoke detectors (Ionisation type) within the analyser shelter. The no. of shelters shall be decided by the vendor based on the shelter size and coverage of area within the shelter.

b) The monitors for the fire detection shall be installed in a pressurised/ purged panel as per NFPA 496 type X purge. This may be shared with LEL monitor panel.

c) The signals from the fire system monitor shall be provided for:

- One contact for alarm on the warning panel.
- One contact each for repeat alarm in the control room DCS and fire panel of Electrical section.

8.5. Oxygen gas monitoring

a) Vendor shall provide a maximum of two nos. of oxygen gas monitoring system for sensing deficiency of oxygen within the shelter.

b) In case the monitors show low concentration of oxygen within the analyser shelter, an alarm shall be initiated on the warning panel. The repeat alarm shall also be provided for DCS in the Main control room.

c) Oxygen monitors should be located in purged panel as per NFPA 496 type X purge. These may be located in the same panel where LEL detectors are installed.

8.6. Warning Panels:

a) Vendor shall provide warning panels for audio visual alarming of hazardous conditions inside the analyser shelter. One such panel shall be installed by vendor on each of the external walls of the analyser shelter where entrance doors are provided.

b) The warning panel shall provide the following audio - visual alarms:

i) Presence of combustible gases inside the analyser shelter.
ii) Loss of analyser shelter pressurisation
iii) Ventilation system failure
iv) Fire/smoke within the shelter
v) Oxygen deficient within the shelter

c) For alarming of analyser shelter pressurisation failure vendor shall provide an explosion proof pressure switch for sensing analyser shelter inside pressure.

d) These warning panels shall be of explosion proof (Exd) construction certified by a statutory body for use in hazardous area.

8.7 Minimum two no beacon assembly and 1 no. hooter suitable for specified hazardous area shall be provided on the shelter to warn the operator of presence of hazardous area inside the shelter.

9.0 FACTORY TESTING AND ACCEPTANCE:

9.1. The analyser systems shall be thoroughly checked and tested prior to shipment to assure correct design, construction and proper operation.

9.2. The Owner/Consultant reserves the right to be involved and satisfy himself at each and every stage of inspection and testing.

9.3. During the final testing vendor shall test and demonstrate to the Owner/Consultant, the functional integrity of all analysers, sampling systems and all other hardware. Repeatability test shall be performed on all analysers for a test period of 24 hours. No material or equipment shall be transported until all required tests are successfully completed and certified `Ready for shipment' by the Purchaser/Consultant. Software's, if involved, shall also be tested.

9.4. Vendor shall submit schedule of factory testing and inspection.

9.5. After placement of order vendor shall submit his factory testing and customer acceptance procedure for Purchaser / Consultant approval. This document shall contain the information

related to each test e.g. purpose of test, definition, test procedure, results expected and acceptance.

9.6. Purchaser / Consultant has every right to add or delete any test in vendor's test procedure and acceptance criteria. The system shall be tested and accepted as per the approved testing procedures and acceptance criteria. The cost of performing all tests shall be borne by the vendor.

9.7. Vendor shall notify the Purchaser / Consultant at least three weeks prior to final system testing at vendor's works. In the event that representatives of Purchaser / Consultant arrive and the system is not ready for testing, the vendor shall be liable for back charging for any extra time and expenses incurred by the Owner.

9.8. It shall be vendor's responsibility to modify and/or replace any hardware, equipment or analyser if the specified functions are not completely achieved satisfactorily during factory testing and acceptance.

10.0 INSTALLATION, TESTING AND COMMISSIONING:

10.1. Vendor shall provide the services of his installation team which would install the equipment in the analyser shelter and in the field, lay the tubing from sample probe to analyser shelter, lay the interconnecting cabling tubing inside the analyser shelter, perform system checkouts, test and commission the entire system.

10.2. All technical personnel assigned to the site by the vendor shall be fully conversant with the system supplied and shall have capability to bring the system on-line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

10.3. Vendor's responsibility at site shall include all activities necessary to be performed to complete the job including;

a) Receipt of all analysers and related hardware, and checking of completeness of supply. In case of shelters, verification of all analysers and accessories duly installed tubed and wired

b) Installation of all analysers, and other associated equipment including all safety equipment like LEL detectors, annunciators, panels etc., all auxiliaries like power supply distribution boxes, all interconnecting tubing/piping etc. so as to complete the job in case of analyser shelter.

c) Installation of sample probes, pressure reducing stations, sample conditioning systems, interconnecting tubing, heat tracing etc.

d) All analyser sample stream bypass, vent and drain tubing/piping.

e) Termination of all field cables or cables to control room, ferruling/ tagging of interconnecting cables in analyser shelter.

f) Interconnection cabling inside the analyser shelter

g) All civil works like grouting, fixing etc and patch up work where vendor is likely to remove the plaster and shall make holes in the walls, floor or ceiling.

h) Checking of interconnections, hardware configuration, overall system functioning.

i) Leakage rate test.

j) Liaison with vendor's home office.

k) Field testing.

l) Commissioning of the complete analyser system.

m) Final acceptance testing.

10.4. System Check-outs:

a) Checking of all interconnections, configuration and overall system functioning.

b) Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge.

c) All the check-outs shall be performed in the presence of Owner/ PMC authorised representative. All headings shall be recorded on a suitable format and shall be submitted for approval.

d) After system checking is completed, vendor shall connect back any terminal or tubing or connection removed for loop checking.

e) All the equipment shall be checked thoroughly after its receipt at site. The tests, as a minimum, shall include;

i) Visual and mechanical testing

ii) Complete system configuration loading

iii) Calibration of all analysers, and other related equipment.

iv) Demonstration of all system functions.

v) Demonstration of all system diagnostics.

vi) Checking of correct change of redundant devices.

vii) Demonstration of analyser accuracies, linearities, repeatabilities, response time etc.

viii Demonstration of proper operation of system at specified voltage supply specifications.

ix A leakage test shall be conducted on entire system. Maximum permissible leakage rates shall not exceed 5% per hour of specified designed pressure.

11.0 TRAINING:

Vendor shall be responsible to train the Purchaser/Consultant personnel in the field for maintenance of hardware and software. The outline of each course including the course contents and the duration shall be forwarded by the vendor along with the offer.

12.0 DOCUMENTATION:

Vendor shall furnish all the manuals, including for maintenance and operation, necessary to test, operate and maintain etc the analysers and other related equipment, hardware and software.

13.0 ENGINEERING DRAWINGS:

13.1. Vendor shall provide a complete set of drawings covering each part of supply for Purchaser/Consultant record. The vendor is required to include Purchaser's project number on each of his drawing.

13.2. All field modifications shall be carefully recorded by the vendor's installation and commissioning personnel and changes shall be incorporated into the final drawings.

14.0 FINAL ACCEPTANCE TEST:

The Owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks with desired accuracy and repeatability. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning.

15.0 TESTING AND CALIBRATION EQUIPMENT:

Vendor shall make available all consumables including calibration gas cylinders, instruments and equipments necessary for testing, calibration, maintenance etc. as defined by the `scope of work'. All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested equipments and shall be certified by National Physical Laboratory or other equivalent agencies.

16.0 SPARE PARTS:

Vendor shall quote separately for spare parts required for a two year period of operation for the complete analyser system and the associated auxiliaries offered. Vendor shall enclose a list of spare parts quoted along with the offer.

17.0 MAINTENANCE CONTRACT:

Vendor shall quote separately for maintenance contract after warranty period for two years as per job requirements. The personnel deployed shall have thorough knowledge of the system and at least two years of experience as maintenance of similar system.

18.0 PACKING AND SHIPPING INSTRUCTIONS:

18.1. All materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are being packaged.

18.2. Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects; imperfections or omissions which would tend to impair the protection of the package as a whole.

18.3. The package shall be suitable for storing in tropicalised climate as per specified ambient conditions.

18.4. Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be fully responsible for any delay in installation or commissioning schedule because of incomplete supply of equipment.

GENERAL SPECIFICATION

FOR

PROCESS STREAM ANALYSER

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets, covers the requirements for the complete design, materials, nameplate marking, inspection, testing and shipping of process stream analysers. This standard specification shall be applicable for all types of process stream analysers irrespective of whether separate specifications are included or not included in this specification.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

ANSI/ASME American National Standards Institute! American Society of Mechanical Engineers.

B 1.20.1 Pipe Threads. General Purpose (Inch)

B 16.5 Steel Pipe Flanges and Flanged Fittings. NPS 1'2 through NPS24.

B 16.20 Metallic Gaskets for Pipe Fittings, Ring Joints, Spiral wound and Gasketed.

API American Petroleum Institute

Manual on Installation of Refining Instruments and Control System
RP 551 Process Measurement Instrumentation
RP 552 Transmission System
RP 554 Process Instrumentation and Control
RP 555 Process Analysers

ASTM693 Standard Practice for cleaning methods and cleanliness levels for material and equipment used in oxygen-enriched environment.

ASTM 0764-92 Standard Practice for Validation of Process Stream Analysers.

EN 50020 Electrical Apparatus for potentially explosive atmospheres-Intrinsic safety '**i'**

EN 10204 Inspection Documents for Metallic Products.

IEC-60079 Electrical Apparatus for Explosive Gas Atmosphere.

IEC-60529 Degree of Protection Provided by Enclosures. (IP Code)

IEC-61000-4 Electromagnetic Compatibility for Industrial Process Measurement and Control Equipment.

IEC-61285 Industrial Process Control Safety of Analyzer Houses.

IS-13947 Specification for Low Voltage Switchgear and Control gears.

IS-2148 Electrical Apparatus for Explosive Gas Atmosphere-Flameproof enclosures **'d'.**

1.1.3 In the event of any conflict between this standard specification, job specification/data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

d) Codes and Standards

1.1.4 In addition to meeting the purchaser's specification in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheet indicates the type of analyser and the minimum sample conditioning system requirements. Vendor shall be responsible for the selection of proper analyser and design of the sample conditioning system to analyse the component/components of interest within the stated performance requirements.

b) Carry out complete application engineering of the process gas analyser so as to achieve the desired analysis within stated performance requirements.

c) Provide all hardware and software, as necessary, to meet the functional requirements specified in the purchaser's specifications.

d) Provide complete data to purchaser for successfully proving serial communication with purchaser's host system i.e. DCS when specified in the job specification.

e) Purchaser's data sheets indicate the minimum requirements of material of construction for the analyser and its sample conditioning system. Alternate superior material of construction shall also be acceptable provided vendor assumes complete responsibility for all the parts of the analyser system so as to be compatible with the process stream and surrounding atmosphere as specified in purchaser's data sheet.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instruction to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer IS required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) A detailed specification sheet for each analyser, which shall provide information regarding type, materials of construction, performance specification and accessories of analyser. The material specification and units of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets. All the relevant terminology used in purchaser's data sheets and standard specifications shall be as per ISA RP 31.1.

c) A detailed drawing showing various components of sample conditioning system and piping/tubing hook-up arrangement including sample return, vent, utilities in connection and requirement of heat tracing (i.e electrical or steam tracing), as necessary.

d) Sample transportation time calculations for the specified distance between sample point and analyser indicating sample flow rate and the recommended size of the sampling tube.

e) Calibration gas cylinder calculations considering. six months of continuous operation with once a week calibration. The calculation sheet shall indicate the rate of gas consumption and specification of gases including composition, concentration, accuracy and shelf life of calibration blend.

f) References gas cylinder calculations considering six months of continuous operation. The calculation sheet shall indicate the rate of gas consumption and specifications of the reference gas.

g) Proven references for each offered model inline with clause 1.2.3 of this specification.

h) A copy of approval for intrinsically safe/flameproof enclosure, whenever specified, from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organisation/Chief Controller of Explosives (CCE), Nagpur or Director general of Mines Safety (DGMS) in India, along with:

i) Test certificate from recognised house CMRI/ERTL etc. for flameproof enclosure as per relevant Indian Standard for all Indian manufactured equipments.

ii) Certificate of conformity from agencies like CSA, BASEEFA, PTB, LCIE, FM, UL etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

i) Utility requirements and their consumption i.e. instrument air, cooling water, steam etc. along with their process conditions like flow, pressure and temperature.

j) Power consumption for each analyser and its accessories.

k) HVAC requirements i.e. heat load, humidity particulate/chemical filtration etc.

l) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations tag number wise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations.

m) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of analyser and accessories covered in the bid.

1.2.3 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date for the similar analysis as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 Whenever specified, vendor must furnish certified values of failure rates, probability of failure on demand and test interval for the safety integrity level analysis.

1.2.5 All documentation submitted by the vendor including their quotation, catalogues, drawings,

installation, operation and maintenance manuals, etc shall be in English language only.

1.2.6 Vendor shall also quote for the following: -

a) Complete calibration kit consisting of calibration gas cylinders, pressure regulators, gauges, cylinder gas piping manifolds and driers, (as required) etc. as a minimum, for each analyser. In case of dual range analyser, separate calibration standards shall be provided for each range. For the purpose of calculating requirement of zero and span calibration samples/gases, consider calibration time of 30 minutes every week for each analyser for a period of six (6) months of continuous operation.

b) Complete reference gas kit consisting of Reference gas cylinders, pressure regulators, gauges, cylinder gas piping manifold and drier etc as a minimum separately for each analyser as applicable. The reference gas cylinders shall be supplied for a period of six (6) months of continuous operation.

c) Consumable spares for the duration of six months with list of items as per vendor recommendations for each analyser system, unless otherwise specified in job specification.

d) Start up and commissioning spare parts for each analyser/analyser system as per vendor recommendations. However this list of spare parts must include 5% or minimum one of each type of following spare parts:

- Solenoid valve
- Pressure regulator
- Filters
- Temperature controller
- IRIUV Source (lamp)
- Peristaltic pump
- Set of fuses
- Set of o-rings
- Tubing and tube fittings (sizes smaller than 6 mm or *y''').*

Additional spare parts, if required, during start-up and commissioning, even though not listed in the list of start-up and commissioning spares, shall be supplied by the vendor without any implication.

e) Any special instrument or tool needed for testing, calibration and maintenance of the analyser such as spanner set (for tubes smaller than 6 mm or *y'''),* non-magnetic tools, bubble rotameter etc.

f) Training at vendor works and at site as specified in job specifications.

g) Two years operational and maintenance spares for each analyser and its accessories as per vendor recommendations, which shall include spare parts like electronic modules, temperature controller, power supply module, flow meter, solenoid valve, pressure regulator, local indicator, tubes, fan assembly, sample cell, detector assembly, UV/IR source/lamps, set of o-rings, set of fuses etc.

1.3 Drawing and Data

1.3.1 Detailed drawing, data, catalogues and manuals required from the vendor are indicated by the purchaser in the vendor data requirement sheet attached with the enquiry. The-required. number of reproducible, prints, and soft copies shall be despatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for each analyser and its accessories.

b) Certified drawings for each analyser and its accessories, tag number wise, which shall provide the following information:

i) Overall dimensions in millimetres.

ii) Sampling system details identifying each component with make and model number, process connection, utility connection, calibration sample/gas connection, heat tracing requirements, sample vent and fast loop details etc.

The flow, pressure and temperature at interface and other appropriate location must be shown in the sampling system drawing.

iii) Detailed interconnection drawing of each analyser identifying each component with terminal number, cable type, cable size and cable entry details. The interface details shall be clearly identified in the drawing.

iv) Grounding details.

v) Power supply distribution details.

c) Programming/configuration data for each analyser, as applicable.

d) Serial interface specification including its configurational data (addresses) for host communication.

e) Power consumptions and utility requirements.

f) Calibration curves and calibration data for each analyser.

g) Zero and span calibration gas specification including composition, shelf life time and accuracy.

h) Copy of type test certificates.

i) Copy of the test certificates of all the tests indicated In clause 4.0 of this specification

j) Installation procedure for each analyser and their accessories.

k) Calibration and maintenance procedures including replacement of its parts/internals wherever applicable.

1.4 Definitions

1.4.1 The following definitions shall apply for analysers and their accessories:

a) Transportation time

Transportation time is the time interval between a step change in the process fluid composition in the process line and the initial analyser response (excluding analyser response time).

b) ResponseTime

The time interval between the initial response of the analyser and the time required for the analyser output to reach a value of 90% of the final output value for a step change in sample quality.

c) Time Constant

The analyser response to reach a value of 63% of the fmal output value for a step change in sample quality is called the analyser time constant.

d) Repeatabilitv

Repeatability of a measurement is the band of values within which an analyser repeats its measurement when the same sample is applied to it. The short termed repeatability is generally determined by multiple readings of a sample during calibration and is usually true random error over short period of time if external influences like pressure and temperature etc remain constant.

It is also defmed as the difference between two successive analyser results that would be exceeded in the long run in only one (I) case in twenty (20) when a single analyser system is operated on a flowing sample of uniform quality.

e) Sensitivity

The sensitivity of an analyser is a measure of an analyser's ability to detect a least change in concentration of a measured component that is not masked by the background noise.

f) Accuracy

Accuracy of a measurement is the measure of how close the measured value is to the true value of the sample. For all type of analysers, accuracy is primarily a function ofthe accuracy of the standards used for calibration.

g) Analyser Rack

An .open analyser mounting structure with/without canopy used for mounting analysers, sample handling system and their accessories individually or together in combination.

h) Analyser Cabinet

Small housing in which analysers are installed individually or grouped together. Maintenance is performed from outside the cabinet with door (s) open.

2.0 DESIGN AND CONSTRUCTION

2.1 Analyser Reqnirements

2.1.1 The type of analyser and its measuring principle is specified in the purchaser's data sheet. Accessories and equipments as required to make online analysis complete are also specified in the data sheet. In general, the scope shall include the following:

a) Sample probe and sampling system, as applicable

b) Analyser complete with all hardware and software consisting of detector, transmitter and associated equipments.

c) Fast loop and Sample return system, as applicable

d) Calibration and maintenance equipment.

e) Gas cylinders for zero and span calibration.

Unless otherwise specified the scope shall also include supply of all interconnecting tubing, piping, fittings, heat tracing equipment etc., excluding sample return piping from analyser battery limit to sample return header.

In-situ analysers when specified may not include items 2. 1.1(a) and (c)

2.1.2 Analysers and its related equipments directly connected to process line and In-situ analysers shall be capable of withstanding line pressure and temperature conditions specified in the purchaser's data sheet.

2.1.3 The analyser design and design of sample handling system shall be such that components or any sub-assembly that requires removal shall be possible without any need to disassemble any other component. Such components shall include items like stream selector valves, filters, pressure regulators, flow-indicator, detector, electronic modules etc.

2.1.4 Analyser shall be microprocessor based with state-of-the-art technology and shall be capable of being configured from analyser front panel locally using built-in keyboard. When specified, it shall also be possible to configure the analyser from remote through a separate terminal.

2.1.5 The configuration related data of the analyser including set range shall be stored in a nonvolatile memory such that this data remains unaffected by power fluctuations or power off condition. In case vendor's standard product stores configuration data in battery backed RAM, analyser shall have facility to provide battery drain alarm as diagnostic maintenance message.

2.1.6 The span of the analyser shall be field adjustable from the analyser front without opening the analyser enclosure. In case, separate device is required to make such a change, the same shall be included, by vendor in their scope of supply.

2.1.7 Analyser shall run diagnostic subroutines on continuous basis and shall be able to provide diagnostic alarms related to analyser optics, detector and electronics, as and when any failure/malfunction is detected.

2.1.8 Analyser shall have an integral output meter with digital readout in engineering units.

2.1.9 All interconnecting wiring shall be colour coded/numbered and terminal blocks be clearly identified.

2.1.10 The analyser shall be capable of providing the following outputs:

a) Isolated 4-20 rnA DC current output for each analysed component. Smart or field bus output shall be provided when specifically indicated in the purchaser's data sheet.

b) RS485 serial output with MODBUS (RTU) protocol, whenever serial output is specifically indicated in the purchaser's data sheet. The serial output signal shall contain analyser data of component of interest and diagnostic alarms, as a minimum.

c) SPDTcontact outputs for various diagnostic alarms (as applicable) such as:

i) High or low set point alarm as measurement
ii) analyser failure
iii) low sample flow
iv) temperature control failure
v) purge failure

Any other alarm contact, either specifically indicated in purchaser's data sheet or available as standard with the analyser, shall also be provided.

Unless specified otherwise, all contacts shall be normally closed type (contact open in alarm) and shall be rated for 11OVAC 5 Amperes.

2.1.11 The design of analyser system shall be in compliance with the electromagnetic compatibility requirements as per IEC-61000-4-X.

2.1.12 Material of Construction

2.1.12.1 Unless otherwise specified, the material of construction of all components wetted by the sample shall be SS316, as a minimum. Vendor must ensure the compatibility of material of each component with the process fluid.

2.1.12.2 Material of all soft parts like diaphragms and o-rings shall be of PTFE. Other vendor standard materials can also be acceptable provided these are compatible with the specified process condition.

2.1.12.3 The material of construction of all non-wetted parts shall be as per manufacturer's standard.

However non-metallic materials for casings, enclosures and instrument covers shall be avoided.

2.1.13 Power Supply

2.1.13.1 Unless indicated otherwise, the analyser including the sample handling system shall operate at IIOV 50Hz power supply.

2.1.13.2 The analyser performance shall be within the specified limits when the supply voltage varies by ± 10% of specified value and supply frequency varies by ±3 Hz of specified value.

2.1.13.3 Electrical tracing when specified, shall operate at 230V 50 Hz supply. 230V 50Hz power supply shall also be used for analyser cabinet/panel lighting and air conditioning unit, when specified.

2.1.14.1 Unless otherwise specified, the following shall govern;

a) Threaded connections shall be NPT to ANSIIASMEB 1.20.1.

b) Flanged connection shall be as per ANSIIASME B16.5.

c) Flange face finish shall be serrated concentric to clauses 6.4.4.1, 6.4.4.2, and 6.4.4.3 of ANSIIASMEB 16.5. The face finish shall be as follows:

125AARH : 125 to 250 AARH
63AARH : 32 to 63 AARH

d) Ring type joint flanges shall have octagonal grooves as per ANSIIASTMBI6.20.

2.1.14.2 End connection of sizes 6 mmor below shall be suitably protected against damage.

2.1.14.3 All end connections shall be clearly identified by attaching labels or stainless steel plate of suitable size.

2.1.15 Enclosure Type

2.1.15.1 Analyser enclosures and related accessories shall be suitable for the electrical area classification indicated in purchaser's data sheets. Unless otherwise specified, the enclosures shall comply to the following standards:

Weather proof housing : IP 55 as per IEC-60529 / IS-13947

Flame proof housing : Flame proofEx (d) as per IEC-60079 / IS-2148

Purged Enclosure : NFPA 496

Flameproof and purged equipment shall also be made weatherproof.

2.1.15.2 In addition to meeting weatherproof requirements specified in clause 2.1.15.1 of this specification, intrinsically safe analysers shall meet the requirements specified in EN 50020 and shall be certified for the area classification specified in the purchaser's data sheet.

2.1.15.3 Analyser where air/nitrogen purge is provided, purge shall be as per NFPA 496 Type X. Analyser power shall cut off in case of purge failure. Purge failure alarm shall be provided for purchaser use.

2.1.15.4 Separate cable entries shall be available in the analyser/enclosure for power and signal cable. Unless otherwise specified, following shall apply:

a) Cable entry and terminal size for power cable shaH be infonned during detail engineering. Explosion proof 3 way junction box with cable glands shall be supplied, if required.

b) Cable entry for Serial cable/signal cables (Signal output) shaH be *1'2"* NPT (F).

c} Cable entry for multi-pair signal cables (Multiple output) shaH be 1\1,"NPT (F).

2.1.15.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by attaching label or stainless steel plate of suitable size.

2.2 Sample Handling System

2.2.1 The sample handling system shall consist of primary sample conditioning near sample take off point, sample transportation line, secondary sample conditioning near the analyser, sample return, sample/analyser vent and sample drain/recovering system, as applicable. The primary sample-conditioning unit shall be a fabricated assembly and shall be mounted on a stainless steel plate suitable for surface mounting.

Secondary sample conditioning shall also be a fabricated assembly and shall be either mounted on a stainless steel plate or within an enclosed cabinetlbox with a viewing window. In case the temperature is required to be maintained at primary and secondary sample conditioning, both these conditioning units shall be installed in the heated box/cabinet.

2.2.2 Process Stream sampling shall be continuous and analyser shall be located as near as possible to the sample take-off point. Where the analyser is located away from the sample take-off point, vendor shall design the sample fast loop (bypass loop) as part of sampling system. Design shall ensure that the sample drawn is true representative of the process stream to be analysed.

2.2.3 In general, sampling systems shall be designed and constructed in accordance with API-RP555. The design of sample handling system shall consider the following factors, as a minimum:

a) The pressure-temperature conditions required for the analyser.
b) Interfering components in the process sample.
c) Normal and abnormal sample compositions.
d) Sample return pressure-temperature conditions.
e) Fouling sample conditions e.g. polymer formation or presence of solids etc.
f) Transportation time requirements.
g) Utilities available and their process conditions.

2.2.4 Unless otherwise specified, material of all components wetted by sample shall be suitable for the process fluid and sample process conditions specified in the purchaser's data sheet. The material of construction for all wetted parts shall be, 316 SS, as a minimum.

2.2.5 Sampling system shall include all elements as necessitated by the process conditions indicated in the purchaser's data sheets, to make the sample suitable for the analysis. This shall include but not limited to filters (coarse and fine), pressure regulators, relief valves, flow indicators, flow controllers, temperature indicators, scrubbers, heaters, coolers, dryers, sample pumps, aspirators etc.

Each sampling system element shall be capable of being removed without disassembling the entire system.

2.2.6 Sample probe shall be provided by the vendor to obtain representative sample from the line. The sample probe shall be inserted in the pipe through a line isolation valve (ball or gate valve), which shall be part of vendor's scope of supply. The probe design shall ensure the following:

a) On-line removal and insertion of the probe with non-fly-off design

b) Unless otherwise specified, end connection for installation in the line shall be 1 1/2" flanged with type and rating as specified in purchaser's data sheet. The line isolation valve shall also be of the same size and rating as probe end connection.

c) The probe diameter shall be such that it can be easily inserted or removed through the line isolation valve when in fully open condition.

d) The length of the probe shall be selected considering its insertion upto the middle of the pipe. For the purpose of calculating probe length, consider nozzle length as 200 mm.

2.2.7 Sampling system shall include a sample block valve on all process sample line. The block valve shall be provided meeting the following requirements:

a) The block valve shall be located immediately after the sample probe.

b) Where purchaser's data sheet do not indicate the requirement of sample probe, the block valve shall be provided in the sample line as a part of primary sample conditioning unit.

c) The size of the sample block valve shall be as per the sample line size while the rating shall be as specified in the purchaser's data sheet.

2.2.8 The size of the sample tubing shall be decided by the vendor considering:

a) The distance between sample take off and analyser specified in purchaser's data sheet.

d) The specified sample transportation time.

e) Pressure at the sample take off point.

Where no transportation time is specified in the purchaser's data sheets, vendor shall consider the sample transportation time as 60 seconds.

2.2.9 Where sample is required to be transported in hot condition, sample shall be drawn using pre-fabricated heated tubes. The heated medium shall be either stearn or electric power asspecified in purchaser's data sheet.
Heating shall be controlled such that the sample temperature is maintained typically around +200e above the sample dew point.

2.2.10 When fast loop is specified or recommended by vendor, vendor shall provide flow meter for sample bypass flow. Sample return line to process shall be provided with isolation valve and check valve. Vendor shall ensure that return pressure of the sample shall be higher than the pressure of the process return point specified in purchaser's data sheet.

2.2.11 Sampling system shall include provision for connecting calibration sample/gases in auto or in manual configuration as specified in purchaser's data sheet. When no specific requirement is indicated, the provision shall be made for manual configuration only.

2.2.12 In case of multi stream analyser, the sample handling system shall utilize double block and bleed configuration to prevent cross-contamination of samples. All stream selection valves shall have bubble tight shut off. The block valves shall be fail-close type while bleed valve shall be fail-open type.

2.2.13 Filters shall always be provided in dual configuration. It shall be possible to replace the filter without upsetting the operation of the analyser.

2.2.14 The sampling system shall be designed to consider plugging of sample lines under following conditions, if applicable:

a) Failure ofheat tracing
b) Failure of sample pump
c) Failure of instrument air, particularly when sample dilution technique is adopted for sample.
d) Upset of short up conditions, if excessive solids/solid particles are expected under these

operating conditions.

2.2.15 Unless specified otherwise, sample lines used for carrying samples for more than one analyser shall be provided with sample pumps in dual configuration. It shall be possible to remove or insert the pump without upsetting the sampling system.

2.2.16 A suitable restriction orifice shall be provided in each sample line to limit the sample flow exceeding thrice the normal flow in the event of tube rupture or opening of tube down the line.

2.2.17 Whenever auto-calibration requirement is specified in the purchaser's data sheet, it shall be possible to initiate auto calibration cycle at preset time interval defined by user either manually via the analyser keyboard or remotely through an external contact.

The sample handling system shall be designed to include all hardware and/or software to meet this requirement. The analysed component concentration output shall remain at the last good measured value during auto calibration cycle.

2.2.18 Analyser rack and cabinet

a) Whenever specified in the purchaser's data sheet, the analyser shall be supplied in pre-assembled, pre-tubed and pre-wired condition complete with sample handling system. The primary sample conditioning unit i.e. conditioning at sample tap off point shall be supplied separately.

b) When open rack mounted installation is specified in purchaser's data sheet, the analyser and sample handling system shall be supplied installed in an open rack with canopy to protect the analyser from direct sunlight and rain. The open rack shall be fabricated using channels/pipes of suitable size. The material of construction shall be stainless steel. The canopy shall also be fabricated out of SS plate of 1.2mm thick.

c) Whenever closed cubical mounted installation is specifically indicated in the purchaser's data sheets, analyser and sample handling system shall be supplied preinstll1led in tree.tanding closed analyser cabinet:-The-analyser-cabinet-shall-be suitable for outdoor installation and shall be provided with a key lock.

Cabinet shall be fabricated out of 2.OmmSS sheet reinforced with angles of suitable sizes. Fittings and hinges shall be of stainless steel. Anchor bolts required for installation of cabinet shall also be supplied by vendor.

A power isolation switch with suitable circuit breaker or fuse shall be provided for the incoming power supply.

All items including analyser installed within the cabinet shall be suitable for the maximum possible temperature likely to be attained within the cabinet (i.e. with all items fully powered-on within the cabinet) and area classification specified in the purchaser's data sheet.

Heating/cooling of analyser cabinet shall be provided either when purchaser's data sheet specify the requirement of heating and/or cooling or recommended by the analyser manufacturer or found necessary by the manufacturer to meet following requirements:

i) The temperature induced measurement error exceeds ± I% of full scale in the worst temperature conditions.

ii) The maximum allowable ambient temperature condition of any component within the cabinet exceeds its limits.

Whenever cooling is specified or found necessary, vendor may select one of the following cooling methodologies, unless specifically indicated otherwise:

a) Cabinet mounted air conditioner certified for the specified area classification.

b) Vortex cooler with compressed air system and air dryer of suitable size and capacity. No separate instrument air shall be provided by purchaser for vortex cooler.

c) The maximum height of rack/cabinet shall be limited to 2100 mm. Cabinet shall be suitable for side and bottom cable entry.

d) Power supply cable entry and terminal size shall be as defined during detail engineering by purchaser.

2.3 Infra-Red/Ultra-Violet (IRIUV) Analysers

2.3.1 IR/UV analyser shall preferably be non-dispersive type.

2.3.2 Analyser cell length shall be selected as per specified analyser component range. In case of dual range analysers, the selected cell length shall be suitable for both the ranges.

2.3.3 The analyser cell material and window material shall be suitable for the specified process condition. Unless otherwise specified or required otherwise by pressure-temperature conditions, the o-ring material shall be Teflon.

2.3.4 The analyser design shall be such that it is insensitive to source fluctuations or degradation or partial cloudiness of cell window.

2.3.5 Special filters shall be offered to minimise the interference of background components, which are of least interest in process stream.

2.3.6 Unless otherwise specified, analyser shall meet the following performance requirements:

Repeatability : ± 1% of full scale
Zero drift : ± I% full scale per 24 hours.
Response Time : 5 seconds for 90% of final reading

2.4 Thermal Conductivity Analyser

2.4.1 Thermal conductivity analyser shall be suitable for measuring hydrogen/hydrocarbon in binary gas mixture or in a multi component gas mixture.

2.4.2 Analyser shall have precise temperature controller which shall be able to maintain temperature within ± 0.1°C to ensure stable detector operation.

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2.4.3 Analyser cell shall have flowing reference gas or sealed in (non-flowing) reference as per manufacturer's standard product.

2.4.4 The analyser sensor cell material shall be suitable for the specified process conditions, unless otherwise specified or required by temperature condition, o-ring material shall be PTFE.

2.4.5 Performance specification

Unless otherwise specified, Analyser shall meet the following performance specifications:

Accuracy	:	± 1%of FSR
Repeatability	:	± 1% of FSR in 24 hours
Response time	:	Maximum 20 seconds for 90% response

2.5 Moisture Analyser

2.5.1 The requirements of moisture analyser for corrosive as well as non-corrosive for application are specified in' this clause. Vendor shall offer the type of analyser as specified in the purchaser's data sheet.

Whenever, the type of analyser is not indicated in the purchaser's data sheet, vendor shall select the type of moisture analyser as per the specified process conditions

2.5.2 Moisture analyzer for non-corrosive application.

2.5.2.1 The probe shall be in-line mounted (i.e. shall be located at the point of measurement) in general and shall not be damaged by severe shock and line abrasion conditions.

2.5.2.2 The pressure and temperature rating of the probe shall be suitable for the process condition specified in the data sheet.

2.5.2.3 When mounted remote, the probe shall be installed in a sample cell. The end connections of sample cell shall be flanged with ANSI rating as specified in the purchaser's data sheets.

2.5.2.4 Unless otherwise specified or found necessary by vendor, no sample handling system shall be required. However, whenever the sample handling system is specified, the design shall ensure the integrity of sample i.e. moisture contents integrity shall be maintained.

2.5.2.5 The probe shall have Aluminum oxide moisture sensor. Alternate type moisture probe shall also be acceptable, if this meets the performance requirements specified in the purchaser's data sheet.

2.5.2.6 Each probe shall be supplied as pre-calibrated and shall be supplied with its own calibration curve. The calibration shall be valid for a period of minimum six (6) months from the date of supply, as a minimum

2.5.2.7 Performance specification.

The moisture probe shall meet the following requirements as a minimum:

Accuracy	:	$\pm 2^0$C within a range of 60°C to 65°C (Dew point) ± 3°C within a range of--66°C to -110^{0}C
Repeatability	:	± 0.5°C in range of 60°C to 65°C ± 1.0°C in range of-60°C to -110°C
Life time	:	One year

Time Constant: 5 seconds for 63% of steady state value.

2.5.3 Moisture analyser for corrosive application

2.5.3.1 The moisture probe shall be hygroscopic ally sensitized quartz crystal or equivalent suitable for the specified process samples containing unsaturated hydrocarbon, chlorides, oils etc

2.5.3.2 Sample shall be conditioned in a sample handling system which shall include filters, condensate trap, dryer, pressure regulator (with or without heating as required) etc., however the design shall ensure that moisture integrity is maintained by the sample handling system.

2.5.3.3 The system shall incorporate a dried reference gas cycle after each sample gas measurement in order to strip volatile contaminants from the detector during reference gas cycle.

2.5.3.4 In order to ensure accuracy and reliability of the moisture analyser, the system shall incorporate a moisture generator, consisting of temperature controlled water reservoir and a permeation tube. The moisture generator shall generate a known moisture sample against which calibration of the analyser can be verified.

2.5.3.5 Performance Specification

The moisture probe shall meet the following performance requirements, as a minimum:

Accuracy	:	± 5% of reading
Repeatability	:	± 1% of reading
Response time	:	max. 60 seconds for 90 % of steady state value

2.5.4 Analyser Monitor/Controller

2.5.4.1 The analyser monitor/controller shall be microprocessor based and shall be programmable type.

2.5.4.2 The monitor/controller shall be remote mounted type with built-in display with keyboard for data display. The cable between analyser and monitor/controller shall be supplied by the vendor.

2.5.4.3 The monitor/controller shall be able to provide sequential display for various parameters and shall be selectable from the display keyboard.

2.6 Oxygen Analyser

2.6.1 The type of oxygen analyser shall be offered as specified in the purchaser's data sheet. Where purchaser's data sheet does not specify the type of oxygen analyser, vendor shall select the type meeting all functional and performance requirements indicated in purchaser's data sheets.

2.6.2 The analyser design shall ensure that the analysis is not affected by other sample constituents present in the sample.

2.6.3 Paramagnetic Type Oxygen Analyser

2.6.3.1 Unless otherwise specified, the paramagnetic type of oxygen analyser shall have magneto dynamic type measuring cell.

2.6.3.2. The analyser shall either have integral or split transducer unit containing the measuring

cell and control unit containing the analyser electronics. The control unit facia shall have withLCD/LED display.

2.6.3.3 Whenever the control unit is remote mounted, cable between control unit and measuring Cell shall be supplied by vendor.

2.6.3.4 Whenever paramagnetic type analyser is specified for pressurized or variable pressure application, the offered analyser shall have required pressure compensation to ensure that the measurement is not affected by changes in sample pressure and sample vent pressure.

The analyser design shall be such that the measurement shall not be affected by changes in ambient temperature and sample flow rate.

2.6.3.5 Paramagnetic analyser shall meet the following performance characteristics as a minimum:

Accuracy	:	±I% of full scale.
Repeatability	:	±0.5% of full scale.
Response time	:	6 seconds for 90% response

2.6.4 Electrochemical (Electrolytic) Type Oxygen Analyser.

2.6.4.1 The electrochemical type of oxygen analyser shall have either aqueous or non-aqueous measuring cell and shall meet the following requirement;

a) The analyser shall be self or auto-calibrating type. The calibration cycle shall be initiated either after a pre-defined time or whenever analyser senses excessive drop/drift in the output.

b) Analyser shall provide a suitable alarm for excessive drift. This information may be available as part of HART output signal.

2.6.4.2 In case, in those analysers where cell need to be replaced after the depletion of electrolyte, the analyser shall, in addition, meet the following requirements;

a) The electro-chemical cell shall be easily replaceable.

b) The analyser shall provide a warning for maintenance i.e. expiration of sensor well in advance (Typically 2 weeks). In addition analyser shall also provide an alarm in case output drops below the minimum reliable calibration level.

c) One spare cell shall be supplied as part of consumable spare.

2.6.4.3 The analyser shall have integral electronics with built in LCDILED display. Electrochemical analyser shall meet the following performance characteristics as a minimum:

Accuracy	:	±1% of full scale.
Repeatability	:	±1% of full scale.
Response time	:	Less than 15 seconds for 90% response

2.6.5 Zirconia Type Oxygen Analyser

2.6.5.1 The Zirconia type oxygen analyser shall be either in-situ type or extractive type as specified in the purchaser's data sheet.

2.6.5.2 In case of in, situ type of analyser, vendor shall ensure that the analyser as offered is suitable for the pressure-temperature specified in the data sheet and the measurement shall not be effected by changes in sample pressure and flow rate. In case of variable pressure application, vendor shall ensure that offered analyser has the provision for pressure compensation and/or pressure balancing arrangement.

2.6.5.3 Zirconia type of oxygen analyser shall be provided with auto-calibration facility to take care of zero-drift of cell.

2.6.5.4 The zirconia analyser shall consist of the following sub-assemblies;

2.6.5.4.1 Sensor Assembly

a) The sensor assembly shall consist of the measuring cell, heater assembly, temperature sensor and connections for reference and calibration gases.

b) The measuring cell shall be a zirconia sensor specific for oxygen measurement.

c) The sensor shall be suitable for operating sample temperature up to 700°C.

2.6.5.4.2 Control Electronics

a) The control electronics shall have capability to execute all required controls, indications, temperature control for normal operation and output signals as specified in purchaser's data sheet.

b) Sensor temperature shall be maintained through temperature controller. Temperature sensor shall preferably be ISA type K thermocouple.

c) Temperature controller shall cut-off power to heater in case of thermocouple burns out.

d) Control electronics shall preferably be remote mounted type. Cable between control electronics and sensor assembly shall be supplied by vendor.

2.6.5.4.3 Reference Gas Control

Reference gas shall be flow and pressure controlled. Flow shall be controlled by rotameter With needle valve while pressure shall be controlled by self-actuated pressure control valve provided with pressure gauge.

2.6.5.5 Zirconia type oxygen analyzer shall meet the following performance characteristics as a minimum:

Accuracy	:	± 2% of measured value.
Repeatability	:	± 1.0.% of full scale.
Response time	:	Less than 10 seconds for 90% response.

2.7 **Calibration Gas and Reference Gas Cylinders**

2.7.1 Each analyser shall be supplied with following gases with stainless steel or Aluminum Cylinders:

a) Reference gas dual cylinder with manifold where required. The reference gas system shall be dedicated one for each analysers, where required along with automatic switchover to standby cylinder when the first cylinder is exhausted.

b) Certified calibration gases. In case of dual range of measurement, separate calibration gas for each range shall be provided.

2.7.2 Each of the gas cylinders shall be provided with two stage pressure regulator. Manifold shall be provided for reference gas with dual cylinder configuration.

2.7.3 All gas cylinders shall be located near the analyser and shall be supplied with gas cylinder rack with free standing support.

2.7.4 In case the calibration gas deteriorates or depletes with time, vendor may either supply calibration gas cylinders with deferred delivery or supply alternate devices for preparing calibration blend.

3.0 NAMEPLATE

3.1 Each analyser and its accessory shall have a stainless steel nameplate firmly attached to it at a visible place, furnishing the following information as applicable:

a) Tag number as per purchaser's data sheets.
b) Manufacturer's serial number and model number.
c) Manufacturer's name/trade mark.
d) Component being analysed and its range.
e) Area classification in which the equipment can be used.
f) Power supply requirements.
g) Analyser Outputs

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with the inspection test plan for process stream analysers. Vendor shall provide necessary facilities, utilities, competent manpower and consumables required for carrying out the inspection.

4.2 Vendor shall submit the following test certificates and test reports for purchaser's review for each of the analyser:

a) Dimensional verification certificate for each analyser.

b) Material test report as per clause 2.2 of EN 10204 for all wetted part

c) Manufacturer's test reports as per clause 3.lB of EN 10204 for various bought out components.

d) Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.

e) Calibration report for each analyser as per clause 4.3 of this specification.

f) Repeatability test for each analyser as per clause 4.4 of this specification.

g) Power supply variation check.

h) Test certificates for zero, span, carrier and fuel gases as applicable.

i) Certificates from statutory body for flameproof/intrinsic safety and weatherproof enclosures as applicable.

4.3 Analyser Calibration

4.3.1 Analyser along with sample handling system shall be calibrated using zero and span calibration gas samples in the following sequence:

a) Check/adjust zero by connecting zero gas and span by connecting span gas.
b) Check again zero by connecting zero gas after (a) above. Also repeat span gas check.
c) If either or both zero and span are adjusted in step (b), repeat (b) again to verify the calibration until no further adjustments are made in zero and span.

4.4 Repeatability Testing

4.4.1 Repeatability of the analyser shall be checked by connecting either span gas (if it is approximately 70% of analyser span) or any other gas sample on continuous basis for the following time period.

a) 24 hours by manufacturer and report to be submitted for review.

b) 8 hours during witness inspection.

4.5 Witness Inspection

4.5.1 All the analysers shall be offered for pre-dispatch inspection by the purchaser at vendor works. Following tests/ checks shall be carried out on each analyser as a minimum:

a) Physical dimensional verification and workmanship.
b) Bill of material check for each analyser system including sample handling system
c) Leakage testing of complete system using nitrogen or instrument air.
d) Calibration check as per clause 4.3 above.
e) Repeatability check as per clause 4.4.
f) Power supply variation check. Analyser must function satisfactorily on specified

variation of power supply voltage.

g) Review of all test certificates and test reports indicated in clause 4.2 above.

4.5.2 In the event when the witness inspection is not carried out by purchaser, the tests shall any way be completed by the vendor and documents for same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably covered to prevent entry of foreign material.

5.2 Each major part shall be sealed in thick plastic bag. Suitable moisture absorbent shall be provided for electronic components.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.

GENERAL SPECIFICATION

FOR

CALIBRATION GAS REQUIRMENT

& UTILITY CONSUMPTION

S. No.	Tag No .	Analyzer Type	ZERO gas cylinder with regulator pressure gauges and relief valve	SPAN gas cylinder with regulator pressure gauges and relief valve	Fuel/Carreir gas cylinder with regulator pressure gauges and relief valve
1.	Note 1	Note 1	*	*	
2.			*	*	
3.			*	*	
4.			*	*	

Note 1 : Vendor to Provide the Tag and Analyzer type

1) Vendor shall supply calibration sample cylinders for zero and span calibration for each analyse Quantity of total cylinders for each analyser shall be calculated by vendor with following basis:-

a) Calibration gases are required for six months of normal operation.

b) These calibration gas cylinders for six-month operation shall be supplied in two sets. One set these cylinders shall be connected to the analyser and another set of cylinders shall be kept i store.

c) Calibration gas accuracy shall be adequate to demonstrate the repeatability of the analysers.

D Calibration / Zero gas quantity shall be calculated based on a frequency of one calibration i fortnight interval as a minimum.

e) Calibration gas cylinders shall be preferably of SS316 material. Aluminium gas cylinders are all: acceptable in place of SS316.

* - Vendor to offer total no. of cylinders accordingly and Indicate the same in the offer.

[ ] DEVIATION [ ] NO DEVIATION [ ] VENDOR SEAL

UTILITY COMSUMPTION

1.0 Power Consumption:

(A) 415 VAC, 50Hz (For Air-conditioning, panel lighting, electrical heat

S. No.	Item	Maximum Power Consumption		In Rush Current	
		Unit Consumption	Total Consumption	Ampere	Duration
1.	**Note 2**				
2.	**Note 2**				

(C) 110 VAC +/- 10 %, 50Hz +/-3%, UPS (for Analyser and its sample handling system)

S. No.	Item	Maximum Power Consumption		In Rush Current	
		Unit Consumption	Total Consumption	Ampere	Duration
1.	**Note 2**				
2.	**Note 2**				

2 Instrument Air:

S. No.	Item	Normal (Nm3/hr)		Maximum (Nm3/hr)	
1.	**Note 2**				
2.	**Note 2**				

Note: 1. All utilities shall be made available to vendor at a single point near the cabinet for the Analyser system, further distribution or conversion if required shall be in Vendor scope. Vendor shall ensure the matching connection to the purchaser provided header connections.

Note 2 : Vendor to Provide the Tag

GENERAL SPECIFICATION
FOR
MASS SPECTROMETER

00	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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1.0 GENERAL

1.1. **Scope**

This specification, defines the minimum requirements for design, construction and testing of mass-spectrometer analyzer..

1.2. Codes, Standards and Reference Documentation

All primary flow elements shall comply with the latest edition of following codes and standard, where applicable:

ASME/ANSIB-1-:20:1-(19837R-199-2-	threads, pipe threads, general purpose (INCH)
ASMEIANSI B 16.5 (1996/ADD.A 1992)	Pipe flanges and flanged fitting, steel nickel alloy _and other special alloy.
API RP555 Ed.2 (Nov. 2001)	Process analyzer.
IEC 60529 (1989)	Classification of degrees of protection provided by enclosures (IP Code)
IEC 79.00 to 79.09, 79.11, 79.15, 79.18	Electrical apparatus for explosive gas atmospheres. Part 0+18.
CENELEC EN 50014 (1993)	Electrical apparatus for potentially explosive atmosphere. General requirements.
CENELEC50016 (1995)	Electrical apparatus for potentially explosive atmosphere. Pressurized apparatus "p".
CENELECEN 50018 (1994)	Electrical apparatus for potentially explosive (with amendment 1 & 2) atmosphere Flame proof enclosure **“d".**
CENELECEN 50019 (1977)	Electrical apparatus for explosive atmosphere safety apparatus "e".
CENELECEN 50020 (1994)	Electrical apparatus for explosive atmosphere safety "i",

In the event of conflict between the provision of the documents listed above and the requirements of this specification, the more stringent interpretation shall apply unless approved otherwise in writing.

-

1.3. Available utilities

1.3.1. Process

For process utilities see General Conditions document.

1.3.2. Power supply

The power supply system shall be designed In accordance with type of instruments reliability of the mains supply, type of plant and relevant safety requirements to be met in case of mains failure. The electrical power supply for the analyzer systems and associated accessories shall be 110 V AC - 50Hz from uninterruptible power supply (supplied by other). **24 VDC is to be derived by Vendor**.

2.0 SAMPLING SYSTEMS DESIGN CRITERIA

This section provides general guidelines to be strictly followed by sampling system Manufacturer unless the application requires different approach for process and/or technical reasons. Sampling system shall be engineered to obtain analyzer maximum performances in terms of accuracy, repeatability and availability. Sampling systems shall be provided by analyzer Manufacturer that shall be fully responsible of sampling system design.

2.1. General requirements

The following are general requirements that, together with good engineering practice have to apply by sampling system Manufacturer. Any other implementation considered necessary to assure good system working shall be provided.

2.1.1. Sampling systems materials

As minimum all metal parts in contact with process sample shall be AISI 316. If the application should require different materials (e.g. monel, hastelloy or other), it shall be notified to PDIL/ . Copper, silver, mercury and their alloys must be avoided for components in contact with process fluids. No plastic composition, fiber or paper are permitted as piping or valving. All components shall be resistant to process fluids and to the plant atmosphere

2.1.2. Components selection

Sampling system components shall be selected according to PDIL/ OWNER approved sub-vendor list. Components sizing shall reflect sampling line size to avoid time lag and/or delta P increasing due to components size reduction (i.e. for ½" OD lines, the size of valves, flowmeters, etc shall be ½").

The following requirements shall be considered for components selection:

a. <u>Compression fittings</u>

Double ferrule compression fittings must be utilized.

b. **<u>Pressure regulators</u>**

Pressure regulators shall be supplied according to the following requirements:

- Type: diaphragm type, single stage as standard (two stages pressure regulator shall be provided for high pressure system)
- Body material: AISI 316
- Connections: 1/4" NPT-F on inlet and outlet.

Pressure regulators shall be provided for all sample lines to regulate the pressure even if the analyzer maximum inlet pressure rating is higher than

process sample pressure.

c. **Pressure safety valves**

Pressure safety valves shall be supplied according to the following requirements:

- Type: Spring activated
- Body material: AISI316
- Connections: 1/4" or 1/2" NPT-F on inlet and discharge.

Relief valves shall be provided where following indicated to protect conditioning system components and analyzer:

- Downstream pressure regulators
- Downstream pumps / compressors discharge

d. **Pressure gauges**

Pressure shall be supplied according to the following requirements:-

- Element type: bourdon
- Case material: stainless steel
- Dial dimensions: 50 mm or 2-1/2"
- Connection: 1/4" NPTM on bottom.

Pressure gauges shall be provided where following indicated:

- After pressure reduction
- On pumps / compressors suction
- On pumps / compressors discharge
- On samples having pressure above/below atmospheric.

e. **Temperature gauges**

Temperature gauges shall be supplied according to the following requirements:

- Element type: bi-metallic
- Case material: stainless steel
- Dial dimensions: 50 mm or 2-1/2"
- Connection: 1/4" NPTM on bottom.

Temperature gauges shall be provided where following Indicated:

- After cooling
- On samples having temperature above ambient.

f. **Flow meters**

Variable area flowmeters shall be provided. Flowmeters range shall be calculated to obtain the required time lag; flowmeters shall be sized for normal flowrates from 50% to 70% of selected range. Float material shall be selected according to process fluid and service. Meter factor and design Specific Gravity shall be stated on flowmeter nameplate.

The following shall be considered for flow meters selection:

• Glass tube meters shall be provided for low flow applications where sample does not exceed 2 bar g. and/or 70 "C.

Glass tube meters shall be suitable for at least 1.5 times the maximum operating pressure of the related system and shall be provided with 5 mm thick polycarbonate screens for personnel protection.

• Metal tube flow meters shall be provided for each one of the following conditions:
i) high flow applications or

ii) low flow applications where:
- pressure is above 2 bar g.
- temperature is above 70 'C.

g. **Filters**

Filters types shall be selected according to application requirements. Rate of filtering shall be as recommended by analyzer manufacturer. The following common requirements shall be considered:

-Body_material:.	-AISI—316 as minimum
- Filter element type:	- application dependent i.e. sinterized, metallic Screen etc.).
- Element replacement:	-to be done without removing the filter body from sample line.

Several types of filters are available; follow a partial description of the most commonly used.

• By-pass filters
By-pass filters shall be provided for the by-pass of fast loop stream and gross filtering of the sample. Filter shall be self cleaning type of appropriate design for the particular sample. The sample to the anaiyzer shall be the slipstream from this filter. By-passed sample shall be returned to process or to fiare *I* sewer according to application requirements.

• Swirlclean filters
Swirlclean filters shall be used as by-pass filters on high particulate high flow samples.

• Coalescing filters
Coalescing filters shall be provided to protect the analyzer from incidental/liquid drops where condensable are foreseen. Coalesced liquid shall be delivered to sewer system.

• Tee filters
Final guard filter, low volume tee type, shall normally be provided before analyzer sample flowmeter. Filter element shall normally be sinterized steel.

• In-line filters
Where required, final guard filter, low volume in-line type, shall normally be provided on analyzer inlet. Filter element shall normally be sinterized steel.

h. **Switching system**

Where two ore more streams have to be introduced in the analyzer, Switching system shall be provided.

Switching shall be done by double block and bleed valve system. Valves shall be ball type. Actuators will be activated using solenoid valves in EExd execution.

Switching valves internal volume shall be as smaller as possible according to analyzer sample flow requirements. If not otherwise requested, calibration shall be manual type. Switching system shall be done to provide to the analyzer the following:

• Process line sample(s)
• Calibration / Validation sample(s) (where required)
For each stream, switching sequence and stream duty cycle shall be fully programmable

i. **Sample cylinders**

If required, two sample cylinders (if not otherwise specified on job individual specification shall be supplied according to the requirements:-

• Seamless type, formed from tubing.

• 500 cc capacity
• Complete of :
- Carrying handle.
- Inlet and outlet needle valves.
- Outage tube where sampled fluid is liquid.

• Factory passivated and cleaned.

j. **Quick connectors**

Quick connectors shall be supplied according to the following requirements:

• Double end shut-off type.
• Self sealing.
• Capable to withstand the required design pressure.
• Provided with stem and body protector caps complete of fixing chain.

k. **Flexible hoses**

Flexible hoses shall be completely made of stainless steel (tube and overbraid). Particular care shall be paid to avoid excessive bending during connection and disconnection of sample cylinder; hoses length shall be determined accordingly

l. **Pumps**

Where a pump is provided, the following requirements shall be considered:

• Pumps shall be diaphragm type. Double diaphragm pumps shall be utilized where high toxic sample (I.e. high H2S content) are sampled.

• Pump material shall be carbon steel as a minimum; cast iron pumps are not acceptable. Teflon lined internals or other suitable materials of construction shall be provided where highly corrosive fluids (i.e, high H2S) are sampled.
• Pump shall be complete with:
- Recycle valve
- Overload thermic protection
- Power switch (to be provided in case pump unit is installed remotely from Analyzer House).
Pump dimensioning shall be done taking into account as safety design margin of the 50%.

2.1.3. **Sampling systems interconnections**

Sampling systems shall be provided of tubing unions or bulkheads for sample and utilities lines interconnection as stated in analyzer individual specifications. Connections shall normally be suitable for 6 mm OD tubing for gaseous samples and ½" OD tubing for liquld samples.

2.1.4. **Sampling-systems layout**

Particular care shall be taken to assure easy accessibility of components for maintenance purpose and routine operational checks. Layout drawings shall be provided for PDIL/ OWNER review and approval.

2.1.5. **Sampling systems tagging**

Sample system shall have a permanently fixed label giving the associated analyzer tag number and a brief service description of the analyzer. Components and indicators within the sample systems shall have permanently fastened labels describing their function (e.g. FI-xxx sample flow to analyzer).Labels shall be weather resistant (i.e trafolite, stainless steel, etc,). Labels shall be fixed on sample system plate by means of stainless steel screw (glue is not acceptable). Labels and tags shall be in the English language.

2.1.6. **Sampling systems - Electrical execution**

Unless otherwise indicated in the individual analysis instrument datasheets, the field electrical/electronic instruments and equipment will be provided in EEx-I execution according to CENELEC Code. Compliance with IEC/CENELEC codes shall be certified by an internationally recognized institute.Other protection (EEx-d, EEx-p etc) could be used when EEx-i execution is not available or practical. The mechanical protection degree for electrical *I* electronic instrumentation shall be IP 65 according to IEC 60529. Enclosure for field mounted equipment will be heavy-duty construction; wiring shall be fully protected against physical damage. The electrical connections shall be NPT threaded (Female) unless otherwise stated in the individual analysis instrument data sheets.

2.1.7. **Sampling systems flow diagram drawing**

Manufacturer shall provide dedicated drawing for each sampling system. Each sampling system component shall be tagged. Operative set for relief valves and flow meters shall be indicated on flow diagram. The drawing shall also include list or table (equivalent to the following sample) reporting tag, description, material, manufacturer, model, selected range and operative set (where applicable) for each sampling system component.

S.No.	Description	Material	Manufacturer	Model	Range	Set
1						
2						
n						

2.2. **Gaseous samples**

When a gaseous process fluid is sampled the following guidelines have to be applied.

2.2.1. **Sample Preconditioning unit**

For a clean and dry sample with process take off point pressure higher than 6 barg. or where sample pressure is greater than analyzer maximum inlet pressure a pressure reducing station (PRS) plate mounted complete with the following shall be provided as a minimum:

- Sample shut-off valve on sample inlet
- In line filter
- Pressure reducer/regulator
- Pressure gauge on regulator outlet
- Relief valve
- Sample shut-off valve on sample outlet

Samples with high particulate content shall be provided with redundant filters at take-off point; if not otherwise indicated manual switch shall be foreseen.

2.2.2. **Condensable Samples**

In case pressure reduction could cause partial condensation or icing, sample vaporizer regulators shall be provided. Double pressure reduction, with or without vaporizer could be considered if necessary due to process conditions. Provision shall be taken to avoid condensation inside sample line; for this purpose it shall be considered the addition of phase separator (complete of automatic drain facility) and/or coalescing filter. Where required, the panel shall be installed inside an heated enclosure (for description refer to para 2.4). Shut-off and calibration valves shall be operable from the outside of the box. Manufacturer shall advise PDIL/ OWNER about the necessity to provide sample line heating. Heating shall normally be by steam.

If sample needs to be maintained at a constant temperature due to condensation and/or polymerization, PDIL/ OWNER shall be informed about the need to provide temperature controlled sampling lines. If sample contains high water concentration, system heating could be avoided and water be removed by cooler/separator or other mechanical device, only if this does not affect measurement reliability (e.g. measured component be solved in water).

2.2.3. **Sample conditioning Unit**

As minimum sample conditioning unit shall be provided with the following:

- Sample shut-off valve on sample inlet

- Fast loop system composed by:
  - By-pass filter
  - flow meter
  - check valve
  - shut-off valve on fast loop outlet

- Fine filter

- Zero calibration inlet by three way valve

- Span calibration inlet by three way valve

- Analyzer sample flow meter

- Sample shut-off valve on sample outlet

Where required, the sample conditioning unit shall be installed inside an heated enclosure (for description refer to para 2.4). Shut-off and calibration valves shall be operable from the outside of the box. Where high pressure fluctuations in the process are expected a pressure regulator for fine pressure control shall be provided on sample conditioning unit inlet. The regulator shall be placed downstream fine filter and zero and span calibration inlets. For samples with process take off point pressure higher than 80 barg and/or where high pressure fluctuations in the process are expected also a pressure regulator for fine pressure control shall be provided on sample system inlet. The regulator shall be placed downstream fine filter and zero and span calibration inlets. In case of analyzers extremely sensitive to sample pressure variations a fine regulator shall be provided to avoid errors due to pressure variation between process sample and calibration gases.

2.3. Calibration System / Analyzer Validation

2.3.1. Analyzer Manufacturer shall specify the type of samples to be supplied for the calibration of the relevant analyzer. Calibration standard gas (zero and span) to be quoted separately. These gas cylinders shall be provided complete with single stage or two stage pressure regulator, shut-off valve, pressure gauge and provision for connection to the analyzer sampling system. Calibration gas cylinder shall be supplied in 47 liter water capacity and will be provided for six months of operation. Sample tubing considered for calibration gas cylinder to mass spectrometer shall be 1/8 inch. Vendor shall advise requirements for zero and span calibration gases and all consumption rates, composition details, and any special quality requirements.

Cylinders shall be supplied with birth certificate (certification of origin) other certification, if any, in compliance to explosive rules for refilling of the cylinders later on.

2.3.2. When required, analyzers shall be provided with permanent validation facilities which shall on demand introduce standard reference sample into the analyzer. The reference sample (if liquid) shall be stored in appropriate container as part of the analyzer sample system. The

validation sample shall be switched into the analyzer sample conditioning systems downstream of all conditioning system components except for the final flow control valve flow meter and final guard filter. The validation samples shall be switched via double block and bleed valve system. The valves shall be ball type. The air actuators will be switched using solenoid valves. When *Validation* is selected at the analyzer selection switch, validation sample shall be routed to the analyzer and remain in this *mode* until the selector switch is turned to another position. During this period the "Analyzer Data Valid" contact should be opened and only closed again at the end of the validation after a time delay.

2.4. **Sampling Systems enclosure**

Where necessary, sample preconditioning system and/or final sampling system shall be installed in a suitable enclosure. Enclosure shall be designed in accordance with the following description; in any case Manufacturer shall provide enclosure specification for PDIL/ OWNER review and approval.

a. Enclosure protection shall be EExd - IIC T3 IP65 execution.

b. Enclosure walls shall be made of AISI 316 stainless steel sheets with a minimum thickness of 1.5 mm.

c. Sampling inlets and outlets shall be provided with suitable bulk-head Compression fittings for tubing connection.

d. Sampling system plate shall be removable from the enclosure.

e. Enclosure door shall be complete with locking device and handle.

f. External fixing eyes shall before seen for installation purpose.

g. All supports, bolts and screws shall be made of stainless steel.

In the event the system should require heating, the followings additional requirements shall be considered for enclosure manufacturing:

a. Enclosure shall be sandwich type:

- Externals shall be made of AISI 316 stainless steel sheets with a minimum thickness of 1.5mm
- Internals shall be made of AISI 316 stainless steel sheets with a thickness of 1 mm.

b. The insulation shall be provided on all sides of the enclosure including the front door. Insulation shall be installed between external and internal steel sheets to guarantee, together with steam heating system, 'the required internal temperature and to mantain the external surface temperature below 60 "C. Insulating material shall be incombustible (e.g. mineral wool).

c Preferably steam heating shall. be provided (low pressure steam shall. Normally be utilized). Heating shall be done using a radiator adequately sized by Vendor. Internal

temperature control system shall be provided where it is necessary to maintain a constant set temperature.

d Thermometer shall be provided on the front door.

In case flammable or toxic gases are handled inside the cabinet, suitable warning label shall placed on cabinet front door (e.g. "CAUTION RISK OF H2S", or "CAUTION FLAMMABLE GAS IS HANDLED").
Notice color shall be white on red back; letter dimensions shall be at least 20 mm height x 20 mm width.

2.5. Sampling Systems Calculations

PDIL/ OWNER shall provide on the analyzer individual specifications the following data that shall be utilized by sampling system Manufacturer for the system design.

a) Sampling and return line lengths
b) Proposed lines size (to be confirmed by Vendor)
c) Sample composition
d) Sample take-off point temperature and pressure
e) Sample return point temperature and pressure
f) Sample take-off point density.
g) Sample take-off point viscosity.
h) Sample take-off point dew point.

Manufacturer shall provide fast loop and time lag calculations for PDIL/ OWNER review and approval, System time lag shall normally be kept below 60 seconds. As safety design margin, the fast loop shall be calculated on the basis of 50% of the available pressure differentia between sample take off pressure and sample return pressure.

2.6. Sampling Systems Components' Sub-Vendor List

Where applicable all sampling systems shall be assembled utilizing components in accordance with the following sub-vendor list. In the event the application should require materials provided by other Manufacturers, the Vendor shall ask PDIL/ OWNER written approval highlighting all the technical aspects carrying to the proposed solution. Components' selection shall be done taking care of standardization criteria, minimizing the choice of different sub-vendors.

3.0 ANALYZERS DESIGN

This section provides general guidelines that shall be followed for the selection of the analyzers utilized for this project.

3.1. General requirements

Analyzer Vendor shall be fully responsible of the suitability of the proposed analyzer for the particular process application in terms of operating personnel safety and analyzer performances.

3.1.1. Analyzer installation

Analyzers not suitable to be directly installed in field shall be placed in common Analyzer House(s). The temperature inside the Analyzer House(s) shall be controlled to ensure adequate ambient conditions.

Analyzers; sample conditioning-systems and fast loops shall be positioned to obtain easy maintenance and routine operational checks. Analyzers control units (if any) shall normally be installed in control room or they may exceptionally be installed in the Analyzer House.

Sample conditioning systems shall be installed on the exterior walls in such a way that analyzer and related sample conditioning systems are located back to back. Cylinders shall be installed against the outside walls of the Analyzer House and shall be provided with fencing for restriction of unauthorized entry. Installation shall be designed for easy replacement. Provisions shall be taken to avoid direct exposure to sunlight.

If required the Analyzer House will be prefabricated type and, if located in hazardous area, shall be provided with redundant forced ventilation system; in this case air intake shall be from a safe area.

CO and flammable gas detection system shall be provided to avoid CO and gas accumulation in the analyzer building or analyzer houses.

Flame proof AC (3.0 Tons) shall also be provided.

Internal of Analyzer House shall be classified as safe area according to IEC 70.16.

3.1.2. **Electrical execution**

Unless otherwise indicated in the individual analysis instrument data sheets, the field electrical/electronic instruments and equipment will be provided in EEx-I execution according to CENELEC Code. Compliance with IEC/CENELEC codes shall be certified by an internationally recognized institute. Other protection (EEx-d, EEx-p etc) could be used when EEx-i execution is not available or practical. The mechanical protection degree for electrical/ electronic instrumentation shall be IP 65 according to IEC 60529.

Enclosure for field mounted equipment will be heavy-duty construction; wiring shall be fully protected against physical damage. The electrical connections shall be NPT threaded (Female) unless otherwise stated in the individual analysis instrument data sheets.

3.1.3. **Analyzers common requirements**

Within practicable limits, analyzer type shall be selected to perform a continuous measurement of the component of interest.

Proposed analyzers (whenever possible) shall be microprocessor based complete with auto diagnostic features providing detailed and guided assistance to facilitate Calibration, maintenance and fault finding.

A summary alarm contact shall be provided in case of malfunction; the contact shall be fail-safe design (Normally-Open type, de-energized in alarm conditions).

As minimum all metal parts in contact with process sample shall be AISI 316. If the application should require different materials (e.g. monel, hastelloy or other), it shall be notified to PDIL/ OWNER..

The use of copper and copper alloy is not allowed (also for carrier gases and instrument air). No plastic composition, fiber or paper are permitted as piping or valving.

If not otherwise stated in the individual specification analysis instrument data sheet , the following performance shall apply:

-sensitivity (minimum detectable limit) shall be 500 ppm of span or less.
-noise (detector deviation at constant input for chromatographs) shall be 0.5% of span or less.

If not otherwise stated in the detailed descriptions and individual specifications, the analyzers shall also be provided with the following:

• 4-20 mA linear output signal fully floating (600 Ohm load).

• Programmable measuring range.

• Self diagnostic.

• Keyboard configuration of functional parameters (range, process alarms, calibration values etc.).

• Storage of software parameters in non volatile memory.

• Automatic and Semiautomatic (on demand, by an external contact) calibration.

• "Hold" function: in case of failure and/or during calibration, the signal output shall be fixed to the last valid measurement, or to a fixed safe value.

• Tropicalization of the electronic parts against humidity and fungus; even those located in air conditioned rooms shall be varnished and electrostatically protected.

• Built-in meter for local indication shall be provided.

• "Zero" and "span" calibration facilities.

• Tropicalizalion of the electronic parts against humidity and fungus; even those located in air conditioned rooms shall be varnished and electrostatically protected.

• Built-in meter for local indication shall be provided.

3.2.**Mass spectrometer**

Mass spectrometer is common for all sample points.

Location and operation/design conditions for each sample point are as show on individual specifications.

Each sample point to have a local sampling system with sample probe (in same cases common with other analyzers or local analysis points) and a common final sampling system at the Mass spectrometer.

Mass spectrometer shall be installed in analyzer building and shall be equipped with printer and PC station. Printer and PC station shall be installed in central control room.

Mass spectrometer shall be stand alone units engineered and developed to satisfy the application as stated on Analyzer individual specification.

The analyzer cabinet shall be complete of vortex cooler for cooling of the electronic components.

The minimum configuration of PC shall be as given below

Intel Core-2 Duo Processor, 3 GHz, 4 GB RAM , 500 GB HDD, 22" TFT color, serial, parallel, USB., Ps/2 ports with Windows XP Professional license with HP laser Printer with PCanywhere software and modem connectivity for Remote Login.

3.2.1. **Electronic and Control section**

Analyzer software shall be designed to perform the required analysis.
As minimum the following features shall be provided:

-Calculation software
-Analysis results continuous updating at the end of each analysis cycle.
-Components data transmission to DCS via 4-20 mA analogic outputs, and serial link transmission MODBUS-RTU (with communication protocol and applicative software).
-Ion source heater control.

Vendor shall confirm availability of such protocol, as industrial products, with the DCS supplier (Vendor shall supply Modbus list for DCS connectivity).

3.2.2. **Analyzer tagging**

Each analyzer will be marked by a stainless steel nameplate permanently fixed which, at least, will include the following informations:

- MFR's name or trademark
- Serial number and model
- Instrument tag
- Range
- Electrical rating (Voltage ,Frequency, Consumption)
- Electrical execution

• Pressure rating of pressurized parts

3.2.3. **Screen Display Configuration**

The analyzer shall have the following as minimum facility but not limited to

1. Menu Organization
2. Main Menu
3. Password Entry
4. Configure Defaults
5. Normal Analyze Screen
6. Incoming Alarms Screen
7. Manual Port Select
8. Manual Analyze Mode
9. Investigative Scan Display
10. Diagnostic Page
11. Auxiliary Menu Screen
12. Alarm History Retrieval Page
13. System Configuration Menu
14. Add/Delete Compounds Screen
15. Mass/Scan Voltage Configuration
16. Port Definition
17. Analysis Sequence Screen
18. Configuration Summary Page
19. Peak Select Mode Screen
20. Compound Calibration Menu
21. Scan Calibration Gas Screen
22. Calc/Examine /Modify Matrices Screen
23. Analyze Calibration Gas Screen

4.0 **AMBIENT CONDITIONS**

Instrumentation will be suitable to operate in the Fertilizers Complex atmosphere at the conditions specified in the General Conditions. Complex is at the sea site location exposed to the aggressive nature of the salt water atmosphere conditions. Ambient conditions will be taken into consideration for the transport. storage and normal operation.

5.0 **TESTS AND INSPECTIONS**

5.1. **General**

Analyzers and accessories will be submitted to all necessary tests and checks in compliance with IDS (Inspection Data Sheets) to verify that the supply is according to this specification and relevant standards and codes. Manufacturer will submit his internal test procedure during the bid phase. The Buyer reserves himself the right to send his Inspectors to the Manufacturer and Sub-vendor shops to check if the time schedule for the construction is respected together with quality of the product. The Inspector will have free access to the areas involved for the construction of the equipment and the Manufacturer will give him the necessary cooperation. However, PDIL/ OWNER inspection will be in no way release the Supplier from guarantee as to materials, apparatus, workmanship and performance of the equipment supplied by him.

Any fault which will be found during test will be corrected by Supplier at his own cost.

5.2. **Test Description**

The analyzers will be submitted, but not limited, to the following checks and tests:

5.2.1. Visual Test

It will be carried out to verify marking, overall dimensions, connection size, housing classification and construction materials.

5.2.2. Performance Test

It will be carried out to verify that instrument performance comply with requirements of para. 2 and 3.

5.2.3. Functional Test

It will be carried out to ascertain the functions requested on individual specification. Calibration and eight (8) hours repeatability test will be performed by the Manufacturer before shipment. Repeatability shall be, at least, that specified on Manufacturer technical brochure.

5.2.4. Pneumatic Test

The sampling systems will be submitted to pneumatic test in accordance with Manufacturer practice.

5.2.5. Factory Acceptance Test

Factory Acceptance Test (FAT) shall be conducted in presence of OWNER/PDIL representative Site Acceptance Test (SAT) shall be conducted for minimum of seven days to prove the guarantees.

5.3. **Test Certificates**

On final test the Supplier will have to provide the following documents in English:

-Chemical analysis/physical properties of construction materials.
-Internal test certificate including tests required in para. 5.2.
-The certificate of calibration shall be given in accordance with the International Standard ISO 9002

5.4. **Training**

Training shall be imparted at Vendor's workshop for one week for two persons. In addition vendor will be required to provide training to representative during commissioning time.

6.0 TECHNICAL DOCUMENTATION

6.1. **General**

All the documentation such as graphic drawings and technical specifications shall be sent to the Contractor who will reserve to approve it within 15 days; after this period, the documents have to be retained approved. The Contractor's approval will not relieve the Vendor of his responsibility for the final performance of the supply. Final issue of Project Documents, shall be supplied in electronic format as specified hereunder.

Only in exceptional case, requiring PDIL/ OWNER prior approval or when Vendor is utilizing software different than those specified at para 6.3 and 6.4 scanned documents in raster format as specified in para 6.5 can be accepted. All the other Vendor documentation, such as Manual, Catalogs, etc. shall be supplied on paper.

6.2. **Title block and heading**

Each document originated by the Vendor shall be numbered according to Vendor procedure.

6.3. **Specification, Data Sheets and other documents**

All shall be produced with Microsoft Office products as Word, Excel or PowerPoint access.
The files shall be delivered in a “workable stand-alone” format, without any special features (links to other files, special fonts, macros, etc.), which may affect the possibility of viewing and editing.

6.4. **Drawings**

Drawings will be made using AutoCAD version 12 or 14 or Latest.
Vendors are permitted to utilise other CAD software, but the produced files are to be converted in AutoCAD format prior the delivery to Contractor.

Drawings files shall be delivered as “single complete file”, without any reference attached, except when not practicable due to the dimension of referenced files. In this case together with the reference files also the information necessary to manage the files shall be given.
Together with the drawings files also the relevant files for plotting format HPGL or HPGL2 are to be delivered.

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6.5. **Scanned documents**

The format of scanned documents shall be CCIIT Group IV TIFF or Adobe PDF Acrobat.
Quality control on file of scanned documents will be completed prior to delivery, including:
Deskew
Despeckle
Hole Fill.
Resolution below 200 Dpi is not acceptable.

The following documents (technical) are required to be submitted by the vendor alongwith bid, after placement of order for approval purposes and final documentation before despatch of consignment.

SL. NO.	DESCRIPTION OF DOCUMENT	ALONGWITH BID	AFTER PLACEMENT OF ORDER	
			FOR APPROVAL/ INFORMATION WITHIN SIX WEEKS	FINAL DOCUMENTS BEFORE DESPATCH OF CONSIGNMENT
1.	Consolidated list of drawings & documents	Yes	yes (I)	yes
2.	Deviation, if any, from the technical spec. giving justification for the same.	Yes	x	x
3.	Catalogue / technical literature of MSP and accessories including cross-sectional view, dimensions, weight etc.	yes	Yes	Yes
4.	Tentative dimensional drawings for each tag no. with technical details like dimensions, weight, special supports, clearances required for easy maintenance etc. , sectional drawings for special control valves.	Yes	x	x
5.	Final certified drawings of MSP	x	yes (A)	Yes
6.	Document required before pre-despatch inspection A.) Calibration certificate B.) Hazardous area use conformity certificates. C.) Electrical wiring diagram. D.) Documents, manuals etc. .	x	x	Yes
7.	Certificates conforming to specific standards from independent recognised agency, wherever applicable, for - Ex-proof items - Intrinsically safe items - Environmental protection - Fire safety	yes	x	Yes
8.	Manuals for installation, operation. maintenance	x	x	Yes
9.	Manufacturer's quality assurance certificate	x	x	Yes
10.	Quality assurance plan	x	yes (A)	x
11.	FAT PROCEDURE			Yes
11.	SAT PROCEDURE			Yes

NOTES

1. (A) for Approval (I) for information only

Number of sets alongwith bid for approval and as final documentation shall be supplied as stipulated in the purchase order.

6.6 METHOD OF TENDERING

General

The Bidder shall present a list of previous applications (References) for equipment similar to the equipment proposed.

Technical information

The equipment offered as a basis shall be of standard production type it shall be based on modern technology, be of a proven and referenced type and designed for continuous operation under the specified operating conditions.

The Bidder shall quote for the materials requested according to the requirements of this specification and of the individual job specifications. With bid shall be supplied the technical documentation.

Deviations

The tender shall be in strict accordance with Purchaser's specifications. However, the Vendor may quote, in addition and as an alternative, different materials from those required in the specifications, provided these materials are suitable for the process conditions specified in the individual job specifications.

Any deviation from the requirements listed in the general specification and in the individual job specifications shall be clearly highlighted.

If no exceptions are listed, the tender - and the possible supply - shall be regarded as being in full conformity with the Purchaser's requirements, and will be accepted after the tests and checks have confirmed that the performance complies with the requirements of the tender documents and order specifications.

6.8. Size of Drawings, Specification and other documents must be according to UNI/ISO standard.

6.10. Addressing documentation

All documentation will be addressed to:

PDIL as per the address given elsewhere.

6.12**. Required Drawings & Documents**

S.No.	Description	Notes
1	Sampling system flow diagram	
2	Sampling system dimensional drawings	
3	Sampling system layout	
4	Sampling system pneumatic interconnections	
5	Sampling system interconnecting wiring	
6	Analyzer dimensional drawings and weights	**2**
7	Analyzer electronic and detector layout	**2**
8	Analyzer terminal strips· Power and signals interconnecting wiring	**2**
9	Analyzer internal wiring	**2**
10	Cabinet dimensional drawings	**1**
11	Cabinet layout	**1**
12	Cabinet power supply distribution	
13	Cabinet terminal strips - Interconnecting wiring	**1**
14	Cabinet internal wiring	**1**
15	Field equipment installation details	**1**
16	Fast loop calculation sheet	**1**
17	Flow meters calculation sheet	**1**

Notes:
1. If any
2. Necessary when not included in analyzer instruction manual

7.0 **SPARE PARTS**

Spares shall be as per section 9.0 of the NIT.

8.0 **PACKING FOR SHIPMENT**

The packing for shipment shall meet the provisions contained in the purchase order conditions.

Packing for shipping of equipment shall be crash proof, weatherproof and road/seaworthy.

9.0 **METHOD OF SUPPLY**

9.1. **General**

The supply shall be in strict accordance with the purchase order conditions and the specifications issued for order and shall be constructed in accordance with the requirements of good engineering practice.

9.2. **Documentation**

The Vendor shall forward the documentation required in the "General Purchase Conditions" attached to the purchase order, in the number of copies and within the time specified in this specification at para 6.

9.3. **Responsibility**

The Vendor shall assume responsibility for the project, construction, assembly, and tests of the supply..

9.4. **Guarantees**

The guarantee period must be according to purchase order conditions. The Vendor shall guarantee that all the equipment supplied is free of design and construction defects, or defects related to poor quality of the materials utilized. During the guarantee period the Vendor shall undertake to replace or repair, at this own charge, all parts found defective due to material quality. improper design, workmanship or assembly.

GENERAL SPECIFICATION

FOR

MASS FLOW METER

ABBREVIATIONS:

AARH	Arithmetic Average Root Height
CMRI	Central Mining Research Institute
ERTL	Electronics Regional Testing Laboratory
FISCO	Field Bus Intrinsically Safety Concept
HART	Highway Addressable Remote Transducer
HHT	Hand Held Terminal
NPS	Nominal Pipe Size
NPT	National Pipe Thread
PID	Proportional, Integral and Derivative
RAM	Random Access Memory

CONTENTS

1.0 GENERAL

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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets attached herewith covers the requirements for the design, materials, inspection, testing and shipping of mass flow meter.

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the data of purchaser's enquiry;

ANSI/ASME	American National Standards Institute / American Society of Mechanical Engineers.	
	B 1.2.1	Pipe Threads General Purpose (Inch)
	B 16.5	Pipe Flanges and Flanged Fittings NPS ½ through NPS24
	B 16.20	Metallic Gaskets for Pipe Flanges, Ring Joint, Spiral wound
	B 16.34	Valves Flanged, Threaded and Welding Eng
	EN 10204	Inspection Documents for Metallic Products
	lEC-60068	Environmental Testing
	lEC-60079	Electrical Apparatus for Explosive Gas Atmosphere.
	IEC/TS-60079	FISCO Technical Specification
	IEC-60529	Degree of Protection Provided by Enclosures (IP code).
.	IEC-60587	Test Method for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions.
	IEC-61000-4	Electromagnetic Compatibility for industrial Process Measurement and Control Equipments
	IEC-61158	Field Bus Standard for use in Industrial Control System
	IEC-61158-2	Physical Layer Specification and service definition for field bus.
	IEC-61508	Functional Safety of Electrical / Electronic / Programmable Electronic safety related system.
	IS-13947	Specification for low Voltage Switchgear and Control gear.
	IS-2148	Flameproof Enclosures for Electrical Apparatus for Explosive Gas Atmospheres - Flameproof Enclosures 'd'.
	ITK-x.x	Interoperability Test Kit (latest version)

1.1.3. In the event of any conflict between this standard specification, job specification/ data sheets, statutory regulations, related standards, codes etc. the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

1.1.4 In addition to compliance to purchaser's specifications in totality, vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets specify the minimum acceptable material for the body and sensor tube of mass flow meter. Alternate superior material of construction shall also be acceptable provided, vendor assumes full responsibility for the selected material for the indicated fluid and its operating conditions.

b) Sizing and selection of mass flow meter suitable to measure the specified fluid flow rate with the stated accuracy.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer IS required, vendor's quotation shall include the following;

a) Compliance to the specifications.

b) A detailed specification sheet for each item, which shall provide information, described as under. The material specifications and the units of measurement for various parts in vendor's specification sheet shall be to the same standard as those indicated in purchaser's data sheets.

i) Type of element and material of construction of various parts and its accessories.

ii) Accuracy of flow measurement at the specified minimum, normal and maximum flows with pressure drop not exceeding the maximum allowable pressure drop indicated in the purchaser's data sheet.

iii) Pressure drop across the mass flow meter at the maximum now specified in the data sheet.

iv) Special cable required, if any, cable specification and the maximum permissible cable length between the flow meter and its associated receiver instruments and unit rate.

c) Mass flow meter sizing calculations for each meter considering accuracy and pressure drop requirements specified in the purchaser's data sheets.

d) Effects of variations in density, viscosity, temperature and pressure on the measurement.

e) Proven reference for each offered model number in line with clause 1.2.3 of this specification, whenever specifically indicated in purchaser's data sheets.

f) A copy of approval from local statutory authority, as applicable, such as Chief of Controller of Explosive (CCE), Nagpur or Director General of Mines Safety (DGMS) in India for the mass flow meters installed in electrically hazardous area along with;

i) Test certificate from recognised house CMRI I ERTL etc. for flameproof enclosure / intrinsic safety, as per relevant standard for all Indian manufactured equipment or items requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, BASEEFA, PTB, CSA, UL etc. for compliance to ATEX or any other recognised standard for all equipment manufactured outside India.

h) Deviation on technical requirements shall not be entertained. In case vendor has some valid technical reason to deviate from the specified requirements, they must include a list of mass flow meters tag number wise, summing up all the deviations from the purchaser's data sheets along with the technical reasons for these deviations.

i) Catalogues giving detailed technical specifications, model decoding details and other related information for each type of mass flow meter covered in the bid.

1.2.3 All items, as offered shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.4 Whenever specified, vendor must furnish tested values of failure rates, probability of failure detection and test intervals for the safety integrity level analysis.

1.2.5 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation manual, operation and maintenance manuals etc shall be in English language only.

1.2.6 Vendor shall also quote for the following:

a) Universal hand held configurator / terminal (HHT) for the configuration and maintenance of instruments with HART output.

b) Field bus hand held tester for configuration and maintenance of field bus network.

c) Field bus configurator with hardware and software for configuration and maintenance of field bus instruments.

d) Safety barriers whenever offered meters are certified intrinsically safe with external barriers.

e) Two year's operation spares for each mass flow meter and its accessories covered in the bid, which shall include the sensor, pre-amplifier, and converter electronics etc. as a minimum.

f) Any special tools needed for maintenance work on the flow meter and its accessories. Vendor must confirm in their offer if no special tools are needed for maintenance of offered mass flow meters.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, and catalogues required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies should be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual submitted by the vendor after placement of purchase order, vendor shall include the following as a minimum:

a) Specification sheet for each mass flow meter.

b) Certified drawing for each mass flow meter, which shall provide:

i) Dimensional details in mm.

ii) Weight of the flow meter in kilogram.

iii) Material of construction.

iv) Installation requirements.

c) Curves for flow measurement vs, accuracy and rangeability.

d) Maximum and minimum supply voltage required for the instrument to function within the stated performance characteristics.

e) Clearance required for maintenance work

f) Copy of type test certification

g) Calibration procedures for mass flow meter.

h) Copy of test certification for all the tests indicated 111 clause 4.0 of this specification.

i) Installation procedures for mass flow meter.

2.0 DESIGN AND CONSTRUCTION

2.1 Flow Meter

2.1.1 Flow meter shall be of in-line mounting design with flow direction clearly marked on the flow meter body to ensure correct installation.

2.1.2 Flow meter design shall ensure that the location and I or orientation of installation of mass flow meter in the line shall not affect the calibration, accuracy and performance of the meter.

2.1.3 The material of construction of mass flow internals and body shall be as specified in the respective data sheets, as a minimum.

2.1.4 The mass now meter shall be provided with the external flow tube housing wherever specifically indicated in the data sheet. In all such cases, the now tube housing shall have provision to monitor housing pressure continuously.

2.1.5 The mass flow meter shall have high vibration immunity. The meter output shall not be effected by the pipeline vibration where the meter is installed.

2.1.6 End Connection

2.1.6.1 Flow meter shall be of flanged body construction with material if construction as specified in purchaser's data sheet. In case meter design where end flanges are welded to the meter body all weld joints shall be of radiography quality.

2.1.6.2 Flow meter shall be of flanged body construction with material of construction as specified in the purchaser's data sheet. In case of meter design where end flanges are "welded to the meter body all weld joints shall be of radiography quality.

2.1.6.3 Unless otherwise specified, the following shall govern:

a) Threaded end connections shall be to NPT as per ANSI/ASME B 1.20.1.

b) Flanged end connections shall be as per ANSI/ASME B 16.5.

c) Flange face finish shall be as per clauses 6.4.4.1,6.4.4.2 and 6.4.4.3 of ANSI/ ASME B16.5. The face finish as specified in data sheets shall be as follows:

125 AARH : 125 TO 200 AARH

63 AARH : 32 TO 63 AARH

2.1.7 Terminal Housing

2.1.7.1 Following shall apply for both integral as well as for remote meter electronics:

a) All connections shall be terminated on the terminals brought out ill the terminal housing located on the flow meter body. Flying leads shall not be provided.

b) All intrinsically safe terminals shall be properly identified and shall be separate from the non-intrinsically safe terminals.

c) Separate cable entry shall be provided in the terminal housing for power and intrinsically safe signals.

d) The flow meter enclosure, housing the electrical parts shall be suitable for the area classification indicated in the purchaser's data sheets. Unless otherwise specified, the enclosure shall conforrn to the following standards, as a minimum:

Weatherproof housing - IP 55 to IEC-60529/IS-13947.

Flameproof housing - Flame proof / Ex (d) as per IEC-60079/1S-2I48.

Flameproof housing shall also be made weatherproof.

2.2 Meter Electronics

2.2.1 Flow meter electronics shall be microprocessor based and shall include pre-amplifier, converter, transmitter electronics and integral output meter. The indication on the output meter shall be digital with engineering units.

2.2.2 The mass flow meter transmitter shall be smart type and shall provide 4-20mA analog output superimposed with digital signal for meter diagnostics (HART Output). When specified, flow meter shall provide field-bus output conforming to the standard specified in the purchaser's specification sheets.

2.2.3 The mass flow meter shall be capable of computing field density and shall incorporate temperature sensor flow fluid temperature measurement. Whenever specified in the purchaser's data sheets, the flow meter electronics shall have capability to compute volumetic flow rates.

2.2.4 The meter electronics shall be protected against transients induced by lightning and power supply surges. Transient protection electronics shall preferably be provided in the terminal block. The transient protection shall meet the requirements specified in IEC-60537.

2.2.5 The configurational data of the instrument shall be stored in a non-volatile memory such that this remains unchanged because of power fluctuations or power off condition. In case, vendor standard instrument has battery backed RAM vendor to ensure that battery drain alarm is provided as diagnostic maintenance message.

2.2.6 For smart transmitters or for field bus based transmitter the following features must be ensured;

i) It shall allow multi master (primary and secondary) for configuration, calibration, diagnosis and maintenance. The primary could be the control system or host computer, and the secondary could be the hand held communicator.

ii) It should be capable of implementing universal command.

2.2.7 In addition to the requirements specified above, field bus based transmitter requirements;

a) All instruments must satisfy the requirements of the field bus registration laboratory with applicable checkmark like foundation field bus, profibus PA, or as specified in the purchaser's data sheets.

b) All instruments snail have two analog input blocks, as a minimum. In addition, when specified the transmitter shall also have PID controller block.

c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field bus or equivalent for profibus PA, as applicable.

d) The field bus instruments shall support peer-to-peer communication.

e) Field bus instruments as offered shall not be polarity sensitive.

f) The field bus instruments in hazardous area shall be certified as per entity concept or shall be FISCO approved as per the requirements specified in the purchaser's specification.

2.2.8 Meter electronics shall also be provided with security lockout feature to disable access to configuration modification features.

2.2.9 Flow meter electronics shall be either integral to flow meter or shall be remote mounted type. Where remote mounted electronics is offered a minimum of 10 metres of· interconnecting cable shall be included.

2.2.10 Flow meter electronics shall have enclosures suitable for the hazardous area classification indicated in purchaser's data sheets. When area classification is specified as electrically hazardous flow meter shall have flameproof enclosure with intrinsically safe circuitry for sensor connectivity. Safety barrier if required for the sensors shall be part of transmitter enclosure.

2.2.11 The meter electronics along with flow meter shall be pre-calibrated at vendor's works with calibration factor duly established for the flow meter.

2.2.12 The meter electronics shall be immune to RFI and EMI radiation and shall be in compliance with the electromagnetic compatibility requirement as per lEC 61000-4.

2.2.13 Purchaser will provide one no. of feeder for 110 V AC ± 10%, 50 Hz power supply at the transmitter. Further distribution if any shall be taken care of by vendor. Accessory like cable gland, conduit and junction box as required to interconnect sensor, transmitter signal cable etc., shall be supplied by the vendor.

Supply voltage fluctuation of ± 10 percent from the specified value and supply frequency fluctuation of± 3 Hz from the specified value shall not affect the meter performance.

2.2.14. Meter electronics housing shall meet the terminal housing requirements specified in Clause 2.1.7 of this specification.

2.3 Meter Sizing

2.3.1 The meter shall be sized considering the following guidelines:

a) Minimum flow, maximum flow and meter maximum as specified in the purchaser's data sheet.

b) Flow accuracy between the minimum and maximum flow specified in the data sheet. Where only normal flow is specified, the maximum and minimum flows considered for the purpose of sizing shall be;

Maximum flow = 1.4 times the normal flow

Minimum flow = 0.4 times the normal flow

When only maximum. flow is specified minimum flow shall be considered as 0.2 times the maximum flow for sizing the meter.

a) The maximum pressure drop at meter maximum shall not exceed the allowable pressure drop across the meter specified in the data sheet.

b) The meter shall be selected such that both accuracy and allowable pressure differential across the meter are complied.

2.4 Performance Requirements

2.4.1 Unless specified otherwise in the purchaser's data sheets, the performance requirements for the mass flow meter shall be as follows;

a) Flow meter repeatability: ± 0.2% of mass flow rate for liquid service.
± 0.5% of mass flow rate for gas / vapour service

b) Flow meter accuracy : ± 0.1% of mass flow rate for liquid service
± 0.25% of mass flow rate for gas / vapour service

The performance requirements specified above excludes the effect of zero stability of the flow meter on these parameters.

2.5 Accessories

2.5.1 Hand held configurator for Smart Instruments

Hand Held configurator shall be universal type and shall be able to communicate with all make and models of smart instruments with HART output like transmitters, smart positioners etc., and shall be capable of carrying out all engineering like calibration, configuration and diagnostics. The hand held configurator shall be certified intrinsically safe when used in hazardous area. Carrying case shall be supplied with each configurator.

2.5.2 Field bus hand held tester

The field bus hand held tester shall be able to communicate with the specified field bus instrument and shall be capable of calibrating and configuring field bus devices. The field bus hand held tester shall be certified intrinsically safe when used in hazardous area. Carrying case shall be supplied with each tester.

2.5.3 Field bus configurator

The field bus configurator shall be a centralised device like personal computer with hardware and software suitable for configuration and maintenance of field bus instruments.

2.5.4 Battery charger

Both field bus hand held tester and hand held configurator for smart instruments with HART output shall be supplied with battery charger for battery charging of hand held configurator / field

bus tester. Unless otherwise specified, battery charger shall operate at 220V 50Hz supply.

3.0 NAME PLATE

3.1 Each mass flow meter and its accessories shall have a stainless steel nameplate attached firmly to it at a visible place, furnishing the following details as applicable.

a) Tag number as per purchaser's data sheets.

b) Manufacturer's model number and serial number.

c) Manufacturer's name/trade mark.

d) Nominal end connection size in inches and rating in Ibs (#).

e) Body and trim material.

f) Area classification in which the equipment can be used.

g) Standard for body/trim materials (eg. ASTM)

h) Enclosure type

i) Calibrated range and unit of measurement of flow.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works, in line with the inspection test plan for mass flow meters.

4.2 Vendor shall submit the following test certificates and test reports for the purchaser's review:

a) Material test certificate as per clause 3.IB of ENI 10204.

b) Certificate from statutory body for intrinsic safety and explosion proof enclosures.

c) Type test certificate for weatherproof enclosures.

d) Certificate of radiography/X-ray for weld joints, wherever specified. Dye Penetration check shall also be carried out for all weld joints.

e) Hydrostatic test reports as per clause 4.3 of this specification.

f) Flow calibration and performance test report including calibration factors for each meter as per clause 4.4 of this specification.

g) Capability of smart and field bus based transmitters to accept multimasters for configuration, calibration, diagnostics and maintenance.

h) Configuration, calibration and diagnostics check through hand held configurator / field bus tester for smart / field bus based instruments.

i) Configuration, calibration and diagnostics check through field bus configurator for Field bus based instruments.

j) Interoperability test certificate as per clause 2.2.7 c) of this specification.

k) Dimensional test report for each mass flow meter.

4.3 Hydrostatic Test

4.3.1 Each mass flow meter shall be subjected to hydrostatic test at test pressure equal to 1.5 times the maximum allowable working pressure at ambient temperature in accordance with ANSI B 16.34. There shall not be any visible leakage during the test.

4.4 Calibration

4.4.1 Each mass flow meter shall be calibrated with the fluid for which it is expected to be used. Else, vendor must indicate;

a) Fluid used for calibration

b) The correction factor / adjustment required for the actual process fluid.

4.5 Witness Inspection

4.5.1 All mass now meter shall be offered for pre-dispatch inspection, for the following as a minimum:

a) Physical dimensional verification and workmanship.

b) Hydrostatic test as per clause 4.3 of this specification on representative sample.

c) Performance testing including establishing accuracy and repeatability over the entire range and calibration testing, on the representative samples.

d) Capability of smart and field bus based transmitters to accept multimasters for configuration, calibration, diagnostics and maintenance.

e) Configuration, calibration and diagnostics check through hand held configurator / field bus tester for smart / field bus based instruments.

f) Configuration, calibration and diagnostics check through field bus configurator for field bus based instruments.

g) Review of all certificates and test reports as indicated-in clause 4.2 of this specification.

4.5.2 In the event when witness inspection is not carried out by purchaser, the tests ~hall be any way completed by the vendor and the documents for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threaded and flanged openings shall be suitably protected to prevent entry of foreign material.

5.2 The mass flow meter remote electronics and its accessories shall be packed separately.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.

GENERAL SPECIFICATION

FOR

INSTRUMENT TUBE FITTINGS

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the Requirements for the design, materials, inspection, testing and shipping of instrument tube fittings which includes the following types:

a) Stainless steel compression fittings (for stainless steel tube)
b) Brass compression fittings (for copper tube)

1.1.2 The related standards referred to herein and mentioned below shall be of the latest Editions prior to the date of the purchaser's enquiry: -

ANSIIASME American National Standards Institute/American Society of Mechanical Engineers

B 1.20.1 Pipe Threads General Purpose (Inch).

B 16.11 Forged Steel Fittings - Socket Welding and Threaded.

BS-4368 Carbon and Stainless Steel Compression Couplings for Tubes.

EN 10204 Inspection Documents For Metallic Products.

IS-319 Specification for free cutting Brass Bars, Rods and Sections.

ISA Instrumentation, Systems and Automation Society.

RP 42.1 Nomenclature for Instrument Tube Fittings.

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations

b) Data Sheets

c) Standard Specification

d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to the vendor attached along with the material requisition.
1.2.2 Whenever a detailed technical offer IS required, vendor's quotation shall include the Following;

a) Compliance to the specifications.

b) Whenever specifically indicated, detailed specification sheet for each item, which

shall provide the information regarding type, size, material of construction etc. of the items. The material specifications and units of measurement for various items in vendor's specification sheets shall be to the same standard as those indicated in purchaser's data sheet.

c) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate, they must include a list of deviations item wise summing up all the deviation from the purchaser's data sheets and other technical specification along with technical reasons for each of these deviations.

d) Catalogues giving detailed technical specifications, model decoding details and other information for each type of instrument tube fitting covered in the bid.

1.2.3 All documentation submitted by vendor including their quotation, catalogues, drawings, Installation, operation and maintenance manuals etc., shall be in English language only.

wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with technical reasons for each of these deviations.

2.0 DESIGN AND CONSTRUCTION

2.1 Stainless Steel Tube Fittings

2.1.1 Nomenclature of all tube fittings shall be as per ISA RP 42.1.

2.1.2 Fittings shall be of flare less compression type having four-piece (for double compression type) construction consisting of two ferrules, nut and body or three piece (compression type construction consisting of single ferrule, nut and body suitable for use on tubes of specified material for example stainless steel tubes conforming to ASTM A269 TP 316L with hardness in the range of HRB 70 to 79.

2.1.3 All parts of the tube fittings shall be of 316 Stainless Steel unless specified otherwise.

2.1.4 Hardness of the ferrules shall be in the range of HRB 85-90 so as to ensure a hardness difference of the order of 5 to 10 between tube and fittings for better sealing.

2.1.5 Nuts and ferrules of a particular size shall be interchangeable for each type.

2.1.6 Spanner hold shall be metric.

2.1.7 Threaded ends of fittings shall be NPT as per ANSI B 1.20.1.

2.1.8 Specific techniques like silver plating shall be used over threading in order to avoid jamming and galling.

2.1.9 Ferrule finish and fitting finish shall be such that there is no abrasion/galling when the nut is tightened.

2.1.10 All instrument tube fittings in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride. End connection shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2 Copper Tube Fittings

2.2.1 Nomenclature of all tube fittings shall be as per ISA RP 42.1.
Fittings shall be of flare less compression type and of three-piece construction consisting of ferrule, nut and body Suitable for use on copper tubes conforming to ASTM B68 *1B68M,* hardness not exceeding HRB 50.

2.2.3 All parts shall be manufactured from brass as per IS 319 bar stock and nickel plated.

2.2.4 For better grip, vendor shall maintain hardness difference between tube and ferrule and indicate the same along with the offer.
2.2.5 Threaded ends of fittings shall be NPT as per ANSI B 1.20.1.
2.2.6 Spanner hold shall be metric.

3.0 NAMEPLATE

3.1 No separate nameplates are required on the fittings. However. manufacturer's name/trademark should be punched on a visible place on the body of each fitting for easy identification.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all items at vendor's works, inline with the inspection test plan for instrument tube fittings.

4.2 Vendor shall submit following test certificates and test reports for purchaser's review:

4.2.1 Type test reports for following tests in accordance with BS-4368·Part IV:

a) Hydrostatic proof pressure test.
b) Minimum hydrostatic burst pressure test.
c) Disassembly and reassembly test.
d) Minimum static gas pressure (vacuum) test.
e) Maximum static gas pressure test.
f) Hydraulic impulse and vibration test.

4.2.2 Material test certificates as per clause 3.1 B of EN 10204.

4.2.3 Routine test reports for following tests:

a) Hydrostatic Test
Instrument tube fittings shall be hydrostatically tested at ambient temperature at test pressures given in Annexure I of this specification. During and after the hydrostatic test, the tube fittings shall not show any leakage or rupture.

b) Pneumatic pressure test The fittings shall be tested at 7 kg/c mg of dry air. There shall not be any visible leakage when immersed in water or coated with a leak detection solution.

c) Disassembly and reassembly test.

d) Hardness verification:
Hardness test shall be carried out on each rod used for machining ferrules. Vendorshall ensure that after machining, the finished ferrules shall meet the required hardness given in the specification.

d) Dimensional test report

4.3 Witness Inspection

4.3.1 All fittings shall be offered for pre-dispatch inspection for the following as a minimum:

a) Physical dimensional verification and workmanship on representative samples.
b) Hydrostatic and pneumatic tests as per clause 4.2.3 of this specification on representative samples.
c) Hardness verification as per clause 4.2.3 of this specification.
d) Disassembly and reassembly test on representative samples.
e) Review of all certificates and test reports as indicated in clause 4.2 of this specification.

4.3.2 In the event when no witness inspection is carried out by purchaser, vendor shall any way complete the tests and test reports for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 All threads/ends shall be protected with plastic caps to prevent damage/entry of foreign matter.

5.2 All the fittings in oxygen and chlorine service shall be separately packed along with a certificate indicating 'SUITABLE FOR OXYGEN/CHLORINE SERVICE', as applicable.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to the above requirements, shall be summarily rejected.

Annexure- 1

Sr. No.	Size of Tube Fittings	Material	Line Pressure No. Class	Hydrostatic Test Pressure
1	6mm and ½”	Stainless steel	<600#	153 Kg/cm2 g
2	6mm and ½”	Stainless steel	>=900# to <=1500#	383 Kg/cm2 g
3	¼” and 3/8”	Brass		80Kg/cm2 g

GENERAL SPECIFICATION

FOR

INSTRUMENT TUBING

ABBRIVATIONS:

ID	Inner Diameter
OD	Outer Diameter
PVC	Polyvinyl Chloride

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1.0 GENERAL

2.0 DESIGN AND CONSTRUCTION

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ANNEXURE S:

ANNEXURE - 1 : MAXIMUM WORKING PRESSURE AND HYDROSTATIC TEST PRESSURES FOR INSTRUMENT TUBING

1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the requirements for the design, materials, inspection, testing and shipping of Instrument Tubing which includes the following types: -

a) Stainless steel tubes

b) Copper tubes

1.1.2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the date of purchaser's enquiry;

ASTM American Society for Testing and Materials.

A 269 Standard Specification for Seamless and Welded, Austenitic Stainless Steel Tubing for General Services.

A632 Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small Diameter) for General Services.

B 251 Specification for general requirements for wrought seamless copper and copper alloy tube.

B 251M Specification for general requirements for wrought seamless copper and copper alloy tube (Metric)

B 68 Specification for seamless copper tube, bright annealed.

B 68 M Specification for seamless copper tube, bright annealed. (Metric)

E 243 Standard Practice for Electromagnetic (Eddy - Current) Examination of Copper and Copper - Alloy Tubes

EN 10204 Inspection Documents for Metallic Products

1.1.3 In the event of any conflict between this standard specification, job specification/data sheets, statutory regulations, related standards, codes etc. the following order ofpriority shall govern:

a) Statutory regulations
b) Job specification
c) Standard specification
d) Codes and standards,

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following;

a) Compliance to the specifications.

b) Whenever the requirement of a detailed specification sheet, is specifically indicated, the specification sheet shall provide information regarding size, length, construction, materials etc. of the Items. The material specifications and units of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheet.

c) Overall dimensions in mm/inch as per purchaser's specification.

d) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate, thc)! must include a list of deviations item wise. summing up all the deviations from the purchaser's data sheet and other technical specification along with the technical reasons for each of these deviations.

e) Catalogues giving detailed technical specifications; model decoding details and other related information for each item covered in the bid,

1.2.3 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation and maintenance manuals shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data by the vendor or after placement of purchase order shall include the following as a minimum;

a) Specification sheet for each type of tube.

b) Copy of test certificates of all tests indicated in clause 4.0 of this specification.

2.0 DESIGN AND CONSTRUCTION

2.1 Stainless Steel Tubes

2.1.1 The tubes shall be 316L Stainless Steel fully annealed, seamless and cold drawn as per ASTM A 269.

2.1.2 The hardness of the tubes shall be limited to HRB 70-79. Equivalent hardness as

Rockwell superficial scale (30T/15T) or Vicker's hardness scale shall also be acceptable.

2.1.3 Tubes shall have good surface finish and shall be free from scratches burrs etc. and suitable for bending.

2.1.4 Maximum working pressure shall be as per Annexure - I attached with this specification.

2.1.5 Tubes shall preferably be supplied in length of 5 to 6 metres without welding in between. Tube length less than 5 meters shall be rejected.

2.1.6 All tubes in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride and tube ends shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

2.2 Copper Tubes

2.2.1 Copper Tubes (PVC Jacketed)

a) The tube shall be soft annealed copper with 6mm OD and a wall thickness of 1.0mm as per ASTM B 68M copper No. C 12200.

b) The tube shall be jacketed with black PVC. The jacket thickness shall be 1.6mm. The PVC jacket shall confirm to ASTM D-I047.

c) The tube ends shall be plugged prior to transportation.

d) The tube shall be continuous length without any brazing in between.

e) The length of single tube shall preferably be100 metres. However any tube length less than 70 meters shall be rejected unless specifically required otherwise in job specification.

f) The dimensional tolerances shall be as per ASTM B 251M.

2.2.2 Bare Copper Tubes (For Steam Tracing)

a) The tube shall be soft annealed copper with 3/8" (10mm) OD with wall thickness of 0.049" or 6mm OD with wall thickness of 1.Omm as per ASTM B6&.copper No.C12200.

b) The tube ends shall be plugged prior to transportation.

c) The tube shall be continuous length without any brazing in between.

d) The length of single tube shall preferably be 100 metres. However any tube length less than 70 meters shall be rejected unless specifically required otherwise in job specification.

e) The dimensional tolerances shall be as per ASTM B 251.

f) Maximum working pressure shall be 53.0 kg/crrr'g at 38°C unless specified otherwise.

3.0 NAME PLATE

3.1 The following information shall he marked on the stainless steel tubes:

a) Name of manufacturer

b) Type and material grade of tube

c) Tube outer diameter and wall thickness.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at vendor's works, in line with the inspection test plan for instrument tubing.

4.2 Vendor shall submit following test certificates and test reports for purchasers review:

a) Material test certificates as per clause 3.1B of EN 10204.

b) Hydrostatic test for stainless steel tube and bare copper tubes as per clause 4.3 of this specification.

c) Pneumatic test for PVC jacketed copper tubes as per clause 4.4 of this specification.

d) Hardness / tension test for stainless steel tubes as per clause 4.5 of this specification.

e) Ball test for copper tubes as per clause 4.6 of this specification.

I) Eddy current examination of copper tubes as per ASTM E-243

g) Dimensional test report.

4.3 Hydrostatic test

4.3.1 Stainless steel and bare copper tube shall be hydrostatically tested at ambient temperature at test pressures given in Annexure - 1 attached with this specification. During and after the hydraulic test, the tubes shall not show any leaks or rupture.

4.4 Pneumatic test

PVC jacketed copper tubes shall be tested at 7.0 kg/crrr'g of dry air. During and after the test, tubes shall not show any leak or rupture.

4.5 Hardness/Tension Test

All mother tubes shall be hardness tested for each heat prior to drawing for proper quality control. The hardness of the drawn tubes shall be checked by Rockwell Hardness Test.
Following shall apply;

a) For tubing less than 0.6Sin (1.6Smm) in wall thickness, Rockwell superficial hardness test on 30T / 1ST scale or Vicker's scale shall be equivalent to HRB 70 - 79.
b) Hardness test is not required for tubes smal1er than 1/4in (6.4mm) inside diameter or tubes having a wall thickness thinner than 0.020in (O.Slmm). These tubes shall be tension tested in accordance with ASTM A632.

4.6 Ball Test

4.6.1 Ball test shall be carried on all copper tubes to ensure clear opening of the tube. The OD of the ball shall be minimum 1.0 mm for 6.0mm 00 tube and 2.0 mm for 3/8" (10mm) OD tube.

4.7 'Witness Inspection

4.7.1 All tubes shall be offered for pre-dispatch inspection for the following, as a minimum;

a) Physical dimensional verification and workmanship.

b) Hardness / tension test for stainless steel tubes.

c) Hydrostatic and pneumatic tests on representative samples.

d) Ball test on copper tubes on representative samples.

c) Eddy current examination of copper tubes on representative samples.

f) Review of all certificates and test reports as indicated in c1ause4.2 of this specification.

4.7.2 In the event that the witness inspection is not carried out by purchaser, vendor shall anyway complete the tests and test reports for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 The tube shall be plugged at both ends to prevent entry of foreign matter.
5.2 The tubes shall be packed carefully so as to avoid damage during transport.

5.3 All tubes III oxygen and chlorine service shall be separately packed along with a certificate indicating 'SUITABLE FOR OXYGEN! CHLORINE SERVICE', as applicable.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents and information which is specifically indicated in the material requisition.

6.2 Any offer not conforming to above requirements, shall summarily be rejected.

ANNEXURE - 1 : MAXIMUM WORKING PRESSURE AND HYDROSTATIC TEST PRESSURES FOR INSTRUMENT TUBING

Sr. No.	Size of Tube (OD)	Material	Line Pressure Class	Thickness	Maximum Working Pressure	Hydrostatic Test Pressure
1.	½" (12 mm)	Stainless Steel	≤ 600 #	0.049" (1.2 mm)	102 Kg/cm2g	153 kg/cm2g
2.	½" (12 mm)	Stainless Steel	≥ 900 # to ≤ 1500 #	0.065" (1.65 mm)	253 Kg/cm2g	383 kg/cm2g
3.	¼" (6 mm)	Stainless Steel	≤ 600 #	1.00 mm	102 Kg/cm2g	153 kg/cm2g
4.	¼" (6 mm)	Stainless Steel	≥ 900 # to ≤ 1500 #	0.065" (1.65 mm)	253 Kg/cm2g	383 kg/cm2g
5.	¾" (10 mm)	Copper	-	0.049"	53 Kg/cm2g	80 kg/cm2g
6.	¼" (6 mm)	Copper	-	1.00 mm	53 Kg/cm2g	80 kg/cm2g

GENERAL SPECIFICATION

FOR

INSTRUMENT VALVES AND MANIFOLDS

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

Abbreviations

CWP	Cold Working Pressure
NPT	National Pipe Thread
PTFE	Poly Tetra Fluoro Ethylene

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2.0 DESIGN AND CONSTRUCTION
3.0 NAMEP LATE
4.0 INSPECTION AND TESTING
5.0 SHIPPING
6.0 REJECTION

ANNEXURE
ANNEXURE - 1: HYDROSTATIC TEST PRESSURES FOR INSTRUMENT VALVES AND MANIFOLDS.

1.0 General

This standard specification shall be used for Instrument Valves and Manifolds.

2.0 DESIGN AND CONSTRUCTION

2.5 The finishing and tolerances of parts like stem, piston, stem threading etc. of the offered Valves and manifolds shall be properly machined to avoid problems like galling.

2.6 The hand wheel material for all valves and manifolds shall be zinc/nickel plated carbon steel. Any other material, if provided as per standard vendor design, shall also be acceptable.

2.7 Instrument Valves (Miniature)

2.7.1 The instrument valves shall be of globe pattern needle valves forged! bar stock with inside screwed bonnet, with back-seated blowout proof system.

2.7.2 Body material shall be 316 Stainless Steel unless otherwise specified.

2.7.3 The minimum cold working pressure (CWP) rating of the valve shall be as per Annexure 1 of this specification, unless otherwise specified.

2.7.4 The end connection shall be *1/2" NPTF* to ANSI B1.20.1, unless otherwise specified.

2.7.5 Flow direction shall be marked on the body.

2.7.6 The valve dimensions shall be as follows:
a) End to end dimensions 76mm (approximately).
b) Height in fully open condition - 135mm maximum.
These dimensions are indicative only.

2.8 **Valve Manifolds**

2.8.1 3-Valve and 5-Valve manifolds:

2.8.1.1 3-Valve manifold

a) 3-Valve manifold shall be designed for direct coupling to differential pressure Transmitters having 2 bolt flanges with 54mm (2-118") centre-to-centre connections and 41.3mm (1-5/8") bolt-to-bolt distance.

b) 3-Valve manifold shall contain two main line block valves and an equalizing by pass valve. The valves shall be needle type. They shall use self-aligning 316 Stainless Steel ball seats, unless otherwise specified.

2.8.1.2 5-Valve manifold

a) 5-Valve manifold shall be designed for direct coupling to differential pressure Transmitters having 2 bolt flanges with 54mm (2-1/8") centre-to-centre connections and 41.3mm (1-5/8") bolt-to-bolt distance.

b) 5-Valve manifold shall contain two main line block valves and a combination Double block and bleed for the bypass line The valve shall of needle type or special ball With bleed hole.

2.8.1.3 The flanges shall be integral part of manifold block.

2.8.1.4 The material of construction shall be 316 Stainless Steel, unless otherwise specified.

2.8.1.5 The minimum cold working pressure (CWP) rating of manifolds shall be as per Annexure 1 of this specification, unless otherwise specified.

2.8.1.6 The process connection shall be 1/2"NPTF to ANSI B 1.20.1.

2.8.1.7 Wherever the manifolds are specified for stanchion mounting, these shall be supplied along with mounting accessories. The bolts and nuts shall be alloy steel as per ASTM A 193 Gr B7 and ASTM A194 Gr. 2H (Hot dip galvanized or zinc plated) respectively. Other accessories shall be zinc plated.

2.8.2 3 way 2 valve manifolds for pressure gauges

2.8.2.1 The manifold shall be designed for use with pressure gauges with block and bleed valves. The manifold body shall be either straight or angle type as specified in the data sheet.

2.8.2.2 The valve shall be a needle type.

2.8.2.3 The body material shall be 316 Stainless Steel, unless otherwise-specified.

2.8.2.4 The minimum cold working pressure rating of the manifold shall be as per Annexure 1 of this specification, unless otherwise specified.

2.8.2.5 The manifold shall have the following connections:

a) The inlet connection shall be %" plain ends with a minimum of 100mm nipple Extension suitable for socket weld or butt weld as per B16.11/ B16.9 as Specified in the job specifications

b) The gauge connection shall be with union nut and tail piece threaded to ½" NPTF.

c) The drain connection shall be ½" NPTF.

2.9 Instrument Air Valves

2.9.1 Instrument Air Isolation Valves (Miniature)

2.9.1.1 The valves shall be full-bore ball type with forged body.

2.9.1.2 Body material shall be 316 Stainless Steel.

2.9.1.3 The minimum cold working pressure rating of instrument air isolation valves shall be as Per Annexure 1 of this specification, unless specified otherwise.

2.9.1.4 The end connection shall be1/4" NPTF to ANSI B 1.20.1, unless otherwise specified.

2.9.1.5 End to end dimensions shall be 70mm (approximately).

2.9.2 Instrument Air Needle Valves (Miniature)

2.9.2.1 The instrument valves shall be globe pattern-needle valves forged/bar stock with inside Screwed bonnet.

2.9.2.2 Body material shall be 316 Stainless Steel.

2.9.2.3 The minimum cold working pressure of Instrument Air Needle valves shall be per Annexure I of this specification. Unless otherwise specified.

2.9.2.4 The end connection shall be 1/4" NPTF to ANSI B1.20.1, unless otherwise specified.

2.9.2.5 Flow direction shall be marked on the body.

2.9.2.6 The valve dimensions shall be as follows:

a) End to end dimensions - 54 mm (approximately).
b) Height in fully open condition - 49 mm maximum.
These dimensions are tentative only.

2.10 All instrument valves in oxygen and chloride service shall be thoroughly degreased using reagents like trichloroethylene or carbon tetrachloride. End connection shall be plugged after degreasing process in order to avoid entrance of grease or oil particles.

3.0 NAME PLATE

Following information shall be punched on the body of each of these items;

a) Material of construction to the same standards as in purchaser's data sheets.
b) Cold working pressure of each item to the same standards as in purchaser's data sheets.
c) Manufacturer's identification and model number.
d) Flow direction (if applicable)
e) Material of construction.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at vendor's works, in line with the inspection test plan for instrument valve and manifolds.

4.2 Vendor shall submit following test certificates and test reports for purchaser's review:
a) Material test certificates as per clause 3.1B of EN 10204 for body and bonnet and as per clause 2.2 for other parts.
b) Dimensional test report.
c) Pressure test report as per clause 4.3 of this specification.
d) Hydrostatic proof and burst tests as per MSS-SP-99 for each design and size of valve.

4.3 Pressure Test Requirements

4.3.1 Each valve and manifold shall be subjected to hydrostatic pressure test at ambient temperature for both seat and shell leakage at test pressures given in Annexure-I of this specification. During and after the hydrostatic test there shall not be any visible leakage.

4.3.2 Pneumatic Test

Each valve and manifold shall be subjected to pneumatic test for both shell and seat leakage at 7.0 kg/cm-g with testing medium as air at ambient temperature. There shall not be any visible leakage when immersed in water or coated with a leak detection solution.

4.4 Witness Inspection

4.4.1 All valves and manifolds shall be offered for pre-dispatch inspection for following, as a Minimum:

a) Physical dimensional verification and workmanship.
b) Pressure test as per clause 4.3 of this specification on representative samples.

c) Review of all certificates and test reports as indicated in clause4.2 of this specification.

4.4.2 In the event, when witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted to purchaser for scrutiny.

5.0 SHIPPING

5.1 The threads/ends shall be protected with plastic caps to prevent damage/entry of foreign matter.

5.2 All instrument valves and manifolds in oxygen and chloride service shall be separately packed along with a certificated indicating 'CERTIFED FOR OXYGEN/CHLORINE SERVICE' as applicable

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per this specification and shall attach only those documents and information, which is specifically- indicated in the material requisition.

6.2 Any offer not conforming to above requirements, shall be summarily rejected.

Annexure-I

HYDROSTATIC TEST PRESSURES FOR INSTRUMENT VALVES AND MANIFOLDS

Sr. No.	Item	Line Pressure Class	Minimum Cold working pressure(CWP)	Hydrostatic Test Pressure For	
				Seat leakage Test	Shell Leakage Test
1	Instrument valve (Miniature)	≤ 600#	102 kg/cm^2 g	112 kg/cm^2 g	153 kg/cm^2 g
		≥900# to ≤1500#	253 kg/ cm^2 g	278 kg/cm^2 g	383 kg/cm^2 g
2	Instrument valve (Manifolds)	≤ 600#	102 kg/cm^2 g	112 kg/cm^2 g	153 kg/cm^2 g
		≥900# to ≤1500#	253 kg/ cm^2 g	278 kg/cm^2 g	383 kg/cm^2 g
3	Instrument Air Isolation Valve		27 kg/cm^2 g	30 kg/cm^2 g	41 kg/cm^2 g
4	Instrument Air Needle Valves		27 kg/cm^2 g	30 kg/cm^2 g	41 kg/cm^2 g

GENERAL SPECIFICATION

FOR

JUNCTION BOXES AND CABLE GLANDS

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1.0 GENERAL

2.0 DESIGNS AND CONSTRUCTION

3.0 NAME PLATE

4.0 INSPECTION AND TESTING

5.0 SHIPPING

6.0 REJECTION

1.0 GENERAL

1.1 Scope

1.1.1 This standard specification, together with the data sheets attached herewith, covers the requirements for design, materials, nameplate marking, testing and shipping of junction boxes and cable glands which include the following types:

a) Electrical junction boxes
b) Pneumatic junction boxes
c) Cable glands (whenever specified)

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the purchaser's enquiry;

ANSI/ASME	American National Standards Institute *I* American Society.of Mechanical Engineers.
B 1.20.1	Pipe Threads, General Purpose (Inch).
EN 10204	Inspection Documents for Metallic Products
IEC-60079	Electrical Apparatus for Explosive Gas Atmosphere
IEC-60529	Degrees of Protection Provided by Enclosures. (IP Code)
IS-5	Colours for ready mixed paints and enamels.
IS-13947	Specification for Low Voltage Switchgear and Control gear.
IS-2148	Electrical Apparatus for Explosive Gas Atmospheres - Flame proof Enclosures ‘d'.

1.1.3 In the event of any conflict between this specification, data sheets, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations
b) Data Sheets
c) Standard Specification
d) Codes and Standards

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached alongwith the material requisition.

1.2.2 Deviation on technical requirements shall not be entertained.

1.2.3 Whenever a detailed technical offer is required, vendor's quotation shall include the following;

a) Compliance to the specifications.

b) Whenever the requirement of a detailed specification sheet for each item is specifically indicated, the specification sheet shall provide information regarding type, construction material. Size and number of cable entries etc. The material specifications and unit of measurement for various parts in vendor's specification sheets shall be to the same standards as those indicated In purchaser's data sheets.

c) Drawing for each type of junction box with dimensional details (in millimetres) showing the terminal, entries arrangement, mounting details etc.

d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in purchaser's specification.

e) Copy of certificate for approval of flameproof junction boxes, adapter, plug and cable glands from local statutory authority as applicable such as Chief Controller of Explosive (CCE), Nagpur or Director General Mines Safety in India along with:

i) Test certificate from recognised testing house like CMRI/ERTL etc. as per relevant Indian Standard for all Indian manufactured items or items requiring DGMS approval.

ii) Certificate of conformity from agencies like LICE, BASEEI:.A, PTB, CSA, UL etc. for compliance to ATEX or any recognised standard for items manufactured outside India.

f) Catalogues in English giving detailed technical specifications, model decoding details and other related information for each type of junction box and cable gland covered in the bid.

1.2.4 All items, as offered, shall be field proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the process conditions similar to those as specified in the purchaser's data sheet. Items with proto-type design or items not meeting provenness criteria specified above shall not be offered.

1.2.5 All documentation submitted by the vendor including their drawings, installation manual etc shall be in English language only.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies, shall be sent to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data and installation manual submitted by the vendor after placement of purchase order shall include the following, as a minimum;

a) Specification sheet for each junction box and its accessories like cable glands etc.
b) Certified drawing sheets for each junction box and its accessories, which shall provide dimensional details, internal constructional details (general arrangement details) and material of construction.
c) Copy of type test certificates.

d) Copy of test certificates for all the tests indicated in clause 4.0 of this specification.

e) Installation procedure for junction boxes and its accessories

2.0 DESIGN AND CONSTRUCTION

2.1 Junction Boxes

2.1.1 Junction boxes shall be either of the following type as specified in data sheets.

a) Weather proof junction boxes.
b) Weather proof and flame proof junction boxes.

No other type of junction boxes shall be offered ,*I* supplied unless specifically indicated otherwise.

2.1.2 Unless otherwise specified, the enclosure shall conform to the following standards:

Weatherproof housing : IP 55 to IEC-60529/IS-13947

Flameproof housing : Flameproof IEx (d) as per IEC-60079/IS-2148.

2.1.3 Number of entries and their location shall be as per data sheets. Junction boxes with top entries shall not be offered. The size of cable entries shall be as per the cable sizes indicated in the data sheet.

2.1.4 Multi-pair junction boxes shall be provided with telephone sockets and plugs for connection of hand-powered telephone set.

2.1.5 Electrical Junction Boxes

a) The material of construction of electrical junction boxes shall be copper free aluminium of minimum 5 mm thick.

b) Weather proof junction box shall have hinged type door with neoprene gasket, which shall be fixed to the box by plated countersunk screws.

c) Flameproof junction box shall have detachable cover, which shall be fixed to the box by means of cadmium plated triangular head/hexagonal head screws.

d) Flameproof junction boxes for signal, alarm and control shall have the following warning engraved/integrally cast on the cover; "Isolate power supply elsewhere before opening"

e) Power junction boxes (junction boxes for power supply cable / distribution) shall have either the warning cast or shall have warning plate with following marking;

"Isolate power supply elsewhere before opening".

Unless otherwise indicated in the job specification, power junction boxes shall be suitable for incoming armoured power cable up to 150 sq.mm conductor size.

f) Terminals shall be spring loaded, vibration proof, clip-on type, mounted on nickel plated steel rails complete with end cover and clamps for each row.

g) All terminals used In signal, alarm and control junction boxes shall be suitable for accepting minimum 2.5sq.mm copper conductor, in general.

h) Terminal used in power junction boxes / power supply distribution box shall be suitable for accepting conductor size of 4 Sq. mm to up to 120 sq. mm. Exact requirement shall be specified in job specification. Higher size of terminals shall be provided when indicated. Bus bar terminals shall be provided for conductor size 50 sq.mm and above. Suitable size

of lugs shall be provided to suit conductor size specified.

i) Each junction shall have minimum of 30% spare terminal of those actually required to be utilised. Unless higher number of terminal are specified in the purchaser's data sheet, the number of terminals for various types of junction boxes shall be as follows;

24 Nos for 6 pair junction box.
48 Nos. for 12 pair junction box
36 Nos for 6 triad junction box.
48 Nos. for 8 triad junction box.

j) Terminals shall be identified as per the type of input signal indicated in data sheets e.g all terminals for intrinsically safe inputs shall be blue while others shall be grey in colour.

k) Junction boxes shall be provided with external earthing lugs.

l) Sizing shall be done with due consideration for accessibility and maintenance in accordance with the following guidelines;

i) 50 to 60 mm gap between terminals and sides of box parallel to terminal strip for up to 50 terminals and additional 25 mm for each additional 25 terminals.

ii) 100 to 120 mm between two terminal strips for upto 50 terminals and additional 25 mm for each additional 25 terminals.

iii) Bottom/top of terminal shall not be less than 100 mm from bottom / top of the junction box.

2.1.6 Pneumatic Junction Boxes

a) Pneumatic junction boxes shall be made of 3 mm thick hot rolled steel, They shall have necessary neoprene gasket between door and body. Door shall be flush with the box and shall be hinged type and provided with wing nuts.

b) Single tube entries shall be suitable for 6 mm 0.0 copper tube with bulk head fittings. Multi tube bundle entry shall be suitable for the data furnished in data sheets.

2.1.7 Painting

a) Surface shall be prepared for painting. It shall be smooth and devoid of rust and scale.

b) Two coats or lead-free base primer and two final coats of lead free epoxy based paint shall be applied both for interior and exterior surfaces.

c) The colour shall be as specified in data sheets. However, following philosophy shall be followed, in general:

(i) Light blue for all intrinsically safe junction boxes.

(ii) Light grey for all others

2.2 Cable glands, Plugs and Reducers/Adaptors

2.2.1 Cable glands shall be supplied by vendor whenever specified.

2.2.2 Cable glands shall be double compression type for use with armoured cables.

2.2.3 The cable glands shall be of nickel plated brass, as a minimum.

2.2.4 The cable glands shall be weatherproof. Whenever specified they shall also be flameproof and certificate for the specified electrical area classification specified in the data sheets.

2.2.5 Cable glands shall be supplied to suit the cable dimensions indicated along with tolerances in data sheets. Various components like rubber ring, metallic ring, metallic cone and the outer / inner nuts etc. shall be capable of adjusting to the indicated tolerances of cable dimensions.

2.2.6 Reducers / adapters shall be supplied as per details indicated in data sheets. They shall be nickel plated brass, as a minimum. These shall also be weatherproof and / or flame proof wherever specified and certified for the electrical area classification specified in the data sheets.

2.2.7 Plugs shall be provided as specified elsewhere.

2.2.8 Plugs shall be certified flameproof when used with flameproof junction boxes.

3.0 NAMEPLATE

3.1 Each junction box shall have an anodised aluminium nameplate permanently fixed to it at a visible place furnishing the following information;

a) Tag number as per purchaser's data sheet.
b) Manufacturer's serial number and model number.

c) Manufacturer's name *i* trade mark.

d) Stamp of certifying agency with certificate number.

e) Electrical area classification.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect all the items at the vendor's works in line with inspection test plan for junction boxes and cable glands.

4.2 Vendor shall submit following test certificates and test reports for purchaser's review:

a) Material test certificates as per clause 2.2 of EN 10204

b) Pressure test on castings for £1ameproofjunction boxes.

c) Dimensional test report.

d) High voltage and msulation resistance test report.

e) Air leak test report on pneumatic junction boxes.

f) Certificate from statutory body for suitability to install in specified hazardous area.

4.3 Witness Inspection

4.3.1 All Junction boxes, cable glands and other accessories shall be offered for pre-dispatch inspection for the following. as a minimum:

a) Physical dimensional verification and workmanship on representative samples.

b) High voltage and Insulation resistance test on representative samples.

c) Air leak test report on representative samples of pneumatic junction boxes.

d) Review of all certificates and test reports as indicated in clause 4.2 of this specification.

4.3.2 In the event when witness inspection is not carried out by purchaser, the tests shall anyway be completed by the vendor and documents for the same shall be submitted for scrutiny of purchaser.

5.0 SHIPPING

5.1 All threaded openings shall he suitably protected to prevent entry of foreign material.

5.2 All threaded components shall be protected with plastic caps to prevent damage of threads.

6.0 REJECTION

6.1 Vendor shall prepare their offer strictly as per clause 1.2 of this specification and shall attach only those documents, which are specifically indicated in the material requisition.

6.2 Any offer not conforming to above requirements, shall be-summarily rejected.

GENERAL SPECIFICATION FOR

MOTORISED ACTUATOR

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi

CONTENTS

SECTION NUMBER	DESCRIPTION
1.00	GENERAL
2.00	CODES AND INDUSTRY STANDARDS
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5.00	PACKAGING
6.00	IDENTIFICATION & MARKING
7.00	SPARES
8.00	DOCUMENTATION
9.00	METHOD OF TENDERING

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
Annexure-1	Actuator torque Specification	1

1.00 GENERAL

1.01 This general specification together with the Instrument specification attached herewith define the technical requirement for the supply of Motorised gate valve, its spares, documentation and testing.

1.02 In the event of any conflict between general specification and Instrument specification the later shall prevail.

2.00 CODES AND INDUSTRY STANDARDS

The design shall be made in accordance with latest Codes & Standards and statutory requirements.

AMERICAN PETROLEUM INSTITUE (API)
API 600 Steel Valves - Flanged & Buttwelding Ends
API 6D Specification for Pipeline Valves (Gate, Plug, Ball and Check Valves)
API 598 Valve Inspection & Testing

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)
ASME Boiler and Pressure Vessel Code, including all mandatory addenda
Section VIII, "Pressure Vessels - Division 1"
ASME B2.1, "Screw Threads - Pipe Threads, General Purpose (Inch)"
ASME B16.5, "Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24"
ASME B16.11, "Forged Steel Fittings, Socket-Welding and Threaded"
ASME B16.20, "Metallic Gaskets for Pipe Flanges - Ring-Joint, Spiral-Wound, and Jacketed"
ASME B16.25, "Buttwelding Ends"
ASME B16.34, "Valves – Flanged, Threaded and Welding End"
ASME B16.47, "Large Diameter Steel Flanges NPS 26 Through NPS 60"

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)
ASTM A193/A193M, "Alloy Steel and Stainless Steel Bolting Materials for High-Temperature Service"
ASTM A194/A194M, "Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service or Both"
ASTM A320/A320M, "Alloy-Steel Bolting Materials for Low-Temperature Service"
ASTM A350/A350M, "Carbon and Low-Alloy Steel Forgings, Requiring Notch Toughness Testing for Piping Components"
ASTM A352/A352M, “Steel Castings Ferritic and Martensitic for Pressure-Containing Parts Suitable for Low-Temperature Service"

AMERICAN WELDING SOCIETY (AWS)
AWS A5.13, "Solid Surfacing Welding Rods and Electrodes"

FLUID CONTROL INSTITUTE (FCI)
FCI 70-2, "Control Valve Seat Leakage"

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)
IEC 60079, "Electrical Apparatus For Explosive Atmospheres"

3.01 Motorised Actuator

The motor shall be conforming to Ex"d", Gas group IIC, T3.

The design, manufacture and performance of equipment covered by this specification shall conform to the relevant Indian/ International standards and codes. In particular the equipment offered shall conform to the following standards with latest revision.

IS-325	Specification for three phase induction motors
IS-2147	Degree of protection provided by enclosures for low voltage switch gears & control gears
IS-2148	Flame proof enclosures of electrical apparatus
IS-2959	A.C. contractors for voltages not exceeding 1000V
IS-4691	Degree of protection provided by enclosures for rotating electrical machinery
IS-4722	Specification for rotating electrical machine.
IS-9334	Specification for electric motor operated actuators

3.02.01 The following devices shall be supplied as integral part of the actuator:

3.02.011 Electrical drive motor

3.02.012 All the accessories required for safe operation and control of actuators shall be Included in the scope of supply but not limited to the following:

a) Electrically and mechanically interlocked contractors for opening and closing direction.
b) Fuses and thermal overload relay for protection of motor and control transformer.
c) Push buttons for opening/ closing and stopping of valve operation.
d) Thermostat/ thermister with electronic controller for protection of motor.
e) Separate torque and travel limit switches for both Open and Close positions.
f) Incoming power supply isolating switch.
g) Indicating lamps for valve fully open, fully closed and ‘in-travel’ condition.
h) Space heater preferably with control thermostat.
i) Local continuous position indicator.
j) Terminal block fully pre-wired upto contacts on individual devices.
k) Control transformer
l) 2 nos. earthing terminals.
m) Hand wheel for manual operation, suitably interlocked to prevent simultaneous manual and electrical operation.

3.02.02 The housing material for actuator shall be anodised aluminium alloy and shall be epoxy painted. Vendor to furnish the thickness and type of paint.

3.02.03 The motor shall be electrical three-phase squirrel cage induction type. The motor enclosure shall be flame proof as per specification sheets and shall conform to IP – 68 or better. The motor design & construction shall be robust, long maintenance free service life. The motor shall be rated for short time duty 5-15 minutes. Motor shall be able to operate the actuator at 75% of the specified voltage. Motor shall have F class insulation (Temperature rise class B) and winding shall be resistant to corrosive agents such as NH_3, CO_2 and moisture. Fuses and thermal overload relay shall be provided for protection of motor and control transformer. Electrical and

mechanical disconnection of the motor should be possible without draining the lubricant from the actuator gearcase.

The motor shall be suitable for the following conditions -
a) Minimum 3 numbers of consecutive starts in hot condition.
b) Minimum 8 no. of starts in time span of 15 minutes.

3.02.04 Push buttons for opening/ closing/ stopping the valve action in the field to be provided. Contact for push buttons shall be “Normally open” type.

3.02.05 Lockable selector switch for “local/off/remote” operation of the valve shall be provided as follows :

1. Position local : The actuator can be operated locally.

2 Position off : The actuator is completely off and cannot be operated either from local control switch or from remote control switch.

3 Position remote : The actuator can be operated only from remote control point. It is not possible to operate it from local control switch.

3.02.06 Torque switches shall be provided for opening and closing direction.

3.02.07 Local indicating lamps for valve fully open (green) and fully closed (red) condition to be provided.

3.02.08 Space heater with thermostat shall be provided.

3.02.09 Control transformer shall be supplied.

3.02.10 Actuator shall have three cable entries :
(i) For Power supply (1 1/2”NPT)
(ii) For remote operation & position indication (1”NPT)
(iii) Spare (1” NPT plugged).
Cable glands shall be double compression, flame proof type of SS material.

3.02.11 Actuator shall be flame proof confirming to Exd IIC T3 as per IEC with environmental protection of IP 65 or better. All the bolts and nuts used in the actuator, bonnet and other parts of the valve body shall be made of stainless steel. The actuator shall be oversized to at least 25% of sizing.

3.02.12 Actuator shall be provided with following control status indicated on DCS/ PLC:

- Valve opening, closing or moving
- Valve full open
- Valve full close
- Valve position at intermediate
- Motor tripped on torque in mid travel, motor stalled
- Remote selected
- Actuator being open by handwheel

3.02.13 The actuator shall include a digital position indicator with a display from fully open to fully closed in 1% increment. Provision shall be made to orientate the display through increment of 90%. Provision shall be made in design for the addition of a contactless

transmitter to give a 4-20 mA analog signal corresponding to valve travel for remote indication when required and actuator output torque for remote indication when rquired.

3.03 Accessories

3.03.01 Limit switches shall be weatherproof IP-65 or better. Limit switches shall be supplied for valve open and close positions suitable for low current intrinsically safe applications (gold plated contacts of 24V DC 1 A rating).

3.03.02 wherever handwheel has been specified, the same shall be side mounted type and engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel or selection lever shall not move on restoration of motor drive. Provision shall be made for the hand/ auto selection lever to locked in both hand and auto position. While the hand/ auto selection lever is locked in auto mode, without damage to the actuator motor it should be possible for hand operation while the motor actuator is in running condition or in starting condition. The handwheel drive must be mechanically independent of the motor drive and any handwheel gearing should be such as to permit emergency manual operation in a reasonable time. Clockwise operation of the handwheel shall give closing movement of the valve unless otherwise started.
Neutral position of the handwheel shall be clearly indicated.

3.03.03 The actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gearbox input shaft. Normally the drive bush shall be positioned in a detachable base of the actuator. Thrust bearing, when housed in a separate thrust base should be of the sealed for life type.

3.03.04 The reversing starter, control transformer and local control shall be integral with the valve actuator suitably housed to prevent breathing and condensation. The starter shall be suitable for 60 starts per hour and of rating appropriate to motor size. The starter contactors shall be protected from excessive current surge during travel reversal by an automatic time delay on energization of contactor coils. The controls supply transformer shall be fed from two of the incoming three phase and incorporate overload protection. It shall have the necessary tapping and be adequately rated to provide power for the following functions: -

- Energization of contactor coils
- 24 VDC output where required for remote controls
- Supply for all the internal electric circuits

3.04 Fugitive Emissions Considerations

Packing shall limit fugitive emissions. Fugitive emissions of any substance containing more than 5% by weight of volatile hazardous air pollutant as defined in the National Emissions Standard for Organic Hazardous Air Pollutants (NESHAP) shall be limited in accordance with the applicable local regulation or to a maximum of 500 parts per million, whichever is more stringent.

4.00 INSPECTION, FACTORY TESTS AND APPROVAL

4.01 All instruments and accessories shall be inspected & tested to ascertain that the supply is in accordance with approved specification. The inspections & tests shall not relieve the supplier/ manufacturer from his responsibilities for materials and the performance of the instrument supplied.

Within two weeks of receipt of the Letter Of Intent (LOI) /order, vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan (QAP) for carrying out Inspection and test.

In absence of any Inspection Agency the vendor must submit the Quality Assurance Plan for principal's approval. All tests, in such cases, shall be conducted by manufacturer's quality department and the results of tests shall be forwarded alongwith the supply.

Procedure and extent of tests shall be governed by QAP mutually agreed between the vendor and principal's inspection authority.

No instrument / accessory shall be shipped until all the required tests are successfully completed and certified "Cleared for despatch" by the inspection authority.

4.02 The following physical checks, routine tests, as a minimum shall be witnessed by Principal's inspection authority.

1. Physical Check

a) Physical conformity of the motorised gate valve and its accessories with order specifications including dimensions check -
- Markings
- Overall dimensions
- Face to face body dimension
- Flanges
- Thickness check
- Check for accessories, connections & installations.
- Test of electrical parts & verifications of hazardous area

In order to check the internal parts the inspector shall have the right to disassemble one valve per type.

2. (i) Routine test for valve

a) Valve inspection and testing shall be in accordance with API 598
b) Hydrostatic testing shall be done in accordance with API 6D, in not it will be tested as per ANSI B 31.3. Unless otherwise stated on the data sheet, component testing of the pressure boundary parts is permitted; provided the valve body assembly is subsequently tested to verify the pressure sealing integrity of gaskets..
c) Seat leakage test with leakage rate conforming to FCI 70.2.
d) Functional tests : If applicable
- Valve position on energy failure
- Limit switches
- Electric actuator
- Handwheel

e) The following checks shall be carried out on the valves successfully tested :
- Rust proof painting (except for SS)
- Cleaning of internal parts of body
- Protective plugs against infiltration of foreign materials
- Protection against possible impacts
- Valve tag plates

f) Fire safe testing as per API 6FA

g) Radiography/ultrasonic test shall be carried out for all valves of rating above 600#. In addition butt weld ends of all butt welded valves for all pressure ratings shall be subjected to radiography/ ultrasonic tests.

h) Magnetic Particle or Die Penetrate test for castings and forging shall be carried out as required.

i) Checking of material composition & test.

j) An alloy verification plan will be issued on projects where alloy verification is required in accordance with General Engineering Procedures. This plan will include instrument items to be alloy verified (with verification class defined), required methods of verification and when and where these test are to be performed. Alloy verification requirements will be noted on each valve data sheet (example: “CLASS I ALLOY VERIFICATIONREQUIRED”). Supplier shall perform all required tests to meet the stated requirements.

k) Valve shall be subjected to 10% hardness test for hard facing.

2 (ii) Routine test for actuator

Each actuator must be performance tested and individual test certificates shall be furnished. The test equipment should simulate a typical valve load, and the following parameters should be recorded.
(a) Current at max. torque setting
(b) Torque at max. torque setting
(c) Flash test voltage
(d) Actuator output speed or operating time

In addition the test certificate should record details of specifications such as gear ratios for both manual & automatic , drive closing direction , wiring diagram code number etc

5.00 PACKAGING

Requirement of packaging stated elsewhere in the bid document.
Vendor should furnish storage requirement of the valves like
Valve should be stored open or close?
Does the valve need to be stroked if stored for an extended period?
Other requirements.

6.00 IDENTIFICATION AND MARKING

6.01 Self adhesive tapes or signs are not permissible for permanent marking of any instrument.

6.02 Each gate valve shall be fitted with a SS tag plate and shall contain the following information:
- Tag no.
- Manufacturer’s name, Serial No. and Model
- Body and trim material and sizes
- Body rating and end connection
- Fail action

Each motorised actuator shall be fitted with a SS tag plate and shall contain the following information:

- Tag no.
- Torque rating
- Power rating
- Power supply

A durable terminal identification card showing plan of terminals shall be provided and attached to the inside of terminal box cover indicating wiring diagram number terminal layout.

Besides the above each instrument shall have a separate circular tag number plate in stainless steel with engraved tag number and range and attached securely to the instrument with a soft stainless wire. The size of letters and figures shall be minimum 4mm and the plate should be 25mm diameter with 1-2 mm thick. Also each instrument shall have lamicoid nameplate with 6 mm minimum size black letters on white background and identified with their relevant loop number

6.03 All spare parts shall be fitted with identification plate with the following data clearly printed and easily readable.
- Spare parts name/model no. as per purchaser's Instrument specification sheet
- Serial no.

7.00 SPARES

Spares shall be as per enclosed spares list.

8.00 DOCUMENTATION

1 Technical documentation

1.1 General

All the documentation such as graphic drawings and technical specifications shall be sent to the Contractor who will reserve to approve it within 15 days; after this period, the documents have to be retained approved.
The Contractor's approval will not relieve the Vendor of his responsibility for the final performance of the supply.
Final issue of Project Documents shall be supplied in electronic format as specified here under.
All the other Vendor documentation, such as Manual, Catalogues, etc. shall be supplied on paper.

1.2 Title block and heading

Each document originated by the Vendor shall be numbered according to Vendor procedure.

1.3 Specification, Data Sheet and other documents.

All shall be produced with Microsoft Office products as Word, Excel or PowerPoint access.
The files shall be delivered in a "workable stand-alone" format, without any special features (links to other files, special fonts, macros, etc.), which may affect the possibility of viewing and editing.

1.4 Drawings

Drawings will be made using AutoCAD version 12 or 14 or Latest.
Vendors are permitted to utilise other CAD software, but the produced files are to be converted in AutoCAD format prior the delivery to Contractor.

Drawings files shall be delivered as “single complete file”, without any reference attached, except when not practicable due to the dimension of referenced files. In this case together with the reference files also the information necessary to manage the files shall be given. Together with the drawings files also the relevant files for plotting format HPGL or HPGL2 are to be delivered.

1.5 Scanned documents

The format of scanned documents shall be CCITT Group IV TIFF or Adobe PDF Acrobat. Quality control on file of scanned documents will be completed prior to delivery, including:
Deskew
Despeckle
Hole Fill.
Resolution below 200 Dpi is not acceptable.

The following documents (Technical) are required to be submitted by the vendor alongwith bid, after placement of order for approval purposes and final documentation before despatch of consignment.

Sl. no.	Description of document	Alongwith bid	After placement of order	
			For approval/ information within two weeks	Final documents before despatch of consignment
1.	Consolidated list of drawings & documents	Yes	Yes (I)	Yes
2.	Deviation, if any, from the technical spec. giving justification for the same.	Yes	x	x
3.	Catalogue / technical literature of valves and accessories including cross-sectional view, dimensions, weight etc.	Yes	Yes	Yes
4.	Tentative dimensional drawings for each Tag No. with technical details like dimensions, weight, special supports, clearances required for easy maintenance etc.	Yes	x	x
5.	Final certified detailed as per Sl. No. 4 for main item & accessories for each tag no.	x	Yes (A)	Yes
6.	Material test certificates from independent recognised agency showing chemical analysis, physical analysis, Ferrite content on finished products.	x	x	Yes
7.	Certificates conforming to specific standards from independent recognised agency, wherever applicable, for - Ex-proof items - Intrinsically safe items - Environmental protection - Fire safety	Yes	x	Yes
8.	Manuals for installation, operation & maintenance	x	x	Yes
9.	Calculation sheet for actuator sizing etc. for each tag no. including KW rating	Yes	Yes(I)	Yes
10.	Calibration certificates for - Hydrostatic test Seat leakage test Performance test Functional test Special test (if specified) (radiography, ultrasonic etc.)	x	x	Yes
11.	"As supplied" data sheet signed by qualified engineer	x	x	Yes
12.	Manufacturer's quality assurance certificate for each actuator	x	x	Yes
13.	Quality assurance plan	x	Yes (A)	x

NOTES

1. (A) for Approval (I) for information only
2. Sl. No. 1 to 12 shall be forwarded to Owner as per details outlined in enquiry /order.
3. Sl. No. 13 shall be mutually finalised with Inspection Authority specified in the order as per clause no.4.01.
4. Number of sets shall be as stipulated elsewhere in the bid document. Final documentations shall be supplied in hard copies as well as soft copies in CD formats. Applicable software are MS Office 2000, Word, Access, Excel. Documentation language shall be English.

9.0 METHOD OF TENDERING

General

The Bidder shall present a list of previous applications (References) for equipment similar to the equipment proposed.

Technical information

The equipment offered as a basis shall be of standard production type it shall be based on modern technology, be of a proven and referenced type and designed for continuous operation under the specified operating conditions.

The Bidder shall quote for the materials requested according to the requirements of this specification and of the individual job specifications. With bid shall be supplied the technical documentation.

Deviations

The tender shall be in strict accordance with Purchaser's specifications.

However, the Vendor may quote, in addition and as an alternative, different materials from those required in the specifications, provided these materials are suitable for the process conditions specified in the individual job specifications.

Any deviation from the requirements listed in the general specification and in the individual job specifications shall be clearly highlighted.

If no exceptions are listed, the tender - and the possible supply - shall be regarded as being in full conformity with the Purchaser's requirements, and will be accepted after the tests and checks have confirmed that the performance complies with the requirements of the tender documents and order specifications.

Annexure – 1 Actuator torque Specification

Note: - Vendor to fill the table for all the tags.

Sl. No.	Tag No	Qty	Valve size	Actuator Model	Gear Box Model (if applicable)	Torque (Nm)			RPM	Travel Time Sec.	Max. stem (mm)	Kw Rating
						Valve Torque (Actual)	Valve Torque with 25% safety factor	Actuator Torque				
1												

GENERAL SPECIFICATION

FOR

GAS DETECTORS

CONTENTS

1.	GENERAL	03
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7.	PROVEN TRACK RECORD	10

1. GENERAL

(1) This specification covers the common and minimum requirements for design and manufacturing of the Gas Detectors.

(2) The design and manufacturing shall be carried out in accordance with this specification together with Codes and Standards to the extent described in this specification.

(3) In case there is any conflict among the requirements, the following priority shall govern.

1ST Data Sheets
2ND This Specification
3RD Codes and Standards

Vendor to bring to the notice of owner/purchaser of any conflict on above documents before proceeding with procurement engineering. If no information is highlighted by vendor during quotation stage it will be presumed by owner purchaser that the vendor is in full compliance to purchaser specification.

(4)The instruments elected for the units shall be rugged in design and must be well proven in the hydrocarbon industry. Prototype design or equipment of experimental nature or design undergoing testing etc. shall not be selected and supplied.

(5)The instruments as being offered supplied should have been operating satisfactorily in a hydrocarbon industry like Refinery, Petrochemical and Gas Processing Plant under similar process conditions for atleast 4000 hours from the bid opening date.

2. CODES AND STANDARDS

(1) ANSI 61.20.1 Pipe threads General Purpose (Inch)
(2) IEC International Electrochemical Commission
(3) NEC National Electric Code
(4) 6SEN5004 Electric Gas Detector for combustible gases.
(5) IEC79Electrical Apparatus for Explosive Gas Atmosphere.
(6) CSA Standard, C22.2No152, Combustible Gas detection Instruments.
(7) NFPAvolume7, National Fire Protection Association.

3. ENVIRONMENT CONDITION

The equipment supplied shall be suitable for the ambient temperature which may rise to 45°C with corresponding humidity of 100%

The vendor shall supply Gas Detectors with protective measures (If any) against the climatic condition indicated below.

Barometric Pressure, mbar : Refer document no 1075-0000-0790

Temperature (Design conditions) : Max.45°C

Min 5°C
35°C for process calculation

Relative Humidity (RH %) : Refer document no 1075-0000-0790

Rainfall : Refer document no 1075-0000-0790

Wind data : Refer document no 1075-0000-0790

Elevation above mean Sea level. : Refer document no 1075-0000-0790

4. TECHNICAL REQUIREMENTS:

4.1 Catalytic Combustion Type H2 Gas Detectors

4.1.1 Type of Sensor

In general, Catalytic combustion type sensor for combustible gas shall be used.

4.1.2 H2 gases shall be continuously detected by catalytic combustion type Gas detectors.

4.1.2 Electrical Requirement

(A)Transmitter Output :- (x) 4-20mA,3 WireType.

(B)Range of Instrument: - 0-100% LEL

(C)Operating Voltage: (x) 24VDC
( ) 110VAC
( ) 230VAc

(D)Response Time:- Less than 10 Sec for 90% of Full scale

(E) Display: - (x) Required
( ) Not Required

4.1.4 Enclosure

(1) Materials (x) Die Cast Aluminum ( ) Manufacturer Standard

(2) Enclosure class:

( ) Weatherproof ( ) General purpose
(x) Explosion proof
-Class: ( ) As spec in Instrument Data/ Schedule sheets
(x) Suitable for IEC Zone 2 Group IIA +IIB+H2,
- Authority's certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(x) CCOE (Chief Controller of Explosives)

(3) Weather hood: (x) Yes ( ) No

(x) For rain
(x) For dust
( ) _____

(4) Cable Entry: (x) WNPT (F)
( ) G1/2 in.

4.1.5 Mounting:
(x) 2 in. pipe mounted
( ) Mounting stand

4.1.6 Accessories:- 2" Pipe Mounting Accessories, Cable Glands & plugs.

All ex-proof components /instruments should have Chief Control of Explosives (CCOE)- Nagpur certification.
All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period.

4.2 Infrared type HC gas detector

4.2.1 Type of Sensor

Infrared type sensor for hydrocarbon gas shall be used.

4.2.2 Hydrocarbon (HC) gases shall be continuously detected by Infrared type gas detectors

4.2.3 Electrical Requirement

(A) Transmitter Output:- (x) 4-20 mA, 3 Wire type
(B) Range of Instrument:- 0-100% LEL
(C) Operating Voltage: (x) 24VDC
( ) 110VAC
( ) 230VAc
(D) Response Time:- Less than 5 sec.
(E) Display:- (x) Required
( ) Not Required

4.2.4 Enclosure

(1) Materials (x) Die cast aluminum epoxy coated ( ) Manufacturer std.

(2) Enclosure Class
( ) Weatherproof ( ) General purpose
(x) Explosion proof (EEx'd')
-Class: ( ) As spec in Instrument Data/ Schedule sheets
(x) Suitable for IEC Zone 2 Group IIA +IIB+H2,
- Authority's certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(x) CCOE (Chief Controller of Explosives)

(3) Weather hood: (x) Yes ( ) No

(x) For rain
(x) For dust
( ) _____

(4) Cable Entry: (x) WNPT (F)
( ) G1/2 in

4.2.5 Mounting:
(x) 2 in. pipe mounted
( ) Mounting stand

All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period

4.2.6 Accessories: - 2" Pipe Mounting Accessories, Cable Glands & plugs.

4.3 Electrochemical Gas Detectors

4.3.1 Type of Sensor

Electrochemical gas sensor for Co gas shall be used.

4.3.2 CO gases shall be continuously detected by electrochemical type Gas detectors.

4.3.3 Electrical Requirement:

(A) Transmitter Output:- (x) 4-20 mA, 3 Wire type
(B) Range of Instrument:- 0-100 ppm
(C) Operating Voltage: (x) 24VDC
( ) 110VAC
( ) 230VAc
(D) Response Time:- Less than 30 sec for 50% full scale.
(E) Display:- (x) Required
( ) Not Required

4.3.4 Enclosure

(1) Materials (x) Die cast aluminum epoxy coated ( ) Manufacturer std.

(2) Enclosure Class:
( ) Weatherproof ( ) General purpose

(x) Explosion proof (EEx'd')
-Class: ( ) As spec in Instrument Data/ Schedule sheets
(x) Suitable for IEC Zone 2 Group IIA +IIB+H2,

- Authority's certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(3) Weather hood: (x) Yes ( ) No

(x) For rain
(x) For dust
( ) _____

(4) Cable Entry: (x) WNPT (F)
( ) G1/2 in

4.3.5 Mounting:

(x) 2 in. pipe mounted
( ) Mounting stand.

4.3.6 Accessories:- 2" Pipe Mounting Accessories.

All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period.

4.4 Catalytic type gas detectors

4.4.1 Type of Sensor

Catalytic type gas sensor for ammonia gas shall be used.

4.4.2 Ammonia gases shall be continuously detected by Catalytic type Gas detectors.

4.4.3 Electrical Requirement:

(A)Transmitter Output:- (x) 4-20 mA, 3 Wire type
(B) Range of Instrument:- 0-100 ppm
(C) Operating Voltage: (x) 24VDC
( ) 110VAC
( ) 230VAc
(D) Response Time:- Less than 60 sec with splash guard & dust guard.
(E) Display:- (x) Required
( ) Not Required

4.4.4 Enclosure

(3) Materials (x) Die cast aluminum epoxy coated ( ) Manufacturer std.

(4) Enclosure Class:
( ) Weatherproof ( ) General purpose

(x) Explosion proof (EEx'd')
-Class: ( ) As spec in Instrument Data/ Schedule sheets
(x) Suitable for IEC Zone 2 Group IIA +IIB+H2,
- Authority's certificate: (x) Yes ( ) No

(x) All gas detectors shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

(3) Weather hood: (x) Yes ( ) No

(x) For rain
(x) For dust
( ) _____

(4) Cable Entry: (x) WNPT (F)
( ) G1/2 in

4.4.5 Mounting:

(x) 2 in. pipe mounted
( ) Mounting stand.

4.4.6 Accessories: - 2" Pipe Mounting Accessories.

All sensors shall be resistant to sulphur poisoning & withstand salt laden amb. Condition for the specified life period.

4.5 HOOTERS

1) The Hooters shall be of electric type.
2) The Hooter shall be pre-assembled with SOV & AFR.
3) The SOV shall confirm to the below requirements.
   a) The SOV shall be suitable for locating in Zone2, Gr IIA+ IIB+ H2 hazardous area.
   b) The SOV shall be intrinsically safe, the intrinsically safe enclosures shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, FM, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India. In addition to this for instruments installed in hazardous area, CCOE (Chief Controller of Explosives), Nagpur certification shall be required.
   c) The solenoid valve shall be direct acting type, three-way, Universal type, shall be continuous rated type with class H insulation as per IEC60085/1S1271.
   d) The body shall be of SS with SS316 trim as minimum, and be operated on 24 VDC. The SOV vent shall have bug screens.
   e) SOV shall have integral junction box with WNPT (F) cable entry. Flying leads are not acceptable.
   f) TheSOVshallbeSIL-2certified.
4) The AFR shall confirm to the below requirements.
   a) Filter mesh shall have 5 micron sintered bronze 1 ceramic filter element and shall be provided with manual drain.
   b) The AFR shall have a 2" pressure gauge; the pressure gauge shall be of SS material.
   c) The connection size for instrument air on AFR shall be clearly indicated.
5) Suitable wall mounting assembly shall be provided with the Hooter.

4.6 BEACONS

1) The beacons shall be of flashing type.
2) The beacons shall be Ex-proof Ex'd' suitable for locating in Zone2, Gr.IIA +IIB+H2, hazardous area.

3) The beacons shall be certified to the specified hazardous area by a statutory body like CSA, BASEEFA, PTB, LCIE, UL, and etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India. In addition to this for instruments installed in hazardous area, CCOE (Chief Controller of Explosives), Nagpur certification shall be required.
4) The beacons shall operate on 24VDC power supply.
5) The cable entry shall be WNPT (F).
6) Suitable wall mounting assembly shall be provided with the Beacon.

4.7 CALIBRATION ACCESSORIES

Vendor to provide following accessories:
(a) Calibration gases shall be provided for warranty period.

4.8 MARKING

Each gas detector shall be marked according to MSS-SP-25. The material of the name plate shall be of SS316 & fully insulated. A name plate engraved with following shall permanently be affixed on each detector.

Tag Number
Manufacturer's Name
Model Number
Serial Number
Power Supply
Target Gas Type
Electrical Classification

4.9 Portable gas detector shall be supplied, one no. each for HC application.

5 INSPECTION AND TESTING:

(1) The testing and acceptance shall be carried out on the mutually agreed procedures and criteria based on this specification and vendor's standard procedures.

(2)The Owner/Purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, including proper workmanship & materials, as a part of approval of testing procedure. The cost of performing all tests shall be borne by the vendor, without affecting the overall delivery schedule.

(3)Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition. It shall be vendor's responsibility to modify and/or replace any hardware if the specified functions are not completely achieved satisfactorily during Inspection and Testing.

(4) Vendor shall make available all consumable instruments & equipments necessary for testing & calibration during all tests. These instruments/equipments shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested instruments & certified by National Physical Laboratory or other equivalent agencies.

(5) Inspection and testing shall be as per attached Inspection and Test Plan (ITP).

6 PROVEN TRACK RECORD

Vendor to provide Proven Track Record (PTR) for the offered gas detectors in similar applications with the quotation.

GENERAL SPECIFICATION

FOR

DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

Abbreviations:

AC	Alternating Current
APC	Advanced Process Control
CFF	Common File Format
CPU	Central Processing System
CRT	Cathode Ray Tube
DA	Data Access
DC	Direct Current
DD	Device Description
DCS	Distributed Control System
DVD	Digital Versatile Disc
EDDL	Enhanced Device Descriptive Language
EPROM	Erasable Programmable Memory
EMI	Electromagnetic Interference
ESD	Emergency Shutdown System
FAT	Factory Acceptance Test
FDT / DTM	Field Device Tool / Device Tool Manager
FF	Foundation Fieldbus
FMEDA	Failure modes, Effects and Diagnostic Analysis
GPS	Global Position System
HART	Highly Addressable Remote Transducer
HDA	Historical Data Access
HI	Foundation Fieldbus low speed (31.25kbps) loop powered bus
HSE	High Speed Ethernet
HVAC	Heating, Ventilation and Air Conditioning
HW	Hardware
HWC	Hardware Console
I/O	Input / Output
IAMS	Instrument Asset Management System
LAN	Local Area Network
LAS	Link Active Scheduler
LCD	Liquid Crystal Diode
MCC	Motor Control Centre
MOV	Motor Operated Valve
MTTF	Mean Time to Failure
MTTR	Mean Time to Repair
OIS	Operator Interface System

OLE	Object Linking and Embedding
OPC	OLE for Process Control
PC	Personnel Computer
P&ID	Piping and Instrumentation Drawing
PID	Proportional, Integral and Derivative
PLC	Programmable Logic Controller
QUAD	Quadruplet
RAID	Redundant array of independent discs
RAM	Random Access Memory
RDBMS	Relational Database Management System
RFI	Radio Frequency Interference
ROM	Read Only Memory
SAT	Site Acceptance Test
SCSI	Small Computer System Interface
SER	Sequence of Event Recorder
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SPD	Surge Protection Device
SQL	Structured Query Language
TCP / IP	Transmission Control Protocol / Internet Protocol
TFT	Thin Film Transistor
UHF	Ultra High Frequency
UPS	Uninterrupted Power Supply
USB	Universal Serial Bus
VDU	Video Display Unit
VFD	Vertical Field Device
VHF	Very High Frequency
WAN	Wide Area Network

Triple Modular redundant (TMR), Quadruple Modular Redundant (QMR)configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)

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PART – I

GENERAL SPECIFICATIONS OF DISTRIBUTED CONTROL SYSTEM

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GENERAL

1.1 SCOPE

1.1.1 This specification, together with the data sheets attached herewith defines the minimum functional requirements for the design; hardware, software and firmware specifications, nameplate marking, testing and shipping of Distributed Control System designed for reliable effective and optimum control and monitoring of a process plant .

1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:-

AG-181	Foundation Fieldbus System Engineering Guidelines	
EN 10204	Inspection Documents for Metallic Products.	
EN 50039	Intrinsically Safe Electrical System	
IEC 60079	Electrical Apparatus for Explosive Gas Atmosphere.	
IEC 60529	Degree of Production Provided by Enclosures.	
IEC 60617	Graphic Symbols for Electronic Diagram	
IEE 4	Guidelines for Documentation of Computer Software for Real time and Interactive Systems	
FF – 569	Foundation Fieldbus Host interoperability support test procedure	
FF – 816	Foundation Fieldbus Specification 31.25 Kbits/s Physical Layer Profile	
FF – 890~894	Foundation Fieldbus Specification Function Block Application process	
ANSI / ISA TR 99.00.01	Security Technologies for Manufacturing and control system	
ANSI / ISA TR 99.00.02	Integrating Electronic Security into the manufacturing and control systems environment	
EEMUA 191	Alarm System, a guide to design, management and procurement	
IS-3043	Code of Practice for Earthing	
IS 13947	Degree of Protection provided by Enclosures for low voltage switchgear and control gear	
IS 13948	Flameproof Enclosures of Electrical Apparatus	
ISA	S 71.01	Environmental Conditions for process Management and Control System : Temperature and Humidity
	S 71.04	Environmental Conditions for Process Measurement and control System: Airborne Contaminants
	S 5.2	Binary Logic Diagrams for Process Operations
	S 5.3	Graphic Symbols for Distributed Control System Display Instrumentation, Logic and Computer System.
	S 5.4	Instrument Loop Diagram

	S 5.5	Graphic Symbols for Process Display
	S 18.1	Annunciator Sequences and Specifications
	S 50.2	Fieldbus Standard for use in Industrial Control System
IEC 61000-4-3	Electromagnetic Compatibility (EMC) – Testing and Measurement Techniques – Radiated Radio Frequency, Electromagnetic Field Immunity Test.	
IEC-61000-4-4	Electromagnetic Capability (EMC) – Testing and measurement techniques – Electrical fast transients / bust immunity test	
IEC-61000-4-5	Electromagnetic Compatibility (EMC) – Testing and Measurement techniques – Surge immunity test	
IEC-61000-6-2	Electromagnetic Compatibility (EMC) – Generic Standards – Immunity for Industrial Environments	
IEEE 472	Electrical Surge protection	
IEC-60584	Thermocouple (Tolerances)	
IEC-60751	Industrial Platinum Resistance Temperature Sensors	
ANSI MC 96.1	Temperature Measurement Thermocouples	
IEEE 802.3	Telecommunication and Information exchange between Systems – Local and Metropolitan Area networks – specific requirements – Part 3 : Carrier Sense Multiple access with collisions Detection (CSMA / CD) Access Method and Physical layer specification.	
IEC 61508	Functional Safety of Electrical / Electronic / Programmable Electronic Safety related Systems.	
IEC 61131	Programmable Controllers	
IEC 61511	Functional Safety – Instrumented System for Process Industry Sector	IEC

61158 Fieldbus Standard for use in Industrial Control Systems.

1.1.3 In the event of any conflict existing between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Design Basis / Statutory regulations

b) Data Sheets

c) Standard specifications

d) Codes and standards

1.1.4 In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

a) Purchaser's data sheet specify the minimum acceptable functional requirements for the control system. It shall be vendor's responsibility to select proper hardware, software and firmware to meet the specified functional requirements.

b) Purchaser's data sheets specify the scan time / cycle time / response time / macro cycle time and loading requirements. Vendor shall be responsible for sizing and selecting their standard product i.e. hardware, software and firmware to meet the requirements specified in the purchaser's data sheets.

c) Selection of proper and adequate hardware, software and firmware to meet architectural requirements specified in the purchaser's specifications, keeping the integrity of functional blocks specified in the configuration diagram attached with the material requisition.

d) Segment design based on requirements specified in the job specifications and its validation during site testing and pre-commissioning.

e) Adequacy of Bill of material selected to meet purchaser's requirements. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.

f) Providing adequate mandatory spares including consumable spares as specified in the purchaser's specifications. Vendor shall be responsible to meet mandatory spare requirements specified by the purchaser.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Detailed specification sheets for each sub-system. The specification sheet shall provide information regarding hardware specifications, software specifications, redundancy requirements, capacity, power consumption etc. of the distributed control system and its accessories. The material specifications and unit of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.

c) System security features and design details

d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in the purchaser's specifications.

e) A copy of approval for flameproof enclosure, intrinsic safety etc whenever specified, from local statutory authority, as applicable, like Petroleum and Explosive Safety Organisation (PESO) / Chief Controller of Explosives (CCE), Nagpur or Director General of Mines Safety (DGMS) in India along with;

i) Test certificate from recognised house CIMFR (Central Institute of Mines & Fuel Research) / ERTL (Electronics Research and Test Laboratory) etc. for specified protection class as per relevant Indian Standard for all Indian manufactured equipments or for equipments requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, BASEAFA, PTB, CSA, UL etc., for compliance to ATEX or other recognised standards for all equipments manufactured outside India.

f) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate from the specified requirement, they must include a list of deviations item wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with the technical reasons for each of these deviations.

g) FMEDA report and calculations for probability of failure on demand to meet specified SIL requirements (e.g. SIL3).

h) Catalogues giving detailed technical specifications, model decoding details and other related information for each item / sub-system covered in the bid.

1.2.3 Vendor shall offer only their standard proven product i.e. hardware, system software and firmware, which shall be configured to meet the functional requirements specified in the material requisition. Whenever any bought out item is offered to meet the configurational requirements specified in the material requisition, it shall also meet the functional requirements. Moreover, the equipment being offered / supplied shall be of latest proven version available in the current manufacturing range and meeting the requirements specified in clause 1.2.4 of this standard specification.

1.2.4 The system hardware, software and firmware as offered, shall be field proven and should have been operating satisfactorily for a period of minimum 4000 hours continuously on the bid due date in the validly similar size and application specified in the purchaser's data sheet. Items with prototype design or items not meeting provenness criteria specified above shall not be offered or supplied.

1.2.5 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. shall be indicated in the job specifications which shall be part of material requisition.

1.2.6 Whenever specified, vendor shall furnish tested values of failure rates, probability of failure on demand and test intervals for safety integrity level analysis.

1.2.7 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language only.

1.2.8 Vendor shall also quote for the following;

a) Two year's operational spares for each sub-system and their accessories which shall include the following as a minimum;

i) All type of electronic modules e.g I/O modules, processor modules, communication modules, memory modules, disc controller module, power supply modules etc.

ii) All type of auxiliary items e.g. barriers / isolators, hardwired instruments, annunciator modules, receiver switches, trip amplifiers, temperature element converters etc.

iii) Switches, lamps, fuses, connectors, terminals, pre-fabricated cables, circuit breaker, relays etc.

iv) Video display units, keyboards, disc drives, PC's, network items (e.g. switches, hubs etc.) etc.

b) Any special tools and test equipments needed for the maintenance of DCS, PLC's and other items being offered by vendor. This shall also include test equipments for fieldbus testing and configuration like fieldbus tester, fieldbus configurator etc. wherever specified in the data sheets. Vendor must confirm in their offer if no special tools or test equipments are needed for maintenance other than those specifically indicated in purchaser's data sheet.

1.3 Drawing and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of producibles, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design manuals, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:

a) Specification sheet for each sub-system, auxiliary instrument and bought out item.

b) Certified drawings for complete system including;

i) GA drawings for panels, cabinets, marshalling racks, hardwired consoles, operator / engineering console etc with complete dimensions details, internal construction and weight in kilograms.

ii) Control room e.g. console room, rack room and engineering room layout with all dimensions in millimeters.

iii) Channel base drawing for console room, rack room and engineering room.

iv) Input / output assignment

v) Fieldbus segment drawing

vi) Loop wiring diagram

vii) Power supply distribution single line diagram

viii) Dynamic graphic diagrams

ix) System grounding drawing

c) Design manuals and functional design specifications which shall include hardware design manual, software design manual and special software specifications.

d) Copy of type test certificates.

e) Copy of test certificates for all tests indicated in Part II of this specification.

f) Installation manual containing installation procedure for distributed control system and other items covered in the material requisition.

g) Power-on, start-up and internal testing procedures.

h) Software debugging and system configuration procedures

i) Calibration and maintenance manual containing maintenance procedures including replacement of parts, application modification etc.

j) Any other drawings and documents specifically indicated in job vendor data requirement enclosed with the material requisition.

2.0 DEFINITIONS

The various terms used in this specification are defined as follows:

2.1 Distributed control system

The class of control systems which in addition to maintaining and managing data bases in distributed fashion also executes the stated control functions and permits transmission of control, measurement and operating information to and from a single or a plurality of user specified locations connected via a communication sub-system.

2.2 Programmable Logic Controller

The class of control systems which can be programmed to execute plant shutdown and / or interlock / sequence logics to the specified safety integrity levels.

2.3 Accessible

A system feature that is viewable by and interactive with the operator and allows the operator to perform user permissible control action e.g. set point change, auto-manual transfers or on-off actions.

2.4 Assignable

A system feature that permits an operator to direct a signal from one device to another without the need for change in wiring, either by means of switches or via other data entry devices like key board commands to the system.

2.5 Configurable

A system feature that permits selection through entry of key board commands or commands from other data entry devices of basic structure and characteristics of a device or system, such as control algorithm, display format or I/O termination.

2.6 I/O

Input / Output with respect to process / operator.

2.7 Fieldbus

Fieldbus is a digital two-way multi drop communications link among intelligent measurement and control devices.

2.8 System Size

System size shall be defined as maximum number of process inputs or tags those can be connected to the system and viewable from any one of the VDUs of an operating console in all hierarchical displays without changing the configuration or without operator interaction considering;

a) all inputs as close loops
b) all inputs as open loops

2.9 Operator console

Operator console is the operator's main plant interface device via which operator can view, monitor and control the plant and can give instructions to peripherals to execute commands, and shall have protective access to configure and maintain the system.

2.10 Engineering console

Engineering console shall be the engineer's main interface device via which engineer can configure and maintain the system, and shall have protective access to monitor and control the plant, give instructions to peripherals to execute commands,.

2.11 Local Level

All those sub-systems, which directly interface with field devices shall be referred to as local level.

2.12 Central Level

Operator consoles and Engineering Console, which present data acquired from local level devices shall be referred as Central Level.

2.13 Data base

Database shall be defined as the information stored temporarily or permanently in the system which can be accessed by various programs to meet all its functional requirements.

2.14 Global Database

Global database is defined as the database that can be accessed by two or more non-nested modules of a program without being explicitly passed as parameters between the modules.

2.15 Loop integrity

A system shall be said to have loop integrity if the failure of one component in the system/ sub-system does not affect more than one loop.

2.16 Interchangeability

System/sub-systems shall be said to have full interchangeability if the functions and information available on one system/sub-system shall also be available on the other in totality.

2.17 System Loading

System loading for a sub-station is defined as the percentage of time a sub-system spends in carrying out various activities referred to the use of memory, CPU time and communication capacity in the worst case of high sub-system operation out of the designed / designated cycle time of the sub-system.

2.18 Bus-degradation

Bus-degradation shall be defined as a change in the system performance from the specified one measured in terms of display update rate while loading the communication sub-system from 10 through 100 percent.

2.19 Redundancy

A system component shall be termed as redundant if it takes over automatically the operation in the event of the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator action without upsetting system operation.

2.20 Switchover Time

Time required for a back up instrument / system to come on-line automatically in case of the failure of the main instrument / system.

2.21 Processor Cycle Time (Tpc)

Processor cycle time is the measure of the processing speed of a processor and is user selectable from the pre-defined discrete values. Processor cycle time for a sub-systems shall be defined as follows:-

a) Controller Sub-system

Processor cycle time for controller sub-system shall be defined as the total time taken by the control processor to read inputs supplied by input module, execute control algorithm and write the outputs for the output module.

b) Data acquisition sub-system

Processor cycle time for data acquisition sub system shall be defined as the total time taken by the processor to read inputs supplied by input processor, perform calculations for all the open loops configured within the data acquisition sub-system and make data available to the communication sub-system.

c) Programmable logic controller

Processor cycle time for programmable logic controller shall be defined as the total time taken by the processor to read input supplied by input module, execute all computations (analog as well as logic as configured) and write the outputs for the output module.

2.22 Scan time (ts)

Scan time is the end-to-end response time of a sub-system and shall be defined as follows:
For fieldbus based system refer clause 2.25 for close loop response time.

a) Close-Loops

Scan time for a close-loop shall be defined as the total time taken by a sub-system e.g. controller and data acquisition sub-system to read inputs from the input terminal, process input, perform control algorithms, update control output and write output at the output terminal for all the loops configured within the sub-system.

b) Open-Loops

Scan time for an open loop shall be defined as the total time taken by a sub-system e.g controller and data acquisition sub-system to read input from input terminal, process input, perform calculations and write output for communication sub-system to pick-up the same for all the open loops configured within the sub-system e.g. controller and data acquisition sub system.

c) Logic Loops

The scan time for a logic loop shall be defined as the total time taken by a sub-system e.g. programmable logic controller to read input from the input terminal, process input, execute logic, updating logic output and write output at the output terminal for all the logics configured within the subsystem.

2.23 Control Cycle time

Control cycle time is defined as the total cycle time taken by the supervisory computer to read data from control system, perform calculations and update the set point of a regulatory loop configured in the control system e.g. controller and data acquisition sub-system.

2.24 Macro Cycle

Macro cycle is defined as a single iteration of a schedule within a fieldbus device.

2.25 Macro Cycle Time

Macro Cycle time or execution time is defined as the amount of time taken by a fieldbus device to complete the macro cycle. Macro cycle time can refer to a single field device, the LAS or a complete segment made up of multiple devices.

2.26 Loop Response Time

Loop response time for fieldbus based system shall be defined as the total time required to perform the following functions in each of the specified loop configuration;

a) Control function in transmitter

Execute the analog input and control (PID) function block in transmitter, publish the output on the fieldbus, receive the controller out value and perform analog output function block in final control element.

b) Control function in final control element

Execute the analog input function block in the transmitter, publish the process variable on the fieldbus, receive the process variable and execute the control algorithm (PID) and analog output function block in the final control element.

c) Control Function in DCS

Execute the analog input function block in the transmitter, publish the process variable at DCS, execute the control algorithm (PID) in DCS, publish the controller output value on the fieldbus and execute the analog output function block in the final control element.

2.27 Display update rate

Display update rate shall be defined as the time taken by the system to display the information present at the system input terminals updated on the current display on the VDU of an operator console

2.28 Call-up time

Call up time shall be defined as the time taken by the system to display a particular display/data on the VDU after getting the corresponding command from the operator.

2.29 User's memory

Free memory space available after utilisation of memory required for system operation, configuration and implementation of application and other system related functions for implementation of user defined specific programs such as plant calculations, process optimization or MIS (like free formatting of certain logs). The programs shall either be written in high level language or system specific language.

2.30 Event

An event shall be defined as any action taken by the operator via operator keyboard or switches on hardwired console like change of set point, change of control mode, start/stop of motor, open/close of shut down valves, alarm acknowledge etc.

2.31 Sequence of Event (SOE)

Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of event.

2.32 Sequence of Event Recorder (SOR)

System of sub-system which presents and / or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

2.33 Real time trend

Real time trend shall be defined as a continuously progressing graphical record showing continuously updated parameter with most recent value and a past record of minimum of 10 minutes without depressing any additional key for moving backward in time.

2.34 Windowing

Ability of software program to break the console screen i.e. video display unit into simultaneous or overlapping zones with separate presentations at the same time.

2.35 Interoperability

Interoperability is the capability to substitute a device from one manufacturer with that of another manufacturer as a fieldbus network without loss of any functionality or degree of integration.

2.36 Acyclic Period

Acyclic period is defined as the portion of communication cycle time during which information other than publish / subscribe data is transmitted.

2.37 Capabilities File

A capabilities file describes the communication objects in a fieldbus device. A configuration file can use DD files and capabilities files to configure a fieldbus system without having the fieldbus device active.

2.38 Link Active Scheduler (LAS)

LAS is defined as a deterministic centralised bus scheduler that maintains a list of transmission times for all data buffers in all devices that need to be cyclically transmitted.

2.39 Link Master

Any device containing the link active scheduler personality that can control communication of a H1 fieldbus segment is designated as link master.

2.40 Segment

Segment is defined as a network or part of network that serves as the primary communication highway for the connected field-bus devices.

2.41 Resource Block (RB)

Resource block describes the characteristics of a fieldbus device such as device name, manufacturer and its serial number. Resource block is unique for a device.

2.42 Vertical Communication Relationship (VCR)

VCR is defined as the pre-configured application layer channels which provide the data transfer between applications. Publisher – subscriber, client – server and report distribution are three VCRs in foundation fieldbus.

2.43 Link Objects

Link object contains information to link function block input / output parameters in the same device and between different devices.

2.44 Plant Control Network

Communication network within a plant that has control information circulating between various plant units or processing locations.

2.45 Plant Information Network

High-level communication network which serves various user's within a plant and transfer information for the purpose of unit / plant monitoring. This network is different than control network and is generally realised using open communication protocol network e.g. OPC etc.

2.46 OPC node

OPC node is any node in the network that provides OPC interfaces consistent with OPC data access, OPC alarm and event and OPC historical data access interface specifications certified against OPC compliance and interoperability test specification.

2.47 Computer Integrated Manufacturing (CIM)

Computer integrated manufacturing shall be defined as the integration of process, plant and business operations made possible through information network.

3.0 SPARES PHILOSOPHY

3.1 The system including programmable logic controller, alarm information management system, sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. This philosophy shall also be applicable for items like field-bus accessories, barriers, relays, terminals, lamps, push buttons etc.

3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply;

3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified system functional requirements by 20%. The basic of offering installed engineering spares shall include;

a) For a system with conventional and / or smart input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.

b) For a system with fieldbus input / output, 20% spare segments of each type of field-bus type (foundation fieldbus, profibus etc.) shall be considered for calculating I/O modules, power supply modules and all other related accessories. When only input / outputs are indicated instead of field-bus segments, the installed spare philosophy as specified in 3.1.1.1 (a) shall be followed.

c) For all serial input / outputs to the system 20% spare serial I/O channels of each type of serial input / output shall be provided.

d) A minimum of one spare I/O module of each type as offered to meet type of inputs / outputs specified in the material requisition.

e) 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.

f) A minimum of one number of input / output module and accessories of, each type such as analog input / output, discrete (contact) input / output, pulse input, serial input / output, foundation fieldbus / profibus PA input / output modules (in case of fieldbus based system) temperature input shall be provided irrespective of those required as per 3.1.1.1(d) as engineering spare.

g) The engineering spares shall be wired up to the field cable interface and shall be in ready-to-operate condition when field cable is connected to spare assigned terminals.

h) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.

i) The system shall be fully engineered considering 20% installed engineering spares including processor loading.

3.1.1.2 Spare Space Requirement

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the system shall be provided with following spare space;

a) The controller and data acquisition racks shall have 10% usable spare space for installing additional I/O and field-bus segment modules in future. However, the control and data acquisition processor shall have additional 10% capacity to handle these I/O's and field-bus segment. In addition, internal wiring for the same shall be completed up to I/O terminals.

b) Each operator console shall contain 10% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.

c) The system shall have capability to extend its historical trending, logging and user's memory by 20% to meet future expansion with/without adding additional memory modules.

d) I/O racks of programmable logic controller shall have 10% usable spare space for installing additional I/O cards of each type in future. However internal wiring for the same shall be connected up to the I/O terminals.

e) Processor system of programmable logic controller shall have capability to execute additional 20% logics.

f) The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O / segments over and above installed engineering spares

g) Usable spare space in panels and cabinets to install 10% spare hardwired items like barriers, trip amplifiers, receiver switches, panel mounted instrument, relays etc. in future.

3.1.1.3 Spare Memory Requirement

a) The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.

b) For field-bus based system, spare memory capacity (and CPU loading) shall be calculated considering all control algorithms being configured in the system and executed at the scan time equal to the specified control loop response time.

c) It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

3.1.1.4 Spare Software Capability

a) Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2(a) to (f) of this specification to meet all functional requirements as per para 5.0 of this specification.

b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the material requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

3.1.1.5 Predefined Mandatory Spares

a) Mandatory spares shall be ware-house spares and shall be supplied as loose items.

b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used including in consoles.

c) For items like hardwired instruments, assignable recorders, Personnel computers, VDU / video screens, keyboards, disc drives, RAID controller, lamps, network components, barriers, fuses and circuit breakers complete item limited to 5% or minimum one of each type shall be supplied as predefined mandatory spare. But this shall not include hardware like discs, terminals, switches, telephone sets etc.

d) Items like personnel computers, operator consoles servers, engineering consoles etc. where complete item needs replacement instead of individual modules, complete unit shall be supplied as mandatory spares in line with clause 3.1.1.5(b).

e) Software which need to be separately loaded in the items specified in clause 3.1.1.5(d) above to define the items personality and can't be uploaded from engineering console or any other network device shall be supplied along with additional software.

3.1.1.6 Consumable Spares

Any paper, ribbon, printer heads and ink required for printers, assignable recorders, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

3.1.1.7 Commissioning Spares

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty softwares while performing pre-commissioning and commissioning activities.

3.1.2 Two years operational spares

Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

4.0 SYSTEM CONFIGURATION

The system configuration shall consist of the following major sub-systems:-

4.1 Controller and Data acquisition sub-system

Controller and data acquisition sub-system is the main field interface sub-system and is capable of performing control and data acquisition functions as one integrated sub-system.

Controller and data acquisition sub-system shall interface with field instrumentation like transmitters, process switches and final control elements to monitor and / or control process parameters like flow, temperature, level etc. The sub-system shall include a comprehensive set of control algorithms and auxiliaries to provide close loop control and data monitoring capability of the system.

4.2 Operator interface sub-system

Operator interface sub-system shall consist of one or more operator consoles for monitoring and controlling process parameters and performing other process related functions.

4.3 Communication sub-system

Communication sub-system interconnects various sub-systems over which they can communicate with each other to meet all functional requirements.

4.4 Engineer interface sub-system

Engineer interface sub-system shall consist of an engineering console primarily for tuning, configuring and maintaining the system.

4.5 Supervisory computer sub-system

Supervisory computer, when specified, shall be employed for providing supervisory level plant control, plant and unit optimization and other computer based plant management capabilities. For the Integrated network , each node where history resides should be minimum RAID-5 configuration to ensure maximum availability of history or otherwise separate redundant Servers in RAID-5 configuration and redundant power supply configuration should be provided

4.6 Programmable Logic Controller

Plant start up and safety shutdowns shall be performed by separate programmable logic controller which shall communicate with other sub-systems over the communication sub-system.

4.7 Foreign Device Interface

Foreign Device like programmable logic controllers, gas chromatographs, analyzer systems, gas turbine systems etc. when specified shall communicate with other subsystems over the communication sub system for plant monitoring and control using foreign device interface. The foreign device interface shall be either dedicated or shall be part of controller data acquisition sub-system as specified in the job requirements.

4.8 OPC Server

OPC Server when specified in this specification is used as synonymous with any server entity on the communication sub-system network which shall allow the user to implement applications, within or

outside the system, without providing any special drivers or custom interfaces. OPC server, when specified, shall be used to transfer / receive data to / from applications run in other systems.

4.9 Unit History Node

4.9.1 Unit history node, when specified, shall store the long term historical data of the complete unit and shall interact with central computer system over plant wide network. In addition every history residing node should be minimum RAID-5 configuration.

4.9.2 Unit history modem, when specified shall be a dedicated node and shall be in addition to historical data required for normal plant operation (specified as part of operating interface sub-system).

4.10 Sequence of Event Recorder (SER)

Sequence of event recorder, when specified, shall be a dedicated equipment which shall identify, store and print alarms with the specified time resolution. SER may also transfer data to operator sub-system over communication sub-system.

4.11 Documentation node (DON)

Documentation node, when specified, shall be a node on the information network sub-system and shall store unit documentation.

4.12 Alarm Information and Management Sub-system (AIMS)

Alarm information and management sub-system when specified, shall be a alarm management package which shall gather alarm information from various sub-systems and shall present the desired meaningful analysed data for information and further analysis.

4.13 Instrument Asset Management System (IAMS)

Instrument asset management sub-system shall acquire store, analysed and present meaningful diagnostic and maintenance related data of field devices for efficient plant maintenance.

4.14 Large Display System (LDS)

Large Display System, when specified, shall consist of one or more large video screens which shall display either operator selected operator console screen or any pre-selected screen on a back projected large video screens as real time basis.

4.15 Hardwired Instrumentation

Hardwired instrumentation shall be provided as a back up to the distributed control system for critical process parameters when specified in the job specification.

4.16 Information Network Sub-system

4.16.1 Information network when specified shall interconnect with various plant wide systems like distributed control system/systems, mainframe computers, personal computers, laboratory information and management system (LIMS) etc over which any information can be exchanged without affecting and disturbing the plant control and operations.

5.0 DESIGN AND CONSTRUCTION

5.1 Design Requirements

5.1.1 The system shall be microprocessor based having functional distribution and data base distribution sub-system wise. The system design shall ensure that;

a) All the functions defined in this specifications are performed in an integrated manner

b) The access to the distributed data base is available system-wide.

This system shall also have networking capability with other systems distributed geographically in the various units of a plant, over a plant wide information network such as Ethernet or other industrially recognised open networks.

5.1.2 The system shall be of modular construction and expandable in future by adding additional modules. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.

5.1.3 System Availability

a) The system shall be designed 'fault avoidant' as a minimum by selecting high grade components of proven quality and proper design of system electronics.

Redundancy shall be provided, as per this specification as a minimum, to improve the system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub- system, if specified in job specifications, during system design.

b) The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.

c) The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows;

$$\text{Availability} = \frac{\text{Meantime Between Failure (MTTF)}}{\text{MTTF + Mean time to repair (MTTR)}}$$

For the purpose of calculations, consider mean time between repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that;

i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.

ii) Vendor provides adequate training to owner's personnel and cover all necessary maintenance related topics in their training programmes to ensure specified MTTR time.

5.1.4 Operating Environmental Conditions

5.1.4.1 Environmentally controlled location installation

a) All subsystem of Distributed Control System located in control room, Local Control Room or in Satellite Rack room shall be able to operate satisfactorily from 15°c to 30°c and 20% to 80% non condensing humidity.

b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°c and 90% non-condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each enclosed cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets etc and also provide alarm for operator alert in case the safe operating temperature limits are exceeded. Alarm in the operator consoles shall be available for each cabinet while group alarms shall be provided on hardwired annunciator located on hardware console.

c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits

Contaminants (Corrosive Gases)	Concentration
SOx	<10ppb
Nox	<5ppb
H2S	<5ppb
Cl2	<10ppb
SPM	<0.2gm/m3

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments.

d) Vendor shall provide continuous corrosion monitoring system consisting of transmitter with 4 – 20mA output and switch unit with setting as per contaminant level exceeding limits specified in clause 5.1.4.1(c) of this specification. Unless otherwise specified the number of corrosion monitors shall be as follows;

Equipment Type	Room Type	Quantity
Corrosion Transmitter	Rack Room / Satellite Rack Room	1 No.
Corrosion Switch Unit	Rack Room / Satellite Rack Room	3 Nos.
	Console Room	1 No.
	Engineering Room	1 No.

Continuous corrosion monitoring trend and alarms shall be provided on the operator console while one group alarm shall be provided on the hardwired annunciator located on the hardwired console.

5.1.4.2 Outdoor Installations

a) Sub-systems or system components which are installed outdoor shall be able to continuously operate at ambient temperature of 50°c and non-condensing humidity of 90%.

b) Unless otherwise specified, all sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

5.1.5 Transient, Static and EMI / RFI Protection

5.1.5.1 The system shall be internally protected against system errors and hard ware damage resulting from:

a) Electrical transients on power wiring

b) Electrical transients on signal wiring

c) Connecting and disconnecting devices or removing or inserting printed circuit boards in the Distributed Control System(DCS) and Programmable Logic Controller (PLC) .

5.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way radios, electrical storms, solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments (RFI) and (EMI) noise generating equipments as per IEC-61000-4. The surge withstand capability for input/output modules shall be as per IEEE standard 472.

5.1.5.3 System cables for interplant, inter unit, and others routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

5.1.6 On-line replacement

5.1.6.1 On-line replacement of electronic module shall be possible in such a way that removal and addition of an I/O module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system while replacing a faulty module wherever redundant modules are provided.

5.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without effecting the system redundancies.

5.1.7 Electrical Isolation

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows;

Analog I/o channel to system ground : 1500 VAC

Discrete I/o channel to system ground : 500 VAC

Isolation shall also be provided between Engineering / operator console/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

5.1.8 Design Requirements of Equipments in Hazardous Area

5.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system including compiling and maintaining the engineering data base of these devices and incorporating the data base into the Asset Management System.

5.1.8.2 General Requirements

a) Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.

b) For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

c) Fieldbus segment in classified area may consist only of the type and number of devices which will not cause the segment current draw to exceed the rated barrier / isolator parameters.

5.1.8.3 Fieldbus design in Hazardous Area

The segment design and equipment solution shall be based on the classified area concept used. The functions and entity / safety parameters of power conditioner, safety barriers / isolator, terminators and field devices shall be considered to verify the compliance to the requirements applicable for the specified concept. Following concepts shall be used depending upon the one specified in the job specifications;

a) Entity Concept

Certified entity / safety parameters of each device shall be used to match the entity parameters on entity concept.

b) FISCO

Certified FISCO parameters shall be used and shall be matched like entity parameters. All elements in the hazardous area and their interface module shall be certified FISCO.

c) FNICO

Certified FNICO parameters and equipment shall be used to design loop on the basis of FNICO.

d) Multi barriers

The safety barriers / isolators shall be installed in the field in an increased safety enclosure. The enclosure shall be metallic either of SS or of anodised alluminium. The entity / safety parameters shall be matched as in case of entity concept. Vendor's scope shall include barriers duly installed in the box / junction box.

5.1.9 Repeat Signals

5.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals;

a) Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed;

i) For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.

ii) For all other contact inputs, repeat contact shall be provided using electro magnetic relays.

b) Whenever repeat analogue outputs are required as per job specifications, following philosophy shall be followed;

i) For intrinsically safe analogue inputs, isolating barrier with dual analogue outputs shall be utilized.

ii) For all other analogue inputs, repeat analogue outputs shall be provided using signal isolators with dual output.

5.1.10 System Integration

The distributed control system shall be a fully integrated control system , also the Shut Down System (Safety Instrument system(ESD)) and the Fire and Gas system should be fully integrated with the control system . Shut Down system and Fire and Gas system should not be integrated with the control system as or with serial/Foreign/third party device card , however engineering database and engineering tool of all the above three system should be separate, dedicated and independent of each other Foreign devices like analyser system, third party equipment, (like compressors etc) etc. shall be functionally integrated with the distributed control system. Functionally integrated system shall meet the following requirements, as a minimum;

a) The foreign devices shall either be configurable from DCS engineering consoles or from the dedicated engineering consoles of each foreign device.

b) Unless specifically indicated otherwise, each foreign device shall be integrated with DCS through MODBUS (RTU) protocol using redundant interface unit.

c) Operator console shall display information in the similar fashion irrespective of source of information. Source of information shall be transparent to the operator.

d) The process alarms and diagnostic alarms shall be presented on the operator console in the similar fashion as DCS alarms.

e) Whenever specifically indicated, the time of all foreign devices shall be synchronized with DCS clock or GPS, as specified in the job specification.

f) The data transfer to and fro from other distributed control systems or supervisory computers through information network shall utilize OPC protocol with adequate security.

5.1.11 Surge Protection

5.1.11.1 Surge protection devices (SPD's) shall be provided on the system to limit the surge voltages reaching beyond the safe limits, under normal, abnormal or lightening strike condition. Unless otherwise specified, SPD's shall be provided at least at the following locations;

a) All serial signal cables (UTP / STP / coaxial and not fibre optical) going from or to control system and from one location to another out side the control building at both ends.

b) All fieldbus segments at control system end.

c) All power incoming cable (220 V AC) UPS or non UPS, at the power supply distribution cabinet.

5.1.11.2 The selection of type and rating of SPD shall be selected such that the introduction of this device shall not change the characteristics or reliability of an application, whether it is for the protection of power system, signal such as fieldbus or analog or communication signal, as applicable.

In case of fieldbus system, the SPR shall be selected such that its inclusion in the segment shall not degrade the fieldbus signal, maximum length of the segment and / or number of devices on a segment significantly.

5.1.12 System Securities

5.1.12.1 The system shall have incorporated a fool proof system security feature in its design which would protect its data base and functioning against viruses, trojans and works through integrated anti virus, fire wall and intrusion detection for the system.

5.1.12.2 All devices and / or servers which interface and interact with external application must be supplied with hardware and software firewalls.

5.1.12.3 All the security protections, hardware or software, as offered shall provide protection against all sort of threats and vulnerabilities which include;

a) Positive user authentication and login privileges.

b) Prevention of importation of viruses.

c) Packet filtering, content filtering, URL filtering protocol filtering and application level filtering to accept only intended data.

d) Strict Access controls like password hash files, cryptographic material used in confidentiality etc.

e) Hardening of operating system.

f) Firewall proxy.

g) Network sniffers and file integrity checkers

h) Scanning, enumeration and vulnerability scanning tools.

i) Log file analysis tools.

The functionalities indicated above are the indicative security features and shall be provided within and where data import / export utilities apply.

5.1.13 System Software

5.1.13.1 The system software shall be governed by the operating system running in a real time mode and shall be able to meet all functional requirements specified in clause 5.2 of this specification as a minimum. Any other standard/special software package, if available, shall also be offered describing the full capabilities.

5.1.13.2 The operating system and other standard softwares (e.g. OPC foundation fieldbus etc.) shall be of latest version.

5.1.14 The system shall have the capability of detecting the open sensors and short sensor. The sensor status reading on failure either upscale or downscale shall be field configurable.

5.1.15 Emergency Switches (ESD Switches)

5.1.15.1 All Emergency (ESD) switches shall he hardwired and shall preferably pull type with red coloured knob. Control room mounted ESD switches shall be installed on hardwired console.

5.1.15.2 ESD switches shall directly trip the final ESD element without any intermediate device. Where multiplication of ESD switch contacts is necessary fail safe relays shall be utilized (SIL3).

5.1.15.3 In addition to utilizing contacts for direct shutdown, the contacts shall also be used in ESD system (PLC etc) for logic implementation and event history.

5.1.16 Alarm by-pass Switches

5.1.16.1 Startup by-pass (SBS) switches

a) Unless otherwise specified, all SBS's shall be configured in the ESD system (i.e. PLC) and shall be operable from DCS operator console and PLC operator console when specified. All such by-pass switches shall be alarmed and shall have audit trail.

5.1.16.2 Maintenance by-pass switches (MBS's)

Unless otherwise specified, following philosophy shall be utilized for MBS's;

a) All process inputs shall have miniature back lighted MBS (else shall have LED to show by-pass status).

b) MBS shall be installed in a cabinet which can be physically lockable. The by-pass status shall also be available in operator console with a common flashing message always appearing on operator server whenever an MBS is operated. All MBS's shall have audit trail.

c) Logic-wise common alarm shall also be available on the hardwired console.

5.1.17 Interface with Electrical Input / Outputs

5.1.17.1 All contact input and output contacts from electrical switch gear panels (MCC / PCC etc.) shall be terminated in a dedicated 'Electrical Interface marshalling cabinet' located in control room. All such I/O's shall have intermediate relays.

5.1.17.2 Remote I/O rack shall be provided in sub-station for non-shutdown related data, when specifically indicated in the material requisition.

5.1.17.3 All serial I/O cables from sub-station to control room shall be redundant including remote I/O cable.

5.1.18 Automatic Loop Tuning Software Package

5.1.18.1 It shall be possible to tune a control loop or group of control loops on selective basis at a time automatically unless otherwise specified. Tuning parameters computed by the system shall either be loaded automatically or manually by operator.

5.1.18.2 The automatic loop tuning software shall be used to tune PID control loops. The auto tuning technology used shall utilize principles like Ziegler – Nichols, Cohen – coon or Internal Model Control (IMC).

5.1.18.3 The software package for loop tuning may reside / run on any system hardware including controller sub system, console sub system, engineering sub system, supervisory computer etc. The tuning software must ensure that the process is not disturbed whenever a loop is being tuned.

5.1.18.4 Automatic look tuning package shall be able to study the dynamics of control loops and shall be able to compute response time, dead time, lead or lag time etc. directly from Engineering / operator console.

5.1.19 The system shall be suitable for power supply as specified in para 6.2 of this specification. Suitable battery back-up shall be provided for volatile memory protection only.

5.1.20 System Upgrade Capability

5.1.20.1 System shall be scalable and upgradeable by adding additional hardware, over and above the spares specified, without rendering the initial hardware and software investment obsolete within the capability of the system.

5.1.20.2 This is in addition to the system upgrades, hardware and software, available from vendor as standard from time to time.

5.1.21 Noise Level

5.1.21.1 Noise level generated by any equipment shall not exceed the following limits;

a) Noise level shall not exceed 55dBA for equipments installed in console room, engineering room and computer room.

b) Noise level shall not exceed 65dBA for equipments installed in rack room and satellite rack room (SRR).

c) For control rooms where consoles and cabinets are installed in the same room, the noise level generated by any equipment shall not exceed 55dBA.

5.1.21.2 The noise level shall be measured in dBA at a distance of 1 metre from the equipment generating noise.

5.1.22 Equipment Identification

Unless otherwise specified, all equipments shall be identified by tag numbers indicated in the data sheet / summary sheet attached with the material requisition. The tag number shall be inscribed on a nameplate which shall be fixed with screws.

The nameplate shall be black laminated plastic with core i.e. black with white characters. The size and description shall be subject to purchaser's approval.

5.1.23 System Furniture

All system furniture required for mounting and operation of the system including mounting of tabletop equipments shall be supplied. Furniture for operating personnel shall be as defined in job specifications.

5.2 Functional requirements

5.2.1 The system, as a minimum, shall meet the following requirements without the supervisory computer:

a) Control
b) Data acquisition & monitoring
c) Alarming
d) Logging & report generation
e) Historical data storage
f) Trending
g) System shall have some free memory space available for the user and CPU shall have the additional capability to perform advance control functions, process optimization programs or generate management reports as specified in job specification in addition to space requirements as per para 3.0 of this specification. The availability of process control language shall be preferred.

h) System shall support functionalities like remote calibration, remote diagnostics and asset management in case of smart or field-bus based instruments.

5.2.2 In addition to above, following functional requirements shall also be complied, when specifically indicated in the job specifications;

a) Sequence of event function.

b) Alarm management

c) Long term historisation

d) Open system connectivity

5.2.3 The system when specified with Programmable Logic Controller (PLC) either as integral part of system or as separate third party device it shall perform follow functions;

a) Process interlocks

b) Plant safety shutdown

c) Monitoring the sequence control units, when specified

Plant process and safety shutdown shall be independently performed by programmable logic controller. (PLC shall be communicating with other sub-systems via communication sub-system).

5.2.4 The system when specified along with a supervisory computer, shall meet the following requirements in addition to as specified in para 5.2.1 of this specification.

a) Advanced Control

b) Unit and plant optimization

c) Management information service reports.

5.2.5 Whenever information network alongwith plant wide interconnectivity is specified, the system shall meet any or all of the following requirements in addition to those specified in para 5.2.1 of this specification as specified in the material requisition:-

a) Centralised information system

b) Statistical process control/statistical quality control.

c) Plant optimization, data reconciliation, overall mass balance, etc.

d) Plant planning and scheduling.

e) Computer integrated manufacturing with information transfer to achieve functions like production and preventive maintenance scheduling and plant wide coordination etc.

5.2.6 The system as offered shall be fully and functionally integrated meeting the requirements specified above. In addition, the system shall also have capability and capacity to interact with smart and field-bus instrumentation simultaneously. The system shall also be capable of accepting signals from different type of field-buses in the same controller and data acquisition sub-system.

5.3 Controller and data acquisition sub-system (CDAS)

5.3.1 Controller and data acquisition sub-system shall primarily be used for plant control and data acquisition and shall interface with physical inputs and outputs from the plant and third party devices.

5.3.2 CDAS shall be microprocessor based and fully programmable sub-system which shall be capable of processing the acquired data from input / output devices utilizing a set of algorithms within its defined processing cycle. The microprocessors utilized in controller and data acquisition sub-system shall generally be of latest generation.

5.3.3 CDAS shall have a multi-processor architecture with each processor responsible to carryout predefined functions like Input / Output processing, control processing, internal communication, external interfaces etc.

5.3.4 The hardware and software capability of this sub-system shall primarily be exploited for processing regulatory close loop and open loop control functions only. Sequencing and interlocking capability shall be utilized whenever specified in job specifications.

5.3.5 CDAS shall be capable of accepting signals from various process sensors and devices with linear, non-linear and serial outputs preferably without requiring external or auxiliary signal conditioning devices and processing signals. Typically the inputs shall include 4-20mA DC (both conventional and HART), 1-5VDC, milli volt signal from thermocouples, resistance from resistance temperature detectors (RTD's), pulse input, field-bus (foundation field-bus, profibus PA etc.), serial inputs (MODBUS) and discrete contacts (powered or potential free), as a minimum. System shall also accept other inputs when specified in job specifications.

System shall be able to accept 2-wire, 3-wire and 4-wire signal inputs without any change in the I/O module.

5.3.6 The system shall have capability to generate analog 4-20mA DC (conventional or HART) current signal, 1-5VDC voltage signal, field-bus output signal, potential free contacts for discrete outputs and serial (MODBUS) outputs, as a minimum, apart from others specified in the job specifications.

5.3.7 The output from the system shall be capable of driving following loads;

a) Analog outputs shall be able to drive loads of output devices such as I/P converters, smart positioners, recorders / indicators etc. In general, it should have load driving capabilities up to 750 ohms.

b) Contact outputs suitable for driving alarm annunications, status lamps, relays, converters, solenoid valves, contactors / breakers of motor control etc. In general, contacts rating shall as follows;

Intrinsically safe load : 30V 0.5 Ampere

AC powered loads : 230 V 5 Ampere

DC powered loads : 110V 0.5 Ampere
DC powered loads : 220V 0.2 Ampere

5.3.8 The system shall be capable of differentiating between out of range measurement (Bad process value) and a failed transmitter signal. In conventional 4-20mA output transmitter this shall be identified by setting bad quality data flags while for smart (HART) and field-bus transmitters data quality indicator from the device shall be utilized.

The detection of device failure alarm and driving output to a pre-defined value shall be configurable within this sub-system.

5.3.9 It shall be possible to override or force an input measurement or an output in the system while testing or on failure of an input.

5.3.10 Controller and data acquisition sub-system shall have a non-volatile memory for storing configurational data. In case vendor's standard product supports only volatile memory, battery back-up shall be provided to store the data for a period of 72 hours, as a minimum. A battery drain indication along with a potential free contact shall be provided to alert the operator.

5.3.11 The sub-system shall have sufficient memory to store the program instructions, CDAS data base, data required for real time trending and point trend and any other data required to be stored to meet specified functional requirements.

5.3.12 The sub-system shall incorporate a hardware or software based watch dog timer to monitor the healthiness of the CDAS processor-health.

5.3.13 Each controller and data acquisition unit shall have its own dual redundant power supply which can be replaced online. Separate dual redundant power supply unit shall be provided for powering field devices.

5.3.14 Controller and data acquisition sub-system shall be modular in construction with rack mounted modules in general. Input / Output modules shall be either rack mounted or DIN Rail mounted type.

5.3.15 Input / Output Modules

5.3.15.1 General

a) I/O modules shall communicate with processor modules serially either through back-plane or through I/O communication network. I/O network shall always be redundant. Data transferring through hardwired connections shall not be acceptable.

b) Analog to digit converters for analog 4-20MA / 1-5VDC modules shall meet the following requirements;

A/D Resolution 12 bits

Repeatability	± ½ LSB
Accuracy	± 0.1% of full scale
Common mode Rejection	60dB at 50Hz
Normal mode Rejection	55dB at 50Hz

c) Digital to analog converters for output module shall meet the following requirements;

D/A Resolution	10 bits (min.)
Repeatability	± 1 LSB
Accuracy	± 0.25% of full scale

d) Each output channel must maintain its own – failure mode value, which is automatically executed upon detection of a communication failure between process and output module.

e) Unless I/O module has universal design it shall have unique keyed facility to prevent faulty operation and termination.

In addition I/O modules shall also meet the specific requirements specified in clause 5.3.15.2 through 5.3.15.7.

5.3.15.2 Analogue Input / Output modules (conventional / smart)

The input module shall meet the following requirements;

a) It shall accept 4-20mA isolated input with maximum input resistance of 250 ohms or 1-5VDC isolated input with input resistance more than 500k ohms.

b) The input module shall support field powered transmitter i.e 2-wir, 3-wire or 4 wire system.

c) Input faults such as open circuit, short circuit and earth fault shall be detected by I/O module.

d) The output module shall provide 4-20mA output driving up to 600ohms of total loop resistance at 24V DC.

e) The system shall provide 24V DC for loop powered 2-wire transmitter and shall also loop power the 2-wire outputs.

f) Input / Output module shall not have more than 16 inputs or outputs.

5.3.15.3 Analogue Input / Output module with HART

a) The Analogue Input / output modules for HART signal shall meet all requirements specified in clause 5.3.15.2 above.

b) Input / Output shall fully support the HART communication signal i.e. the American Bell 202 standard frequency shift keeping signal superimposed at a low level on analogue measurement signal.

5.3.15.4 Foundation Fieldbus (H1) Interface Module

a) Foundation fieldbus HI interface module shall be capable of supporting multiple segments and able to operate in full redundancy mode.

b) Foundation fieldbus H1 interface module shall always be provided in redundant configuration with Link Active Schedulers (LAS) configured in primary and back-up HI interface modules respectively to ensure that failure of primary LAS shall not cause failure of H1 bus communication. Power for H1 segment shall be provided by power conditioner module which shall be separate from H1 interface module to ensure that failure or removal of H1 interface module does not affect the supply of power to the segment.

c) HI interface module shall be supplied with link active scheduler (LAS) capability and running foundation fieldbus (FF) function blocks which include PID, PD, Bias, Gain, calculations etc. These function blocks shall be code identical to FB code provided in the field devices. The manufacturer shall guarantee the interoperability of HI interface module with any function box residing in the field device.

d) Foundation fieldbus HI interface card shall utilize a fieldbus Foundation Registered mark.

e) The sub-system shall accept all the dynamic variables transmitted by the field-bus-device.

5.3.15.5 Temperature Input Module

a) The thermocouple input module shall accept grounded or ungrounded inputs from various thermocouple types i.e. T, E, J, K, R, S and B. The module shall be capable of linearising the thermocouple inputs and provide cold junction compensation.

b) The module shall have 12 bit resolution with digital accuracy of ±1°c

c) The RTD input module shall accept 100ohm platinum resistance temperature detector (Pt 100) in 3-wire or 4-wire configuration.

d) The module shall be capable of linearising the RTD input.

e) The module shall have 12 bit resolution with digital accuracy of ±0.28°c

5.3.15.6 Serial Interface Modules

a) Serial Interface modules shall be capable of communicating with RS232C, RS422 or RS485 signals.

b) Unless otherwise specified, all serial interface modules shall be configured in redundant configuration.

5.3.15.7 Discrete Digital Input / Output Module

a) Digital input module shall be capable of detecting close or open status of powered or potential free contacts. The interrogation voltage of the contacts shall be 24VDC or as per selected barrier for barrier powered contacts.

b) The input module shall also be suitable to accept inputs from proximity switches or from open collector output from proximity input barrier.

c) The digital output module shall provide output contact rated for 220V AC 10 Ampere 110V AC 5 Ampere or 110V DC *0.3* Ampere.

d) The type of contact output ie. normally open or normally closed shall be user selectable.

e) Maximum number of inputs or outputs shall not exceed 32.

5.3.16 Fieldbus Segment Power supply and terminators

5.3.16.1 The power supply used for powering fieldbus segment shall have a impedance matching network, preferably part of power supply unit.

5.3.16.2 Short-circuit at spur level shall not lead to failure of any fieldbus segment except the short-circuited spur.

5.3.16.3 Unless otherwise specified, fieldbus power supply / conditioner shall meet the requirement of type selected instruments and shall be as per;

a) Foundation fieldbus power supply Type 131 non – IS power supply intended for feeding IS barriers.

b) Foundation fieldbus type 133 IS power supply compliant with IS parameters.

c) For Non-Intrinsically safe segment, the power conditioner shall be capable of each drawing 20mA current supplying power to at least sixteen field devices including a segment terminator.

d) For intrinsically safe segment, the power conditioner shall comply with FISCO or entity concept requirements as specified in purchaser's specifications.

e) For a segment designed with Non-insendive concept, the power conditioner shall meet the requirements of FNICO.

5.3.16.4 Each foundation fieldbus power supply shall have redundant power conditioners (unless limited by concept design), current limited outputs to all foundation fieldbus segment and surge protection as applicable.

5.3.16.5 Individual power conditioners and input power supplies can be replaced without interrupting power or communication fieldbus segment.

5.3.16.6 Terminators

Terminators shall be provided by vendor at both ends of a foundation fieldbus segment. The terminator at DCS side shall be incorporated into the foundation fieldbus power supply / conditioner while field side terminator shall be installed in the junction box.

5.3.17 Control functions and algorithms

Controller and data acquisition sub-system shall have capability to perform conventional and advanced control algorithms for implementation of regulatory and advanced control strategies. This sub-system shall have real time computational capability and shall be able to perform following algorithms and computations in addition to those specified in job specifications;

a) Control algorithms

Proportional (P), Proportional – Integral (PI), Proportional – integral – derivative (PID), adaptive gain, feed forward, cascade, split-range etc.

b) Dynamic Functions

Lead-lag, dead time, timers, counters etc.

c) Signal Selector

High selector, low selector, high-low selector.

d) Calculation Blocks

Linearisation, pressure-temperature compensation, polynomial, multiplication / division / addition / subtraction etc.

e) Signal Limiters

Low limiter, high limiter, high-low limiter etc.

f) Logic Blocks

Logic 'GATES' (OR, AND, NOR, NOT NAND etc), Flip-flops etc.

5.3.18 Controller shall be able to operate in either manual, auto, cascade or computer mode. Mode changeover in either direction shall be procedure-less and bump-less. Following functional capability shall necessarily be possible;

a) In cascade loops, the primary controller shall be able to track the set point of the secondary controller when the secondary controller is not operating in cascade mode.

b) In computer mode, controller shall be able to track computer generated set point and shall hold the last generated value in case of computer failure. In such case, controller shall fall back on auto-mode and continue to operate at the last received set point, in general. Other options like

pre-defined set point operation and fail safe condition shall also be possible. On the resumption of computer set point again, the controller shall not return to the computer mode automatically. Computer failure indicator shall be provided at central and local level.

5.3.19 Controller shall accept the change in set point command from central level (as operator interface function) and take action accordingly. It shall have facility for slow and fast ramping of set point as well as output. In addition, it shall have anti-reset wind-up feature as standard.

In addition to above, it shall also be possible to change set point, tuning constant, operating mode, controller configuration from the central level i.e. operator's interface keyboard and engineer's interface keyboard.

5.3.20 Loop Integrity

5.3.20.1 Loop integrity shall be maintained in controller functionality in such a way that the single component failure in the sub-system shall not effect more than one control loop (single loop integrity). This shall be achieved in offered sub-system architecture in one of the following ways;

a) By providing one to one controller back-up. In case failure is detected in the active controller all the loops of the failed controller shall be transferred to the back-up controller.

b) Where single loop controller is specified in the purchase specifications, no controller back-up shall be necessary provided no input other than that required for the specified loop is connected to the controller.

5.3.20.2 Loop integrity shall be maintained for the data acquisition functionality i.e openloop processing including processor such that a single component failure shall not effect more than 16 analog inputs or 32 discrete inputs.

5.3.20.3 Loop integrity shall also be applicable to I/O modules, power supply modules, communication modules and other associated devices as per the philosophy explained in clause 5.3.20.1 and 5.3.20.2 of this specification.

5.3.21 Sub-system Redundancy

5.3.21.1 In case of redundant configuration (where back-up components are provided), the design shall incorporate a fail-safe automatic control transfer switching mechanism which shall transfer the entire configuration, data base and loop control of the failed controller to the back-up controller. Design must also ensure that data integrity is maintained during switchover and no portion of data to be transferred is corrupted or lost before and during switch over to the redundant (back-up) controller. The indication of the failed controller / component shall be displayed at the level as well as on the central level.

5.3.21.2 The switchover from primary to back-up component / device shall be bumpless and transparent to the operator i.e. the outputs shall be held at the last value during switchover to avoid any process upset. The switchover time shall be of the order of one (1) second.

In case of redundant HI modules, the back-up module shall maintain connectivity with all publishers and shall subscribe to all publishers to minimise switchover time.

5.3.22 Sub-system configuration and on-line modifications

5.3.22.1 Controller and data acquisition sub-system shall be configured from the central level i.e. through engineers interface sub-system under password or hardwired key lock protection. Single loop controller when specified shall be configured from the local level.

5.3.22.2 Sub-system shall allow following configurational functions to be performed for each loop;

a) Control function parameters
b) Processor cycle time for each loop tagwise.
d) Macro-cycle time for foundation fieldbus HI segment as per segment loading.

d) Output status of each control loop in case of processor failure.

5.3.22.3 It shall be possible to carryout online modifications or perform back-up without interrupting the central software of preventing the operator commands. Such modifications shall be possible without any plant upset or process interruption.

5.3.22.4 Downloading of modifications to the respective controller and data acquisition sub-system shall be possible in running condition.

5.3.22.5 Sub-system shall perform saving and back-up of data base as per changes made automatically.

5.3.23 System Diagnostics

5.3.23.1 Each module shall have a board diagnostic with on board LED for indicating status of the module at local level.

5.3.23.2 All diagnostic subroutines shall carryout various diagnostic tests to check the healthiness. The test shall include memory test (RAM and ROM), on-board processor test and back-up module communication healthiness test etc. Failure of any of the tests shall be alarmed as module failure.

5.3.24 Sub-System Performance

The sub-system response time shall be the indicator for the performance of the sub-system. The control system shall be able to perform control algorithm, calculation function etc. for each loop within the specified response time unless specified otherwise in the purchaser's data sheets, the system

response time (scan time) and loop response time as defined in clause 2.22 and clause 2.26 (for fieldbus based system) respectively of this specification shall be as follows;

- 20 msec. for anti-surge control loops
- 200 msec. for flow and pressure control loops.
- 500 msec. for all other control loops
- 1 sec. for temperature acquisition and other acquisition loops

The processor cycle time shall be set to achieve the scan time and loop response time values specified above.

Scan time of multi-variable advanced control loops when implemented in controller and data acquisition sub-system shall be specified in purchaser's data sheets.

5.3.25 Controller & data acquisition subsystem loading

The system loading for controller and data acquisition subsystem shall not exceed 60%. The loading as indicated here is the worst case of high system activity referred to the use of memory, CPU time and communication capacity for this sub-system.

5.3.26 Sub-system Sizing

5.3.26.1 Sizing of controller and data acquisition sub-system shall be carried out considering the following parameters, as a minimum;

a) Unit-wise segregation of CADS as specified in the job specification.

b) Number and type of inputs / outputs specified in each unit in the job specifications e.g. analogue I/Os (conventional / smart (HART), Fieldbus I/Os, discrete I/Os etc.

c) Intrinsically safe and non-intrinsically safe I/Os.

d) Spares philosophy.

e) Distribution of spare I/O's in I/O modules

f) Scan time (Response time) and loop response time specified for each type of I/O.

g) Segment design criteria

h) Worst-case processor loading specified in the specifications.

i) Calculation blocks specified in the job specification. Following philosophy shall be followed for computing calculation blocks in addition to those indicated;

PID Blocks	-	No of outputs
Calculation Blocks	-	50% of PID Blocks or 130% of specified calculation Blocks whichever is higher.
Logic Blocks	-	150% of specified blocks or 100% of specified Discrete outputs whichever is higher.
Advanced blocks	-	150% of actual numbers specified.

For the purpose of block calculation, consider actual I/O's along with installed engineering spares. Also consider clause 5.3.26.2 (e) for fieldbus based system.

j) Serial interface modules in redundant and single configuration as specified.

k) Any parameter not specified above but required to be considered for size because of vendors standard sizing methodology.

Processor loading factor / calculation available in standard product guide for sizing shall be utilised else vendor shall reduce the sub-system block handling capability by a factor of loading.

5.3.26.2 In addition to relevant requirements specified in Clause No.5.3.26.1, following process control functionalities and requirement must be considered for fieldbus segment design;

a) The sensor device and the corresponding actuator in a control loop shall be on the same fieldbus segment.

b) Control loop that include a cascade type controller, the primary and secondary loop measurement as well as final control element shall be on the same fieldbus segment.

c) Split range measurement and final control element shall be on the same fieldbus segment.

d) Discrete fieldbus device used in an interlock alongwith a control loop, discrete device shall preferably be on the same fieldbus segment. Discrete device here means fieldbus converter.

e) The default configuration shall be for control (except high level calculations) to reside in fieldbus device. System shall be configured for control to fail over to CDAS

f) Type of hazardous area philosophy i.e entity concept, FISCO, FNICO or high power trunk.

g) Length of each segment with respect to the physical distance between control system (host) and field devices.

h) Loop response time or macro cycle time as specified.

i) Sufficient unscheduled time must be kept in each cycle to transmit a cycle information within defined loop response time. This shall be 50% of the specified loop response time.

5.4 Operator interface sub-system

5.4.1 General

5.4.1.1 The operator interface sub-system shall provide the centralized information to the plant operator/Engineer in the following fields:

a) Indication of all analog and digital process variables of control loops, open loops and all loop related parameters

b) Manipulation of control loops including changing set point, mode, output, configuration, tuning, and computational constants.

c) Alarm displays and annunciation.

d) Graphic displays and status indication.

e) Logging and trending including historical trend recording.

f) Trend recording on assignable trend recorders.

g) Self diagnostic messages.

5.4.1.2 The operator interface sub-system shall consist of a single or multiple operator consoles (VDU's driven by console electronics) and hardwired consoles. The number of consoles for a unit shall depend upon the size and operating philosophy of the plant. The number of console shall be specified in the job specifications.

5.4.1.3 The operator interface subsystem shall have either single tier construction or stacked construction. The type of construction shall be specified in the material requisition.

5.4.1.4 The operator station shall comply with ISO 9241-5 'Workstation layout and postural requirements' and ISO 9241-7 'Display requirements with reflections'. The layout of the operator interface sub-system shall be as indicated in the material requisition. The consoles required to meet the shape and symmetry indicated shall be supplied by the vendor.

5.4.1.5 Unless otherwise specified in job specifications, each VDU shall be a 459.7mm active matrix TFT type LCD display unit and shall have native resolution of 1280 x 1060 pixels, as a minimum, with a 160° wide viewing angle.

5.4.2 Operator Consoles

5.4.2.1 Each operator console shall consist of the following;

a) Single tier construction shall have three (3) VDU screens with its own dedicated keyboards (a total of three keyboards) each driven by an independent electronics.

b) Stacked construction shall have the two stacks of VDU's with four VDU's (2VDU's / stack) and two sets of keyboards (one keyboard / stack) each stack driven by an independent electronics.

c) Each operator video screen or 2 VDUs of stacked construction shall be driven by a dedicated driver electronics which also keeps the desired data base for various functions defined and termed as workstation. All the three operator workstations shall be operationally interchangeable in such a way that all the three workstations have similar data base and functionalities.

d) The operator console shall also have a logging printer, a alarm and event printer and a hard copy unit, unless otherwise specified in job specifications.

5.4.2.2 Hardware Configuration

The operator console shall meet any one of the following configuration options;

5.4.2.2.1 Option I

Each operator video screen shall be driven by a dedicated driver electronics which also keeps the desired data base for various functions defined and termed as workstation in this case each as has data stored in it should be minimum RAID-5 configuration to ensure maximum availability of history/data . All the three operator workstations shall be operationally interchangeable in such a way that all the three workstations have similar data base and functionalities.

5.4.2.2.2 Option II

One or more number of operator console (consisting of three video screens and dedicated keyboards) are driven by a common redundant server machine storing a common database for all the three video screens (three video screens may work like clients to this server).

Server shall be a multifunction higher end server grade machine which may support functionalities such as;

a) Data connectivity between CDAS and other sub-systems (i.e. operator sub-system, engineering sub-system, IAMS etc.)
b) Database storage and engineering functionality as per Clause 5.4.2.3 of this specification.
c) Historisation of data related to associated operator consoles.

This server can also be used for functions like;

a) Plant history (UHN)
b) Connectivity to information network or OPC node.
c) Running specific applications like generating advance controls, MIS reports, IAMS, AIMS etc.

5.4.2.2.3 Option III

a) Two parallel servers (each containing same data base, each driving), two of the operator console VDU's are driven by a server which stores complete data base for the units being assigned. In this case, operator console shall have four operator console VDU's (instead of three specified as operator console). Similar philosophy shall apply in case of stacked VDUs operator console.
b) In case, multiple servers are used to support different functions like data connectivity, data base storage and historian function, similar philosophy as 5.4.2.2.3(a) may be followed.

5.4.2.3 The system shall have global data available at each operator console electronics and all the functions explained in Clause 5.4 shall be available / executed at operator console. However, in case functionalities are distributed in various intelligent hardwares / softwares or in case of distributed database / console functions is supported by the standard system architecture, each data base electronics / functionality shall be RAID 5 configuration dual redundant. Further any change made in the data base of one operator console shall automatically update the data base of other operator consoles if configured identically. Following shall apply;

a) history function, for the units monitored and controlled from the operator console, shall be RAID 5 configuration dual redundant with each node have dual disc drives dedicated for history storage.

b) Data base storage function for the units being monitored and controlled by the unit shall be RAID 5 dual redundant and shall have dual disc drive configuration.

c) All stations used for data storage and such functionalities shall have RAID5 configuration.

5.4.2.4 The operator, as a minimum, shall have access to the following through the operator key board at all times:

a) Selection of all the displays including the direct selection of loop in alarm, page turning facility, overview, group view and loop view selection etc.

b) Selection of loop for operation.

c) To acknowledge alarms as and when they are annunciated on the operator console.

d) Facility to enter any changed parameter like setpoint, manipulated variable, digital commands and to cancel any wrong entry while making such change.

f) Facility for easy positioning of cursor for the selection of any parameter.

g) Selection of hardcopy printout, logging printout, alarm history printout and assignable trend recorder points.

h) Auto/manual/cascade/computer mode changeover of each controller.

5.4.2.5 In addition the Engineering keyboard shall have the following capabilities for restricted user/engineer through a key-lock or with password protection;

a) Data base configuration including overview, group, loop, multi-loop and multi-variable control configuration.

b) Group or multi-group alarm inhibit from a plant under maintenance.

c) Reconfiguration of alarm settings and their values, addition and deletion of components in a loop.

d) Tuning of control loops including change of P, I, D and dead-time contacts

e) On-line compilation of graphic displays using standard user defined symbols.

f) Changing of parameters to be logged.

g) Setting of real time clock.

h) Assigning of parameters for historical trending.

i) To call detailed self-diagnostic for maintenance.

Any change made for any parameter for an input from any display shall be automatically updated on all displays configured for that input.

5.4.2.6 Operational Protection

A key-lock switch or software password shall be provided for operational protection. Following minimum level of access and authorisation shall be available;

Operator Level	-	Authorises all commands for plant operation.
Engineers level	-	Authorises all commands for plant operation and system engineering.
Management Level	-	Authorises all operational data and reports to be viewed.

Other levels of key-lock / password protections if available as standard with the system shall also be offered.

5.4.2.7 It shall not be possible to override any process variable or digital status from operator keyboard.

5.4.2.8 Each keyboard either integral or as a separate attachment shall have a set of dual function user configurable keys. These keys shall be configured to access important pages in single keystroke. These keys shall have LEDs which flash on pre-configured alarm conditions. A minimum of 32 number of such keys shall be offered with each keyboard. Systems, which do not support dual function keys with their standard keyboard shall offer either;

i) a dedicated VDU and keyboard with each operator console configured with an intelligent graphic which would replicate the functionality of dual function keys.

ii) a dedicated keyboard with dual function keys alongwith each standard keyboard.

5.4.3 Process displays

5.4.3.1 Process information and operational aids shall be presented to the operator in the form of display. These displays shall cover all points related to tag numbers built within the system. The process displays shall include different type of displays and the functionalities associated with each of these displays. Various types of process displays, as envisaged, are detailed out in the clauses to follow. The details provided herein are typical and explain only the functional requirements. The systems as offered must provide displays which meet these functional requirements.

5.4.3.2 Overview display

5.4.3.2.1 Overview display shall present the overall status of a unit or large segment of the process plant. The analysed data and alarm conditions are displayed with colour changes.

5.4.3.2.2 Overview display shall incorporate a minimum of 128 analog or discrete inputs which can be monitored simultaneously on the VDU screen (Referred as page). Each page shall be organized into a

suitable number of groups. Each group shall be identified separately. Each group shall further incorporate suitable number of inputs (Referred as tags). Suitable identification and description shall be shown for each group on the overview display to relate it to a group or loop display.

5.4.3.2.3 All analog points in the overview shall be represented as variable lengths indicating deviation above or below the normal operating value or set point.

5.4.3.2.4 Alarms shall be displayed in change of colour against each variable if the variable crosses a set value. Control loops operating in manual mode shall be indicated.

5.4.3.2.5 An input in alarm condition shall be identified by flashing.

5.4.3.2.6 In case, any hard wired instrumentation backup is provided, overview pages shall be assigned indicating the tag number and type of hardwired instrument.

5.4.3.2.7 The operator shall be able to call directly any group display or loop display or any predetermined displays covered in the overview display.

5.4.3.2.8 It shall not be possible to acknowledge alarms directly from the overview display.

5.4.3.3 Group Display

5.4.3.3.1 Group display shall be limited to the group of inputs as displayed in the overview display. Each group shall preferably include eight (8) number of inputs.

5.4.3.3.2 Each input in the group shall be identified by the tag number, unit of measurement and process description which shall be displayed on the VDU screen.

5.4.3.3.3 Display, as a minimum, shall show following degree of details:

a) Process variable in analog form shall show, as a percentage of the transmitter span on a linear scale bar graph of 0- 100% or engineering units and in digital form as alphanumeric display in engineering units.

b) Set point value in analog form as a percentage of the transmitter span on linear scale bar graph of 0-100% engineering units and in digital form as alpha-numeric display in engineering units.

c) Output value in analog form as a percentage of linear scale bar graph of 0-100% and digital form as percentage.

d) Controller mode i.e. auto, manual, cascade, computer.

e) Process alarm on process variable, deviation or velocity.

f) Selected loop within the group shall be identified by cursor marking or similar identification.

g) Control valve failure position.

h) The contact input / output shall be represented by simulated graphic lamps and configurable alphanumeric status description.

5.4.3.3.4 It shall be possible to control the process from group views. Following control actions shall be possible;

a) Increase / decrease of set point value either slow or fast.

b) Change of controller mode i.e. Auto/manual transfer.

c) Changing output to the final control element.

d) For digital points, start/stop or open/close command.

5.4.3.3.5 It shall be possible to repeat any tag number in more than one group/console. However it shall be possible to control or change configuration from only pre-assigned group/console.

5.4.3.4 Loop Display

5.4.3.4.1 Loop display shall provide a separate detailed display for each of the process inputs. The graphic representation of analog and digital points shall be similar to group display. However in addition following information shall also be presented in alphanumeric form as a minimum

a) Controller tuning constants.
b) Process variable zero and span values.
c) Alarm set point on various parameters.
d) Limits on set point, output, velocity etc.
e) Controller action (direction/reverse).
f) Failure position of final control element.
g) Computational constants like ratio or bias.
h) Integrated value.
i) Output to the final control element.
j) Engineering units.

5.4.3.4.2 It shall be possible to change the following through the keyboard of operator console:

a) Tuning constants.
b) Scale, zero and span.
c) Limits on set point, output, velocity etc.
d) Configuration of any loop.
e) Alarm set points.
f) Control mode.
g) Output to the final control element.
h) For digital points, it shall be possible to issue start/stop or open/close command.

5.4.3.4.3 Loop control parameters changes as specified in para 5.4.3.4.2 (a) to (e) shall be restricted by a key lock control or password.

5.4.3.4.4 The loop display shall also contain a trend displaying process variable, set point and output with a sample interval time of maximum 1 second and full scale time base of minimum 60 seconds for tuning the process control loops.

5.4.3.5 Graphic display

5.4.3.5.1 It shall be possible to display dynamic graphic of different sections of plant on the operator console VDU screens. Graphic displays shall be field configurable only through engineering key-board with standard / user defined graphic symbols. Dynamic graphic displays if different sections of the plant shall be displayed on different pages.

5.4.3.5.2 The system shall have graphic symbol library as per ISA-5.1 and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc. shall also be provided as a standard.

5.4.3.5.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display.

5.4.3.5.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours.

5.4.3.5.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering.

Red	:	All points alarm
Blue	:	Valve open, pump running.
Green	:	Valve closed, pump stopped.
Flashing green	:	Shut down valve transition state.

5.4.3.5.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.

5.4.3.6 Trend Display

5.4.3.6.1 The system shall be capable of displaying the following trends:

a) Real time trends for the parameters specified in job specifications displaying current data for a period of minimum one (1) hour as defined in clause 2.33 of this specification. However it shall be possible to assign any parameter for real time trend.

b) Historical trend for number of parameters as specified in the job specification for a period of 30 days with sampling rate of 10 minutes. However, it shall be possible to assign any parameter for historical trending.

5.4.3.6.2 Historical data shall be stored on the nonvolatile memory device like hard disc in such a way that such historical data can be utilized for archival storage and subsequent recall.

5.4.3.6.3 Real time and historical trend shall be possible on any parameter or variable like measured variable, set point, output, calculated variable etc.

5.4.3.6.4 It shall be possible to sample and store data of instantaneous and average value at the intervals mentioned below. However it shall be possible to display by scrolling or expanding the time base for all the trends.

a) At intervals 1 second or higher for the real time trend.

b) At 1 minute, 10 minute & 1 hour interval for historical trend.
Historical data trends shall be displayed for a period of minimum up to 72 hours for a data sampling rate of 1 minute.

5.4.3.6.5 The requirement of fast trend (trends with sample time faster than Real time trend) if any, shall be specified in the job specification. This shall be in addition to tuning trend requirement specified in this specification.

5.4.3.6.6 Selection of the tag number and sampling time for real time and historical trending shall be possible from operator keyboard.

5.4.3.6.7 The system shall also have a multi trend capability in such a way that it shall be able to display set point, measured variable and output on the same display, the trend of either the same process variable or any other process variable.

5.4.3.6.8 Trend display shall be single line type or bar graph type with additional information like loop tag number, engineering units, span, present value of the trended point, alarm status etc displayed.

5.4.3.7 Closed Circuit Television Window display

It shall be possible to display close circuit television (CCTV) video monitor image on the operator console as a CCTV window. A function key on the operator keyboard shall be assigned to select the

desired CCTV monitor window. The CCTV window on the operator console video shall always be on-top.

5.4.3.8 Alarm Monitoring and display

5.4.3.8.1 Alarm Management

a) It shall be possible to display process as well as system alarms on the operator console for operator's attention and action. Alarms shall appear immediately on the operator console as and when they occur on priority basis.

b) It shall be possible to set process alarm limits from the engineering keyboard i.e. alarm limits on absolute value of measured variable; rate of change of measured variable; high and low deviation set points; high, extra-high, low and extra-low points on process variable and output etc. In addition, it shall be possible to derive alarm conditions on the basis of few calculations performed by the system.

c) Alarm messages shall be displayed by flashing the page and group number of the input under alarm irrespective of type of display. It shall be possible to access the group or tag in alarm condition with a maximum of two key-strokes of operator's console keyboard. The plant overview display, in addition to display alarm message, shall also be able to provide warning by changing colour of excessive deviation of process variable from their set value.

d) All alarms shall be displayed as and when they occur or generated with change in the colour of display in the following sequence, activating an audio signal:

Continuous flashing	:	Un-acknowledged alarm
Steady display	:	Acknowledged alarm

e) The system shall not put off the audio alarm and visual flashing even after the condition returns to normal unless it is acknowledged by the operator.

f) In order to provide immediate attention to critical alarms, alarms shall be classified in the priority of their criticality.

g) In addition to alarms appearing on the different displays as mentioned in para 5.4.3.1 to 5.4.3.5 of this specification, the system shall also be able to display alarm summary and alarm history as per para 5.4.3.8.2 and 5.4.3.8.3 of this specification.

5.4.3.8.2 Alarm summary display

a) It shall be possible to display summary of all alarms in the sequence of their occurrence and shall disappear from display only when they are acknowledged and cleared. The alarm display shall list the following for each alarm as a minimum:-

i) The date and time of occurrence.

ii) Point identification (i.e.Tag number)

iii) Point description.

iv) Type of alarm (absolute value or deviation.)

v) Serial number of alarm in the sequence of its occurrence.

b) The system shall be able to display on alarm summary a minimum of 100 alarms.

c) Alarms shall preferably be listed in the form of alarm list like current, List I, List II etc. The minimum number of alarms per list shall be 25. Alternately system may provide a common list of alarms in the sequence of their occurrence (with respect to time).

5.4.3.8.3 Alarm history

a) The history of alarm conditions shall be maintained in the database for alarm history display and printed on shift-wise basis for the parameters specified in the job specifications. The alarm display and print out shall list the following for each alarm as a minimum:-

i) The data and time of occurrence.

ii) Point identification (i.e. Tag number)

iii) Point description.

iv) Type of alarm (absolute value or deviation.)

v) Time of acknowledgement.

vi) Time of return to normal.

vii) Serial number of alarm in the sequence of occurrence.

b) The system shall be able to display and print out the alarm history of minimum of 300 alarms.

c) Alarms shall be listed in the form of alarm lists like List I, List II, List III etc. The minimum number of alarm points per list shall be 25. Alternately system may provide a common list of alarm in the sequence of their occurrence.

5.4.3.8.4 System alarm

a) System shall have capability of on-line self diagnostics as mentioned in para 5.4.5 of this specification.

b) Any abnormal conditions in and sub- system or any other functional device shall be displayed as system alarm message on the operator console irrespective of the display selected.

5.4.3.9 Configuration display

5.4.3.9.1 Configuration display shall provide a separate detailed display for each loop indicating the configuration of that loop. When control requires more than one loop, all interrelated loops shall also be displayed. Following information is required to be available on configuration display.

a) Loop configuration giving designation of each block.

b) Control block interconnection showing soft-wiring or hardwiring.

c) Value of each block parameter like P.I.D., ratio, bias, dead-time, lead- time etc.

5.4.3.9.2 It shall be possible to configure & reconfigure the loops from this view using user friendly software.

5.4.4 Logging and Report Generation function

5.4.4.1 It shall be possible to log all real time data, historical data, computed parameters, operator actions, alarms and events etc from operator consoles irrespective of data source connected to communication sub-system. In general, the data type shall include;

a) All measured and manipulated variables (inputs as well as output data)

b) System calculated variables

c) Historical data values

d) Alarm and event data

e) Operator data entry and operator actions

f) Equipment status data

g) Data through serial links

h) Data through OPC server

i) Batch related data

j) System clock time

k) System diagnostic data

5.4.4.2 The system shall have a report builder and report scheduler which shall have following capabilities;

a) The system shall be able to generate reports on hourly basis, shiftly basis (8 hourly), daily basis and in some cases weekly or monthly basis, as specified in job specifications.

b) The system shall be able to generate reports as per operator command either on-demand or on predefined time.

c) In general, the type of reports shall be;

- On demand report initiated by operator action
- Predefined time initiated report e.g. hourly, shiftly, daily etc.
- Event driven report
- Shutdown driven report
- Equipment runtime status report

d) The generation of on demand report shall not affect any scheduled report.

e) These reports shall be stored in separate files independent from historical and trend data files.

5.4.4.3 All parameters required for logging shall be stored in the system memory as per data base update rate. The system shall be able to perform following functions on all such stored data prior to logging as per the requirement of the report;

a) Basic arithmetic calculations such as averaging, summing, multiplication, division etc.

b) Advanced calculations like efficiency calculations, conditional calculations etc.

c) Extended log reports such as weekly and monthly reports.

d) Batch Reports

5.4.4.4 The formats used to generate log reports shall be user definable, in general. Typical log formats for hourly, shiftly and daily reports have been attached alongwith (Refer Annexure 1) for reference. System shall have a user friendly structured programming language suitable to generate and access various reports. System may utilize high level language for generating reports with advanced calculations. High level language compiler software shall be supplied as part of standard system function.

5.4.4.5 Number of log reports generated for a project shall be governed by the number and type of log formats defined for a project like hourly report format, daily report format, shutdown report format etc. Number of pages in each log report shall be sufficient to accommodate all the parameters defined in the job specifications.

5.4.4.6 In addition to the real time and historical data, the report builder programme shall incorporate report title, sub-headings, notes and messages.

5.4.4.7 Hourly report shall be printed only as and when initiated on demand by the operator and shall not be printed automatically after the end of the hour. All other reports shall be printed automatically at the end of the pre-defined time as well as on demand by the operator. The maximum storage time for a log information shall be 15 minutes after the pre-defined print out time for a format, within which time log report must be printed. In case report could not be printed within the scheduled defined time, data shall remain stored till the report is finally printed.

5.4.4.8 Logging hardware

Data required to be logged shall be finalised during log report finalisation stage. However, typically following shall apply;

a) All tag numbers, analogs as well as digitals, shall be available for hourly log.

b) All flow tag numbers and other selective tag numbers shall be available for daily log report.

c) Only selective tag numbers shall be available for weekly and monthly report.

d) Average (over the defined period) for flow and instantaneous shall be used for log printing with maximum and minimum value as defined in log formats.

5.4.4.9 Logging Hardware and Software

5.4.4.9.1 The system shall be supplied with all hardware and software necessary to meet functional requirements specified in Clause 5.4.4.7 of this specification. Log reports shall be generated, compiled and printed using system standard hardware and software. No separate computer / server shall be used.

Separate server, if necessary, may be utilised, to generate extended logs or reports requiring advanced calculation.

5.4.4.9.2 It shall be possible to archive log reports on an external computer. Facility shall also be available to retrieve these reports as a magnetic tape or a disc for future reference.

5.4.4.9.3 In the event of printer failure, the system shall maintain the data in the point buffer memory of the report originating device buffer with a printer failure alarm.

It shall also be possible to print the report at an alternate printer without any data loss, whenever necessary.

5.4.4.9.4 System Printers

a) In addition to configuration and maintenance (C&M) printing, printers shall be used for printing reports like log reports and alarm and event reports.

C&M printers shall be dedicated for each machine whenever such a function is required.

b) All printers shall be low noise industrial type and shall be suitable for continuous duty.

c) Logging printer

Logging printer shall be A3 size colour laser printer and shall be able to meet the following requirements;

i) Logging printer shall be able to print the following reports;

- Printing of hourly, shift-wise, daily and weekly log.
- Shut down report printing.
- Any other report defined in the job specification.

ii) In addition to above, logging printer shall also be used for printing hard copy of any video screen, whenever necessary.

d) Alarm and event printer

Alarm and event printer shall be low speed dot matrix printers capable of meeting the following requirements;

i) Alarm and Event printer shall be able to print out following reports;

- Log the process and system alarm messages with a time stamp as and when they occur
- Print the alarm history for every shift of operation or on demand from operator console.
- Log events such as operator actions as defined in para 2.30 of this specification, as and when they are initiated.
- System alarms as per self-diagnostic reported alarms.

ii) Alarms and Events shall be clearly distinguishable on the report, preferably by colour.

iii) Print out shall show as a minimum the tag number, description, date and time of occurrence, time of acknowledgement and time of return to normal.

iv) The time stamp shall include month, day, hour and minute.

e) Multifunction printer

Multifunction printer be a colour laser printer which shall be able to print out log reports as well as alarm and event reports. Multifunction shall be specified either common for a unit or a group of units. The functionality of multifunction printer shall be same as (a) through (d) specified in clause 5.4.4.9.4 of this specification.

The command for printing of any report shall be generated from any operator and / or engineering console. The reports shall be generated in the priority of which shall be as per request time for printing report.

f) Hard-copier

i) Hard-copier shall preferably be a coloured heavy duty laser printer. The command for copying shall be initiated from any operator console.

ii) The screen display may be changed on the console after the copy command is initiated for any screen. This video copier shall have buffer memory storage for at-least two screen pages.

5.4.5 Self diagnostics

5.4.5.1 The self diagnostic message for a subsystem failure shall appear on the operator console irrespective of display selected. The choice of the detailed self diagnostic displays shall be made by a key-lock switch.

5.4.5.2 The system shall have an extensive set of self-diagnostic routines which shall locate and identify the system failure at least up to module level including redundant components.

5.4.5.3 At the local level, failure of a module in a sub-system shall be identified by an individual LED display.

5.4.5.4 Failure of a subsystem shall be annunciated with the change in colour. To aid system maintenance and for effective fault location, following displays shall be provided as a minimum.

5.4.5.4.1 Communication system status display.

The display shall show an over view of different sub-systems connected over the communication sub-system showing status of each sub-system. When a failure is detected by the system self diagnostic routine, the display shall indicate the location and nature of malfunction. Display shall as a minimum have

- Type of sub-system.
- Failure of communication bus/link with the sub-system.

5.4.5.4.2 Sub-system diagnostic display

One display page shall be available for each sub-system on the communication sub-system which can be called on demand.

The display as a minimum shall contain:

- Sub-system number and type
- Error code and description
- Details of failed module

5.4.6 Data Storage, Archival and Retrieval

5.4.6.1 **Historical data shall be stored on a non-volatile memory device like hard disc which can be subsequently recalled by operator on any screen. System must support multiple historical data discs in order to avoid data loss in case of disc crash.**

5.4.6.2 It shall also be possible to store and retrieve this data on removable mass storage media like floppy disc, cartridge or tape etc.

5.4.7 Assignable Trend Recorder

5.4.7.1 It shall be possible to provide real-time trend on the assignable recorders for any process or calculated variable. The variable shall be assigned through the keyboard of operator console on any point and any recorder connected to that console.

5.4.7.2 Assignable trend recorders shall be located on the hard wired console. Each recorder shall have four pens.

5.4.8 Hard copy unit

5.4.8.1 Hard copy unit shall be used to make permanent copy of any VDU page when demanded through the operator console/Engineer console.

5.4.8.2 VDU page shall not be locked for more than 5 seconds while taking the video-copy.

5.4.8.3 Copies of display shall be in full colour.

5.4.9 System Servers sizing criteria

5.4.9.1 The servers provided as part of standard system architecture shall have fault tolerant architecture with a minimum availability of 99.999%. The design requirements of each server shall be dependent on its functional requirements such as;

a) Guaranteed throughput performance.
b) Continuous and consistent data connectivity even during fault.
c) Continuous and consistent processing of data even during fault.
d) Fault tolerant operating system.

The fault tolerant configuration of server shall include synchronised redundant processors such that failure, if any, is transparent to the user and server applications.

Transparent to the user implies that the data display on the graphic of any VDU shall not be lost for more than three (3) seconds in case of failure of the main server.

5.4.9.2 In case if redundant server configuration, the maximum switchover time shall not exceed ten (20) seconds.

System servers which have switchover time exceed 3 seconds, shall ensure that real time data is available on at least two of the three operator console VDU's even during switch over.

5.4.9.3 All machines that are used for data is storage shall be high end server garde machine with minimum RAID – 5 configuration. General purpose servers(below RAID 5 Configuration) shall not be acceptable.

5.4.9.4 Server Sizing

5.4.9.4.1 Unless otherwise specified, following criteria shall be considered while sizing the server / servers used for driving operator console(for configurations where data is not stored in the operator station);

a) Number of operator workstation (clients)

Consider 1.2 times the specified number of operator workstations rounded to next higher whole number for each type.

b) Number of Engineering workstations (clients)

Consider 1.2 times the specified number of engineering stations round to next higher whole number.

c) Number of Controller and data acquisition nodes

Consider 1.4 times the specified number of CDAS nodes.

d) Maximum number of nodes / sub-systems on the network should be less than 60% of the system capacity specified in the standard printed catalogues of manufacturers.

e) Maximum history storage tag numbers per second

Consider 1.4 times the specified number of tag points in the material requisition with storage rate of 1 second.

f) Maximum number of trends

Consider 1.4 times the specified number of trend points. Where no separate trend points are indicated consider all analog inputs and outputs as required trend points.

g) Maximum number of Reports

Maximum number of log reports (formats) shall be 50 with 1000 points in each log report.

h) Maximum number of Tag data

Consider 1.4 times the total number of tags and associated parameters i.e. process variable, set point, manipulated variable, auto-manual-computer status, alarm values, diagnostic data from field devices, serial data (process and diagnostics) from third party devices SOE data etc.

i) Maximum number of process alarms, operator events and operator messages

Consider 1.4 times the maximum specified parameters. Where no operator-events or operator messages are indicated in material requisition, consider a total of 1000 points for sizing.

j) Number of Peripheral devices

Consider 1.4 times the maximum number of peripheral devices specified in the configuration diagram.

k) Maximum number of fieldbus segments

Consider 1.4 times the maximum number of fieldbus segments specified or computed by the vendor, as applicable.

l) Maximum number of data for UHN and OPC node (If applicable)

Consider 1.4 times the maximum number of tag data specified in the job specification. Where no separate data is given in the job specification consider through put requirements specified for UHN and OPC node sizing in this specification. The polling rate shall be considered as 1000 tags per second.

m) Maximum amount of Asset Management data

Consider 1.4 times the maximum data available from field devices for asset management.

5.4.9.4.2 While sizing the server / system consider the following operational features;

a) Number of Operator Console VDU (WS) with over view display. : 33% of 'A'

b) Number of operator console VDU's (WS) with trend displays. : 33% of 'A'

c) Number of operator console VDU's (WS) with graphic displays. : 33% of 'A'

Consider 'A' as number of workstations specified in clause 5.4.9.4.1(a) of this specification.

5.4.10 System Operational Response Time

The system shall meet the following response times beyond which the delay may have detrimental effect on the operator's performance;

System activation or Logging-on of a terminal	:	1 sec.
Display call-up time		
- Simple pages like menu display	:	0.5 sec.
- Graphic page	:	1 sec.
Command execution response	:	4 sec
Data entry error reporting	:	1 sec.
Response to mouse / keyboard commands	:	0.5 sec.

5.5 Engineer interface sub-system

5.5.1 Engineer interface sub-system shall be primarily an engineer's interface which shall normally be used for configuring, tuning and maintenance of the Distributed Control System. This sub-system shall also be used as operator console whenever necessary (e.g. during start-up etc).

5.5.2 It shall consist of an Engineering console which shall be able to perform all engineering functions related to each operator console and other sub-systems e.g. controller and data acquisition sub-system, interface devices etc (except PLC for which dedicated engineering console shall be provided). It shall also be possible to configure field-bus function blocks on any segment from engineering console.

5.5.3 Each Engineering console shall consist of single or multiple colour 459.7mm active matrix TFT LCD video screens with full integrated audio capability and shall have an integral USB hub. The video screen shall have a native resolution of 1280 x 1024 pixels with wide viewing angle. Each engineering video screen shall be provided with one operator key-board and one engineering keyboard. This, as a minimum shall also have one configuration and maintenance printer.

5.5.4 Engineering console shall also have, the capability of an operator console. However, the operation of the plant shall be restricted from this console. All the operator console displays as specified under clause 5.4.3 of this specification shall also be available on Engineering console.

5.5.5 Engineering console like any other sub-system shall be capable of communicating with all other sub-systems over the communication sub-system.

5.5.6 Engineering console shall have individual dedicated electronics with RAID 5 disk configuration.

5.5.7 It shall be possible to perform all system configuration functions and configuration modification functions from the Engineering console typically;

a) Data base configuration including overview, group view, loop view, trend view, sequential programming, multi-loop multi-variable control configuration for connection, smart and field-bus based inputs.

b) Group or multi group alarm inhibit from the plant under maintenance.

c) Configuration or re-configuration of alarm settings, their values, addition or deletion of any control block or component in a loop.

d) Compilation of graphic displays.

e) Setting of real time clock.

f) Compilation of logs/reports/historical trend points.

g) To call detailed self diagnostic displays for maintenance aid.

5.5.8 Configuration Requirements

5.5.8.1 It shall be possible to configure conventional, smart (HART) and fieldbus I/O's and control strategies the same way. The device configuration application for HART and fieldbus devices shall utilize EDDL or FDT / DTM as specified in data sheet. It shall include the following;

a) Capability to display all device parameters directly from the device itself.

b) Modify and download device configuration directly to device.

c) Separate display of process values and device alarms.

d) Capability to modify multi-device and download all at the same time.

5.5.8.2 Fieldbus HI interface configuration

a) The configuration software shall have capability to configure all HI fieldbus interfaces such as;
   - LAS assignment and management
   - LAS scheduling
   - Macro cycle time calculations / optimisation

b) Interface configuration software shall support multiple LAS as a segment. Graphical tool shall be provided which shall provide sequence of execution, execution time of each fieldbus device and overall macro-cycle time.

5.5.8.3 Fieldbus Function blocks

a) The configuration software shall be able to configure all fieldbus functional blocks available in fieldbus devices.

b) Function block configuration shall be downloaded from engineering console to field devices on line.

c) Downloads that will result in change in segment macro-cycle shall proceed with a positive confirmation before the download is allowed.

5.5.8.4 Segment Scheduling

a) The engineering software shall have capability to carryout segment scheduling against the scheduling constraints such as number of parameters which LAS can transmit during the single cycle.

b) Response time for an HI segment shall be from 32μ seconds to 2.2milliseconds.

5.5.8.5 Automation configuration tool

5.5.8.5.1 The configuration software shall be capable of auto-detection of following I/O devices;

a) Identification of I/O ports and all types of I/O modules with software configuration defined. If mismatch is detected, an alarm message shall be generated.

b) Function block configuration tool shall be capable of identifying the installed field devices. An alarm message shall be generated in case of mismatch.

c) Automatic address and tag name assignment for fieldbus devices. These capabilities shall also include handling of any foundation fieldbus registered device using the device DD and CFF files.

5.5.8.5.2 The system shall be pre-configured to identify the attributes of all I/O interface ports and general characteristics of any connected field device, which comply with FDDL (of latest version) or FDT / DTM as specified.

5.5.9 Tuning of a control loop shall be possible from Engineering as well as from operator console, the location for tuning shall be selected by the operator.

5.5.10 On-line Configuration

The system shall have the capability to copy, store, modify and restore the configuration data on-line without shutting the system partly or completely. The system shall be capable of downloading controller configuration from engineering console without taking controller off-line.

5.5.11 Off-line Configuration

5.5.11.1 It shall be possible to generate system configuration i.e. controller and data acquisition sub-system and display configuration including graphics from an independent PC with windows software loaded. System engineering features like continuous control, advanced controls, displays, alarm, historical functions, logging functions etc. shall be configurable from above station. The configuration shall be possible without the availability of actual engineering station. Configuration generated off-line shall be loaded on to engineering station without any limitation.

5.5.11.2 Fieldbus engineering software tool shall be able to perform offline fieldbus engineering by accessing CFF and DD files of field devices without connecting the field devices.

5.5.12 During the normal operation, the Engineering console, in no case, shall interfere with the process operation or system software. However any change in the configuration shall be down loaded into the system with proper knowledge of the operator.

5.5.13 All detailed diagnostics of the system shall appear on the Engineering console with a print out on the Configuration and Maintenance (C & M) printer. A common diagnostic message on the operator console shall indicate the need of the maintenance.

5.5.14 To aid the system maintenance and effective fault identification, following displays shall appear on the engineering console;

a) Communication system status display

b) Device diagnostic display and System diagnostics upto module level should be possible from the diagnostic software. The details of system diagnostics are described under para 5.4.5 of this specification.

5.5.15 Any special diagnostic package, in addition to as mentioned under para 5.4.5 of this specification, if available with the system shall also be offered. Detailed description and capability of this package shall be supplied.

5.5.16 C&M Printer shall be used for printing the configuration or configuration changes, printing system alarms as and when they appear and to print out any engineers command from Engineering console. Hard copy unit, when specified, shall be used to take hard copy of the engineers console screen.

5.5.17 The system shall have adequate security features to secure plant operation and DCS data base. Engineering console shall have the following security features, as a minimum;

a) Key-lock or password protection for accessing operator functions and engineering functions.

b) Redundant disc and RAID-5 controller configuration

c) Disc interface to enable 'disc down loading' / database or configuration data back-up.

d) Defuncting / inhibiting all functions other than those functions which are required for engineering and operation as defined above.

5.5.18 System Back-up and Re-initialization

a) The entire control software including control database (application program), system software, source code, schematics etc shall be backed up on system hard disc automatically at a regular interval.

b) It shall be possible to have a complete back-up of system including the historical data on-demand without interrupting the system normal function.

c) It shall be possible to have back-ups on remarkable media like CD-RW, DVD-RAM or DVD-RW.

d) The maximum time acceptable for reloading a device like console is five (5) minutes.

5.5.19 Global database Management and Configuration

5.5.19.1 System configuration software shall provide a common database configuration environment and shall support the following data management facilities, as a minimum;

a) System design shall follow the data centric approach and shall manage entire system data in global manner. Paths and connections between data objects shall be automatically maintained when configuration is changed.

b) Whenever the offered system maintains multiple data bases, the design must ensure a close coordination between these data bases such as management of cross reference table and data reconciliation algorithms.

c) Configuration of operator graphics including management of change tools so that the changes made in graphics are updated uniformly throughout the system.

d) All control historical trend function configuration and interconnection between data elements in the system without any need to maintain user based cross references.

5.6 Communication sub-system

5.6.1 The communication shall be a digital communication network bus, that provides a high speed data transfer rapidly and reliably between the operator consoles, process I/O devices, process computer and other devices connected to it. Each network node shall be capable of communicating with other nodes over the communication network.

5.6.2 The Communication network topology shall preferably be bus structure. Other vendor standard topologies shall also be acceptable provided these meet all the functional requirements specified in this specifications and in the material requisition.

5.6.3 The communication over the communication network shall not be affected even if a node connected to network is powered down or fails to respond. It shall be possible to connect or disconnect a device from the system without disturbing the operation.

5.6.4 The communication sub-system shall be dual redundant, consisting of two separate communication networks and two separate communication system interfaces for each device. The systems requiring traffic directors shall be avoided. However, if unavoidable, dual redundant traffic directors shall be provided

5.6.5 Design shall ensure that there is no cause of common mode failure in communication sub-system.

In general, both the communication networks / devices shall be active at all the times in such a way that either they shall take the communication data load or switch the communication path at regular interval whenever vendor standard data transfer technique allows data transfer to one network while redundant network takes control on the failure of the main network fails. Vendor shall ensure that there shall not be any system degradation or data loss before, during and after the changeover.

Redundant communication network and communication components / modules shall be continuously checked for their availability and healthiness. In case of main bus failure or any communication device failure, the transfer to the back-up device or bus shall be automatic without interrupting the system operation and without any operator's intervention. Information about the failed device / bus shall be displayed on the operator console.

5.6.6 Communication network protocol used within the system shall safeguard against false date transfer and allow error detection, recovery failure detection and initiatives of switchover to the redundant network / network component / module.

5.6.7 In addition to automatic switchover of communication network on detection of failure of active / one of the network / network device, it shall be possible to switch over the communication from main bus to the redundant bus manually without disturbing the system operation. Manual switchover shall be effected whenever the network integrity and switchover is to be verified during testing.

5.6.8 The mechanism used by the communication system for error check, parity error, over-run error etc and other advanced codes.

5.6.9 In general, the transmitting message shall identify the transmitting the receiving device. The transmitting device shall receive a reply from the receiving device on the receipt of correct message. Lack of response shall be considered as a receiver failure. These shall be positive acknowledgement of all messages transmitted over the communication network.

5.6.10 Communication speed on the communication bus shall be sufficient to update the operator console data base once in every second. The overall system performance shall not be degraded whether communication sub-system is 10% loaded or 100% loaded. Degradation of communication bus shall be as defined under para 2.18 of this specification. Failure of one or more nodes shall not degrade the communication performance in any way.

5.6.11 Network Diagnostics

5.6.11.1 Network management software shall be resident on all the network modules in order to ensure reporting of node status to other network nodes and reporting node failure alarm within one second.

5.6.11.2 Communication network diagnostics shall run continuously so that the failure of any network / network component / communication module is alarmed without any delay.

The diagnostics sub-routines shall detect and isolate faulty network component and noisy network cables. Communication shall automatically transfer to the redundant component/ module / network whenever the failure is detailed without interruption of system operation and loss of data.

5.6.11.3 Diagnostic sub routines shall be available to monitor the network performance and generate an on-demand report of all the accumulated number of errors over a specified time period.

5.6.12 Network Components and their Requirements

5.6.12.1 All hardware like network cables, connectors, media converters, network switches and hubs and fibre-optic patch-cards required for completing communication network shall be supplied by the vendor.

5.6.12.2 Network can be either screened twisted pair copper and / or fibre optic cable. All network cables shall be armoured type. Fibre optic cable in addition shall be jelly filled for protection against ingress of moisture.

5.6.12.3 Communication network if routed outside the control room shall be fibre optic type only and shall support the use of media converters for fibre optic network. The system design shall allow the use of unequal network lengths in case of redundant network configuration to make-up for the difference in routing lengths.

5.6.12.4 Type and specifications of the fibre-optic cable shall be decided by vendor based on the distance, band-width required for data transfer and allowable signal attention. Minimum two number of spare fibres shall be provided in fibre optic cable.

5.6.12.5 Fibre optic cable shall always be routed in enclosed HDPE conduit with matching fittings. HDPE conduit shall be as per IS-4984 or as per equivalent IEC code. The outer sheath colour of HDPE conduits shall be orange with black for the fittings throughout the fibre optic cable run.

5.6.12.6 The network devices such as network switches, media converters, connectors etc, utilized in communication sub-system shall be of industrial grade type and of rugged design. These components shall be selected as per the make and model number listed in the vendor standard product guide.

5.6.12.7 The network switches used shall have multiple speed ports (10/100/1000 MBPS) and shall have;

a) Multi-processor design for high performance operation.

b) Routine diagnostics to detect and isolate noisy cables and jabbering nodes.

5.6.13 Network Loading and OPC Server

Worst-case network loading for the systems supporting determinable protocol shall not exceed 50% while for non-determinable protocol shall not exceed 15%.

5.7 **Open System Connectivity**

5.7.1 The system shall be capable of interacting with other plant systems and computers over a well established communication network like ethernet (HSE) conforming to IEEE 802.3. This connectivity with the other systems shall always be made via a firewall.

5.7.2 The system software shall be support industry standards like Windows, OSF/ MOTIF, TCP/IP etc. as applicable.

5.7.3 The method of data access by any user on this network shall be by I/O Tag name and not by any physical or logical address.

5.7.4 Whenever the communication network is required to connect to any other system network or to plant information network, fire-wall (hardware and software) and routers shall be used.

5.7.5 The system shall be capable of acting as a Dynamic data Exchange (DDE) or OPC client or server to exchange real time data with DDC or OPC compliant application.

5.7.6 When OPC is used for interfacing, system shall exchange the data with any client's application in the standard OPC format. Design shall ensure that OPC connectivity tools are fully integrated within the standard product providing seamless integration. Following shall be ensured;

a) System shall provide alarm and event information with no point building from other OPC alarm and event server directly into DCS system alarm summary.

b) Allows OPC data access clients to view DCS system data, hierarchical area, point and parameter structure.

e) Allows access to historical data from DCS.

f) Allows third party OPC server information to be mapped, displayed, alarmed, get historical data and controller data into the system server.

g) Integrates supervisory monitoring, alarming and control data between two or more OPC servers.

h) All graphic applications and all control function blocks supported by operator console software shall have direct access to data integrated with DCS via OPC.

i) OPC data groups, items and tags shall be viewable in any browser function provided in graphics, devices or control configuration tools as if it were data native to the controller sub-system.

5.7.7 OPC Server

5.7.7.1 Vendor shall offer integrated or dedicated OPC server in a high grade minimum RAID 5 Configuration only This node in no way restricts the data transfer. In any case, the device shall be intelligent with adequate memory and software capabilities.

5.7.7.2 OPC Data Access (DA) Server

a) OPC data access server functionality shall allow bi-directional data transfer between multiple OPC data access servers for monitoring, alarming and control. DA server shall read and write process data using item ID is identifier.

b) Rate of data transfer in case of DA server is typically 1000 tags per second.

5.7.7.2.2 OPC Historical data access (HDA) Server

a) OPC client shall access DCS data by connecting to HDA server. It shall also automatically save instantaneous data acquired from DA server and A&E server to be a historical database in HDA server.

b) HDA server shall be able to receive and publish data timely and efficiently whether online or from archived source. System shall be able to read raw data at the rate of 1000 tags per second and read manipulated data at the rate of 100 data per second.

5.7.7.2.3 OPC Alarm and Event (A&E) Server

a) OPC A&E server shall publish DCS alarm and events to OPC clients. The server shall support event types such as conditions, tracking and simple events (e.g. component failure). It shall also publish DCS alarm and event such as process alarms, alerts, messages, event, sequence of events and operator changes.

b) OPC A&E server shall write the following messages to DCS, as a minimum;

i) System and process alarm messages

ii) Mode change and status change message

iii) Sequence message

iv) Operator guide message

v) OPC server alarms and errors

vi) Engineering maintenance messages

c) The maximum number of alarms and events received by OPC A&E server shall be of the order of 1 A&E per second.

5.7.7.2.4 OPC Batch Server

OPC batch server shall read and write the batch related data and information of DCS.

5.7.7.3 The OPC server software shall have the following features, as a minimum;

a) It shall meet support standard OPC standard interface functions such as DA, A&E, HDA, Batch and security as specified by OPC foundation.

b) The software shall be able to interact with another OPC compliant software loaded in another Third party server machine associated with different make of DCS or control system without the need of any additional hardware or / and software.

c) The software shall support automatic data back-up in such a way that process data acquired by DA / A&E server are automatically saved as back-up data on a disc without client having requested to save the data by server.

d) The software shall allow viewing of contents of OPC server from OPC client.

e) The software shall have capability to restrict the access of OPC server to its client to avoid exceeding the maximum accessible data to avoid load concentration which may slow down the data access.

5.7.7.4 System Sizing

Following criteria shall be followed for sizing OPC notes;

a) Number of third party OPC servers / nodes (This shall include UHN connected to other DCS systems) shall be minimum 10. Ten (10) concurrent licenses shall be supplied as part of OPC node.

b) In addition to third party servers, consider the following;

Number of client per OPC node	:	10
Number of third party OPC devices Such as RTU's	:	10 (when specified)

c) Follow up rate of data read / write shall be considered for sizing;

OPC client data read (cache read)	:	1000 per second
OPC client data read access (Device)	:	500 per second
OPC client write	:	500 per second
d) Maximum number read and write data for OPC node	:	2000 data points (unless otherwise specified)

One data point shall include PV, MV, SP for analog control loop.

5.7.7.5 System performance

OPC node shall meet the following performance requirements;

Data read and write on client machine (This includes data display update for real time data)	:	max. 5 seconds
Data read and write on server machine	:	max. 5 seconds
Maximum server loading	:	50%

5.7.7.6 OPC node configuration shall be minimul RAID -5

5.7.7.6.2 OPC node shall be supplied with operating system and other softwares to meet functional requirements specified herein.

5.7.7.6.3 Whenever OPC node is provided with historisation or dedicated , it shall have RAID 5 configuration.

5.7.7.6.4 The system when specified, shall offer a standalone software application that provides OPC server redundancy by transparently redirecting client requests to secondary OPC server when primary OPC server is unavailable or fails.

5.8 Time Synchronization

5.8.1 The system shall have capability to synchronize the time of all the sub-systems within the system either by internal or external clock as specified in the job specification.

5.8.2 Time Synchronization with Internal clock

Unless specified otherwise, all the sub-system node clocks shall be synchronized with designated system master clock. Master clock shall either be assigned automatically by system or assigned manually during system configuration. In both the above cases, whenever the master clock node fails, an alternate sub-system clock assumes the charge of time synchronization. In no case, the system shall operate without time synchronization.

5.8.3 Time Synchronisation with External Clock

a) When specifically indicated, the time shall be synchronised with external time reference eg GPS. This shall ensure that data acquired by all sub-systems will have the same and common global time reference. All hardware and / or software required to meet this requirement shall be supplied by the vendor.

b) In general, the system shall be provided with an external GPS antenna connected to a master clock server. This server shall synchronise all DCS clocks and also provide time synchronising outputs to synchronise all non DCS sub-system clocks. The node shall not exceed 30 millisecond time difference between GPS and any node clock come.

c) In case of failure of master clock server the time synchronisation shall be carried by the designated DCS master clock.

5.9 Shutdown Sub-system - Programmable logic controller (PLC)

5.9.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant when specified, it shall also execute plant interlock logics as well. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.

5.9.2 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality of effect operation. The system shall have certified Safety Integrity Level as per IEC-61508 / 61511 as applicable and specified in job specification. Unless otherwise specified it meet the availability requirement specified in Clause 5.1.3 of this specification.

5.9.3 The system shall have a very high noise immunity in order to ensure safe and reliable operation when subjected to electrical radio frequency interference and Electro-magnetic disturbances expected in a plant.

5.9.4 Unless otherwise specified, the scan time of programmable controller shall be of the order of 250 milliseconds. Scan time for a PLC shall be as defined under para 2.21(c) of this specification.

5.9.5 Operation of PLC shall be completely unaffected by a momentary loss of power of the order of 20 milliseconds.

5.9.6 On line replacement of any module of programmable logic controller shall be governed by Clause 5.1.6 of this specification in general. However, in case of Triple redundant, Quadruple Modular Redundant (QMR)configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR) configuration there shall not be any process upset while replacement of failed module.

5.9.7 It shall be possible to Hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swaped module shall take over the function of the failed module without any manual programming.

5.9.8 The system shall be programmed in principle as per the logic diagrams furnished during detail engineering. Vendor shall prepare their own Logic/Ladder diagrams depending upon the capability of the programmable logic controller offered by them. Owner / Consultant reserves the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.

5.9.9 Whenever the requirement of SIL is specified for the, it shall meet the requirements of SIL level specified and shall be certified by an indepedent body (e.g. TUV) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.

5.9.8 Power supplies in the system shall be provided as follows:

5.9.8.1 Each I/O rack shall have a separate independent power supply system. Each power supply shall be sized to take full load of the I/O rack/signal conditioning panel/rack and shall be provided with dual redundant power supply.

5.9.8.2 Each processor shall be provided with separate power supply. Failure of one power supply shall not affect the system operation in case of dual processor system. Wherever triple redundant system is specified each processor shall preferably be provided with a separate power supply. Also separate power supply must be provided for each multiplied process I/O channel.

5.9.9 System Architecture

5.9.9.1 General

a) PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL 3 classifiction, the system configuration shall be TMR QMR , FMR or VMR

b) Regardless the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 3-2-0 or 4-2-0 or 3-2-1-0 etc. shall be documented in SIL certification report.

c) In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 5.9.9.

5.9.9.2.1 Input/Output system

5.9.9.2.2 Each I/O module shall have its own processor working asynchronocally w.r.t control processor and other I/O processors. However, I/O modules configured in redundant configuration, shall have their processors properly ynchronized.

5.9.9.2.3 Unless otherwise specified, system shall accept analog 4 – 20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.

Sl. No.	**Type of Configuration**	**Maximum No. of I/Os**
1	Single I/O system	8
2	Dual I/O system	16
3	Triple Modular Redundant system (TMR)	32
4	Quadruplicate Modular redundant System (QMR), Virtual Modular Redundant (VMR) configuration	16
5	Flexible Modular Redundant (FMR) configuration,	16

In case of PLC certified for SIL requirements, the maximum number of I/O's shall governed by the SIL certification applicable for specified SIL level.

5.9.9.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 volts DC.

5.9.9.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

5.9.9.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact bouncing noise, as applicable.

5.9.9.2.6 All the inputs shall be double ended i.e. two wires per input and not with common return for all inputs.

5.9.9.2.7 The interrogation voltage to the inputs and power supply for 2-wise instruments shall be powered from separate redundant power supply / supplies and shall not be a part of PLC, unless otherwise specified. This power supply shall be supplied at one point and shall be distributed by the vendor.

5.9.9.2.8 a) Each I/O module shall have a LED per channel to indicate the status of each Input/Output.

b) When specified, input module shall be capable of monitoring the input contacts for any wire open fault (i.e. 4 – 20mA).

5.9.9.2.9 Analog input module

a) Input module shall be capable to accept input from transmitters (.e.g. 4 – 20mA).

b) The module shall have 12 bit A/D resolution accuracy of ±0.25% of full scale over the entire range, unless otherwise specified.

5.9.9.2.10 a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 5.9.9.2.10 b) of this specification. Wet contacts/ powered contacts / TTL outputs etc. shall not be acceptable. Vendor must provide arc suppression device for each output contact.

b) The output contact rating shall be as follows:

Sl. No.	APPLICABLE FOR	VOLTAGE RATING	CURRENT RATING
1.	All output cards driving solenoid valve and alarm annunciator system unless otherwise specified.	110 V DC	0.5 A
2	All motors/pumps/compressor output cards unless otherwise specified. Category – I Category - II	240 V AC 220 V DC	5.0 A 0.2 A

The category of contacts shall be specified in the material requisition.

c) Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.

d) When specified contact output module shall have monitored output features like 5.9.9.2.8(b).

5.9.9.2.11 The communication of I/O system with central processor shall be carried out redundant with complete error checking.

5.9.9.2.12 Where inputs or outputs have multiple field devices for the same measurement or device, the outputs shall be configured in separate I/O modules.

2.9.9.2.13 Where single input signal is available for TMR VMR, FMR, or QMR configuration, inputs shall be multiplied to feed independent inputs to each input modules.

5.9.9.3 Processor system

5.9.9.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme attached alongwith, as logic/ladder diagram.

5.9.9.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for later program modifications or additions.

5.9.9.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery back up shall be provided with a minimum of 3 months lifetime to keep the program storage intact. A battery drain indication shall be provided at least one week before the battery gets drained. A potential free contact shall be provided for hardwired annunciation in the central control room.

5.9.9.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.

5.9.9.3.5 Wherever Qurd redundant processor is specified, redundancy, shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover, shall be bumpless and the system shall be fail proof, unless any other requirement is specified in the job specifications. Redundancy shall be provided for complete processor system including CPU, memory, power supply and communication sub system.

5.9.9.3.6 In case of triple redundant system all the three processors shall execute the same instructions / programs and check their results and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.

5.9.9.3.7 In case of VMR, FMR, QMR system, individual processors shall execute the same instructions / programs and check their results within same CPU module and vote to correct any faulty result. The faulty processor diagnostic shall be made available.

5.9.9.3.8 Failure of a single processor in triple redundant system and two processors in quad system shall not affect the system. In case of failure of complete processor system i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more than two in case of quad system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.

5.9.9.3.9 In case multiprocessor configuration is offered, the processors must be able to communicate with each other over the interconnecting data link. Vendor must ensure that system performance shall not be degraded by any means when such a system is offered.

5.9.9.3.10 It shall be possible to generate the first out alarm contact by the PLC in case where a group of parameters are likely to trip a system.

5.9.9.4 PLC console (Programming)

5.9.9.4.1 The PLC console shall be used for programming, program storing, fault diagnostics and alarm monitoring and should be completely independent of control system(DCS) network /functionality/hardware/software. Whenever specified, it shall also be possible to use this for plant operation. The functionality to operate as engineering terminal or operator terminal or both shall be specified in the material requisition.

5.9.9.4.2 It shall consist of a at least one coloured 21" size TFT screen and one programming / operating keyboard and printer unless specified otherwise.

5.9.9.4.11 PLC console when used for plant operation shall also meet the following functional requirements.

5.9.9.4.3 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified.

5.9.9.4.4 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on VDU.

5.9.9.4.5 Manual forcing of any input or output contact connected to PLC shall be possible from keyboard. Forced functions shall have an associated audit trail.

5.9.9.4.6 It shall be possible to modify, add or delete the application program on line without affecting the outputs.

5.9.9.4.7 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show description and status of each contact. It shall also be possible to display process alarms and diagnostic messages as and when they appear. Further it shall also be able to display I/O map in a user defined format.

5.9.9.4.8 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out;

a) The diagnostic messages as and when generated and diagnostic reports, when called for.

b) Process alarms connected to the programmable logic controller as and when they appear and alarm report whenever initiated. The choice of printing alarms on this printer shall be operator selectable from a key lock switch on PLC console.

c) The I/O maps showing status of all inputs and corresponding outputs in a user defined format.

5.9.9.4.9 The PLC console shall be provided with self diagnostics feature which shall display error messages and initiate an audible alarm if the fault is detected. A potential free contact for diagnostic group alarm shall be provided which shall be connected to the hardwired alarm and annunciator system.

5.9.9.4.10 The system shall be able to identify the failure at least up to the module level including I/O system and redundant processor and report print out.

a) When PLC console is specified, it shall have complete graphic capacity and shall be used for plant operation, process monitoring and control, fault diagnostics, alarm monitoring and report generation.

b) At least three number cursor control devices shall be provided in addition to keyboard which may include touch screen, mouse, track ball etc.

c) PLC operator console shall have complete graphic capability and shall be able to display process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves etc. from dynamic graphics and group displays available on PLC operator console.

d) It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.

e) The time stamping of all alarms shall be as per PLC processor time stamping .

f) The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.

g) The system shall be able to generate shiftily, hourly, daily, weekly and monthly reports. The log format shall be furnished during configuration.

h) The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time.

5.9.9.5 PLC Communication Subsystem

5.9.9.5.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

5.9.9.5.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified.

a) The communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.

b) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.

c) For the QMR, VMR, FMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.

d) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.

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5.9.9.5.3 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

5.9.9.6 Interface with Distributed Digital Control System

5.9.9.6.1 The PLC shall be required to be interfaced to the offered Distributed Digital Control System bus. A suitable interface shall be offered in order to achieve the following functions:

a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC on the main operator console.

b) Generate shutdown reports on the logging printer of Distributed Digital Control System.

c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC.

d) To display diagnostic messages of PLC.

5.9.9.6.2 In general, PLC shall provide data in a well established protocol format preferably MODBUS protocol.

5.9.9.6.3 The interface shall be dual redundant unless otherwise specified meeting all requirements as specified under para 5.9.9.5.3 and 5.9.9.5.4 of this specification.

5.9.10 System software

5.9.10.1 The system software shall include all programs for the PLC and PLC console which are required to perform all PLC functions including communication and self-diagnostics.

Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511.

Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.

5.9.10.2 Logic program shall be recorded on the CD which shall be delivered in duplicate together with the system.

5.9.10.3 The PLC programming language for implementation of logic operations shall be based on the following representations:

a) Logic diagrams - Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.

b) Ladder diagram - Series parallel connection of relay contacts.

c) Combination of (a) & (b) above.

5.9.10.4 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. Vendor must supply the off line software package to enable the owner to modify/add/delete any part of program and for documentation.

5.9.10.5 Software for the generation of various displays including dynamic graphics, whenever specified, to be provided as per para 5.4.3.5 of this specification.

5.9.10.6 The software for printing alarms, system as well as process and events on the PLC printer must be provided. All alarms must be printed as and when they appear.

5.9.10.7 Software package for displaying I/O map showing status of inputs and corresponding output as per logic shall be offered. The I/O map format shall be users definable.

5.9.10.8 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and report print out. Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a statement.

5.9.10.9 System for the following functionalities shall be supplied when specified;

a) Long storage historisation

b) Log report generation

c) First out alarm generation

5.9.10.10 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum;

a) Processor fault

b) Communication fault

c) I/O module fault

d) Power supply fault

e) Over temperature monitoring

f) Permanently close / open (stuck on or off) fault

g) Scan time failure

h) Memory fault

i) Signal redundancy fault

Any other additional diagnostic alarm if available as standard shall also be provided by vendor.

5.9.10.11 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (incase of triple redundant system, whenever specified in the job specifications, this may be achieved by automatically running the testing software at cyclic intervals) The automatic cyclic testing feature shall also be provided for dual I/O configuration and dual I/O signal conditioning for triple redundant system. The testing software cycle time may be considered one in 30 minutes however this shall be field adjustable by engineer. However, system performance shall not be degraded whenever testing feature is specified.

5.9.10.12 In case of triple redundant system or quadruplicate system, whenever output module testing software detects any faulty channel, the power supply to that particular module in that particular bank is removed automatically and further testing on the corresponding module in the other mirror image bank is stopped. However, the testing continues uninterruptedly in other output modules.

5.9.10.13 Feedback must be provided in case of triple redundant system and quadruplicate system from the output voter system to detect any latest faults of the system in addition to other diagnostic software as per para 5.9.10.9 through 5.9.10.10 of this specification.

5.9.10.14 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote.

5.9.11 Sequence of Event (SOE) Function Requirement

Sequence of Event for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with 21" size TFT screen and laser printer shall be provided for each PLC sub-system unless specified otherwise.

5.10 Foreign Device Interface

5.10.1 Foreign device interface shall be capable to transfer data from the foreign devices like analyser systems, gas chromatographs, gas turbine system etc. to other sub-systems connected to communication sub-system and vice-versa wherever specified in the job specifications.

5.10.2 Each device interface shall be redundant unless otherwise specified in job specifications.

5.10.3 Interface hardware and software shall be suitable to match the foreign device communication requirements like hardware interface, communication protocols etc.

5.10.4 While writing software or mapping the input/output in the interface device it must be ensured that integrity of the data to be transferred like resolution, correctness etc. shall be maintained.

5.10.5 Redundant interface switchover shall be designed based on the type of redundancy available in the foreign devices.

5.10.6 The total responsibility of selection of hardware, writing of software, switchover of redundant interface etc. shall be of distributed control system vendor only. All necessary information, assistance and help shall be rendered by the Foreign device vendor.

5.10.7 The exact requirements of Input/outputs to be transferred shall be as per job specifications.

5.11 **Interface with Smart Transmitters**

5.11.1 System shall be provided with suitable hardware and software to interface with the communication protocol of specified smart transmitters.

5.11.2 In case, smart transmitters are specified with 'HART PROTOCOL', the maintenance data related to these transmitters shall be made available on a separate Personnel Computer. The system shall meet the following requirements as a minimum :-

a) The system shall allow the maintenance functions like configuration, calibration and monitoring of transmitter's data from the associated personnel computer in addition to Hand held terminal, whenever used.

b) The hardware used shall allow unrestricted transfer of digital signal without degrading the analog data i.e process variable.

c) The software supplied shall be 'CORNER STONE' OR EQUIVALENT compatible with the specified transmitter protocol. The software shall allow the following data to be displayed on the PC:-

(i) Complete configurational data base of all transmitters including data of commissioning, last calibration, next due calibration etc.

(ii) Historical data for calibrations and configuration changes.

(iii) Event and log reports.

(iv) Multiple authorisation levels for carrying out Configuration changes and Calibration adjustments.

(v) Manual editing of data base with Password and /or keylock protection.

5.12 **Hard-wired Instrumentation**

5.12.1 Hardwired instruments shall be stand-alone type and shall meet their functional requirements fully without depending on DCS system. Even power supply and input/output circuits of hardwired instruments shall be totally independent of DCS system.

5.12.2 Hard wired instruments shall be microprocessor based. Each instrument shall have as a minimum the necessary firm-ware to meet its functional and operational requirements.

5.12.3 Each device shall have its own analog to digital/digital to analog converter.

5.12.4 The display of each device shall preferably be bar graph type.

5.12.5 Controller shall be digital type capable of performing automatic control based on the set points given locally or from a remote device like another controller or Distributed Control System or Supervisory computer. The controller as an instrument shall also have provision for manually controlling the process by means of a manual loader and cascade-computer auto-manual transfer switch. The operation of the transfer switch shall be procedure-less and bumpless while changing mode from computer to cascade to manual and from manual to auto to cascade to computer. During such a change the output shall not change by more than 1% of span. Controller shall have a facia giving continuous indication of process variable, set value, controller output, and controller mode. It shall be possible to remove an instrument for maintenance without upsetting the process by use of device like service station. Operation of the controller like set point change, manual control, controller mode change shall be possible from the front of the controller. Controller shall be flush panel mounting type on the panel/hard wired console. Configuration and tuning of controller shall be possible through a portable and pluggable configurator.

5.12.6 Recorder shall have independent circuit and pen drive assembly for each channel. Recorder shall have capability of continuous line marking or digitized marking of input value with high resolution. Recorder chart drives shall be of multi-speed type and shall be operator selectable. Recorders shall be flush panel mounting type on the panel/hard wired console.

5.12.7 Manual loader unit shall have continuous display of process variable and manual loader output. It shall be possible to manually change the output to control valve. Manual loaders shall be flush panel mounting type on the panel/hardwired console.

5.12.8 Temperature transducers and trip amplifiers shall accept inputs from standard industrial thermocouple and resistance temperature detector (RTD). Linearization of the thermocouple and RTDs shall be done inside each instrument. Transducers and amplifiers shall be suitable for rack mounting.

5.12.9 Alarm cards shall accept standard outputs and shall produce changeover contact output. Each alarm card shall have one continuously adjustable blind setting device. Alarm cards shall be suitable for rack mounting.

5.12.10 Alarm and annunciator system

5.12.10.1 The alarm logic shall be executed in single input plug-in type logic modules. Where integral logic has been indicated, the logic module shall be accessible from the front of the annunciator after opening the swing door. The design of each module shall be such that by simply jumpering suitable point, it may be changed from normally open mode of operation to a normally closed mode of operation and vice versa.

5.12.10.2 Lamps shall be replaceable from the front. The power consumption of each lamp shall be approximately 10 watts.

5.12.10.3 The initiation of alarm condition in the annunciator shall take place approximately 330 millisecond after the condition sensing contact have assumed the off- normal state.

5.12.10.4 Hooter, in general, shall be solid state type with audibility of the order of 100 dB at a distance of 3 metres.

5.12.10.5 An interruption of power supply for a duration of 20 milliseconds or less shall not affect the functioning of the annunciator.

5.13 Instrument Asset Management System (IAMS)

5.13.1 Instrument Asset Management System shall facilitate the maintenance management of all smart, field-bus based and conventional field instruments. Unless otherwise specified, the system shall manage the maintenance of following;

a) All smart and field-bus based instruments connected to Distributed Control System or Programmable Logic Controller.
b) Conventional (non-smart / non field-bus) instruments connected to DCS or PLC or any other dedicated instruments.
c) Field Instruments other than (a) and (b) above eg. local gauges etc.

5.13.2 The system shall include all hardware and software to meet specified functional requirements. In general, IAMS shall be an integral part of Distributed Control System and shall acquire the data from the controller and data acquisition sub-system. Inputs, which are connected to programmable logic controller, shall be parallely connected to DCS in such a way that the hardware used shall allow unrestricted transfer of digital signal without degrading the analog signal.

5.13.3 A dedicated IAM console consisting of one video display unit along with a printer shall be provided;

a) Display all data related to device diagnostics.
b) Provide historical data for calibration and device configuration / reconfiguration etc.
c) Generate event and other device reports.
d) Manual data entry with password / key lock.

The VDU shall be 21" colour TFT monitor along with a keyboard and a printer.

5.13.4 The system shall support multiple authorisation levels for carrying out configuration charges and calibration adjustment.

5.13.5 The Instrument Asset Management System shall meet the following requirements:

a) Instrument Configuration

It shall be possible to configure, verify the configured parameters, reconfigure, re-range and calibrate / recalibrate the smart and field-bus devices from IAM console.

b) Device Status Monitoring

The system shall monitor the status of all field devices and shall report any maintenance alarm generated by these devices. In general, following shall apply;

- Diagnostic alarms from smart and fieldbus devices shall be classified into device failure and device diagnostic categories.
- Out of limit alarm shall be generated to indicate device failure alarm for conventional devices.

The system shall be capable of displaying and generating maintenance report listing all devices currently under alarm. The report may be generated unit-wise / area-wise or for complete plant.

c) Maintenance database

The system shall be able to maintain maintenance database for all the instruments which shall include date of commissioning, last calibration date, next due calibration. The system software shall have capability to manage and track scheduling of all such maintenance related activities.

The software shall also provide data as predictive maintenance such as list of transmitters experiences excessive drift, list of control valves loosing on shipping characteristics etc.

d) Audit Trail

The system shall have capability to provide an audit trail for a complete historical record of all configuration, calibration and device alert data. This shall include tracking of maintenance history for all instruments in the plant, typically recording the type of maintenance work done, smart and compilation times of activity, person responsible for the activity etc.

e) Advanced diagnostics

The system shall be able to provide advanced diagnostics such as device step response, device signature, dynamic error band etc. special device diagnostic software whenever required (like for smart / field-bus position) shall run in the system.

f) Documentation

System shall generate documentation like trend reports, diagnostic reports, pre-detective maintenance report, audit report, historical data and device specification sheet etc. Definition,

engineering, configuration, loading and completion of all reports whether specifically indicated are available as standard and shall be supplied as part of vendor scope of supply.

5.14 Alarm Information Management System (AIMS)

5.14.1 The purpose of Alarm Information Management System (AIMS) is to provide a centralised Alarm information over and above the requirements specified in Clause 5.4.3.8 of this specification and shall be used for acquiring, sorting, add value and provide redistribution platform, so as to streamline and transform the raw alarm data into intelligent, add actionable information for plant operation personnel.

5.14.2 The system shall acquire inputs from various systems such as;

- Distributed Control System / Systems and Programmable Logic Controllers.
- ESD and F&G Systems
- Package unit control systems
- Machine monitoring and Analyser system
- Electrical control system / systems
- Electrical numerical relays
- Any other system defined specifically in the job specifications.

5.14.3 Unless otherwise indicated, the AIMS shall have a high speed data transfer OPC link connectivity with the systems. Where OPC link is not available, the data transfer shall be through dedicated serial links. In addition, AIMS shall also have capability to accept hardwired inputs.

5.14.4 Unless otherwise specified, the following type of data shall be acquired by the AIMS software for further analysis;

- Process and utility alarms
- System diagnostic alarm
- Sub system status alarms
- Operator activities
- Maintenance alarms

The AIMS shall offer a variety of alarm handling feature for processing, and presenting alarms in most efficient way. The package shall be a comprehensive tool with capabilities of;

a) Logical filtration of alarms during normal and special operating conditions such as start-up, process upset and turndown conditions.

b) Logical processing of events and sequence of events for facilitating quick assessment of normal or emergency situation based on pre-defined rule-sets.

c) Generation of different levels of alerts, based on type of alarms, sequence of alarms,

logical processing of alarms etc. and propagation of the same to different groups and categories of personnel's, based on pre-defined alarm distribution matrix.

5.14.5 AIMS shall meet the following functional requirements, as a minimum;

5.14.5.1 Data Acquisition

The data acquired from the various sub-systems and other control systems shall be stored in a dedicated AIMS server. The data shall be stored in a structured format and shall contain tag number, time of occurrence, text information like service description, event type, alarm priority, alarm group priority etc.

5.14.5.2 Alarm Computing

The package shall have capability to generate / compute alarms based on a logical combination of states, conditions and events.

5.14.5.3 Information Analysis

The package shall have capability to analyse and present only the meaningful information. This shall include the following;

a) Analyse the alarm frequency within the predefined period and its repetition period.

b) Analysis of various alarms to identify nuisance, chattering and redundant alarms and eliminate them, if necessary.

c) Analysis of various alarms to identify serious alarms and monitor their frequency of occurrence.

d) Monitoring Operator actions.

5.14.5.4 Expert Alarming

i) The system shall be able to carry out statistical analysis on the alarms data gathered and perform;

- Real-time frequency analysis
- Alarm frequency break-up
- Alarm frequency monitoring
- Standing alarms
- Time elapsed between two alarms / events

ii) The system shall have capability of implementing rule sets to analyse various alarms / data and inform plant operator the probable reason, make recommendations for the action to be taken and provide operational alternatives.

iii) System shall also be capable of analysing and recommending maintenance requirements based on preset rules.

iv) The system shall have advanced search and sort features to provide quick access of alarm data to operator.

5.14.5.5 Alarm Prioritisation

The system shall have the capability to segregate the alarms as per their criticality and operational importance, which may be defined as per the severity with respect to its;

- Production losses
- Human and equipment safety
- Environmental safety
- Process reaction time like run-down reactions

The alarms shall be differentiated in different displays by allocating different colour codes.

The system shall be able to be configured with different priority levels which shall be defined based on the process criticality and operational requirements. As a minimum following priority levels shall be definable;

Level 1 - Alarms directly related to human safety – leading to heavy casualties

Level 2 - Alarms directly leading to total plant shutdown – personnel, environmental and equipment safety hazard.

Level 3 - Alarms leading to partial plant trip conditions.

Level 4 - Maintenance alarms not leading to immediate plant trip.

Level 5 - Status or low priority alarms for operator information.

Other priorities shall also be user definable. It shall also be possible to set priority for each and every alarm point. Assignment or change of level of priority shall be possible only under password protection.

Number of alarms under each level of priority shall be user definable. However, for the purpose of internal assignment, following numbers may be considered

Priority Level	No. of Alarms
Level 1	10 Nos.
Level 2	70 Nos.
Level 3	5% of Total
Level 4	20% of Total
Level 5	75% of Total

5.14.5.6 Alarm Display

a) AIMS shall display alarms gathered from all Nodes / subsystems seamlessly and shall be displayed on any display irrespective of source or location.

b) Alarm display shall be sorted out in the form of alarms groups in the following categories;

- Priority level sorting
- Sorting as per type, frequency, unit-wise, area wise and operating area wise.

c) AIMS displays shall be in graphic form with user friendly displays, color modifiers etc.

d) The system shall process alarms using well proven analysis techniques, directly related to specific alarms, which are trendable.

The system shall have advanced Rule-based and latest abnormal condition management tool which shall provide prediction and anticipation of plant deterioration with sufficient lead time for operation action. The system shall also have real time root cause analysis.

5.14.5.7 Operator Actions

The system shall be able to acquire and analyse operation action required during plant operation such as;

° Time to alarm acknowledge

° Controller mode changes

° Controller set point changes

° Analogue output changes (in manual mode)

° Discrete output changes (in manual mode)

° Alarm level of priority changes

° Range changes

° Tuning constant changes

° System configuration changes e.g. control algorithm, cycle time changes etc.

° Manual time adjustment

° Alarm acknowledgement

° ESD switch actuation (full or partial)

° Any other operator action not specifically indicated above but required during operation. The operator actions shall also be categorised based on their criticality in various levels.

Level – 1 - Most critical operator actions leading to plant shutdown in full eg.

ESD switch action.

Level – 2 - Configuration changes or set point changes which may lead to mal Operation or partial plant shutdown eg. set point changes, range Changes, time adjustment etc.

Level – 3 - Changes which may effect control but rarely could lead to plant Shutdown full or partial eg. controller mode change, range changes, tuning constant changes etc.

Level – 4 - Actions which are mere operation but does not lead to plant operation.

The system shall also able to provide information like;

i) Time to acknowledge alarms

ii) Alarm acknowledge time exceeding a pre-set value.

5.14.5.8 Report Generation Printing

The package shall have capability to;

a) Store alarm messages for a period of minimum one year and shall have facility for data archival on portable media.

b) AIMS shall be capable of generating and printing reports in user defined formats. The data in each report shall be either raw, manipulated, calculated, compressed or analysed.

c) The alarm shall be possible to be printed as and when required, as a user defined formats. These formats shall be defined during engineering.

5.14.5.9 System Diagnostics

The AIMS shall have extensive set of diagnostic subroutines running in real time basis and shall provide at least the following diagnostic alarms;

- System software failure
- Disc / Disc drive failure
- Application software failure
- Network failure
- Communication software failure
- Disc full
- Power supply failure

These diagnostic alarms shall also be made available at DCS operator and engineering consoles.

5.14.5.10 Data Storage and Archival

AIMS shall store alarms and events indicated in Clause 5.4.6 for a period of minimum 1 (one) year in the hard disc. Multiple disc configuration, if required, shall be provided for the purpose of calculating data storage capacity consider occurrence of 30% of alarm and events per day apart from other system defined functionalities.

5.14.5.11 Alarm Notification and Audio Messaging

The system shall be capable of performing following alarm notification and messaging functions;

a) Dial Telephone

In case of predefined alarm or alert condition the system shall automatically dial a telephone number and plays a pre-recorded message. All hardware and software for auto-dialing shall be included.

b) Dial a Cell phone

The system shall have facility to dial up mobile pager or mobile cell phone. When an alarm occurs, the system shall be able to send a test (SMS) message also.

c) E-mail

When a predefined alarm occurs, the system shall be able to send message through an e-mail to the predefined user. This facility shall also be utilised to send e-mails to the manufacturers of various system oriented items like DCS, PLC etc in case of occurrence of a critical system diagnostic alarm.

d) Audio Messages

The system shall be capable to play a pre-recorded message in case of predefined critical alarms on the plant public address system. For example, this shall be useful for alerting plant personnel's on gas / fire alarm in a particular area.

e) Emergency Hooters

The system shall be capable of generating input such that in case of an emergency condition emergency hooters can be initiated along with audio messages on the public address system.

5.14.6 System Hardware & Software

5.14.6.1 AIMS shall have all the hardware and software to meet the following major functional requirements;

a) Efficient storage and archiving of acquired and manipulated data to allow retrieval of reports or alarm analysis information.

b) Retrieval of important information on-line to a network drive disc or dedicated device.

c) Remote access to more than one clients on the network.

d) Export alarm, events or other information to other applications, Excel or Access.

e) Advanced diagnostic techniques for analysis of acquired data.

f) Log the time between specified alarms / messages.

g) Assignment of various level of pass-ports.

h) Multiple client's displaying different data or data screens simultaneously.

i) Disc mirroring for data storage over the network.

j) Automatic Triggering of alarm reports and messages on devices like mobiles, telephones, computer networks etc.

k) Data search facilities with efficient search engines like SQL.

l) Data sorting facility as per defined rule-set.

m) Time stamping of data as per AIMS clock wherever required.

5.14.6.2 AIMS can be reealised on either the DCS platform or as a stand along system. In either case the offered solution shall meet all the requirements specified in MR without exception.

5.14.6.3 In case AIMS functionality realised on DCS platform a separate dedicated AIMS station shall be provided. This station shall have same hardware and software configuration as operator console and shall have redundant storage disks for bulk data storage.

5.14.6.4 In case stand-alone system is considered, the same shall meet the following requirements;

a) The system shall be capable of interaction with DCS via a serial port or by OPC connectivity.

b) The system shall have a minimum of one dedicated server with monitor and cursor control devices capable of meeting all functional requirements for AIMS. If the system demands more than one server to meet job requirements, the same shall be supported and provided.

c) The AIMS console shall be server based machine and shall have 21" LCD display screen with keyboard, mouse and read / write DVD drive.

d) The system shall support client server architecture with minimum of 4 clients. Detailed functionalities of these clients shall be finalised during engineering. The clients shall also meet hardware and software requirement specified in Clause 5.14.6.4(c).

e) AIMS server shall have redundancy in storage discs for bulk-data storage.

5.14.6.5 In general, all alarms and events shall be transferred to AIMS with time stamped by the originating devices. AIMS shall maintain this time for further analysis. AIMS shall time stamp the acquired data only when this data is not transferred by the originating device with time stamp.

5.14.6.6 The AIMS connectivity to third party devices and systems shall be either from the control network (i.e. communication sub system) or from the serial ports available in these devices. For third party systems direct connectivity from the station having master database is preferred.

5.14.6.7 When multi drop serial link connectivity, not more than four (4) devices shall be multi-dropped on one serial link to server.

5.14.6.8 AIMS shall have sufficient flexibility in hardware and software to interface a variety of peripheral devices, these include but shall not be limited to;

- Printer to be provided and attached to the server or client for printing reports and alarms.
- Public Address system for automatic broadcasting of alert messages in pre-designated areas. (The package shall be supplied with a voice package, which shall automatically broadcast the message as the occurrences of the particular alarm).
- Fixed line EPBAXs and Mobile telephones
- Horn and / or beacons for Audio / Visual alarming.

5.14.6.9 AIMS server memory shall be sized suitably to display and printout the alarm history of all the tags of all the systems and sub-systems connected to it.

5.15 **Unit History Node (UHN)**

5.15.1 UHN shall primarily used to carryout the following activities;

a) Store automatically gathered data from control system (DCS, PLC, etc), other DCS systems over OPC and manually entered data.
b) Present data in a meaningful manner for performance enhancements and fault analysis.
c) Long term historisation of data for future reference and decision making.
d) Carryout calculations on the real time and stored data, as necessary.

5.15.2 The UHN shall be a high capacity data storage device where data from various process units shall be stored in a fast access database. The node shall support standard open system interfaces like OPC, SQL, OLE, DDE and shall provide active X facility.

5.15.3 UHN shall collect data from;

a) Distributed Control system of which this UHN is a node.
b) UHN's of other control systems
c) Nodes other than UHN's connected on information network.
d) Manually entered data.

The data collected shall be of various types like process variable, set point, computed variable, manipulated data, outputs, alarms, events, which shall be used for long term storage, trending and report generation.

5.15.4 UHN shall have capability of storing real time data in real time database and shall perform functions like;

a) Identification of bad data (algorithm to run in UHN when necessary)

b) Specify dead band and data sampling rate (or collection rate) as user definable parameter.

c) Calculate maximum, minimum, average, summission, and, integrated values of collected data. The time period of calculating average shall be user definable.

d) Specify high / low, high – high / low – low alarm limits for triggering an event or message or alarm as applicable.

e) Specify damping parameter, delay parameter etc. to reject unwanted data.

f) Specify data storage / sampling rate and period of storage necessary for historical storage of data.

g) Mathematical functions and application program as specified in material requisition which are necessary for report generation. (This does not include advanced control functions but do include MIS reports)

All the parameters indicated or functions performed shall be definable tag number wise.

5.15.5 Data Management and data presentation

5.15.5.1 UHN shall act as a network server and shall support two way data communication between;

a) DCS and UHN for real time data transfer. UHN shall acquire real time data from DCS and provide derived and calculated data to DCS.

b) UHN and information network to transfer data from other systems on information network to UHN and vice versa.

5.15.5.2 UHN provides the user with current raw and calculated / manipulated data on predefined graphic screens or pre-defined report formats. The graphic screens and report formats are user configurable.

5.15.5.3 UHN perform long-term historization of raw and calculated / manipulated data.

5.15.5.4 The data received or sent from the UHN shall have time stamp associated with it from the originator of the data. The data update is effected in case the data value has changed by more than the configured dead band since the last update.

For manually entered data, the time stamp shall be time of entering data (by default) or the time entered with the data as applicable.

5.15.5.5 UHN time shall be synchronized with DCS time clock. For time synchronization refer clause 5.8 of this specification.

5.15.5.6 UHN shall maintain relational database and shall support oracle ROBMS tool.

5.15.5.7 All data raw, manipulated or manually entered acquired or calculated by UHN shall be stored, as unit-wide historian. Historian can be accessed to retrieve the data from specified period in the past.

Historian should have capability to store data for a period of one year (365 days) with a sampling rate of 30 seconds, as a minimum. Other sampling rates such as 1 minute, 5 minutes, 10 minutes and 1 hour shall also be possible. The duration of on-line storage shall be controlled by the archiving facilities which in turn shall be dependent on specified sampling rate.

5.15.5.8 The data shall be presented to the user in a well structured hierarchically configured user displays. User shall be able to navigate down to any detailed data displays without any system configuration knowledge.

The display structure may include;

a) Overview display or main menu display, displaying key process parameters and performance indicators like real time data, swap-shot, calculated variables, real time trend, historical trends, manual data entry, function block, alarm and events, reports etc.

b) The reports generated shall include both tabular and graphical type (i.e. trend and bar graph). The reports as a minimum, shall include shiftily, daily, weekly, monthly and yearly reports. The report formats and specific data shall be finalised during system configuration stage.

5.15.6 System Administration and Security functions

5.15.6.1 The system shall perform the following administration functions;

a) System start-up and shutdown

b) System configuration and configuration changes

c) System diagnostic alarm management

d) Archiving and storing history data.

e) System back-up and system restoration from back-up.

f) Manning user and security files.

g) Maintenance sub-routines and manipulation of data in the database with Audit.

5.15.6.2 UHN shall provide a full data security guarantee and shall be equipped with proper fire wall security features. For details refer clause 5.1.12 of this specification. Typically firewall shall be CISCO system appliance firewall (PIX) and software (IOS) or equivalent.

5.15.7 System Configuration

5.15.7.1 UHN shall be higher grade RAID 5 server machine with preferably Xeon CPU. The selected UHN hardware platform shall meet system throughput and capacity requirements. As a minimum, the system hardware shall meet the following requirements;

a) VDU shall be 459.7 mm active matrix TFT type coloured LCD screen.

b) QWERTY keyboard with SCSI interfaces

c) Mouse or track-ball control

d) Memory as 1GB RAM and 80GB hard disc (HDD) and shall support DAT and DVD / CD ROM.

e) Clock speed as 2.4 GHZ

f) Coloured laser printer

5.15.7.2 The system shall be supplied with a robust operating system and all supporting softwares necessary to meet functional requirements specified here in including RDBMS such as oracle or SQL with TCP / IP as network protocol.

5.15.8 System Sizing

Following criteria shall be followed for sizing UHN;

a) UHN shall interact concurrently with minimum 10 number of users in addition to DCS (of which UHN is the node) and clients main computer. Unless otherwise specified, ten concurrent user licenses shall be supplied along with UHN node. For the purpose of sizing consider at least 20 concurrent users.

b) The data shall be accessed from remotely located data sources through information network or through auto-dialing with proper ID address and password protection. The rate of data access from / to this network shall be considered as 1000 tags per second.

c) The data access from DCS shall be all 1.4 times the all analog (PV, MV, SV) and digital tags accessed at the rate of 1000 tags per second.

d) UHN historian shall be sized considering following factors;

Storage data	:	2 times the total analog (PV, MV, SV) and digital data of all DCS connected tag number (through hardwiring, serial ports, fieldbus etc.
Storage time	:	1 year (365 days)
Storage rate	:	30 seconds for all data
Storage interval on RAM:		20 minutes

5.15.9 System Performance

5.15.9.1 The response to all online enquiries and actions from any user shall be complied with 95% confidence level from any client with a maximum of 20 concurrent users as defined in clause 5.15.8(a) of this specification shall be as follows;

a) A data query to display on graphic or report : 5 second

b) Pre-defined trends up to 1hour data : 5 seconds

c) A data query to present a 24 hours report : 10 seconds

5.15.9.2 Average loading shall not exceed 50% when averaged over 15 minutes with peak loading at any time not to exceed 70%.

5.15.9.3 All securities shall be positioned while evaluating system performance.

5.16 Sequence of Event Recorder (SER)

5.16.1 Sequence of event recorder shall be provided for recording sequence of alarms / events for shutdown inputs.

5.16.2 The inputs for sequence of event recording shall be handled as follows;

a) The maximum number of inputs for I/P module shall be 32.

b) The contact inputs (either open or close on alarm) shall be multiplied using dual output contact barrier one of which contact shall be connected to PLC while the other contact is routed to SER. Wherever necessary, fast response multiplying relays may be used (certified by SER manufacturer)

c) For analog input, the signal shall be connected in parallel across the conditioning resistance to PLC or dual output barrier and to a dedicated alarm card, the contact of which shall be routed to SER.

In case analog input are to be routed to different physical locations or more than two devices, analog isolators shall be used.

5.16.3 SER shall be capable of providing demonstrable alarm resolution of 1millisecond between the events and shall also be able to print out the same with similar resolution.

5.16.4 The contacts or alarm may be close or open on failure and must be configurable for close / open on failure.

5.16.5 The SER system shall be capable of providing alarm monitoring, printing and inputs for management packages. The configuration of inputs and other functions mentioned above shall be carried out using a dedicated terminal, which is also provided with a printer. Once configured, the access to configuration shall be denied except with 3 level of password protection.

5.16.6 All the trip / alarm settings should be same as that of PLC in all respects. The accuracy and resolution of measurements and settings are to be equal or greater than that of PLC.

5.16.6.7 Vendor shall make a provision to connect PLC outputs to SER recorder whenever necessary and decided during engineering with proper isolation.

5.16.8 There must be 20% installed and wired spare input channels up to the marshalling cabinet for each type of input / output of DCS, PLC and other systems.

5.16.9 The system must have facility of keeping at least 96 hours of record at the time with last in and first out facility.

5.16.10 It shall be possible to configure / modify / reconfigure the system online through a dedicated programming unit. Engineering shall be possible to engineer the system using menu driven fashion. Any addition and deletion of inputs should be menu driven only and should be possible to be done during running condition.

5.16.11 It shall be possible to archive data from the SOE recorder on tape drive / CD drivt. CD driver and CD writer along with all necessary software shall be part of system supply by the vendor. The CD driver and CD writer must be with latest hardware and latest software.

5.16.12 The system shall have an extensive set of diagnostic package, which shall be able to provide the fault alarms up to the module level. The same shall be also printable on the laser printer.

The system shall be able to generate an audit report, which can be printed on demand. The audit report shall be able to provide shutdown area, time of shutdown and reason for shutdown.

5.16.13 Sequence of events shall also record PLC shutdown outputs.

5.17 Large Screen

5.17.1 The Giant Screen (Large screen) in the control room, is primarily used for:

a) Display important operational data of the plant /unit for ready reference like daily production, shutdown required /requested etc.

b) Display operational situations like start up or shutdown to enable mangers / operators to discuss without disturbing the unit operator.

c) Display any operator screen on the large screen.

d) To provide real time clear luminous view of the unit to share information's between operators, unit managers and refinery manager.

e) To hold demonstrations to visitors for ready impressive and effective plant overview and plant highlights.

5.17.2 The giant screen shall be installed in the control room wall. The size of the screen shall be approximately 3200mm(L) X 1300mm(H) as a minimum.

5.17.3 The giant screen system shall have the following specifications:

i) The screen design shall be based on single chip DLP technology.

ii) Optical system shall have a resolution of 1024 pixels X 768 pixels Colour pixels per cubic. Each cube shall have a screen diagonal of 70 inches with 16.7 million colours

The lamp shall be pre-adjusted in lamp module, which shall not require any readjustment after replacement. The minimum operational time of lamp shall be 8000Hrs.

They shall be able to provide uniform brightness of 95% with a contrast 250:1, which shall be able to provide high contrast even in bright ambient light.

iii) The display screen shall be seamless and flicker less. It shall be black or grey in colour. The brightness and contrast shall remain uniform irrespective of the number of cubes used.

iv) The control of screen displays shall be carried out either from the operator console. The signal transfer shall provide guaranteed disturbance free operation, which shall not effect sharpness and colour quality.

v) The giant screen shall be lightweight and low thickness type, which can be supported from the control room wall. Only the front access shall be provided for any maintenance.

vi) The system shall perform satisfactorily in ambient conditions with maximum temperature of +40 degree Celsius and 80% non-condensing humidity.

vii) Provision of automatic switch off of Giant screen if temperature in the console room increases above the maximum permissible limit for Giant screen is required.

viii) VDU shall be provided with the Giant screen Control station.
Ethernet card shall be provided in Giant Screen to connect it with Ethernet port for necessary functionality.

5.17.5 The Giant screen system shall be interfaced with the system such that any operator display of any screen could be displayed on the Giant screen suitably. It shall meet the following requirements;

i) Any operator console display or all operator console displays shall be able to be displayed or switched as desired.

ii) Screen areas should be protected for each console group.

iii) Priority of displays should be assignable.

iv) The system shall be supplied complete with all hardware and software as necessary for the specified application including interface software for DCS.

6.0 MISCELLANEOUS REQUIREMENTS

6.1 Safety requirements

6.1.1 Unless otherwise specifically indicated in job specification, all the equipment covered in this specification shall be located in general purpose non hazardous area, normally in control room or / and satellite rack room. However, transmitters, process switches and final control elements including smart positioners, solenoid valves etc. I/P converters (not forming part of this specification) shall be located in the field and shall be specified as per the electrical area classifications.

6.1.2 Unless otherwise specified, intrinsically safe certified transmitters, smart positioners, field-bus devices, and I/P converters shall be used when located in hazardous area.

6.1.3 Intrinsic Safety Protection

6.1.3.1 I/O modules of Distributed system shall have either built in intrinsic safety or shall use external barriers for intrinsic safety. Safety barriers shall also be used whenever intrinsic safety is specified for contact inputs and solenoid valves. Barriers shall not be required when protection other than intrinsic safety are specified.

6.1.3.2 The system as a whole shall be intrinsically safe based on entity concept. It may be noted that the field instruments are being bought separately and can be of different make and models by different recognised statutory body. These details shall be furnished during detailed engineering. Safety barriers selection shall be carried out based on the entity (safety) parameters which shall be properly matched. Field-bus segment terminator shall be considered for evaluating intrinsic safety of a segment. Any

limitation or special requirements for cables to meet the intrinsic safety requirements shall be brought out in the offer.

6.1.3.3 Conventional or smart Instrumentation

a) Whenever intrinsic safety is specified for conventional and smart instrumentation entity parameters of the elements in loop shall be matched with the barrier safety description parameters (i.e. loop design as per entity concept).

b) In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.

c) Unless otherwise specified all intrinsically safe barriers shall be isolating type only providing isolation between;

i) Input and output (non-hazardous to hazardous side of barriers)

ii) Power supply and input

iii) Power supply and output

The minimum isolation level shall be 250V. In case of I/O modules have built in barriers, I/O modules shall also meet the requirements specified in Clause 6.1.3 of this specification.

d) Unless specifically indicated, only single channel barriers shall be selected. Following shall apply;

i) Dual input barriers shall not be selected

ii) Single input and single output barriers shall be selected.

iii) Single input dual output shall be selected when specifically indicated.

6.1.3.4 Field-bus instrumentation

a) Whenever intrinsically safe field-bus system is specified with Entity concept, safety parameters of various items in the segment shall be matched with the selected barrier.

b) Whenever FISCO system is specified, all components in the segment is FISCO complied, segment power supply selected shall also meet FISCO compliance. Segment design shall also meet FISCO requirements.

c) Whenever non-incendive is specified, all components in the segment shall be FINICO complied including segment power supply.

6.1.4 All intrinsically safe barriers shall be of the isolating type only, shunt diode type of safety barriers shall not be used. Only single channel type of barriers shall be used.

6.2 Power supplies and distribution

6.2.1 System Power Supply

6.2.1.1 Unless specified otherwise, the system shall operate on uninterrupted power supply (UPS). However the system shall be capable of operating satisfactorily at the following power supply specifications :

Voltage	:	220 V AC ±10%
Frequency	:	50 Hz ±3 Hz
Harmonic contents	:	Less than 5%
Power interruption	:	10 millisecond

Various main load centres of distributed control system may be sequentially started whenever the starting current are high. The requirement of sequential starting shall be specified in job specification. The sequential starting circuit shall be designed using hardware timers and contactors of adequate rating.

6.2.1.2 The system shall be supplied with dual DCS feeders each capable of handling 100% of the total power supply load requirements. The system shall be engineered such that;

a) The redundant systems / sub-systems shall be powered such that main and redundant components are powered from separate UPS feeders.

b) The non-redundant components / items shall be powered from either of the feeders, unless otherwise specified in the job specification.

c) In case of failure of one feeders, redundant feeder shall supply the total load.

6.2.1.3 Each power feeder shall be monitored for its voltage and current in DCS, the transducers required for the measurement shall be located in power supply distribution cabinet/cabinets.

In addition to above, following indication / alarms shall also be provided for each feeder;

a) Voltmeter, ammeter and power-on-lamp on the cabinet front of respective power supply distribution cabinet.

b) Power failure Alarm contacts for such feeder for DCS monitoring.

c) One common power failure alarm contact for alarm on hardwired console.

6.2.2 DC Power Supply

6.2.2.1 DC supply shall be generally used for ESD devices and shall be 24V DC as specified in job specifications. In general, DC supply shall have the following specifications;

Voltage	:	24V ±10%
Harmonic Contacts	:	...

6.2.2.2 Each DC power supply feeder shall be monitored for its voltage. The voltage transducer shall be installed in the DC supply distribution cabinet.

6.2.2.3 In addition to above, following indications and alarms shall also be provided for each DC supply feeder;

a) Voltmeter installed on the respective DC power supply distribution cabinet.

b) Power failure alarm contacts for each feeder for DCS monitoring.

c) One common power failure contact for alarm as hardwired console.

6.2.3 Non-UPS Power Supply

6.2.3.1 Non-UPS power supply shall be generally used for panel / cabinet / console lighting, power sockets. The voltage shall be 240V 50Hz power supply. In general, 240V 50Hz Non-UPS power supply shall follow the following specifications;

Voltage : 240V ± 10%

Frequency : 50Hz ± 3%

6.2.3 All cubicles lighting shall be on 240 V, 50 Hz normal power supply.

6.2.4 Power supply shall be made available at one point. Further power distribution network shall be designed such that a single power fault in any instrument branch system shall not cause a trip of the entire system. Each consumer shall be provided with a separate switch and fuse for isolation and protection of the system.

6.2.5 Each transmitter shall preferably be powered with individual power supply. However when several transmitters are powered by a common DC source, each power supply branch shall have a separate switch and fuse. The distribution network shall be designed in such a way that overload in any branch shall not trip the main power supply. Enough redundant power supplies/battery banks shall be provided which shall take over automatically in case of main common power source failure. All power supplies shall have one to one redundancy and shall be sized for full load.

6.3 Equipment assembly

6.3.1 General

6.3.1.1 All system equipment like instruments, electronic modules, power supplies, barriers, relays etc shall be installed in either of the following enclosures / cubicles as specified in purchaser's job specifications. The layout of these enclosures shall be prepared considering proper accessibility and maintainability;

a) Control Panels

All indicating types of dedicated instruments like single loop controllers, indicators, recorders, alarm annunciators, manual loading station manual switches etc shall be installed on control panel when control panel is the operator interface or when specifically indicated in the job specifications.

b) Hardwired Console

All indicating type of dedicated instruments like single loop controllers, indicators, recorders, alarm annunicators manual switches shall be installed on hardwired console when hardwired cosole is the operator interface or whenever specifically indicated in the job specifications.

Hardwired consoles form the part of main operator console and shall have same design, dimensions, colour, and shape as operator consoles.

c) System cabinets

All system hardware (excluding consoles) shall be installed in system cabinets. This shall include system racks, system modules, communication modules, power supply modules etc.

System cabinets shall be pre-standing type and shall be freely accessible from front and / or back as required. Following system cabinets shall be required, in general;

i) Power distribution cabinet (for AC and DC distribution).

ii) Safety barrier mounting cabinet (when field instrument is intrinsically safe).

iii) Controller and data acquisition sub-system cabinet.

iv) Temperature converter trip amplifier and other auxiliary card mounting cabinet.

v) Shutdown system cabinets (PLC processor and I/O cabinets)

vi) SER Cabinet

vii) Marshalling cabinets

Free issue items mounting cabinet (for mounting items which are free issued to vendor)

6.3.1.2 In general, control panels and hardwired consoles supplement the operator consoles for plant operation. Those instruments which provide direct operating interface to the plant operator are installed on these enclosures / cubicles.

In contrast, system cabinets generally house back and items / equipments / instruments which are not required by the plant operator for direct operation.

6.3.1.3 Mechanical Design

6.3.1.3.1 As far as possible, panels / cabinets / consoles shall be manufactured using standard modular design and standard equipment. Vendor may follow their standard manufacturing procedures, however following points must be ensured;

a) All nuts, bolts, screws, washers (lock or flat) and hinges shall be of stainless steel. All fastening links shall also be of stainless steel.

b) Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.

6.3.1.3.2 Control Panels

a) Control panels shall have self-supporting free standing cubical construction with back doors made up of sectional steel panels. Two doors shall be provided for each panel, as standard.

b) Each panel section shall have the following dimensional details;

Height : 2000mm

Width : 1200mm

Depth : 1000mm

Panel shall be rigidly mounted on 100mm high channel base.

c) The panel shall be fabricated using angle iron frame section of minimum 50mm x 50mm x 4.0mm size. The control panel front shall be fabricated preferable from 3.0mm cold rolled carbon steel sheet.

d) Unless otherwise specified the panel shall be straight face type. Desk type panel shall be supplied where specified. Case shall be taken to ensure that the face of the panel is truly float and smooth.

e) Panel painting procedure shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high grade lacquer with wet sand blasting between coats. Two coats of paint in the panel colour shall be provided. Final coat shall be given after assembly at site of non-glossy high satin finish when specified in the job specifications. Colour of the panels shall be as per job specifications.

f) Normal mounting heights of instruments (centre lines of instruments to floor) on panel shall conform to the following, with minor adjustments depending upon instruments selected.

1	Miniature and sub-miniature instruments. (3 rows)	Bottom Row Middle Row Top Row	1100 mm 1350 mm 1600 mm
2	Annunciators		1950 mm
3	Electrical push buttons		700 mm

d) Door locking arrangement

All doors of cabinets / panels / consoles shall have flush mounted handles with key operated mechanical door locking arrangement. The locking arrangement shall be interchangeable and shall have common key for locking / unlocking all locks (master keying arrangement).

e) Internal lighting arrangement

Internal illumination shall be provided for all panels / cabinets / consoles to ensure proper illumination level of 250 lux for performing maintenance activities.

Fluorescent lamps shall be provided in each cabinet / console / panel which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at lest 10,00000 operations. A manual over-ride switch shall be provided inside the panel / cabinet / console which shall keep the lamp deactivated even when the door is open. Panels / cabinets / consoles housing memories, which are likely to be effected by fluorescent light, shall have incandescent lamps.

The cabinet / panel / console lighting shall operate on 240V AC emergency power supply.

f) Utility Sockets

Each cabinet / panel / console shall have at least one number each of 240V AC (emergency power) and 220V AC, (UPS) power socket. The sockets shall be rated for 10A as a minimum.

g) Ventilation

In order to effectively remove dissipated heat from the cabinets / panels / consoles, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets / panels / consoles where the temperature rise with all doors closed and all internal and external loads energised shall exceed 10°c above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a minimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel / cabinet / console in part or in complete.

Ventilation fan assembly shall operate at 240V AC emergency power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the number of panels / cabinets / consoles are compacted (supplied in mechanical joined conditions), each panel / cabinet / console shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

Following signals and alarms shall be provided for each panel, cabinet and console separately;

i) Fan failure alarm for each cubicle in DCS.

ii) Temperature indication of each cabinet or compacted combination, as applicable in DCS.

iii) A common alarm each for high temperature and fan-failure on hardwired console.

h) Earthing

Each cubical (panel / cabinet / console) shall be provided with earth bus bars of at least 15 x 5 square mm cross-section for the following;

i) Electrical earthing (non-isolated earth) where all metal components like all cabinet panels, doors etc shall be connected.

ii) System earthing (isolated earth) where cable shielding of all cables shall be earthed. System earth bus bar shall be isolated from electrical earth and also from metallic doors, panels etc.

iii) DC earth (isolated earth) where cable shielding of all 110V DC shall be earthed. DC earth shall be isolated from electrical earth, system earth and also from metallic doors, panels etc.

i) Lifting lugs

All control panels and system cabinets shall be provided with removable lifting lugs to permit lifting of panels / cabinets. The panel structure / frame shall be designed to permit panel / cabinet lifting without deformation. The normal working load of the lifting lugs shall be more than 1.5 time the panel / cabinet load. The eye bolts shall be certified for their normal working load.

Panels / cabinets shall also be supplied with plugs which can be fitted after the lifting lugs are removed after their placement.

j) Name Plates

All panels / consoles / cabinets shall have name plates fixed on the front, back and inside with following details;

Front and Back : Tag number and description

Inside : Manufacturer's name, purchase order number and year of manufacture, port number of manufacture.

All other details shall be as per clause 5.1.22 of this specification.

6.3.1.3.3 System cabinets

a) All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry for cable connection. Cabinets structure shall be sound and rigid.

b) Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for each door removal.

c) Each cabinet shall have the following dimensional details;

Height : 2000mm
Width : 600mm / 1200mm
Depth : 800mm

Cabinets shall be rigidly mounted on 100mm high channel base. Construction shall be modular preferably to accommodate 19" standard electrical racks. All racks shall be of same height. Maximum swing out for doors and drawers shall be limited to 600 mm.

d) Cabinets shall be fabricated from cold rolled steel sheet of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum 1.6 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.

e) Equipment, within the cabinet, shall be laid out in an accessible and logically segregated manner. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with a common grounding lug.

f) Cabinet painting procedure shall include sand blasting, grinding, chemical clearing, surface finish by suitable filler and two coats of high grade lacquer with wet sand blasting between the coats. Two coats of paint shall be provided. Colour of the cabinet shall be as per job specifications.

6.3.1.3.4 Electrical Wiring

All the cabinets, consoles and panels shall be completely wired and/or tubed, as required. Interconnections shall preferably be done with the help of pre-tracked cables. Vebdir may follow their standard wiring practices, however the requirements specified herein must be complied.

6.3.1.4.1 Terminals and Terminal Blocks

a) All terminal / terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical.

b) All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.

c) Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip.

d) Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components are listed below. These distances are clear distances, and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered;

i) Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50mm.

ii) Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75mm.

iii) Distance between two adjacent terminal strips shall be minimum 100mm.

iv) Additional distance for each additional 25 terminals shall be minimum 25mm.

v) Distance between cable gland plate and the bottom of the strip shall be minimum 300mm.

6.3.1.4.2 Terminals

a) Terminals shall be non-hygroscopic type made up of unbreakable fire-retardant, safe extinguishable, halogen free polyamide compound of VO grade of 960°c. These shall be manufactured as per IEC-60947-7-1.

b) Terminals shall be suitable for wires up to 2.5 sq. mm base solid or standard conductor in general. For power cables, higher size terminals shall be used.

c) The metal parts of terminals shall be of high quality (pure electrolytic) copper and shall be tin or nickel plated (of thickness up to 15 micron). The contact terminal resistance shall be of the order of 0.3 multi ohm.

d) The spring material for all terminals shall be chrome nickel spring steel of high tensile strength and of excellent corrosion resistance.

e) Voltage withstand capacity of the terminals shall be up to 4KV for 60 seconds as per IEC/EN-60664-1.

f) Field side terminal blocks in marshalling cabinet shall be cage clamp interruptable (i.e. disconnect) terminals providing necessary polarity distribution, protection, test point and earthing.

6.3.1.4.3 Wiring Requirements

a) All wiring shall conform to SPI RP 550 Part-I, Sections 7 and 12. Different signal level cables shall be routed under false flooring with separation distances as recommended by API RP 550 Section 7.

b) All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal.

c) All wiring in the raceways shall be properly clamped. All incoming cable shall be terminated by vendor at marshalling rack with cable glanding including supply of cable glands. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.

d) Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wiring. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.

e) Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.

f) Wire termination shall be done using self-insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.

g) No splicing is allowed in between wire / cable straight run.

6.3.1.3.5 Hardwired console

a) Hardwired console shall be non-graphic self supporting, free standing cubicle with back doors and shall be designed for batter cable entry for connections. Console structure shall be sound and rigid.

b) The design and dimensions of hardwired console shall strictly match with the operator consoles. For designing hardwired console, following points must be ensured;
   - No instrument or switch shall be installed on the horizontal portion of console.
   - Horizontal portion of console shall be spill proof, as well as scratch proof. Materials other than metallics can also be accepted for horizontal portion provided this can provide rigid, hard, flat and smooth surface. This shall require the purchaser's approval prior to deciding the material.
   - In order to reduce number of hardwired consoles, vendor may utilize back-lighted switches and miniature instrumentation and annunciator windows.

c) Whenever the operator consoles are specified with table top design instead of console type of design, the hardwired console shall be identical and symmetrical to the operator console design.

d) Panels/hard wired console shall be fabricated preferably from 3 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50 x 50 x 4 mm angle.

e) Cabinet paint procedure shall include sand blasting, grinding, chemical cleaning, surface finish by suitable filler and two coats of high quality lacquer with wet sand blasting between two coats. Two coats of paint shall be provided. Colour of hardwired console shall be as specified in job specification.

6.4 Earthing

6.4.1 All system equipments such as panels, marshalling cabinets, system cabinets and other powered equipments shall be provided with following type grounding system;

a) Protective Earth / Electrical Earth

b) System earth / signal earth

c) Safety earth / ZB earth (when required)

d) SPD Earth

Both system earth and safety earth shall be totally separate from protective earth.

6.4.2 Protective earth / Electrical earth

a) Earth metallic enclosure / cabinet / panel / console etc shall be provided with electrical earth lug, as a minimum. Door hinges, flexible conduits or self-detachable connectors shall not be considered path for earth connectivity/earth return paths. Separate earth lug or permanent connectivity shall be considered.

b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipments indicated in Clause 6.4.2(a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using a maximum of 10sq mm solid copper conductor PVC installed wires.

c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Two earthing connection wires as indicated in Clause No.6.4.2(b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

6.4.3 System Earth

a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.

b) System earth shall be less than one (1) ohm grounding system with its own dedicated earthing pits. These earth pits shall be away from any heavy noise plant equipment. Outside the control room building is the most appropriate location.

c) The earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of four (4) number of earth pits shall be provided for grounding system integrity. In case number of pits required to meet 1 ohm resistance are more than (2), the number of earth pits shall be two times the actual number of pits required to meet resistance criteria. All these pits shall be security connected with each other to form a one homogeneous system earth grid.

d) Each marshalling / system cabinet / panels etc shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of

spare conductor pairs / cores of multi-pair signal / control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.

e) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq mm stranded copper conductor cable in a looped both ends except for the following exceptions;

6.4.4 Safety earth / Zener barrier earth

a) Whenever Zener barriers are selected or used to meet intrinsically safe requirements, the earthing terminal of the zener barriers shall be connected to a separate earth bus bar.

b) This earth shall meet all the requirements specified in Clause 6.4.3 of this specification.

c) Safety earth bus bar shall be directly connected to earth pits using dual insulated cable. Cable conductor size shall be minimum 95 sq. mm (copper).

6.4.5 SPD Earth

a) SPD earthing terminals are connected to separate earthing bus bar in the cabinets.

b) This earth shall meet all the requirements specified in Clause 6.4.3 and 6.4.4(c) of this specification.

PART - II

TESTING, INSTALLATION, COMMISSIONING

AND ACCEPTANCE OF

DISTRIBUTED CONTROL SYSTEM

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1.0 SCOPE

1.1 This specification defines the basic guidelines to Distributed Control System vendor for factory testing and acceptance, installation, commissioning and field acceptance of the fully integrated system.

1.2 These guidelines shall also be applicable to all sub-systems and hardware bought by DCS vendor.

1.3 On the basis of this specification, vendor shall submit detailed testing and acceptance procedures specifically applicable for their system. The procedure shall include both hardware as well as software testing and acceptance methodology covering following details;

a) Hardware Testing;

The procedure shall include;

i) Test name
ii) Purpose of Test
iii) Test equipment
iv) Test set-up (Block diagram)
v) Input definition
vi) Test procedure
vii) Results expected
viii) Acceptance criteria.

b) Software Testing;

The procedure shall include;

i) Test name
ii) Purpose of Test
iii) Test equipment
iv) Test set-up
v) Sequence of Execution
vi) Results expected
vii) Acceptance criteria

The procedure shall not omit any column as indicated above in the procedure submitted. Indicate 'NA' whenever any column is not applicable. Additional requirement, if any may be include, as applicable.

1.4 The testing and acceptance of the system shall be carried out on the approved testing procedures and criterion based on this specification and vendor's standard testing requirements and procedures.

2.0 FACTORY TESTING AND ACCEPTANCE

2.1 General

2.1.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified "Ready for Shipment" by the owner/consultant.

2.1.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.

2.1.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition.

2.1.4 It shall be vendor's responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.

2.1.5 Failure of components/ modules/ sub-systems during Testing

2.1.5.1 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub- system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed.

2.1.5.2 If malfunction of a component/module in a sub-system repeat, the test shall terminate and vendor shall replace the faulty component/module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system to the one meeting the requirements and the system shall be tested all over again.

2.1.5.3 If a sub-system fails during the test and is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.

2.2 The factory testing and acceptance shall be carried out in two phases i.e. Phase I and Phase II. The schedule for the testing shall be submitted by the vendor for both Phase I and Phase II separately. The minimum requirements for testing during these two phases are as follows:

2.2.1 Phase-I

2.2.1.1 Vendor shall perform tests at his works to ensure that all components function in accordance with their respective specifications. A test report shall be submitted to the owner/consultant for review within one week of completion of testing giving details. Phase II testing (witness inspection) shall start only after.

2.2.1.2 All sub-systems shall undergo a minimum of 30 days (720 hours) burn-in period. The system shall be offered for factory acceptance only after it has completed the specified burn-in period. The requirements shall be as follows;

a) The burn-in time shall start after the sub-system is fully assembled and is powered up. It may include any such time for which the system has been kept powered on even for system generation and Phase I testing.

b) Burn-in period log report shall be maintained by the vendor clearly recording sub-system (Tag No. / Identification No.), date and time of power-on, date and time of power-off, failed component (if any) with identification, communicative power-on time and sign-off. In case power to the sub-system is switched off because of any reason, the same shall be recorded in this log report.

c) Vendor shall submit burn-in period log report as part of Phase I test report for purchaser's review.

2.2.1.3 All the test results shall be recorded in the test log report. The test logbook shall contain the following information about the tests:

a) Date/time

b) Assembly /loop tag number

c) Test input

d) Test results and sign off with personnel name

e) Action required (if deficiency is detected)

f) Action taken, date of completion and sign off

g) Special test methods (including special equipment requirement, bypasses used etc.)

2.2.1.4 Test details

Following tests shall be performed by the vendor and report shall be forwarded to the owner/consultant.

2.2.1.4.1 Quality control test

a) Quality control tests shall be carried out to assure quality of all components and modules in accordance with vendor's quality control and assurance procedures. QA / QC test methodology shall be in accordance with relevant international standards and practices. Vendor shall forward the details of these procedures for purchaser's review.

b) The sampling procedures for all purchased components or components manufactured by the vendor shall be in accordance with the vendor standard quality assurance / quality control procedures.

c) All assemblies shall be aligned and adjusted before conducting tests. All tests shall be carried out as per manufacture's published / established testing methods and shall be recorded in a test logbook. The test logbook shall be duly signed by the QA / QC manager.

2.2.1.4.2 System power-up tests

All sub-systems shall undergo complete functional testing as part of Phase I power-up testing. Testing shall include, but not limited to, the following;

a) System hardware functional testing including redundancy, wherever applicable, as per vendor standard testing procedures

b) System software testing as per vendor standard testing procedure including builder functionality.

c) System performance on power supply variations as per vendor standard procedures.

d) Application, Software testing;

Complete application programme generated by the vendor specific to the job shall be tested by simulating inputs. This shall include the following, as a minimum;

- Database verification including loop configuration as per approved functional schematics.
- Display verification including dynamic graphics and hierarchical displays.
- Trending, real time and historical, functionality and assignment.
- Logging and report generation
- Serial port assignment and its proving
- Security functionalities, as applicable e.g. password functionalities, fire-wall protection
- Testing of third party equipments (if applicable)
- Verification of logic diagrams
- Alarm management verification
- Any other software verification necessary for the offered system, as per vendor standard.

e) System Diagnostic verification

All the test results shall be recorded as per Clause 2.2.1.3 of this specification.

2.2.2 Phase II (Witness Inspection)

2.2.2.1 During Phase II testing, all the hardware and software shall be systematically, fully and functionally tested in the presence of purchaser representative.

All the sub- systems shall be interconnected to simulate, the totally integrated system as close as possible. Vendor purchased items (third party equipment) e.g. programmable logic controller, sequence of event recorder, alarm information management system etc shall also be integrated with the system. Free issue item, if any supplied by purchaser to the vendor for integrated factory acceptance test, shall also be integrated with the system. Barrier cabinets shall be used as the connecting points for the test inputs and outputs.

2.2.2.2 The duration of Phase II testing shall be communicated by the vendor along with day wise testing schedule to the purchaser. System shall be shipped to site only after the successful completion of this testing and the system is certified 'ready for shipment' by purchaser.

2.2.2.3 Data review:

Purchaser shall review the following documents before starting the witness Inspection (Phase II));

a) The latest document revisions, based on which vendor has generated the system, to the current data. Any revision or changes required shall be informed to the vendor before starting the witness inspection.

b) Test reports of all bought-out items by their respective manufacturers.

c) The test report/log book forwarded by vendor after Phase-I testing. Owner / consultant has right to witness any test performed in Phase I, if found necessary.

2.2.2.4 Testing record

a) During testing of Phase II, each test carried out shall be recorded. Any deficiency or problem observed during testing shall be clearly recorded and corrected thereafter.

b) Vendor shall prepare a punch list report listing out all the action points. All punch list actions must be completed before system dispatch.

c) Any change in the data or configuration etc informed to the vendor during testing by purchaser shall be recorded and modifications required shall be carried out by the vendor.

2.2.2.5 Visual and mechanical testing.

Visual and mechanical testing shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor. This testing shall include the following, as a minimum;

i) Dimensional verification

ii) Sheet thickness

iii) Layout verification as per approved GA drawings

iv) Quality of painting (outer and inner)

v) Nameplates, identifiers and tag plates

vi) Adherence to ferruling philosophy.

vii) Dressing of wires / prefabricated cables and clearances

viii) Locks and handles

2.2.2.6 Verification of Bill of Material (BOM)

Hardware and software including bought-out items shall be available for verification with the bill of material (BOM) document submitted by the vendor during engineering. Vendor must obtain purchaser's prior approval if any sub-system or bought-out equipment / item can't be made available during Phase II testing i.e. witness inspection. The verification of BOM shall include the following;

a) Hardware verification

The verification shall include verification of all hardware including mandatory spares as per the model numbers and quantities indicated in bill of material document. Items which can't be identified with model numbers, shall be verified with manufacturer's serial numbers. In all such cases, vendor must ensure that the serial number has been indicated against all such items in the BOM document.

b) Software verification

The verification shall include verification of licenses and their numbers for all softwares as listed in bill of material document. All licenses shall be in the client's name. Number of copies of as built application programmes shall be verified at the time of site acceptance test and not during factory acceptance test.

All system hardware including network interfaces and all software including operating system, console software, network software, complete application software etc. shall be installed and tested as part of function testing.

2.2.2.7 Functional testing

All system hardware including network interfaces and all software including operating system, console software, network software, complete application software etc. shall be installed and tested as part of function testing.

Functional testing shall include the simulation of inputs and outputs to verify proper system response for both analog and discrete signals. Unless otherwise specified, at least 20% of I/O's shall be simulated in controller and data acquisition sub-system while all I/O's shall be simulated and corresponding logics shall be verified in case of Programmable logic controllers. The I/O sampling shall be at random and shall be selected by the purchaser during testing. The testing, as a minimum, shall include the following:-

a) Complete system configuration loading.

b) Controller and Data acquisition Sub-system

Demonstration of all controller functionalities verification and data acquisition sub-system functions from local as well as from central level including;

- Changing control algorithms
- Changing control mode and controller action
- Changing alarm limits
- Controller tuning using tuning trend.
- Controller tuning using auto-tuning package and change in tuning package and change in tuning parameters either automatically or manually.
- Output status on controller failure.
- Setting of macro-cycle time for fieldbus segment.

c) Scan time verification of scan time values for controllers and data acquisition sub-system and PLC testing shall be carried out by simulating the inputs as follows;

i) Open or close the contact input as per logic execution requirements.

ii) Step input or slow ramp input (typical frequency of 4 cycles / second) with amplitude corresponding to 16mA (4mA to 20mA or vice versa) for all conventional analog and smart (HART) inputs from a signal generated.

The processor cycle time setting and the processor loading shall not exceed the specified limits while verifying scan time.

Checking of scan time values for controllers and data acquisition sub-system and PLC;

The inputs to the system shall be;

- Step input i.e. 0 or 1 for all contact inputs.

- Step input or ramp input for all analog inputs

The processor cycle time setting and the processor loading shall not exceed the specified limits while verifying scan time.

Control cycle time shall be measured by simulating a segment with transmitters and positioners in the worst case fieldbus segment (w.r.t number of transmitters and positioners) and scheduled activities.

d) Checking of correct change-over of the back-up units in case of main unit failure. This shall include the following:-

i) Uninterrupted controller operation shall be verified even during and after switchover of back-up device. The failed controller Database, point records, inputs and outputs of the failed main controller shall be transferred to the back up controller without any interruption. The same shall be repeated for transfer back from back up controller to the main controller. Maximum transfer time shall not exceed the specified value. The test shall be repeated for controller all redundant devices including input /output modules.

ii) Uninterrupted data transfer from main communication network and communication interfaces to the redundant ones shall be checked. The transfer back from back-up device or back-up communication network to main network or interface shall not be automatic (automatic transfer from back-up device / network to main device / network shall also be acceptable in case the changeover procedure is flawless and smooth). This test shall be repeated for all interface units in the system including foreign device interfaces.

iii) Uninterrupted operation of system shall be checked on failure and resumption of any of the power supplies where redundant power supplies are provided.

iv) Uninterrupted operation of the system incase of redundant H1 module, power supply conditioners and LAS functionality.

e) Checking of controller loading

Controller loading shall be verified as displayed by the system by simulating as many as inputs to simulate worst case data transfer condition.

f) Simulation of fieldbus segment

At least one fieldbus segment of each type (e.g. foundation fieldbus, profibus etc) shall be simulated as applicable. The segment shall include at least one device of each make and model number being used in the project (purchaser shall identify and provide the device to vendor for segment simulation). Following minimum tests shall be carried out;

i) Inter operability test to ensure correct data transfer between devices of different makes and host (i.e. DCS).

ii) Control cycle time verification as per specifications.

iii) Control loop functionality when control algorithm is configured in DCS and in a field device i.e. positioner and in transmitter.

iv) Verification of functionality of control input data transfer along with fieldbus converter by simulating inputs.

g) Functional verification of cursor movement devices

Verification of correct functioning of all keyboards, mouse, touch screens, light pen etc shall be carried which shall include;

i) Smooth functioning of all devices.

ii) Functional commands verification

iii) Dual function key configuration.

The devices shall include those attached to operator console, engineering console, PLC console, personal computers, other sub-systems / accessories.

h) Verification of loop configuration

Data base and the configuration of all the loops shall be verified for their correctness with respect to range, limits, engineering units, alarm set points, software configuration, output status of controller / control block failure etc with respect to latest revisions of instrument details and functional schematics / P&ID's supplied by purchaser.

i) Verification of Displays

All types of displays, process as well as system, configured on operator console, engineering console and PLC console shall be verified with respect to correct display configuration, colour scheme, colour modifiers, engineering units, windowing feature, alarms, flags, restricted operation etc.

j) Verification of functionality of accessories

All the accessories like printers and hard copiers shall be verified for their proper operation by printing either test data or actual data.

k) System Diagnostics

System diagnostics shall be thoroughly checked for all sub-systems on local level as well as on operator/engineering console. These shall include diagnostics of failure of main as well as redundant items such as a sub-system, sub-system module, HI module, LAS functionality, power supply, interface unit, network and network module, consoles, third party device interfaced with DCS, printers, hard copier, server failures, key-board / cursor movement devices, disc and disc drives, field-bus devices, field-bus segment, network devices etc. and other detailed diagnostics and their corresponding displays. Diagnostic alarms for any ventilation fan failure, cabinet temperature high and corrosion monitor shall also be verified.

l) Verification of Application programme

Following application programming shall also be verified thoroughly in addition to the complete loop operation by simulation;

i) Verification of trending and trend displays.

ii) Verification of historisation functionalities

iii) Verification of alarm management

iv) Verification of data retrieval functionalities.

v) Verification of all dynamic graphics.

vi) Verification of interchangeability between various video screens of a console.

vii) Synchronisation of system clocks.

viii) Verification of various log formats and log reports including MIS reports as applicable.

ix) Complete (100%) verification of interlock and shutdown logic by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.

x) Verification of third party device (like PLC, analyser system, computers, MMS, F&G systems etc) interfaces for complete data transfer between device and DCS and vice versa. Where third party devices are not supplied by vendor (and cannot be provided by purchaser for conducting factory testing), the complete address mapping shall be verified and the link shall be proved using third party device simulation.

xii) Verification of data and reports related to instrument asset management system.

m) Verification of other specific requirements when specified like;

i) Large screen functionality and display solution shall be verified along with large screen controller. Where large screen is not available during factory acceptance test, vendor may utilize a PC in place of display unit for application verification.

ii) Verification of all functionalities of alarm information and management system including report generation.

iii) Verification of functionalities of unit history node and its verification. The verification shall include configuration verification, sample rate versus storage time verification (by extrapolated method for extended time period), throughput, report formats and report generation.

iv) OPC node verification with respect to its configuration, data structure and throughput.

v) Sequence of Event Recorder functionalities verification by verifying identification of events with the specified resolution. The input shall be generated using pulse generator of suitable frequency.

vi) Functionalities of other items when specified shall also be verified.

n) Verification of hardwired console and its functionality. All functions shall be 100% verified such as operation of hardwired instruments, hardwired annunciator, switches, ramps, pushbuttons, instruments like controllers, indicators, recorders etc. Hardwired consoles must be present during

factory acceptance test and shall be interconnected for functional verification. All hardwired instruments like alarm cards, barriers and relay shall also be verified for their proper operation.

o) Verification of all system builder functions and engineering console functionalities.

p) Verification of fieldbus simulator functionalities when specified and purchased along with the system.

q) Verification of display update rate and call-up time under worst loading conditions. Network performance shall also be verified by verifying display update rate of an analog tag number when all other inputs in the system are under varying conditions.

2.2.2.8 The vendor shall notify the owner/consultant at least three weeks prior to final system testing. In the event that representatives arrive and the system is not ready for testing, the vendor will be liable for back charges for any extra time and expenses incurred.

2.2.2.6.4 Checking of loop configuration for correctness with respect to ranges, limits, alarm points, engineering units etc.

2.2.2.6.5 Checking of all types of VDU displays including process and system displays on operator Engineering and PLC console.

2.2.2.6.6 Checking of correct functioning of key-board operation for operator, Engineering and PLC console.

2.2.2.6.9 Testing of proper functioning of all printers and hard copy units.

2.2.2.6.10 Testing of system features like interchangeability between VDUs of a console, synchronisation of system clocks, selective tuning from Engineering console, key-lock functions etc.

2.2.2.6.11 Checking of various log formats, shut down reports, I/O mapping and other MIS formats printing.

2.2.2.6.12 Checking of shutdown and interlock configuration and proper operation thoroughly.

2.2.2.6.13 Proper system operation at power supply specifications specified in the Material Requisition.

2.2.2.6.14 Checking of proper operation of all interfaces with the system like interface with PLC, computer, analyzer system etc as specified in Material Requisition.

2.2.2.6.15 Checking of bus-degradation while loading the bus from 10% to 100%.

2.2.2.6.16 Simulation of power failure and restarts.

2.2.2.6.17 Checking of all hardwired instrumentation including all alarm cards, alarm annunciator system, switches and other indicating instruments.

3.0 INSTALLATION, TESTING AND COMMISSIONING

3.1 Vendor shall offer the services of the installation team which would install the equipment in the control room, lay the interconnecting cabling inside the control room, check out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities.

3.2 Vendor's responsibility at site shall include all activities necessary to be performed to complete the job as per material Requisition including:

a) Receipt of hardware/software and checking for completeness of supplies.

b) Installation of the system including free supply equipment and field cable termination in the system.

c) Check out of the equipment installation.

d) Checking of interconnection, hardware & software configuration, overall system functioning etc.

e) Loop checking.

f) Liaison with vendor's home office.

g) Field tests

h) Commissioning and on-line debugging of the system.

i) Performance of final acceptance test.

3.3 The only exclusion from vendor's responsibility shall include the following:

a) All civil works in the control room including false flooring, control room lighting and air conditioning ducting.

b) Laying and identification of field cables.

c) Field instrument installation and calibration.

3.4 Field Inspection

3.4.1 All equipments shall be inspected thoroughly by vendor after its receipt at site. The tests, as a minimum, shall include;

(a) Hardware verification as per packing list.

(b) Visual and mechanical checking.

(c) Complete System Configuration loading.

(d) Functioning of all VDUs, keyboards, disc drives, printers, hardcopy units etc.

(e) Checking of correct change-over of redundant devices.

(f) Checking of hardwired instruments.

(g) Any other checking.

3.4.2 The testing defined in para 3.4.1 shall be carried out to ensure functional integrity of all hardware being supplied. Vendor must initiate the remedial action in case unsatisfactory operation of any equipment or item is observed during this testing with an intimation to Engineer-in charge.

3.4.3 Vendor must document all observations including details of malfunctions observed, if any. Items/ equipments requiring total replacement must document reasons for the same.

3.5 **Loop Checking**

3.5.1 Vendor shall be responsible for loop checking which shall also include checking of the interconnection, at control room end, configuration and ensuring over all system functioning.

3.5.2 Calibration and installation of field instruments, installation of junction boxes, interconnection between instruments and junction boxes, laying of single, multi pair cables upto control room, tagging all field cables, performing continuity/ insulation test of cable, core identification of field cables etc. shall not be in the vendor scope. This work shall be carried out by the field contractor.

3.5.3 Vendor's scope of work, as a part of system installation and loop checking shall include termination of all field cables in control room, checking of interconnection between instrument glanding and equipment, ferruling and tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.

3.5.4 Loop checking shall be carried out to check the functional performance of all elements comprising the loop and thereby ensuring proper configuration, functioning and interconnection.
For fieldbus devices the loop checking shall include the checking of complete fieldbus segment connectivity with its devices including noise, device configuration, waveform checking. The complete device configuration shall be downloaded to all field devices from DCS prior to the start of loop checking.

3.5.5 Vendor shall co-ordinate with the field contractor for smooth and proper loop checking. Any discrepancy found during checking shall be brought to the notice of Engineer-in-Charge. Complete loop checking shall be performed in the presence of Engineer-in Charge or his authorised representative. All readings shall be recorded on a suitable format which shall be handed over to the vendor by the field contractor after completing calibration record of each field device. On the completion of loop checking, remaining information related to loop checking shall be filled by the vendor. Completely filled format duly signed shall be submitted for approval, to Engineer-in Charge.

3.5.6 a) All the components of the loop shall be checked for proper functioning. All field instruments connected to control room shall be loop checked at 0%, 50% & 100% of FS (for both increasing and decreasing signals). The mode of generating signal from the field by field contractor shall be as follows for different instruments types:-

	Type of Instrument	Mode of Signal Generation
a)	Differential pressure/ flow instruments/ DP type level instruments	By applying impulse to the primary by squeeze bulb or regulator at field
b)	Pressure instruments	By applying impulse to the instrument using instrument air, regulator & standard gage or using portable hydraulic pump and standard gage.
c)	External Displacer	Cage shall be filled with water for different levels and specific gravity correction shall be applied
d)	Other type of tank level instruments	By lifting the float of the level instruments for 0% and 100% of range
e)	Temperature loops with thermocouple	Appropriate mV signals shall be fed from thermocouple head
f)	Temperature loops with RTD	Appropriate resistance shall be fed from RTD head
g)	Field switches for Alarm & Shutdown	Abnormality shall be simulated by disconnecting and connecting the wires at field instruments end
h)	Owner supplied items	As per Engineer-in-Charge's Instructions
i)	Special instruments & any other type of instruments	As per Engineer-in-Charge's Instructions

b) Receiver alarm cards shall be checked by the vendor for different settings on both increasing and decreasing signals.

c) Shutdown schemes shall be checked for proper functioning, configuration and actuation.

d) Performance of individual loops may be accepted for an overall accuracy of ± 1.0% unless otherwise specified. Where deviation exists, re-calibration of instruments, based on the scope of work, shall be carried out either by field contractor or by vendor.

e) Signal from controllers/shutdown schemes to control valves/shutdown valves shall be checked at the respective valves. The stroke checking including checking of time of operation of control valves/shutdown valves also forms a part of loop checking. Vendor shall coordinate this activity with field contractor and record the same in the loop checking format.

f) For the loop checking of loops connected to substation, vendor shall be responsible to coordinate with the Electrical Contractor.

g) After loop checking is completed, vendor shall connect back any terminals and connections removed for loop checking.

4.0 SYSTEM ACCEPTANCE

4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.

4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing.

4.3 Vendor shall carry out the following functional tests on the fully integrated system as a part of System acceptance test, as a minimum;

a) Hardware verification as per final Bill-of-material.

b) Visual and mechanical checking for proper workmanship, identification, ferruling, nameplates, etc.

c) System configuration as per approved configuration diagram.

d) Checking of correct functioning of all keyboards and dual function keys.

e) Checking of proper operation of hardcopy unit and all printers including printing of Alarms and Events on the Alarm & Event (A&E) printer.

f) Demonstration of all system diagnostics.

g) Checking of correct changeover of redundant devices.

h) Checking of redundancy for LAS functionality for fieldbus segments.

i) Checking of communication between DCS, PLC and other foreign devices.

j) Checking of proper functioning of all disc drives, historical trend-points, alarm summary and alarm history.

k) Verification of proper functioning of assignable trend recorder

l) Printing of Configuration and Configuration changes on C&M printer.

m) Proper information transfer on the information network by verifying system displays and printouts.

5.0 FINAL ACCEPTANCE TEST

5.1 The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks for all units of the plant. Vendor’s personnel shall be present during the test.Any malfunctioning of the system components shall be replaced/repaired as required. Para 2.1.6 of this specification shall be applied for failure of components & readjustments.Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.

6.0 TESTING/CALIBRATION EQUIPMENTS

6.1 Vendor shall make available all consumable, instruments, and equipments necessary for testing, calibration, maintenance etc. as required by the defined scope of works. All instruments and equipments used for the above purpose shall be of standard make with accuracy better than the accuracy expected from the calibrated/tested instruments, and certified by National Physical Laboratory or other equivalent agencies. These instruments/equipments are necessary only during testing/calibration/maintenance.

PART - III

GENERAL REQUIREMENTS

OF

DISTRIBUTED CONTROL SYSTEM

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1.0 SCOPE

1.1 This specification defines the general requirements expected to be fully complied by Distributed Control System vendor including logistic sup ports, documentation, warranty, maintenance contract and shipping instructions etc.

1.2 The requirements defined in this specification shall also be applicable for all sub-system and hardware bought and supplied by vendor from manufactures other than his own.

2.0 LOGISTIC SUPPORT SERVICES

2.1 The hardware maintenance engineers shall be trained for module level nd optionally component level diagnostics of the system. Vendor is required to quote separately for these training facilities. It is also necessary to include in the proposal the details of diagnostic software package for isolating the fault at module level for all the sub- system of Distributed Control System.

2.2 Training

2.2.1 The requirements of training for owner/consultant personnel (one group consisting of operators and other group consisting of hardware/software maintenance engineers) in the operational software and diagnostic programs, are set forth herein.

2.2.2 Vendor shall be responsible for furnishing details of course outlines, manuals of training, equipment necessary to conduct the training, exercises to evaluate trainees' progress. Vendor shall also be responsible for any other requirements necessary to train the engineers deputed by owner within a time limit so that they acquire the necessary expertise to operate and maintain the programs and the equipments supplied.

2.2.3 Owner/ consultant or his authorised representatives shall select personnel for training on the basis of his requirements and will review all materials furnished for adequacy of teaching aids and time tables.

2.2.4 Training Personnel.

Each instructor-designate shall have the following minimum qualifications for his area of instructions:

a) Six months of formal class-room instructor experience.

b) Complete and thorough technical knowledge of the equipment and system supplied under the contract and skilled experience in their programming, maintenance and operation.

c) Complete and thorough knowledge of the test and laboratory equipment maintaining, diagnosing, programming, operating and trouble shooting the hardware software system.

2.2.5 Course contents

2.2.5.1 The outline of each course shall give the subject matter, a short resume of the pre-requisite subjects (if applicable), the position of the course in the training programme, the aim and yardsticks for evaluation and other topics which will add to the usefulness of the program. In order that the selected trainees shall have time to participate in the course, sufficient advance notice of minimum 8 weeks shall be given by the vendor. The course outlines shall be submitted 10 weeks ahead for review.

2.2.5.2 The training exercise shall be designed to be objective in nature and shall include trouble shooting exercises on similar equipments.

2.2.6 Training manuals

2.2.6.1 All training manuals shall be prepared by the vendor and submitted for review 10 weeks ahead of the commencement of the course. After course completion, these manuals shall become the property of the owner. Any change in equipment, manuals and other material shall be informed to the owner during the guarantee period. In addition to vendor documentation, the following minimum requirements shall be adhered to for the training manuals:

a) Functional flow-charts, descriptive material, program source listings applicable to all operating and application software and diagnostics programs.

b) Schematic drawings of each assembly of the hardware for the course on maintenance.

c) All manuals pertaining to procedures, specifications and operation for each equipment.

2.2.7 **DCS hardware and software maintenance training**

2.2.7.1 Vendor shall conduct a course in hardware (module level and optional component level) maintenance, software maintenance and diagnostic of the system for owner at vendor's facility. The course shall be conducted prior to the factory system performance tests so that trained personnel can participate effectively in the final testing.

2.2.7.2 The hardware maintenance training course shall cover every equipment item supplied as part of the Distributed Control System. This course shall include:

a) Actual operation, detection and correction of faults in equipments.
b) Familiarisation with maintenance procedures for the system offered.

2.2.7.3 Some of the topics covered in the course shall include:
a) Fundamentals of the system
b) Equipment logic diagrams
c) Diagnostic procedures
d) Peripherals maintenance
e) Preventive maintenance procedures

2.2.7.4 Software maintenance training shall cover all software supplied with the system. The trained personnel shall be able to write and debug the application and system software.

2.2.7.5 The vendor is required to quote for in-house and on-site training separately and manhour rate for additional training, if required by the owner.

2.2.8 **Site training facility and training kit**

2.2.8.1 The training kit shall essentially be used for refresher and training courses for process engineers, operating and instrument maintenance staff. The training kit shall be simple control system with process simulator for a group of loops and shall include:

a) An operator console with a VDU, operator key board and engineering keyboard.
b) Controller with auto backup facility.
c) One each of the varieties of PCBs used in data acquisition.
d) Signal simulator.

2.2.8.2 Vendor to provide the details of the kit offered alongwith the proposal.

2.2.8.3 Training kit system shall be stand alone with respect to hardware and software and in no way be lined with the main system.

2.3 **Spare parts**

2.3.1 Vendor shall include in the proposal, provisions for special tools, test equipments and initial stock of maintenance spares for a period of two years after commissioning as are essential for proper maintenance and operation of the equipment. In addition, estimated requirements of spares consumption per annum should also be indicated. Full particulars of the tools, test equipments and spare parts shall be provided separately. The list should also include the item wise price.

2.3.2 The successful vendor shall warrant that spare parts for the system would be available for a minimum of fifteen years. After this period, if vendor discontinues the production of spare parts, vendor shall give at least twenty four (24) months notice prior to such discontinuation so that the owner may order his requirements of spares in one lot.

3.0 DOCUMENTATION

Vendor shall furnish all the manuals necessary to test, operate and maintain Distributed Control System hardware and software.

3.1 **Hardware documentation**

3.1.1 The following documentation for all hardware supplied and as built under this contract shall be submitted for review two months before the start of factory acceptance testing.

a) The specifications for all off-the-shelf hardware manufactured by vendor, his sub-contractors or suppliers.
Supplier's name and identification of ordered hardware and expected delivery data to vendor's premises shall also be supplied along with this.

b) Documentation relating to off-the-shelf hard ware and hardware developed by vendor including description, specifications, theory of operation, maintenance procedures, installation information and drawings. This information shall exclude all non-applicable information.

c) Where more than one size, rating or type of construction appears on the submitted catalogue data, those characteristics applicable shall be identified. Non applicable information shall be suppressed.

d) Test plans and test reports as specified in Part II of this specification for each item of hardware, to be supplied.

e) Bill of material listing all hardware to be supplied including manufactures part numbers, name plates data, approximate volume, weight and overall dimensions.

f) Spare parts catalogue for all items (at component level) to be supplied.

g) Recommended spare parts for two years.

3.2 **Software documentation**

The following documents shall be submitted for review before 90 days of the shipment of the system, for the software packages included in the supply:

a) The specifications for all software to be obtained in-house or from subcontractors or suppliers. The details supplied shall also include the name of the suppliers, software identification including latest modification data.

b) Reference manuals, operating manuals, programming manuals and other software manuals (if any).

c) Description of the function of each program. This shall include the logic, configuration requirements and constraints and sub-programs used,, memory map and special characteristics.

d) Input and output details for each program.

e) Listing of assembled programs with label and symbol tables in assembler/compiler language.

3.3 **System manuals**

3.3.1 Manuals shall be submitted for assuring satisfactory operation and maintenance of the system. Detailed literature for installation and maintenance of all hardware should be provided to the owner.

3.3.2 All system manuals shall be supplied in hard cover loose ring folders in A size i.e. 216 x 279 mm. All drawings and sketches shall be in multiple of 'A' size like 'B' (279 mm x 432 mm) or 'C' type (406 mm x 518 mm) etc. but folded to 'A' size.

3.3.3 Instruction Manual

The information submitted shall preferably be in three parts.

I Part
First part shall give the following information:
a) A general functional description of the whole system.
b) General software description.
c) General Instructions and start up procedures.

II Part
Second part shall describe the system software in detail including its interaction with application programs and other programs used as supporting software.

III Part
The third part shall include detailed maintenance information including all data pertaining to equipment required for maintenance of the system.

3.3.4 Maintenance manuals

3.3.4.1 The maintenance manual shall include details of

a) Preventive maintenance procedures.
b) Trouble shooting procedures including failure analysis.

3.3.4.2 A section on repairs shall provide enough information on repairs including removal, repairs, adjustment and replacement.

3.3.4.3 The maintenance manuals shall contain a list of all maintenance parts to facilitate quick identification of the parts for replacement and ordering. Standard hardware structural parts, or other parts not requiring maintenance shall not be included here. At the end of the list of parts requiring maintenance, a list of special tools required for the maintenance of each unit shall be given. List of manufacturers of each part shall also be included.

3.3.5 The final system manuals shall be furnished to owner within a month of completion of final satisfactory field testing. All field modifications shall be incorporated and system as built drawings and documents shall be included. Fifteen copies of each manuals shall be submitted to the owner/consultant.

3.3.6 Engineering drawings

3.3.6.1 The vendor shall provide a complete set of drawings covering each art of the supply for the owner/consultant record. The vendor is required to include owner's project number on each of his drawings in order to ease owner/consultant's record keeping.

3.3.6.2 Functional schematics and logic diagrams are furnished by owner/consultant to provide an idea of system hardware and software requirements to the vendor. Functional schematics shall be furnished in two parts.

a) Part-I, containing all system hardware and software requirements is furnished along with Material Requisition.

b) Part-II, containing the field devices details like transmitter, junction box details, final actuating device single and multi cable/core details, shall be furnished later.
Vendor shall develop loop wiring diagrams, containing full information of each loop (one drawing per loop) including field termination, junction box details, cables numbering, rack number, bus address code, device address code, power supply connections, final actuating device details including positioner and air supply etc and furnish these before the installation of system.

3.3.6.3 All field modifications shall be carefully recorded by the vendor's commissioning personnel and change shall be incorporated into final drawings. Fifteen copies of each drawing shall be submitted with one reproducible.

4.0 WARRANTY

4.1 Vendor shall be fully responsible for the manufacture in respect of proper design, quality, workmanship and operation of all the equipment, accessories etc. supplied by the vendor for a period of 18 months from the date of taking over by the owner at the site as mentioned in this specification or 24 months from the shipment date whichever is later.

4.2 It shall be obligatory on the part of vendor to modify and/or replace any hardware and modify the operating, application and diagnostic software free of cost, in case any malfunction is revealed even during on line operation after taking over within the warranty period.

4.3 Vendor shall also provide the total maintenance of the system during warranty period. The cost for warranty maintenance, if any, shall be included in the proposal separately in 'vendor proposal outline and pricing details'.

5.0 MAINTENANCE CONTRACT

5.1 Vendor shall quote separately for maintenance contract after warranty period for two years based on per day rate for each category of personnel required. The personnel deployed shall have thorough knowledge of the system and atleast two years of experience on the maintenance of similar system. Any other conditions of contract required by vendor shall be explained in the offer.

6.0 PACKING AND SHIPPING INSTRUCTIONS

6.1 All the material used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packaged.

6.2 Workmanship shall be in accordance with best commercial practice with the requirement of applicable specifications. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.

6.3 The package shall be suitable for storing in tropicalised climate, the ambient conditions being specified in the job specifications.

6.4 Shipment shall be thoroughly checked for completeness before final packing and shipment.

GENERAL SPECIFICATION

FOR

PROGRAMMABLE LOGIC CONTOROLLER (PLC)

#

AC	:	Alternating Current
API	:	American Petroleum Institute
SIS	:	Bureau of Indian Standards
CCOE	:	Chief Controller of Explosives
CPU	:	Central Processing System
DC	:	Direct Current
DCS	:	Distributed Control System
DGMS	:	Director General of Mines Safety
DMR	:	Dual Modular Redundant
DVD	:	Digital Versatile Disc
EMI	:	Electromagnetic Interference
ERTL	:	Electronic Regional Testing Laboratory
ESD	:	Emergency Shutdown System
FAT	:	Factory Acceptance Test
FMEDA	:	Failure Modes, Effects and Diagnostic Analysis
HART	:	Highway Addressable Remote Transducer
HW	:	Hardware
HWC	:	Hardwired Console
I/O	:	Input / Output
IEC	:	International Electrotechnical Commission
IEEE	:	Institute of Electrical and Electronic Engineers
IS	:	Indian Standards
ISA	:	International Society of Automation
ISO	:	International Organization for Standardization
LAN	:	Local Area Network
LCD	:	Liquid Crystal Display
LCIE	:	Laboratorie Central Industries Electriques
LED	:	Light Emitting Diode
MTBF	:	Mean Time Between Failure
MTTR	:	Mean Time to Repair
OPC	:	OLE for Process Control
P&ID	:	Piping and Instrumentation Diagram
PC	:	Personal Computer
PESO	:	Petroleum and Explosives Safety Organisation
PID	:	Proportional, Integral and Derivative
PLC	:	Programmable Logic Controller
PTB	:	Physlkalisch Technische Bundersanstalt
QMR	:	Quadruple Modular Redundant
RFI	:	Radio Frequency Interference
SAT	:	Site Acceptance Test
SER	:	Sequence of Event Recorder
SIL	:	Safety Integrity Level
SIS	:	Safety Instrumented System
TCP / IP	:	Transmission Control Protocol /Internet Protocol
TFT	:	Thin Film Transistor
TMR	:	Triple Modular Redundant
TUV	:	Technische Uberwachungsvereine
UHF	:	Ultra High Frequency

UL	:	Underwriter's Laboratories
UPS	:	Uninterrupted Power Supply
VDU	:	Video Display Unit
VHF	:	Very High Frequency

Triple Modular redundant (TMR), Quadruple Modular Redundant (QMR)configuration, Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)

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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the Material Requisition defines the minimum functional requirements for the design, hardware, software and firmware specifications, nameplate marking, testing and shipping of Programmable Logic Controllers (PLC) designed for reliable effective and optimum control and monitoring of a process plant 1.1.2 The related standards referred to herein and mentioned below shall be of the latest editions prior to the date of the purchaser's enquiry:

APIRP 552	Transmission Systems
EEMUA 191	Alarm System -A Guide to Design, Management and Procurement
EN 10204	Metallic Products -Types of Inspection Documents
EN 50039	Electrical Apparatus for Potentially Explosive Atmospheres: Intrinsically Safe Electrical System 'I'
IEC 60079	Electrical Apparatus for Explosive Gas Atmosphere
IEC 60529	Degree of Protection Provided by Enclosures
IEC-60584	Thermocouple Part 2: Tolerances
IEC 60617	Graphical Symbols for Diagram
IEC-60751	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors
IEC 61000-4-3	Electromagnetic Compatibility (EMC) -Testing and Measurement Techniques - Radiated, Radio Frequency, Electromagnetic Field Immunity
IEC-61000-4-4	Electromagnetic Compatibility (EMC) -Testing and Measurement Techniques - Electrical Fast Transients / Bust Immunity Test
IEC-61000-4-5	Electromagnetic Compatibility (EMC) -Testing and Measurement Techniques – Surge Immunity Test
IEC-61000-6-2	Electromagnetic Compatibility (EMC) -Generic Standards -Susceptibility - Industrial
IEC 61508	Functional Safety of Electrical/Electronic / Programmable Electronic Safety-related Systems
IEC 61131	Programmable Logic Controllers
IEC 61511	Functional Safety -Safety Instrumented Systems for the Process Industry Sector
IEEE 802.3	Telecommunication and Information Exchange between Systems -Local and

	Metropolitan Area Networks -Specific Requirements -Part 3: Carrier Sense Multiple Access with Collisions Detection (CSMA / CD) Access Method and Physical Layer Specifications
IS 2148	Flameproof Enclosures of Electrical Apparatus
IS-3043	Code of Practice for Earthing
IS 13947	Specifications for Low Voltage Switchgears and Control Gears
ISA 5.1	Instrumentation Symbols and Identification
5.2	Binary Logic Diagrams for Process Operations
5.3	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer System.
5.4	Instrument Loop Diagrams
5.5	Graphic Symbols for Process Displays
18.1	Annunciator Sequences and Specifications
71.01	Environmental Conditions for Process Management and Control Systems: Temperature and Humidity
71.04	Environmental Conditions for Process Measurement and control Systems: Airborne Contaminants
ANSI/ISA	Security Technologies for Industrial Automation and Control Systems TR 99.00.01 Manufacturing and Control System
ISO 216	Writing Paper and Certain Classes of Printer matter-Trimmed Sizes-A & B Series
ISO 9241-5	Workstation Layout and Postural Requirements
ISO 9241-7	Display Requirements with Reflections

1.1.3 In the event of any conflict between this specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Design Basis / Statutory regulations

b) Data Sheets

c) Standard Specifications

d) Codes and Standards

1.1.4 In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

a) Purchaser's data sheets specify the minimum acceptable functional requirements for the programmable logic controllers. It shall be vendor's responsibility to select proper hardware, software and firmware to meet the specified functional requirements.

b) Purchaser's data sheets specify the scan time / cycle time / response time and loading requirements. Vendor shall be responsible for sizing and selecting their standard product i.e. hardware, software and firmware to meet the requirements specified in the purchaser's data sheets.

c) Selection of proper and adequate hardware, software and firmware to meet system requirements specified in the purchaser's specifications, keeping the integrity of functional blocks specified in the configuration 'diagram attached with the material requisition.

d) Adequacy of Bill of Material selected to meet purchaser's requirements. Vendor to note that bill of material shall not be verified by the purchaser during evaluation stage. Any hardware, software and firmware required to meet the purchaser's specified requirements shall be provided by the vendor without any implication.

e) Providing adequate mandatory spares including consumable spares as specified in the purchaser's specifications. Vendor shall be responsible to meet mandatory spare requirements specified by the purchaser.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition. Vendor's quotation shall enumerate and include the detailed specification of each subsystem and each module of programmable logic controller, detailed system configuration, hardware and software capabilities, programming aids, display facilities and other relevant information.

1.2.2 Whenever a detailed technical offer is required, vendor's quotation shall include the following:

a) Compliance to the specifications.

b) Detailed specification sheets for each sub-system. The specification sheet shall provide information regarding hardware specifications, software specifications, redundancy requirements, capacity, power consumption etc. of the programmable logic controllers and its accessories. The material specifications and unit of measurement for various items in vendor's specification sheets shall be to the same standards as those indicated in purchaser's data sheets.

c) System security features and design details.

d) Proven references for each offered model in line with clause 1.2.4 of this specification whenever specifically indicated in the purchaser's specifications.

e) A copy of approval for flameproof enclosure, intrinsic safety etc whenever specified, from local statutory authority, as applicable, like Petroleum and

Explosive Safety Organization (PESO) / Chief Controller of Explosives (CCOE), Nagpur or Director General of Mines Safety (DGMS) in India along with:

i) Test certificate from recognized house CIMFR (Central Institute of Mines & Fuel Research) / ERTL (Electronics Research and Test Laboratory) etc. for specified protection class as per relevant Indian Standard for all Indian manufactured equipments or for equipments requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, Baseefa, PTB, CSA, UL etc., for compliance to ATEX or other recognized standards for all equipments manufactured outside India.

f) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason to deviate from the specified requirement, they must include a list of deviations item wise, summing up all the deviations from the purchaser's data sheets and other technical specification along with the technical reasons for each of these deviations.

g) Certificate for specified SIL requirement (e.g. SIL-3) from Independent Testing Agency.

h) Catalogues giving detailed technical specifications, model decoding details and other related information for each item / sub-system covered in the bid.

1.2.3 Vendor shall offer only their standard proven product i.e. system hardware, system software and firmware, which shall be configured to meet the functional requirements specified in the material requisition. Moreover, the equipment being offered / supplied shall be of latest proven version available in the current manufacturing range and meeting the requirements specified in clause 1.2.4 of this standard specification.

1.2.4 The system hardware, software and firmware as offered, shall be field proven and should have been completed trouble free satisfactory operation for a period of minimum 4000 hours on the bid due date in the similar application with equal or higher than the proposed system size with respect to number of inputs and outputs specified in the purchaser's data sheet. Items with prototype design or items not meeting proneness criteria specified above shall not be offered or supplied.

1.2.5 The detailed scope of work, specific job requirements, exclusions, deviations, additions etc. shall be indicated in the job specifications which shall be part of material requisition.

1.2.6 Whenever specified, vendor shall furnish tested values of failure rates, probability of failure on demand and test intervals for safety integrity level analysis.

1.2.7 All documentation submitted by the vendor including their quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language only.

1.2.8 Vendor shall also quote for the following:

a) Two year's operational spares for each sub-system and their accessories which shall include the following as a minimum:

i) All type of electronic modules e.g. I/O modules, processor modules, communication modules, memory modules, disc controller module, power supply modules etc.

ii) All type of auxiliary items e.g. barriers / isolators, hardwired instruments, annunciator modules, receiver switches, trip amplifiers, temperature element converters etc.

iii) Switches, lamps, fuses, connectors, terminals, pre-fabricated cables, circuit breakers, relays etc.

iv) Video display units, keyboards, disc drives, PC's, network items (e.g. switches, hubs etc.) etc. \

b) Any special tools and test equipments needed for the maintenance of PLCs and other items being offered by vendor. Vendor must confirm in their offer if no special tools or test equipments are needed for maintenance other than those specifically indicated in purchaser's data sheet.

1.3 Drawing and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from thy vendor are indicated by the purchaser in vendor data requirement sheets. The required number of prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design manuals, installation manual, operation and maintenance manual etc., submitted by the vendor after placement of purchase order shall include the following, as a minimum:

a) Specification sheet for each sub-system, auxiliary instrument and bought out item.

b) Certified drawings for complete system including the following:

i) GA drawings for panels, cabinets, marshalling racks, hardwired consoles, operator console, programming terminal etc with complete dimensional details, internal construction and weight in kilograms.

ii) Control room layouts e.g. console room, rack room and engineering room layout with all dimensions in millimetres.

iii) Channel base frame drawing for console room, rack room and engineering room.

iv) Input / output assignment.

v) Logic / Ladder diagrams.

vi) Loop wiring diagram.

vii) Power supply distribution diagram.

viii) Memory loading calculations/Scan time calculation.

ix) Protocol/Pin Details.

x) Dynamic graphic diagrams.

xi) System grounding drawing.

c) Design manuals and functional design specifications which shall include hardware design manual, software design manual and special software specifications.

d) Copy of type test certificates.

e) Copy of test certificates for all tests indicated in this specification.

f) Installation manual containing installation procedure for programmable logic controllers and other items covered in the material requisition.

g) Power-on, start-up and internal testing procedures.

h) Software debugging and system configuration procedures.

i) Calibration and maintenance manual containing maintenance procedures including replacement of parts, application modification etc.

j) Any other drawings and documents specifically indicated in job vendor data requirement enclosed with the material requisition.

All system manuals and documentation shall be supplied in hard dover loose ring folders in 'A4' size as per ISO 216 i.e. of size 210mm x 297mm. All drawings and sketches shall be in multiple of'A4' size like 'A3' (297mm x 420mm) or 'A2' type (420mm x 594mm) etc. but folded to 'A4' size.

2.0 DEFINITIONS

The various terms used in this specification are defined as follows:

2.1 Programmable Logic Controller

The class of control systems which can be programmed to execute plant shutdown and / or interlock / sequence logics to the specified safety integrity levels.

2.2 Accessible

A system feature that is viewable by and interactive with the operator and allows the operator to perform user permissible control action e.g. set point change, auto-manual transfers or on-off actions.

2.3 Assignable

A system feature that permits an operator to direct a signal from one device to another without the need for change in wiring, either by means of switches or via other data entry

devices like keyboard commands to the system.

2.4 Configurable

The capability to select and connect standard hardware modules to create a system or the capability to change functionality or sizing of software functions by changing parameters without having to modify or regenerate software.

2.5 I/O

Input / Output with respect to process / operator

2.6 PLC Console (Operator)

PLC console (Operator) is the operator's main plant interface device through which operator can view, monitor and control the plant and can give instructions to peripherals to execute commands, and shall have protective access to configure and maintain the system.

2.7 **PLC Console (Programming Terminal)**

PLC console (Programming Terminal) shall be the engineer's main interface device through which engineer can configure / program and maintain the system, and shall have protective access to monitor and control the plant, give instructions to peripherals to execute commands.

2.8 Local Level

All those sub-systems;' which directly interface with field devices shall be referred to as local level.

2.9 Central Level

Operator Console and Programming Terminal, which present data acquired from local level devices shall be referred as Central Level.

2.10 Database

Database shall be defined as the information stored temporarily or permanently in the system which can be accessed by various programs to meet all its functional requirements.

2.11 Loop Integrity

A system shall be said to have loop integrity if the failure of one component in the system/ sub-system does not affect more than one loop.

2.12 System Loading

System loading for a sub-system is defined as the percentage of time a sub-system spends in carrying out various activities referred to the use of memory, CPU time and communication capacity in the worst case of high sub-system operation out of the designed / designated cycle time of the sub-system.

2.13 Redundancy

A system component shall be termed as redundant if it takes over automatically the operation in the event of the failure of the main component without causing any interruption in the system and upsetting the process. The repaired or replaced device shall be brought in-line only through operator action without upsetting system operation.

2.14 Switchover Time

Time required for a back up instrument / system to come on-line automatically in case of the failure of the main instrument / system.

2.15 Processor Cycle Time (tpc)

Processor cycle time is the measure of the processing speed of a processor. Processor cycle time for a sub-system ofthe programmable logic controller shall be defined as follows:

Processor cycle time for programmable logic controller shall be defined as the total time taken by the processor to read input supplied by input module, execute all computations (analog as well as logic as configured) and write the outputs for the output module.

2.16 Scan Time (ts)

Scan time of a logic loops is the end-to-end response time of a sub-system and shall be defined as follows:

The scan time for a logic loop shall be defined as the total time taken by a sub-system e.g. programmable logic controller to read input from the input terminal, process input, execute logic, updating logic output and write output at the output terminal for all the logics configured within the subsystem.

2.17 User's Memory

Free memory space available after utilisation of memory required for system operation, configuration and implementation of application and other system related functions for implementation of user defined specific programs such as plant calculations, process optimization or MIS (like free formatting of certain logs). The programs shall either be written in high level language or system specific language.

2.18 Event

An event shall be defined as any action taken by the operator via operator keyboard or switches on hardwired console like change of set point, change of control mode, start/stop of motor, open/close of shut down valves, alarm acknowledge etc.

2.19 Sequence of Event (SOE)

Arranging events in the sequence of their occurrence in time with a specified time resolution by a program is defined as sequence of event.

2.20 Sequence of Event Recorder (SER)

System or sub-system which presents and / or records the events in the sequence of their occurrence in time with a specified time resolution utilizing its hardware and software capabilities is termed as sequence of event recorder.

2.21 Real Time Trend

Real time trend shall be defined as a continuously progressing graphical record showing updated parameter with most recent value and a past record of minimum of 10 minutes without pressing any additional key for moving backward in time.

2.22 Plant Information Network

High-level communication network which serves various users within a plant and transfer information for the purpose of unit / plant monitoring. This network is different than control network and is generally realised using open communication protocol network e.g. OPC etc.

2.23 Tag

A Tag is a collection of attributes that specify either a control loop or a process variable, or a measured input, or a calculated value, or some combination of these, and all associated control and output algorithms. Each tag is unique.

3.0 SPARES PHILOSOPHY

3.1 The system including sequence of event recorder, hardwired instruments etc. shall meet the following spare philosophy. This philosophy shall also be applicable for items like barriers, relays, terminals, lamps, push buttons etc.

3.1.1 Mandatory Spares

Vendor shall include following mandatory spares in their scope of supply:

3.1.1.1 Installed Engineering Spares

Installed engineering spares shall be provided in each sub-system for each type of module to enhance the specified" system functional requirements by 20%. The basis of offering installed engineering spares shall include:

a) For a system with conventional and / or smart analog input / output, discrete (contact) input / output, 20% spare input / output of each type shall be considered for calculating I/O modules and all other related accessories.

b) For all serial input / outputs to the system, 20% spare serial\I/O ports ofeach type of serial input / output shall be provided.

c) 20% spare accessories like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.

d) The engineering spares shall be wired up to the field cable interface and shall be

in ready-to-operate condition when field cable is connected to spare assigned terminals.

e) Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling / barrier cabinets as applicable.

f) The system shall be fully engineered considering 20% installed engineering spares including processor loading.

3.1.1.2 Spare Space Requirement

In addition to installed engineering spares specified in Clause 3.1.1.1 of this specification, the system shall be provided with following spare space:

a) I/O racks of programmable logic controller shall have 10% usable spare space for installing additional I/O cards of each type in future. However internal wiring for the same shall be connected up to the I/O terminals.

b) Processor system of programmable logic controller shall have capability to execute additional 20% logics.

c) Each operator console shall contain 20% usable spare group and related display capability in addition to as specified in para 3.1.1.1 of this specification.

d) The system shall have capability to extend its historical trending, logging and user's memory by 20% to meet future expansion with/without adding additional memory modules.

e) The communication sub-system shall have sufficient capacity to handle additional data contributed by addition of 20% I/O over and above installed engineering spares.

f) Usable spare space in panels and cabinets to install 10% spare hardwired items like relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals, panel mounted instrument etc. in future.

3.1.1.3 Spare Memory Requirement

a) The system shall be provided with a minimum of 40% spare memory capacity, as required for application program and data base to meet specified functional requirements.

b) It shall be possible to extend the memory by at least 20% over and above the actual requirement at a later date.

3.1.1.4 Spare Software Capability

a) Sufficient additional software capacity shall be available in the system to take care of spares requirement as specified in para 3.1.1.1 and 3.1.1.2 of this specification to meet all functional requirements as per para 4.0 of this specification.

b) Unless specifically indicated otherwise, the offered system shall have software licenses to cover all the tag numbers indicated in the material requisition, including installed engineering spares and spare space indicated in clause 3.1.1.1 and 3.1.1.2 of this specification.

3.1.1.5 Predefined Mandatory Spares

a) Mandatory spares shall be ware-house spares and shall be supplied as loose items.

b) Mandatory spare module of 5% or one module of each type, whichever is higher, must be supplied for each type of modules being used excluding modules used in consoles, servers, Personal Computers.

c) For items like, Video Display Units, keyboards, disc drives, network components, hardwired instruments like barriers, lamps, fuses and circuit breakers, complete item limited to 5% or minimum one of each type shall be supplied' as predefined mandatory spare. But this shall not include hardware like hard discs, terminals.

3.1.1.6 Consumable Spares

Any paper, ribbon, printer heads, toner and ink required for printers, video copier or any other consumable item shall be supplied along with system required for minimum of six months duration after system acceptance.

3.1.1.7 Commissioning Spares

Unless otherwise specified, vendor shall be responsible to supply all spares which are found necessary to replace failed modules, failed sub-systems, or corrupted / faulty softwares while performing pre-commissioning and commissioning activities.

3.1.2 Two Years Operational Spares

Two years operational spares shall be as per Clause 1.2.8(a) of this specification and shall be quoted separately.

4.0 DESIGN AND CONSTRUCTION

4.1 Design Requirements

4.1.1 Programmable logic controller shall be microprocessor based system which shall be used to execute all the process and safety shut-down logic of the plant. When specified, it shall also execute plant interlock logics and sequence operation. Programmable logic controller shall be an independent unit and shall not depend on any of its functionality on any other system including Distributed Control System.

4.1.2 The system shall be of modular construction and expandable in future by adding additional modules which shall be easily accessible for maintenance and repair. The type of modules shall be kept to the minimum possible in order to have interchangeability and low inventory.

4.1.3 System Availability

a) The system shall be designed 'fault avoidant' as a minimum by selecting high grade components of proven quality and proper design of system electronics.

Redundancy shall be provided, as a minimum, as per this specification to improve system availability and reliability. Due considerations shall be given to the environmental conditions particularly for field mounted sub-system, if specified in job specifications, during system design.

b) The system shall have a high MTBF value and shall have well proven record of operating in hydrocarbon plants.

c) The system shall be designed with 99.995% or greater availability. The availability shall be defined as follows:

$$\text{Availability} = \frac{\text{Mean Time Between Failure (MTBF)}}{\text{MTBF + Mean time to repair (MTTR)}}$$

For the purpose of calculations, consider mean time to repairs as four (4) hours unless the manufacturer recommends higher value for MTTR. It is therefore necessary that:

i) Vendor covers all necessary spare parts in 2 years recommended operational spares which shall be necessary to meet specified MTTR time.

ii) Vendor provides adequate training to owner's personnel and cover all necessary maintenance related topics in their training programmes to ensure specified MTTR time.

4.1.4 Operating Environmental Conditions

4.1.4.1 Environmentally Controlled Location Installation

a) All subsystem of Programmable Logic Controllers located in Control Room, Local Control Room or in Satellite Rack Room shall be able to operate satisfactorily from 15°C to 30°C and 20% to 80% non condensing humidity.

b) In addition to above, all such sub-systems shall also be able to operate satisfactorily in case of air conditioning failure with ambient temperature of 50°C and 90% no condensing humidity until the system safe operating limits are exceeded. The minimum period of continuous operation in such condition shall be 48 hours at least once in a month without any damage or degradation of system performance. Vendor, therefore, shall provide continuous temperature monitoring for each enclosed cabinet housing items / equipments generating heat, such as system cabinets, barrier cabinets, relay cabinets etc and also provide alarm for operator alert in case the safe operating temperature limits are exceeded.

c) Chemical filters have been provided in the incoming air conditioning air to limit the concentration of contaminants below following limits:

Contaminants (Corrosive Gases)	Concentration

SOx	< 0.01 ppm by volume
NOx	< 0.05 ppm by volume
H2S	< 0.003 ppm by volume
Cb	< O.OOlppm by volume
NH3	< 0.5 ppm by volume
SPM	< 200 ugm/m'
RSPM	< 100 ugm/nr'

All sub-systems and system components shall be suitable for operating continuously in the above mentioned corrosive environments

4.1.4.2 Outdoor Installations

a) Sub-systems or system components which are installed outdoor shall be suitable to continuously operate at ambient temperature and humidity specified under ambient conditions. The heat generation effect of current carrying for the electronic modules shall also be considered. For this purpose the system shall be\rated for minimum 5 deg C more than the maximum ambient temperature specified. In case the system is not suitable for the above conditions, necessary cooling arrangement shall be provided.

b) Unless otherwise specified, all PLC sub-systems or system components installed outdoor shall have corrosive environmental protection coating meeting the environmental classification class G3 as per ISA-S71.04.

4.1.5 Transient, Static and EMI / RFI Protection

4.1.5.1 The system shall be internally protected against system errors and hardware damage resulting from:

a) Electrical transients on power wiring.

b) Electrical transients on signal wiring.

c) Connecting and disconnecting devices or removing or inserting printed circuit boards in the Programmable Logic Controller (PLC).

4.1.5.2 All sub-systems and system components shall be capable of accepting various signal inputs for its direct use while preventing noise errors due to electromagnetic interference (EMI) or radio frequency interference (RFI) including nearby radio stations, hand held two way radios, solenoids, relays or contactors carrying heavy currents as per levels of Environmental electromagnetic phenomenon defined in IEC-61000-6-2. The system shall have total noise immunity from UHF / VHF radio communication equipments, (RFI) and (EMI) noise generating equipments as per IEC-61000-4.

4.1.5.3 For interplant, inter unit and other system cables routed in the field, the level of surge immunity required for equipment signal ports shall be increased to level 4 as defined in IEC-61000-4-5 and the system shall operate according to performance criterion B as defined in IEC-61000-6-2.

4.1.6 On-line Replacement

4.1.6.1 On-line replacement of any module of programmable logic controller shall be possible in such a way that removal and addition of the module shall be possible and safe without de-energising the system. Furthermore, there shall not be any interruption of the system while replacing a faulty module wherever redundant modules are provided.

4.1.6.2 Apart from system modules, power supply units shall be replaceable on-line without disrupting the process and without affecting the system redundancies. It shall be possible to hot swap any faulty system module without degrading the system safety or operation or freezing the output status. The switchover to the healthy module shall be bumpless. The swapped module shall take over the function of the failed module without any manual programming.

4.1.7 Electrical Isolation

Galvanic or optical isolation shall be provided for all field signals. The isolation levels shall be as follows:

Analog I/O channel to system ground 1500V AC

Discrete I/O channel to system ground 500V AC

External isolator shall be provided, if necessary to meet the above.

Isolation shall also be provided between Engineering / operator cbnsole/PLC programming terminal and related sub-systems connected to it if there is any possibility of high voltage being transmitted to the sub-systems.

4.1.8 Design Requirements of Equipments in Hazardous Area

4.1.8.1 Unless specifically indicated, the field devices are beyond the scope of this specification. However vendor shall be fully responsible for integrating these devices with their system.

4.1.8.2 General requirements

a) Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.

b) For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

4.1.9 Repeat Signals

4.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals:

a) Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed:

i) For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.

ii) For all other contact inputs, repeat contact shall be provided using electro-magnetic relays.

4.1.10 The system shall be designed fault tolerant and shall utilize high quality components of proven quality. Any single system fault shall not degrade the system safety or functionality or affect operation. The system shall have certified Safety Integrity Level as per IEC61508/ 61511 as applicable and specified in job specification. Unless otherwise specified, it shall meet the availability requirement specified in Clause 4.1.3 ofthis specification.

4.1.11 Unless otherwise specified, the scan time of programmable controller shall be of the order of 250 milliseconds for SIL certified PLCs. Scan time for a PLC shall be as defined under para 2.16 of this specification.

4.1.12 Operation of the PLC shall be completely unaffected by a momentary power loss of the order of 20 milliseconds.

1.1.13 The system shall be programmed in principle as per the logic diagrams furnished during detailed engineering. Vendor shall prepare their own Logic/Ladder diagrams depending upon the capability of the programmable logic controller offered by them. Owner / Consultant reserve the right to revise or review the logic diagrams even after acceptance of any offer. The programming language of offered PLC shall be as per IEC 61131.

1.1.14 Whenever the requirement of SIL is specified for the PLC, it shall meet the requirements of SIL level specified and shall be certified by an independent body (e.g. TUV) for complying requirements of IEC-61508 / 61511 as specified. For shutdown application requiring SIL certification, PLC shall always meet SIL 3 requirements.

1.1.15 The system shall have extensive set of self diagnostics hardware and software for easy and fast maintenance of PLC. Routine checks should run automatically at frequent intervals for identifying any fault in software or hardware. Diagnostics shall be required at local as well as console level. \

1.1.16 Safety barriers shall be provided by the vendor for intrinsically safe input/output circuits wherever specified. In such cases, the system shall be designed intrinsically safe based on entity concept. The barriers shall be certified by a statutory authority like Baseefa, LCIE, CSA, UL, PTB, CIMFR etc., for the use in the area classification as specified elsewhere in the job specifications. The proper selection of the safety barriers shall be the vendor's total responsibility. In case of smart transmitter, the entity parameters of the hand held terminals shall also be considered while selecting proper barriers.

1.1.17 Unless otherwise specified all intrinsically safe barriers shall be 3 port isolating type only providing isolation between;

i) Input and output (non-hazardous to hazardous side of barriers)

ii) Power supply and input

iii) Power supply and output

The minimum isolation level shall be 250V.

4.2 System Configuration

4.2.1 General

a) PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL classification, the system configuration shall be TMR or QMR or DMR or VMR as per the job specification and shall be certified by independent agency e.g. TUV.

b) Regardless of the action feature selected (except for single architecture), the failure of single component shall not result in a failure of correctly executed safety function. The degradation mode for the selected configuration e.g. 4-2-0 or 3-2-0 or 3-2-1-0, etc. shall be documented in SIL certification report.

c) In general, the PLC system shall comprise of various sub-systems as described in the subsequent clauses of 4.2.

4.2.2 Input/ Output Subsystem

4.2.2.1 Each I/O module shall have its own processor. I/O modules configured m redundant configuration, shall have their processors properly synchronised.

4.2.2.2 Unless otherwise specified, system shall accept analog 4 -20mA inputs and contact inputs. The maximum number of Input/Output per I/O module shall be limited as per the following table.

Sl No.	Type of Configuration	Maximum No. I/O s
1	Single I/O system	8
2	Dual I/O system	16
3	Triple Modular Redundant system (TMR)	32
4	Quadruple Modular redundant System (QMR), Flexible Modular Redundant (FMR) configuration, Virtual Modular Redundant (VMR)	16

4.2.2.3 Each I/O shall be galvanically isolated from external control circuit by suitable means. The minimum isolation level between I/O and logic circuit shall be 1000 volts DC.

4.2.2.4 Each I/O shall be protected against the reversal of polarity of the power voltage to I/O.

4.2.2.5 Each input shall be provided with filters to filter out any noise in the input line and contact bouncing noise, as applicable.

2.2.2.6 All the inputs / outputs shall be double ended i.e. two wires per input / output and not with common return for all inputs.

4.2.2.7 The interrogation voltage to the inputs and power supply for 2-wire instruments shall be powered from separate redundant power supply / supplies and shall not be a part of PLC, unless otherwise specified. This power supply shall be supplied at one point and shall be distributed by the vendor.

4.2.2.8

a) Each module shall have a LED per channel to indicate the status of each input output.

b) When specified, input module shall be capable of monitoring the input contacts for any wire open fault and short circuit.

4.2.2.9 Analog Input Module

a) Input module shall be able to accept 4~20 rnA DC input from smart transmitters (e.g. 4 -20mA HART).

b) The module shall have 12 bit Analog to Digital resolution accuracy of ±0.2S% of full scale over the entire range, unless otherwise specified.

4.2.2.10

a) Output contacts from the PLC shall be potential free dry contacts with contact rating as per para 4.2.2.10 b) of this specification. Vendor must provide arc suppression device for each output contact.

b) The output contact rating shall be as follows:

SL.No.	APPLICABLE FOR	VOLTAGE RATING	CURRENT RATING
1	All output cards driving solenoid valve and alarm annunciator system unless otherwise specified Category -I Category -II	 **110 V DC** **24VDC**	 0.5 A 2A
2	All motors/pumps/compressor output cards unless otherwise specified. Category –I Category -II	 **240 V AC** **220 V DC**	 5.0A 0.2 A

c) The category of contacts shall be specified in the material requisition. Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.

d) When specified contact output module shall have monitored\ output features like

wire open and short circuit.

4.2.2.11 Where inputs or outputs have multiple field devices for the same measurement or device, the corresponding inputs / outputs shall be configured in separate I/O modules.

4.2.2.12 Where single input signal is available for QMR or TMR or FMR or VMR configuration, inputs shall be multiplied to feed inputs to each input modules / channels.

4.2.2.13 PLC shall be provided with Auto I/O testing facility as a standard diagnostics features. PLCs which do not have auto I/O testing facility, manual testing facility shall be provided to detect any system fault. For manual testing, manual switches shall be provided to bypass each input at a time and its effect on the output shall be monitored.

4.2.3 Processor System

4.2.3.1 The processor shall have capability to implement all the control functions required to implement the logic scheme as logic/ladder diagram.

4.2.3.2 The size of the memory shall be sufficient for storage of the program instructions required by the logic schemes and other functional requirements. Offer shall indicate the amount of memory capacity occupied by the actual program and spare capacity available for future program modifications or additions.

4.2.3.3 Memory shall be non-volatile. However in case volatile memory is provided, battery backup shall be provided with a minimum of 3 months lifetime to keep the program storage intact. A battery drain indication shall be provided at least one week before the battery gets drained.

4.2.3.4 Watchdog timer shall be a software device. The healthiness of processors shall be continuously monitored by watchdog timer. Any hardware or software problem in the processor system, which shall include, CPU, memory, power supply, communication interface etc. shall cause the watch dog timer to report processor failure.

4.2.3.5 Wherever dual redundant processor is specified, redundancy shall be provided in such a way that in case of failure of the main processor, the standby shall take over automatically. The changeover shall be bump less. Redundancy shall be provided for complete processor system including processor, power supply and communication sub system.

4.2.3.6 In case of triple modular redundant system all the three processors shall execute the same instructions/program and check their results and vote to correct any faulty result. The faulty processor diagnostic shall be made available.

4.2.3.7 In case of QMR system, individual processor shall execute the same instructions/ programs and check their results within same CPU module and majority vote to correct any faulty result. The faulty processor diagnostic shall be made available.

4.2.3.8 Failure of a single processor in dual redundant, triple redundant system and two processors in QMR system shall not affect the system. In case of failure of complete processor system

i.e. both processors in case of dual configuration, two or more in case of triple redundant system and more thah two in case of QMR system, outputs shall take failsafe state automatically unless otherwise specified in the data sheets.

4.2.3.10 It shall be possible to generate the first out alarm contact by the PLC in case where a group of parameters are likely to trip a system.

4.2.4 PLC Console (Programming Terminal)

4.2.4.10 The PLC console (Programming Terminal) shall be used for programming, program storing, fault diagnostics and alarm monitoring. Whenever specified, it shall also be possible to use this console for plant operation. The functionality to operate as engineering / programming terminal or operator terminal or both shall be as specified in the job specification.

4.2.4.2 It shall consist of at least one coloured 21" Flat screen LCD monitor with TFT technology and one programming / operating keyboard, mouse and printer unless specified otherwise.

4.2.4.3 PLC console when used for plant operation shall also meet the functional requirements as per clause 4.2.5 ofthis specification

4.2.4.4 The keyboard shall preferably be touch sensitive sealed type, easy to operate with each key clearly identified.

4.2.4.5 All illegal entries shall be rejected by the terminal and shall be identified by warning signal on VDU.

4.2.4.6 Manual forcing of any input or output contact connected to PLC shall be possible from keyboard. Forced functions shall have an associated audit trail.

4.2.4.7 It shall be possible to modify, add or delete the application program on line without affecting the outputs.

4.2.4.8 PLC Console shall display logic and/or ladder diagram indicating power flow and shall show description and status of each contact. It shall also be possible to display process alarms and diagnostic messages as and when they appear. Further it shall also be able to display I/O map in a user defined format.

4.2.4.9 I t shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out:

a) The diagnostic messages as and when generated and diagnostic reports, when called for.

b) Process alarms connected to the programmable logic controller as and when they appear and alarm report whenever initiated. The choice of printing alarms on this printer shall be operator selectable from a key lock / password protected switch on PLC console.

c) The I/O maps showing status of all inputs and corresponding outputs in a user defined format.

4.2.4.10 The PLC console shall be provided with self diagnostics feature which shall display error messages and initiate an audible alarm if the fault is detected. Wherever specified, a potential free contact for diagnostic group alarm shall be provided which shall be connected to the hardwired alarm 'annunciator system.

4.2.4.11 The system shall be able to identify the failure at least up to the module level including I/O system and redundant processor and report print out.

4.2.5 PLC Console (Operator)

4.2.5.1 Where dedicated PLC operator console is specified, it shall be used for operation of plant, fault diagnostics, alarm monitoring and report generation.

4.2.5.2 It shall consist of coloured 21" Flat screen LCD monitor with TFT technology, operator keyboard and printer unless specified otherwise.

4.2.5.3 At least two number cursor control devices shall be provided in addition to keyboard which may include touch screen, mouse, track ball etc.

4.2.5.4 PLC operator console shall have complete graphic capability and shall be able to display process dynamic graphics, overview and group view displays. It shall be possible to operate the plant i.e. start and stop of rotating machinery, opening and closing of valves, Pill function etc. from dynamic graphics and group displays available on PLC operator console.

4.2.5.5 It shall be possible to monitor, historise and print out all process alarms, diagnostic alarms and alarm reports.

4.2.5.6 Unless otherwise specified, the time stamping of all alarms shall be as per PLC processor time stamping.

4.2.5.7 The system shall be able to store and display stored data wherever required. The minimum storage capacity shall be for 30 days at 1 minute sample rate for all the inputs specified, diagnostic alarms, process and first out alarms, manipulation data etc.

4.2.5.8 The system shall be able to generate shiftly, hourly, daily, weekly and monthly reports. The log format shall be furnished during detailed engineering.

4.2.5.9 The system shall be supplied with first out alarm generation capability. The resolution of alarm shall be as per processor cycle time, as a minimum.

4.2.6 Communication Subsystem

4.2.6.1 The PLC communication subsystem shall be a digital communication bus that provides a high speed data transfer rapidly and reliably between the processor, I/O sub-system, PLC console and other devices connected in the PLC system.

4.2.6.2 Redundancy in PLC communication subsystem shall be provided as follows unless otherwise specified:

a) For single architecture, the communication subsystem between PLC processor and I/O subsystem shall be single unless otherwise specified. This shall include single communication bus and single interfaces/buffers.

b) For dual I/O configuration, each I/O sub set shall have separate communication interface and bus for connecting to PLC processors.

c) For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.

d) For the QMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.

e) The communication subsystem between processor subsystem and PLC console shall be dual redundant, consisting of two separate communication interfaces and two buses, each one configured in redundant mode, unless this is only used as programming aid.

4.2.6.3 In case of redundant PLC communication sub system, on the failure of the active device, the redundant device shall take over automatically without interrupting the system operation. Information about the failed device shall be displayed at local as well as on PLC console. It shall be possible to manually switch over the communication from main bus / device to redundant bus / device without interrupting any system function.

4.2.6.4 The mechanism used by the system for error checks and control shall be transparent to the application information / program. Error checking shall be done on all data transfers by suitable codes.

4.2.6.5 In general, PLC shall provide data m a well established protocol format preferably MODBUS protocol.

4.2.7 System Power Supplies

4.2.7.1 Unless specified otherwise, the programmable logic controller shall operate on uninterrupted power supply (UPS). However the system shall be capable of operating satisfactorily at the following power supply specifications:

Voltage	220 V ±10%
Frequency	50 Hz±3 Hz
Harmonic contents less than	5%
Power interruption	10 millisec

4.2.7.2 The power supply system shall be supplied with dual PLC feeders each capable of handling 100% of the total power supply load requirements. In case of failure of one feeder, redundant feeder shall supply the total load.

4.2.7.3 Each I/O rack shall be provided with separate power supply unless otherwise specified in job specifications. Each power supply shall be sized to take full load of the I/O rack/signal conditioning panel. Each rack shall be provided with dual redundant power supply.

4.2.7.4 Processor subsystem shall be provided with separate power supply, as a minimum, unless otherwise specified in job specification. Failure of one power supply shall not affect the system operation/processor switchover in case of dual processor system. Wherever triple redundant system is specified each processor shall preferably be provided with a separate power supply. Also separate power supply must be provided for each multiplied process I/O

channel.

4.2.8 Self Diagnostics

4.2.8.1 The system shall have an extensive set of self diagnostic routines which shall be able to identify all permanent and transient system faults / failures at least up to module level including redundant components and power supplies through detailed VDU displays and report print out.

4.2.8.2 At the local level, failure of a module in any subsystem shall be identified by an individual LED.

4.2.8.3 Diagnostic software shall have the capability to provide information about the failed module/system either in the form of a system configuration display or provide information in the form of a "statement".

4.2.8.4 Self diagnostic software shall have capability to detect faults which make the system permanently close/open in the I/O modules or I/O signal conditioning modules (in case of triple redundant system, whenever specified in the job specifications, this may be achieved by automatically running the testing software at cyclic intervals), The automatic cyclic testing feature shall also be provided for dual I/O configuration and dual I/O signal conditioning for triple redundant system. The testing software cycle time may be considered once in 30 minutes however this shall be field adjustable by engineer. However, system performance shall not be degraded whenever testing feature is specified.

4.2.8.5 System for the following functionalities shall be supplied when specified:

a) Long storage historisation

b) Log report generation

c) First out alarm generation

4.2.8.6 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum:

a) Processor fault

b) Communication fault

c) I/O module fault

d) Power supply fault

e) Over temperature monitoring

f) Permanently close / open (stuck on or off) fault

g) Memory fault

h) Signal redundancy fault

Any other additional diagnostic alarm if available as a standard shall also be provided by vendor.

4.2.8.7 Testing software shall be capable of detecting faults in case of normally closed system as well as in normally open system.

4.2.8.8 Feedback must be provided in case of triple redundant system and QMR system from the output voter system to detect any latest faults of the system in addition to other diagnostic software.

4.2.9 System Software

4.2.9.1 The system software shall include all programs for the PLC and PLC console which are required to perform all the PLC functions including communication and self-diagnostics. Whenever PLC is specified for shutdown application with SIL classification, the system shall be designed and engineered in full compliance with the requirement of IEC-61511. Whenever different functional logics are combined within a common PLC, the safety related I/O's of each functionality shall be kept segregated within the system.

4.2.9.2 Logic program shall also be recorded on the external electronic media like DVD which shall be delivered in duplicate together with the system.

4.2.9.3 The PLC programming language for implementation of logic operations shall be based on the following representations:

a) Logic diagrams -Binary logic symbols such as AND, OR, NOT Gates, Timers and Flip-Flops.

b) Ladder diagram -Series / parallel connection of relay contacts.

c) Combination of (a) & (b) above.

4.2.9.4 Diagnostic package and its related equipment and software shall be supplied. A list of additional diagnostic packages available and the packages provided, including the description and capabilities, shall be provided with separate quote, wherever asked.

4.2.9.5 It shall be possible to print out the ladder/logic diagram on a dedicated printer. The printer shall also print out all diagnostic reports. Vendor must supply the off line software package to enable the owner to modify/add/delete any part of program and for documentation.

4.2.9.6 Software for the generation of various displays including dynamic graphics wherever specified to be provided as per given below:

4.2.9.6.1 It shall be possible to display dynamic graphic of plant on the operator console VDU screens. Graphic displays shall be field configurable only through PLC Console (Programming terminal) with standard / user defined graphic symbols. Dynamic graphic displays of different sections of the plant shall be displayed on different pages.

4.2.9.6.2 The system shall have graphic symbol library as per ISA-5.! and 5.3. In addition standard industrial symbols like distillation columns, heat exchangers, pumps, compressors, tanks etc. shall also provided as a standard.

4.2.9.6.3 Graphic displays shall be interactive type through which it shall be possible to control the process. It shall also be possible to send motor start/stop and shutdown valve open/close commands, as specified in job specifications, from this display

4.2.9.6.4 It shall be possible to view the process variable and alarm points and view and change set point value, manipulated variable, controller mode etc. from the graphic display. Also rotating machinery (i.e. compressor / pump) status and valve status shall be displayed on the graphic display with different colours

4.2.9.6.5 Various colours used in the generation of graphics like colour of the process lines, utility lines, Instrument signal lines and event modifier conditions shall be finalised during detailed engineering. The colours used to identify event modified conditions shall generally be as follows unless otherwise indicated during detailed engineering

Red -	All points alarm
Blue-	Valve open, pump running
Green -	Valve closed, pump stopped
Flashing green -	Shut down valve transition state

4.2.9.6.6 It shall be possible to go from any graphic page to related graphic pages or any group view or alarm summary in single key stroke using soft key function.

4.2.9.7 The software for printing alarms, system as well as process, and events on the PLC printer must be provided. All alarms must be printed as and when they appear.

4.2.9.8 Software package for displaying I/O map showing status of inputs and corresponding output providing tag numbers as per logic diagram shall be offered. The I/O map format shall be user definable.

4.2.10 Power Supply Distribution

4.2.10.1 All type of power supplies shall be made available at one point. Further distribution of power supply shall be in vendor's scope.

4.2.10.2 In general, all output contacts and solenoids shall be powered with 1l0V±10% DC/ 24V±10% DC power supply. However, the actual interrogation voltages shall be as per job specifications and logic diagrams.

4.2.10.3 The distribution network for interrogation voltage shall be designed such that a single fault in any branch shall not cause trip of the logic other than where the fault has occurred.

4.2.10.4 Sequential starting of various load centers shall be provided whenever specified.

4.2.10.5 Power distribution network must use bus bars of adequate capacity with DPDT (Double Pole Double Throw) switches and HRC (High Rupture Capacity) fuses in each branch network. Vendor may select circuit breaker if short circuit characteristics do not match the HRC fuse.

4.2.10.6 All cubicles lighting shall be on 240 V, 50 Hz AC normal power supply.

4.2.11 PLC System Cabinets

4.2.11.1 All PLC system cabinets shall be completely wired with all modules in place. Inside cabinet wiring shall preferably be done using ribbon type pre-fabricated cables.

4.2.11.2 All the cabinets shall be free standing, enclosed type and shall be designed for bottom entry of cables. Cabinet structure shall be sound and rigid. Cabinet shall be provided with removable lifting lugs to permit lifting of the cabinets.

4.2.11.3 Cabinet shall be fabricated from cold rolled steel sheet of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum 1.6 mm thickness. Cabinets shall be thoroughly deburred and all sharp edges shall be grounded smooth after fabrication.

4.2.11.4 Cabinet finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filter and two coats of high grade lacquer with wet sanding between two coats. Two coats of paint in the cabinet colour shall be given for non-glossy high satin finish. Colour of the cabinets shall be as per job specification. Final coat shall be given after assembly at site when specified in the job specifications.

4.2.11.5 Each cabinet shall be maximum 2100 mm high (excluding 100 mm channel base), 800 mm wide and 800 mm deep, in general. Construction shall be modular preferably to accommodate 19" standard electrical racks. All cabinets shall be of same height.

4.2.11.6 Cabinets shall be equipped with front and rear access doors. Doors shall be equipped with lockable handles and concealed hinges with pull pins for easy door removal.

4.2.11.7 In order to effectively remove dissipated heat from the cabinets, ventilation fans along with vent louvers backed by wire fly screen shall be provided as required. Ventilation fans shall be provided in all cabinets where the temperature rise with all doors closed and all internal and external loads ertergised shall exceed 10° C above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature measurement. Ventilation fans shall be provided in dual configuration, as a mmimum.

Each fan shall have a separate dedicated assembly and shall be replaceable on-line without shutting down any equipment / panel/cabinet / console in part or in complete. \

Ventilation fan assembly shall operate at 240V AC power supply. Each fan shall have its own dedicated circuit breaker.

Each ventilation fan shall be fitted with a protection type finger guard. Whenever, the numbers of cabinets are compacted (supplied in mechanical joined conditions), each cabinet shall be provided with separate ventilation fan assembly.

The maximum noise level with all fans operating and cubicle doors open shall not exceed 85dBA.

Following signals and alarms shall be provided for each cabinet:

i) Fan failure alarm for each cubicle in PLC.

ii) Temperature indication of each cabinet or compacted combination, as applicable in PLC.

iii) A common alarm each for high temperature and fan-failure shall be made available.

4.2.11.8 Internal illumination shall be provided for cabinets to ensure proper illumination level of250 lux for performing maintenance activities. Illumination shall be provided for all cabinets by incandescent lamps, which shall be activated individually by door operated magnetic switches. The lamps shall activate when door is opened and deactivate when the door is closed. The magnetic switches selected shall have undergone life cycle cyclic test of at least 1000000 operations. A manual over-ride switch shall be provided inside the cabinet which shall keep the lamp deactivated even when the door is open.

4.2.11.9 Equipment within the cabinet shall be laid out in an accessible and logically segregated manner. Cable glands shall be provided and supplied by vendor for incoming and outgoing cables to prevent excessive stress on the individual terminals. All metal parts of the cabinet shall be electrically continuous and shall be provided with a common grounding lug.

4.2.12 Control Panels/ Hardwired Console

4.2.12.1 Control panels, if required, shall be non-graphic self supporting, free standing cubicle with back doors made up of sectional steel panels. Each section shall be maximum 2100 mm high, 1200 mm wide and 1000 mm deep and shall be mounted on 100 mm high channel base. Care shall be taken to ensure that the face of the panel is truly flat and smooth.

4.2.12.2 Panels / hardwired console shall be fabricated from 3.0 mm thick cold rolled steel sheet. Angle iron frame shall use a minimum section of 50x50x4mm angle.

4.2.12.3 Front of panel/console instrument nameplates shall be black laminated plastic with white core. Nameplate shall be provided on the rear of the panel also for each instrument.

4.2.12.4 Document pocket / wallet shall be provided on the inner side of front and rear doors of each cabinet and on the inner side of the door of each panel. Similar arrangement shall also be made on the inner side of doors of console.

4.2.13 Wiring Requirements'!

4.2.13.1 All wiring shall conform to API RP 552-Transmission Systems. Different signal level cables shall be routed with separation distances as recommended by this code.

4.2.13.2 All wiring inside racks, cabinets, and back of the panels shall be housed in covered, non-flammable plastic raceways arranged to permit easy assembly to various instruments for maintenance, adjustments, repair and removal. \

4.2.13.3 All wiring in the raceways shall be properly clamped. All incoming cable and outgoing cables shall be terminated by vendor at marshalling rack. Total wiring cross-sectional area shall not exceed 50% of the raceway cross sectional area.

4.2.13.4 Separate wiring raceways shall be used for power supply wiring, DC and low level signal wiring, and intrinsically safe wifing. Parallel runs of AC and DC wiring closer than 300mm shall be avoided.

4.2.13.5 Vendor can alternately offer prefabricated cables for interconnection between different cabinets and panels.

4.2.13.6 Wire termination shall be done using self insulating crimping lugs. More than two wires shall not be terminated on one side of single terminal. The use of shorting links for looping shall be avoided.

4.2.13.7 Terminal housing shall be strictly sized with considerations for accessibility and maintenance. Minimum distance required between various components is listed below. These distances are clear distances and are excluding the width of the raceways or any other component / item mentioned herein. Following clearances should be considered:

a) Distance between terminal strip and side of the cabinet parallel to the strip, up to 50 terminals, shall be minimum 50 mm.

b) Distance between terminal strip and, top and bottom of the cabinet shall be minimum 75mm.

c) Distance between two adjacent terminal strips shall be minimum 100 mm.

d) Additional distance for each additional 25 terminals shall be minimum 25 mm.

e) Distance between cable gland plate and the bottom of the strip shall be minimum 300 mm.

4.2.13.8 All terminal/terminal blocks shall be DIN Rail mounted type and shall be easily removable. The size of the terminal blocks / terminals of different types shall be consistent and identical. All terminal blocks shall be mounted on suitable anodised metallic or plastic stand-off.

4.2.13.9 No splicing is allowed in between wire/ cable straight run.

4.2.13.10 Terminal strips shall be arranged group-wise for incoming and outgoing cables separately. Terminal blocks for intrinsically safe wiring shall be separate. 20% spare terminals shall be provided, as a minimum, preferably in each terminal strip. Terminals shall be suitable for wires up to 2.5 sq. mm base solid or stranded conductor in general. For power cables, higher size terminals shall be used.

4.2.13.11 Cabinet and rack layout shall be made considering proper accessibility and maintenance.

4.3 Earthing

4.3.1 All system equipments such as panels, marshalling cabinets, system cabinets and other powered equipments shall be provided with following type grounding system:

a) Protective Earth/ Electrical Earth

b) System Earth! Signal Earth

c) Safety Earth! Barrier Earth (when required)

Both system earth and safety earth shall be totally separate from protective earth.

4.3.2 Protective Earth / Electrical Earth

a) Each metallic enclosure / cabinet / panel/console etc. shall be provided with electrical earth lug, as a minimum.

b) Unless recommended otherwise by vendor, all earthing lugs of metallic equipments indicated in Clause 4.3.2 (a) above shall be connected individually to electrical protective earthing system bus-bar / earthing station using ,a maximum of 10sq mm solid copper conductor PVC insulated wires.

c) Where multiple cabinets are multiplexed together, earth looping with permanent shorting link cables shall be acceptable. Two earthing connection wires as indicated in Clause NoA.3.2 (b) above shall be used for connecting multiplexed cabinets to protective earth station / bus-bar.

4.3.3 System Earth

a) System earth shall be totally noise free dedicated earthing system and shall be fully isolated from electrical protective earth. This earth must be very high integrity system and shall be used to ground zero volt references and signal cable grounds.

b) System earth shall be less than one (l) ohm grounding system with its own dedicated earthing pits. These earth pits shall be away from any heavy noise plant equipment. Outside the control room building is the most appropriate location.

c) Wherever supply of earth pit is kept in vendor's scope in the Material Requisition, the earth pit design shall be as per IS-3043 code of practice for earthing. A minimum of four (4) number of earth pits shall be provided for grounding system integrity. In case number of pits required to meet 1 ohm resistance are more than (2), the number of earth pits shall be two times the actual number of pits required to meet resistance criteria. All these pits shall be securely connected with each other to form a one homogeneous system earth grid.

d) Each marshalling / system cabinet / panels etc shall be provided with system earth bus-bar which shall be insulated from the metallic body frame. This bus-bar shall be used to earth also signal zero volt references and signal cable screens. Terminals used for termination of spare conductor pairs / cores of multi-pair signal/control cables shall be connected to system earth bus-bar. Shorting links shall be used for spare terminal looping.

e) System bus-bars in the multiplexed cabinets can be joined together by permanent shorting links. System bus-bars of other cabinets can also be connected together provided they are permanently joined using 35 sq mm stranded copper conductor cable.

4.3.4 Safety Earth / Zener Barrier Earth

a) Whenever Zener barriers are selected or used to meet intrinsically safe requirements, the earthing terni'inal of the zener barriers shall be connected to a separate earth bus bar.

b) This earth shall meet all the requirements specified in Clause 4.3.3 of this specification.

c) Safety earth bus bar shall be directly connected to earth pits using dual insulated cable. Cable conductor size shall be minimum 95 sq. mm (c~pper).

4.4 Interface with DCS

The PLC shall be required to be interfaced to the Distributed Control System bus whenever specified. A suitable interface shall be offered in order to achieve the following functions:

a) Display of all input points under alarm/first out alarm connected to PLC or generated by PLC, continuous indication for analog signal on the main DCS operator console.

b) Generate shutdown reports on the logging printer of Distributed Control system.

c) To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC

d) To display diagnostic message of PLC.

In general, PLC shall provide data in a well established MODBUS protocol format.

The interface shall be dual redundant unless otherwise specified.

The speed of data transfer shall be such that any change in I/O which is to be updated on the operator console shall not exceed 3 second from the time event to update on the operator console screen considering one second standard update rate in DCS operator console.

4.5 Sequence of Event (SOE) Function Requirement

Sequence of Event, whenever specified, for analog and digital inputs shall be generated and time stamped in PLC. The maximum resolution between two events shall not exceed specified PLC scan time unless specified otherwise. A separate SOE PC with 21" size TFT screen and printer shall be provided for PLC sub-system unless specified otherwise.

5.0 TESTING, INSTALLATION, COMMISSIONING AND ACCEPTANCE

5.1 General

5.1.1 This specification defines the basic guidelines to vendor for factory testing and acceptance, installation, commissioning and field acceptance of the complete PLC system. On the basis of

this specification, vendor shall submit their own detailed testing, installation, commissioning and acceptance procedure. For hardware, the procedure shall include test name, purpose of test, test equipment / set up, definition of input, test procedure, results expected and acceptance criteria. Similarly for software, it shall include test name, details of the method, list of tests, sequence of execution, results expected and acceptance criteria. For PLC system with SIL 3 requirement, certificate for hardware & software (Like TUV etc.) shall be verified.

5.1.2 The testing and acceptance of the system shall be carried out on the approved testing procedures and criteria based on this specification and vendor's standard testing requirements and procedures.

5.2 Factory Acceptance Tests (FAT)

5.2.1 Vendor shall test and demonstrate the functional integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified "Ready for Shipment" by the owner/consultant.

5.2.2 The purchaser reserves the right to be involved and satisfy himself at each and every stage of inspection. The purchaser shall be free to request any specific test on any equipment considered necessary by him although not listed in this specification, as a part of approval of factory testing procedure. The cost of performing all tests shall be borne by the vendor.

5.2.3 Vendor to note that acceptance of any equipment or the exemption of inspection or testing shall in no way absolve the vendor of the responsibility for delivering the equipment meeting all the requirements specified in Material Requisition.

5.2.4 It shall be vendor's responsibility to modify and/or replace any hardware and modify the software if the specified functions are not completely achieved satisfactorily during testing and factory acceptance.

5.2.5 Schedule of FAT shall be included in the Vendor's proposal.

5.2.6 Vendor shall not replace any system component/module/sub-system unless it is failed. A log of all failed components/modules in a sub-system shall be maintained which shall give description of the failed component/module, effect of failure on the sub-system, cause of failure and number of hours of operation before it failed. If malfunction of a component/ module in a sub-system repeats, the test shall terminate and vendor shall replace the faulty component/ module. Thereafter the test shall commence all over again. If even after this replacement, the sub-system fails to meet the requirements, vendor shall replace the full sub-system by the one meeting the requirements and the system shall be tested all over again. If a sub-system fails during the test, which is not repaired and made operational within four hours of active repair time after the failure, the test shall be suspended and restarted all over again only after the vendor has replaced the device in the acceptable operation.

5.2.7 Testing and FAT shall be carried out in two phases. The minimum requirements for testing during these two phases shall be as follows:

5.2.7.1 Under the first phase, vendor shall perform tests at his works to ensure that all components function in accordance with the specification for each type of test. A test report shall be submitted for purchaser review within one week of completion of this test. Phase II testing

(witness inspection) shall start only after this.

All subsystem shall undergo a minimum of 30 days burn in period. The burn-in time shall start after the sub-system is fully assembled and is powered up. It may include any such time for which the system has been kept powered on even for system generation and Phase I testing.

Following tests shall be performed by the vendor and reports shall be forwarded to purchaser:

a) Quality control test which shall be carried out to assure quality of all components and modules in accordance with vendor's quality control and assurance procedures.

b) System pre-test which shall be physical check of all modules, racks, cabinets etc.

c) System power-up test which shall test functionally all hardware and software. This shall include testing of redundancy, System performance on power supply variations, application software testing and system diagnostic verification.

5.2.7.2 The second phase of testing shall systematically, fully and functionally test all hardware and software in the pre~ence of purchaser representatives. All subsystems shall be interconnected to simulate, as close as possible, the total integrated system. Following minimum tests shall be carried out:

a) Visual and mechanical testing, which shall be carried out in principle to assure correct, proper, good and neat workmanship by the vendor This testing shall include dimensional verification, Layout verification as per approved GA drawings, Verification of Sheet thickness / Quality of painting (outer and inner) / N~meplates, identifiers and tag plates / Adherence to ferruling philosophy / Dressing of wires / prefabricated cables and clearances / Locks and handles as a minimum.

b) Verification of Bill of Material. The Bill of material verification shall include both hardware and software.

c) Functional testing:

This shall include the simulation of each input and output to verify proper system response. The testing as a minimum shall include:

i) Complete system configuration loading.

ii) Demonstration of all PLC system builder functions including addition/deletion of an input/output, addition/ deletion of a rung or an element in a rung, generation of dynamic graphics and other views, report generation etc.

iii) 100% checking of logics configured in the PLC by connecting switch/lamp at input/output, by simulating inputs and verifying outputs preferably using simulator, other related functions like forcing, first out shall also be verified.

iv) Checking of scan time. Scan time verification shall be carried out using high resolution storage oscilloscope during Factory Acceptance Test based on the specified requirements considering discrete input by given step change. The scan time values so observed shall be within 90% confidence level. Incase of analog inputs, input shall be ramp or minimal step, however such reading for analog inputs should be noted only for reference.

v) Checking of all PLC console displays, keyboard and touch-screen operation (wherever specified), printer/hard copier functions etc.

vi) System redundancy check including correct change over of the back-up unit in case of failure of main unit.

vii) System diagnostic checking for all subsystems on local level as well as on console, including checking of the testing software for I/O modules/signal conditioning modules, when specified.

viii) Checking of output status on processor failure.

ix) Checking of first-out alarm generation.

x) Simulation of power failure and system restart auto boot-up of system configuration and program after power restoration.

5.2.8 Vendor shall notify the purchaser at least three (3) weeks prior to factory acceptance test. In the event that representative arrives and the system is not ready for testing, vendor shall be liable for back charges for any extra time and expenses incurred.

5.3 Installation, Testing and Commissioning

5.3.1 Vendor shall offer the services of an installation team which would install the equipment in the control room, lay the interconnecting cables inside control room, check-out, test and commission the system.

All technical personnel assigned to the site by the vendor shall be fully conversant with the supplied system and software package, and shall have both hardware and software capability to bring the system on line quickly and efficiently with a minimum of interference with other concurrent construction and commissioning activities

5.3.2 Vendor's responsibility at site shall include all activities necessary to be performed to complete the job as per material requisition including:

a) Receipt of hardware/software and checking for completeness of supplies.

b) Installation of the system including for free supply equipment, if any.

c) Field cable termination and inter-cabinet cabling and termination.

d) Check out equipment installation.

e) Checking of interconnections, hardware and software configuration, overall system

f) Loop checking.

g) Field tests.

h) Commissioning and on-line debugging of the system.

i) Involvement during plant commissioning and performance of final acceptance test.

j) Co ordination for integration with DCS / other third party system.

5.3.3 Field Inspection

5.3.3.1 All equipments shall be inspected thoroughly by vendor after its receipt at site for completeness and proper functioning. Vendor must initiate the remedial action, in case unsatisfactory operation of any item is observed, with intimation to Engineer-in-charge.

5.3.3.2 Vendor must document all observations including details of any malfunction observed. Items/ equipments requiring total replacement must document the reasons for the same.

5.3.4 Loop Checking

5.3.4.1 Loop checking shall be carried out by vendor including checking the interconnections, configuration and overall system functioning.

5.3.4.2 Vendor's scope of work as a part of system installation and loop checking shall include termination of field cables in the control room, checking of interconnection between instrument/equipment, glanding, ferruling/tagging of interconnecting cables in control room, ferruling of field cables in control room and performing overall loop performance check.

5.3.4.4 The input signals shall be simulated by disconnecting/connecting the field wires for all field switches connected to 'PLC. All field transmitters connected to control room shall be loop checked at 0%, 50% & 100% of full scale (for both increasing and decreasing signals). Wherever receiver cards are used, the set point shall be generated by giving the input signal to receiver card. All outputs shall be checked in field, either for actual operation of solenoid valve or actual pick-up of electrical contractor for rotary equipments. Shutdown schemes shall be checked for proper functioning, configuration and actuation.

5.3.4.5 After loop checking is completed, vendor shall connect back any ~erminals and connections removed for loop checking.

5.4 System Acceptance

5.4.1 The owner shall provisionally takeover the system from vendor after System acceptance test. System acceptance test shall be started only after the satisfactory performance of loop checking and verification of all loop checking records by Engineer-in-charge.

5.4.2 The system acceptance test shall be carried out in the presence of owner's representative and Engineer-in-charge or his authorised representative. The tests carried out in System acceptance test shall be fully recorded and duly signed by all representatives participating in the System Acceptance Testing. .

5.4.3 Vendor shall carry out the following functional tests, as a part of system acceptance test, as a minimum.

a) Hardware verification as per final Bill of Material.

b) Visual and mechanical check-up for proper workmanship, identification, ferruling, nameplates etc.

c) System configuration as per approved configuration diagram.

d) Demonstration of all system function, display and diagnostics.

e) Checking of correct change-over of redundant devices.

f) Checking of various peripheral devices like printers and printing of all reports.

g) Complete checking of logic system, loading of user's program and checkout of results.

h) Checking of proper functioning of all disc drives, alarm summary, alarm history etc.

i) Proper information transfer on the information network by verifying system displays and printout.

5.5 Final Acceptance Test

The owner will take over the system from the vendor after the final acceptance test, which is defined as successful uninterrupted operation of the integrated system for three weeks. Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced / repaired as required. Once the system failure is detected, the acceptance test shall start all over again from the beginning. The warranty period commences from the day owner takes over the system.

6.0 GENERAL REQUIREMENTS

6.1 Vendor shall comply fully with the general requirements of PLC system including logistic support services, documentation, warranty, maintenance contract and shipping instructions.

Post Warranty Maintenance Contract

Vendor shall quote separately for post warranty maintenance contract after warranty period for five years for the complete system as per commercial terms and condition of the requisition and the type (i.e. comprehensive or non-comprehensive) of post warranty maintenance shall be as specified in job specification. The personnel deployed during post-warranty maintenance shall have thorough knowledge of the system and at least two years of experience on the maintenance of similar system. Any other conditions of contract required by vendor shall be explained in the offer.

7.0 SHIPPING

7.1 All the materials used for packing, wrapping, sealers, moisture resistant barriers and corrosion preventers shall be of recognised brands and shall conform to the best standards in the areas for the articles which are packed

7.2 Workmanship shall be in accordance with best commercial practices and requirements of applicable specification. There shall be no defects, imperfections or omissions which would tend to impair the protection offered by the package as a whole.

7.3 The packing shall be suitable for storing in tropicalised climate, the ambient conditions, being specified injob specifications.

7.4 Shipment shall be thoroughly checked for completeness before final packing and shipment. Vendor shall be responsible for any delay in installation or commissioning schedule because of incomplete supply of equipments.

GENERAL SPECIFICATION

FOR

MACHINE MONITORING SYSETM

0	05.12.2016	05.12.2016	For Tender	Ritu Agarwal	Sanjay Kr Tripathi	Sanjay Kr Tripathi
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

As a minimum, all steam turbines/motor driven compressors (i.e. Process air compressors, N2 compressor, Refrigeration compressor, CO2 compressor and Syngas Compressor, Gas Turbine, Lean/Semi-lean pumps, LTS blower, HP Ammonai Pump, Carbamate Pump, ID Fa, Purifier/Expander, GTG , etc.) shall be provided with highly reliable, continuous monitoring type Bentley Nevada make vibration monitoring system as per minimum requirements given below. For all the machines, the identical BN system, including central parts, probes, proximeters and panels, all power supply, isolators and wiring philosophy; shall only be used.

There shall be separate racks of Bentley Nevada System for each of these machines. Also there shall be separate racks of Bentley Nevada System for both machines, if two machines are running in parallel or one running one standby mode in the same section/plant. Vibration monitoring system shall be Bentley Nevada make 3500 series (or latest) central hardware and series 3300 or latest probes, proximeters and accessories, only. Bentley Nevada system shall be 3500 series or latest with all central rack and related hardware installed at central cabinet room in standard RITTAL panels (Process Interface Panels). The panel shall be back side openable only with front side flush type mounting of various BN racks. Max. two racks can be accommodated in one panel. Also more than one machine's racks and IO related to BN will be not installed in one panel. This standard shall be followed by all machine package unit vendors also to maintain good aesthetic and similar wiring/maint. practices for all machines.

The requirement of measurement point and location for axial and radial vibrations, casing vibrations and various bearing temperature measurement points shall be as per vendor's recommendation.

1. Instrumentation for Compressor and Rotating Equipments

1..1 Compressor vendor shall be completely responsible for providing adequate instrumentation for safe and efficient operation of the machine. The commonly used instruments are being detailed out in the following clauses, however this does not absolve the vendor of providing additional instrumentation, if required.

1..2 Anti surge and performance control system (ASC).

a) Vendor shall be fully responsible for the complete design of Anti surge/performance control system (ASC) including selection of type of flow element, controller Algorithm, type of explosion protection, type and operating timings of final control element. Vendor shall guarantee the performance of machine with the offered ASC system. Wherever required, ASC system shall be designed in such a way that it is capable of correcting the compressor operating point so as to avoid surge in order to protect machine from possible damage, to minimize process upsets and to minimize recirculation.

b) ASC system shall typically consist of but not limited to flow element, flow transmitter, differential pressure transmitter, ASC controller, control valve and other accessories as felt necessary by the Vendor.

c) Vendor shall supply all the hardware and software related to the operation and safety of the compressor. This shall include but not limited to the following:
- Design and operation of surge control loop scheme based on offered compressor, performance.
- Supply of all hardwares in antisurge control loop including dedicated controller, transmitters, measuring elements, final control element etc.

- Fast response transmitter and control valve etc. as required.
- Algorithm required for antisurge/Performance control application.

d) The ASC shall be a dedicated single loop controller on proprietary Hardware Platform or single/multi loop controllers of common hardware platform such as PLC. The single loop controller shall be dedicated controller for each Anti-surge or Performance control application/Tag. Dedicated panel mounted facia shall be provided. The ASC system when provided on common hardware platform shall be with redundant configuration as minimum viz-dual processor, dual input/output, redundant communication & dual power supply system. The multiloop controller/system shall be dedicated for Antisurge/ Performance applications/Tags of each machine/each machine tag. Unless specified otherwise dedicated panel facia for each application shall be provided to mount on hardwired console in control room

e) It should be able to accept 4-20 mA signal from field or from HIC at purchaser DCS or at LCP as a manual override to anti-surge control system with bump less transfer.

f) Auto-manual operation with bump less transfer shall be provided.

g) The controller response time (total time to read input, processing time and output) shall be as per the machine dynamics and safety and shall be of the order of max. 40-milisec. Any faster response required based on machine dynamics shall be considered by vendor. The input sampling interval shall be as per machine dynamics within the controller response time as above. The processor cycle time shall be considered to meet the overall response time.

h) The ASC shall be field proven, specific to the make of machine and for the similar application in hydrocarbon industries. Bidder shall provide the proven track record for the offered ASC meeting the above.

i) The Anti surge/Performance control algorithm shall be implemented using standard firmware in the controller/Processor system.

j) The Algorithm developed by vendor shall be specific for given application, surge

control, performance, load sharing etc. and shall be field proven for the compressor make.

k) The algorithm implemented in the system shall be protected against any modifications/changes.

l) The configuration shall be stored in non-volatile memory or battery back-up for configuration shall be provided (min 72 hours) in case of volatile memory along with battery drain indication.

m) In case of ASC on common hardwired platform separate configurator with necessary hard ware/ soft ware shall be provided for application programming.

n) Anti surge controller shall not be used for performing any other machine related inter locks/logics.

o) All the instruments (transmitters, I/P converters and temperature elements and / or transmitters) connected with anti-surge control loop shall be flame proof "EExd" type suitable for the area as specified. The suitability of smart transmitter shall be confirmed by vendor and to be provided accordingly.

1..3 Machine Monitoring System (MMS):

Machine Monitoring system shall be provided for continuous monitoring and indicator of machine parameters like vibration & axial displacement, bearing and winding temperature, keyphasor etc.

1..3.1 Vibration and Axial Displacement Monitoring

1..3.1.1 The machine monitoring system shall be Bently Nevada 3500, the system shall be provided with built in intrinsically safe barrier and shall be duly mounted in separate panel. No external barrier shall be provided for the same.

1..3.1.2 For MMS the display unit shall be provided at local control panel with necessary statutory certification. Alternately purged enclosure is also acceptable with necessary certification.

1..3.1.3 Vibration and displacement monitoring system shall be as per API-670. The extent and type of monitoring shall be as defined elsewhere. However, vendor shall furnish any additional requirements for monitoring deemed essential by them with reasons. Two probes at 90 degree apart for each location shall be provided and connected to same dual channel monitor for vibration monitoring.

1..3.1.4 The sensing probe shall be accessible for adjustment, repair and replacement without dismantling the machine.

1..3.1.5 Vendor shall provide continuous 4-20 mA dc isolated output for each channel of measurement for remote indication and potential free contacts for alarm/shutdown setting from the monitors.

1..3.1.6 In addition to this, it shall be provided with necessary hardware (communication Gateway Module) (including the cable for serial data communication from monitoring system to purchaser's DCS) for machine monitoring through purchaser's DCS via redundant serial data interface between this system and purchaser's DCS. Bidder shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. for smooth interfacing of this communication link with DCS.

1..3.1.7 Bidder shall also supply one common laptop based configuration unit with required configuration software and hardware for configuration of MMS system including the serial communication cable required between configuration unit (laptop) & MMS monitors.

1..3.1.8 Monitors shall be dual channel type and shall meet the following specifications as a minimum:

a) Continuous two channel monitoring with each channel input from one probe. Readout scale shall read higher of the two sensors.

b) Each channel shall have two independent alarm levels one for pre trip alarm and one for each trip, settable continuously over measurement range. Two relay contacts for each pre trip alarm and trip alarm per channel shall be provided.

c) Broken sensor failure detection without causing shut down.

d) LED lamps on monitor front for each channel to indicate pre-trip alarm, trip-alarm and circuit not OK conditions.

e) Selector switches on monitor front to read vibration/ displacement pre-trip alarm and trip set points for each channel shall be provided.

f) Analog output 4-20 mA dc isolated signals shall be provided for each channel for remote indication.

1..3.2 Bearing & Winding Temperature Monitoring

1..3.2.1 In general, bearing temperature shall be measured at the points which are under maximum loading.

1..3.2.2 Sensor shall be three wires RTD element of platinum having 100 ohms resistance at 0^0C. Calibration shall be to DIN 43760 standards.

1..3.2.3 The temperature sensor, cables, terminal heads, junction boxes etc. should be capable of withstanding the mechanical vibration and environment of a rotating machinery atmosphere.

1..3.2.4 Bearing and Winding temperature shall be monitored by means of a temperature monitor. The temperature monitors shall be mounted on the local control panel in hazardous area and shall meet following requirements:

a) Accept RTD inputs (platinum, 100ohm at 0 Deg C calibrated to DIN 43760 standards).

b) Continuous six channel monitoring with each channel input from one RTD. Read out scale shall read higher of the six temperatures.

c) Each channel shall have two independent alarm levels one for pre-trip alarm and one for trip alarm, settable continuously over measurement range.

d) Broken sensor failure detection without causing shut down.

e) Selector switches on monitor front, to read temperature, pre-trip alarm and trip set points for each channel shall be provided.

f) Analog output 4-20 mA dc isolated signals shall be provided for each channel for remote indication.

g) Monitor shall be Bentley Nevada 3300/3500 series and latest.

1..3.2.5 Separate temperature monitors shall be provided for motor winding and bearings temperature monitoring.

1..3.3 Key Phasor

1..3.3.1 Key phasor system shall be provided by vendor for performing analysis of vibration signals to determine machine malfunctions. It shall consist of a proximity probe and transmitter, extension cable etc. and other accessories to make the system complete. Vendor shall provide necessary reference on the shaft to determine one-per-turn occurrence.

1..4 Speed Governor System

Digital microprocessor based fault tolerant tripple modular redundant governing system of mounted in standalone cabinet and located in rack room.

1..4.1 HMI for operator interface shall be supplied loose with all mounting accessories for mounting this HMI in purchaser's hardwired console in general. This shall include all basic features of governor to enable operator to do all control and monitoring operations from console itself. 1..4.2 This shall include features like assignable speed range, adjustable speed set point, remote speed set point input, digital speed indication, adjustable speed ramp, override for testing the external over speed trip system etc.

1..4.3 It should be able to accept 4-20 mA signal from HIC at purchaser's DCS or LCP as a manual override to governor and pass on the same, after a bump less auto / manual selection & local / remote selector switches configured in woodward governor (shall be possible through HMI) to governor valve as manual control.

1..4.4 Bidder shall provide all hardware & software in the system (including the cable for serial data communication from system to purchaser's DCS) for serial communication link for all data transfer from governor to purchaser's DCS. This serial link shall be RS 422 / RS 485 with MODBUS RTU protocol, bidder shall furnish all details like pin configuration and tag number wise MODBUS address mapping list etc. For smooth interfacing of this communication link with DCS.

1..4.5 The Governor Control System shall be Woodward or equivalent.

1..5 Accumulator of Lube Oil System

1..5.1 If accumulators are used with nitrogen for lube oil dampening at the desired pressure to meet the system requirement the following instrumentation with the accumulator to be provided by vendor:

a) Accumulator shall have charge kit with isolation valves and connection hoses.

b) Standard Nitrogen cylinders available in India are at pressure of 140 kg/cm^{2}g with standard connection sizes. Vendor shall provide the complete regulator system with protection for charging Nitrogen from Nitrogen cylinder to accumulator at the desired

pressure. Regulator shall be suitable for the inlet pressure variation of 140 to 150 kg/cm^{2}g while charging with suitable inlet connection to match the Nitrogen cylinder connection. Regulator system shall have pressure indicator, regulator, relief valve, needle valve etc. as a minimum. Material of construction shall be stainless steel.

1..6 The compressor loading-unloading scheme for reciprocating compressors shall be provided as per the minimum requirements specified in the job specifications. Manual as well as automatic schemes shall be provided.

1..7 Emergency switch shall be provided in the local panel/local. All such switches shall have a protective cover to avoid inadvertent shutdown.

1..8 Vendor shall provide the following common alarms for purchaser:

a) Common machine pre-trip alarms.

b) Common machine trip alarm.

2. System Cabinets, Racks And Consoles

2..1 All system cabinets, marshalling racks and hardwired consoles shall be free standing and enclosed cubicles type. All these items shall have bottom cable entry.

2..2 Cabinets shall be fabricated from cold rolled steel sheet (CRCA) of minimum 2.0mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated out of 1.6 mm thick CRCA sheet. Cabinets having modular construction and with basic frame structure of heavy duty aluminium shall also be acceptable.

2..3 Cabinet/Console finish shall include sand blasting, grinding, chemical cleaning, surface finishing by suitable filler and two coats of high-grade lacquer with sanding between coats. Two coats of paint in the cabinet colour and a final coat after assembly at site, shall be given for non-glossy high satin finish.

2..4 In order to remove dissipated heat effectively vent louvers backed by wire fly screen shall be provided. Further, ventilation fans shall be provided wherever required. High temperature annunciation shall be provided on operator console.

2..5 Illumination shall be provided for all cabinets by fluorescent lamps, which shall be operated by door switch.

2..6 All cabinets/racks/consoles shall be adequately sized to avoid any congestion.

2..7 The height and colour of the cabinets shall be inline with other equipments being installed in the control room.

3. System-1 Software

The latest System-I software modules for Orbit analysis and polar plots and other various diagnostics for machine health shall be supplied with the following minimum features.

The System-1 software shall be Version 6.x or latest at the time of supply having Enterprise Application package covering all the centrifugal, integral geared and reciprocating and its drive (i.e. motor or steam turbine) with all required stages' probes. It shall have min. 3 Display client with one Web based client, Data Export thru' OPC A &E, Data acquisition license with Microsoft SQL (5 CAL min lic), Data importer suitable for accommodating all installed probes/sensors/stages TDI Transient Channels ' license, static channels' license and min. 500 point OPC data import license. It will also have System Extender with 2 Smart Notifiers, This will also have Rule Pack license software to cater to include the requirement of various stages, bearing/rotor, gearbox, Electric Motor, power turbine, centrifugal pump, of various steam turbines, gas turbines, hydraulic turbines, centrifugal and integral geared compressors, reciprocating compressors if any, installed in the entire project.

The central rack shall be supplied with required hardware and a lap top PC with a rack configuration software. The specification of lap top shall be latest at the time of supply with Microsoft Windows OS and MS Office license package.

The above System-1 software and its associated programming shall be performed via a common central Engineering station, which will be a server grade machine with the latest hardware and software at the time of supply (The specs of this server machine shall be identical to those of DCS engineering station). This shall be accommodated in central engineering room in the close vicinity of central cabinet room. The server shall be same as those of DCS/ESD system servers.

The Server shall interface with various racks via Ethernet interface via Industrial Ethernet switches/FO or UTP CAT-6 cable LAN/WAN. Similarly this set up will have one hardware firewall via which it will connect to LAN for viewing remote Display Client and web based client on other dedicated machines and/or any other machine from LAN.

The MCMS software shall be following facility

1. The Machine Condition Monitoring Software System should be capable of integrating all Online , Scanning, Wireless and Portable Vibration Monitoring System in a single software in line with API 670 latest edition
2. The condition Monitoring Software should have seamless integration with MPS supplied by different OEMs/ Pkg. Vendors. No interface hardware should be required to fetch the analysis data from Machine Protection System.
3. As per API 670 clause: 3.1.35, the buffered output has to allow connection of vibration analyzers, oscilloscope and other test instrumentations to the transducer's signals for advanced Analysis by third party (OEM / Diagnostic company).
4. In case of the decision support module capabilities mentioned what will be the input and the output of the decision support module for each category like Centrifugal compressor, Recip compressor, Gas Turbine generator, centrifugal pumps, motors, blowers, etc. This has to be formalized for each equipment.

5. The diagnostic plots required in the machine monitoring software should include plots like P-V Diagram, Rod position profile, which are important for Reciprocating Compressor.
6. Machine monitoring software should capture transient data. It is required that, the machine monitoring software should be capable of accepting unlimited number of data samples in transient state of equipment both in delta rpm (1rpm) and delta time (1second) basis simultaneously for all the measurement points in the equipment train.
   The software should also freeze pre transient data (200 samples) once equipment enters transient state.

   a. MCMS vendors should have the capability to provide Machinery diagnostic services from a remote location, by connecting to the machinery management software's database.
   b. Machinery management software shall have seamless integration with Meridium / SAP PM Module.

7. The machine condition software should have the capability to notify designated users via SMS / E- MAIL, the events like equipment trip on real time basis.

8. MCMS Software should be capable of informing ESD related problems.

9. MCMS SW should be able to capture static & dynamic vibration data before and after the occurrence of any event. This is important to observe & co-relate equipment behavior after the event to study either continued excursion or available damping.

10. MCMS SW should be able to collect data based on change in amplitudes or phase angle or any software or hardware alarm. It is essential to store additional samples simultaneously across the entire machine train when there is alarm triggered on may be only one probe. Such co-relation helps to identify the cross effect of vibration excursion for entire machine train

11. The software should also be enabled with Cyber Security for Industrial Internet requirement in future.

GENERAL SPECIFICATION FOR

SAFETY RELIEF VALVE

CONTENTS

SECTION NUMBER	DESCRIPTION	SHEET NUMBER
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LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS

Safety Valve sizing will be done only after control valve sizing is fixed.

All Safety Valves / Thermal relief valves shall be flanged type, irrespective of licensor's recommendation of NPT.

1.00 General

1.01 This general specification together with the data sheets and inspection standards attached herewith define the technical requirement for the supply of Safety / Relief valves, spares, documentation, inspection-testing and shipping.

1.02 In the event of any conflict between Engineering specification and Instrument specification the later shall prevail.

2.00 Codes and Standards

2.01 The pressure relieving devices design, manufacture, installation and testing shall be in accordance with the following codes and recommendations and as specified in the individual specification sheets:

a) ASME Boiler and pressure vessel code section I

- Design, manufacture and calculation for steam services in fired pressure vessels.

b) ASME Boiler and pressure vessel code section VIII

- Design, manufacture and calculation for steam, gas, vapour and liquid services in unfired pressure vessels

c) API-RP-520, part I and II sizing, selection & installation of pressure relieving system in refineries.

d) API standard 521 guide for pressure and depressurising system.

e) API standard 526 flanged steel safety relief valves.

- Design and manufacture as per ASME section VIII and orifice calculation as per API -RP-520 part I and II , appendix C

f) API standard 527 commercial seat tightness of safety relief valves with metal to metal seat.

g) API 2000 for sizing of pressure / vacuum relief valves on storage tanks.

h) ASME B16.5 steel pipe flanges, flanged valves and fittings.

i) ASME B46.1 surface textures.

j) Indian Boiler Regulations for valves on steam service, Paragraph 293.

k) ASME B16.34 for non destructive tests

3.00 Sizing and Design Criteria

Sizing of safety relief valves shall be in accordance with API RP-520 (latest edition), Indian Boiler Regulations ASME Section I (Power Boilers) and ASME code for Pressure Vessels Section VIII'. The code stamps shall be provided for safety valves in case ASME and Indian Boiler Regulations design.

Safety relief valves shall normally be direct spring loaded types and provided with full nozzle type. Balanced bellows type safety valves shall be provided when variable backpressure exceeds 10% of the set pressure or fluid is corrosive. Pilot operated pressure relief valves shall be used for special services and where set pressure is closer than 10% of the operating pressure, in general. Thermal relief type valves shall be used for thermal expansion of liquid or gas. Vacuum relief type valves shall be used for Storage tank. Steam jacket type safety valves shall be used for crystallizing fluid at ambient temperature.

The body material shall, as a minimum, be as per piping specifications. Nozzle and disc material shall be SS316 as a minimum with machined stainless steel guide, and spindle. Whenever semi nozzle designs are unavoidable, body material shall be atleast same as nozzle material.

The spring material of pressure relief valves shall be as follows unless otherwise necessary because of process conditions.

-25ºC to 250ºC	:	Metal plated carbon steel
Above 250ºC	:	Tungsten alloy or high temp. Alloy steel
Below – 25ºC	:	Stainless steel 316

Carbon steel is permitted above 200°C for open bonnets.

Flanged connection shall normally be specified

Conventional type safety valves shall have vented bonnets with screwed caps; balanced bellows type safety valves shall be of the yoke type with screw settled caps.

Plain lifting levers shall be provided for steam and air services. Packed lifting levers shall be used when protection against leakage is required.

CONTRACTOR shall submit calculations for all safety relief valves.

All safety relief valves relieving to flare header shall be balanced bellows type only with trims and bellows in SS 316 L.

Pressure relief valves required for liquid service shall have liquid trim with discharge coefficient certified by ASME.

Pressure relief valve body casting and nozzle casting with inlet rating of 600 # and above in Hydrogen service shall undergo Helium leak test.

3.01 The manufacturer shall furnish calculations in accordance with the code specified in the individual instrument specification sheets. Each manufacturer to state its own “K” factor and actual measurable area. In addition, approx. weight of each valve shall be specified. All the above information shall be submitted at the time of bidding, approval after order placement & along with final despatch.

3.02 The percent over-pressure and accumulation used in calculation for sizing of relieving devices shall be considered as indicated in the individual specification sheet.

3.03 For Steam, BFW & condensate services the instrument shall be IBR certified. For items of foreign origin the certification shall be done by Lloyds or any other IBR approved authorities in specific IBR format.

3.04 Wherever NACE certificate requirement has been specified in Instrument specification, the material composition & hardness tests shall be conducted only as per MR-0175 latest edition. The tests shall be carried out in an approved laboratory

3.05 Deleted

3.06 All safety valves of inlet rating 900# and above shall be subjected to radiography/ultrasonic test as per procedures outlined in ASME-B16.34 and mutually agreed quality assurance plan, if not otherwise stated in the individual specification sheet .

3.07 Safety / relief valves for thermal expansion (on liquids) shall be flanged type . Thermal relief valves shall be flanged with Inlet 1” 600# RF and outlet 2” 150# RF with typical “D” designation and typically 0.38 cm2 orifice size

3.08 All valves except thermal relief ones shall be full nozzle type. All valves shall have the facility of blow-down adjustment except thermal relief valves. Base/modified or semi-nozzle types shall be specified for thermal relief valves.

3.09 Lifting Levers shall be furnished for exposed spring bonnets on valves in steam and hot water service, on air and hot water valves with closed bonnets. All the lifting levers shall be packed type unless the valve is handling inert gas at ambient temperature.

3.10 Bonnets shall be plain closed ones for toxic or inflammable gases as well as for vapours and liquids. Exposed spring bonnet shall be specified for steam service and in boiler feed water service above 200^0 C. Extension type of bonnet shall be used above 400^0 C & cryogenic service.

3.11 Balancing or Sealing Bellows shall be used under the following conditions or as specified in the individual specification sheet.

a) When the back pressure exceeds 10% of the set pressure.
b) The back pressure is variable.
c) The valve is handling corrosive fluid.

3.12 Material Of Valve Body shall conform to the material specified in the enclosed individual instrument specification sheets. In general valve body material and rating shall conform to upstream line specification or specification of the vessel wherever it is mounted.

3.13 Material of nozzle and disc shall be, in general, SS 316 (A182 F316) and 17.4 pH or 316SS with stellite facing if not otherwise stated in the individual instrument specification sheets.

3.14 Springs shall be carbon steel cadmium plated (rust proof) for normal process operating temperature (-) 25^0 C to 200^0 C and tungsten/ alloy steel for high temperature above 200^0 C. Below (-) 25^0 C stainless steel may be used. Carbon steel (Rust proof) is permitted above 200^0 C when the bonnet is open.

3.15 Test Gag shall be furnished on all safety and relief valves and they shall be handed over to owner after testing clearly labelled with the tag number of the valve they belong to.

3.16 The manufacturer must specify Cold Differential Set Pressure (CDSP) for each pressure relieving devices at 25^0 C.

3.17 Rupture disc if specified used at inlet of safety valves shall have fragmentation free burst. The stamped capacity of safety valves shall be derated by 20%, unless the combined capacity of the rupture disc and safety relief valve is established by the disc manufacturer.

3.18 The space between safety valve and rupture disc shall be vented during normal operation. The disc holder shall be supplied with 4" telltale pressure gauge with SS body, wetted parts, pipe nipple, excess flow valve. The excess flow valve and pressure gauge shall have 1/2" NPT connections.

3.19 Burst sensors with rupture discs in hazardous areas shall either be ex-proof or intrinsic safe confirming to area classification & execution specified against each item in the individual specification sheets.

Ex-proof certification confirming to CENELEC, FM, BASEEFA and IS is preferred. IS - 2148 certification must be supplemented with the temperature classification certification confirming to IS - 8239.

Intrinsic safe certification shall in general confirm to CENELEC standard EN 500014 and EN 50020, if not otherwise specified in the individual specification sheet.

3.20 All pressure relief valves in oxygen and chlorine service shall be thoroughly degreased using reagents like trichloro-ethylene or carbon tetrachloride. End connections shall be blinded Iplugged after this degreasing process to avoid images of oil particles

Pilot Safety Valves

- For pilot operated valves, the pilot design shall be of inherently fail safe.
- Unless specified otherwise, pilot shall be non-flowing type.
- All accessories like back flow preventer, pilot filter etc. required for proper operation of pilot operated valves as per indicated service conditions shall be included.
- Material of construction of pilot shall be same as that of main valve nozzle as a minimum.
- The o-ring and diaphragm material of pilot shall be suitable for the pressure and temperature conditions specified in the data sheet.

4.00 Inspection, Factory tests and approval

4.01 Within two weeks of receipt of the LOI/order the vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan for carrying out Inspection and test. In absence of any Inspection Agency the vendor must submit the quality Assurance Plan for OWNER's approval. All tests, in such cases, shall be conducted by vendor's Quality Department and the results of tests shall be forwarded alongwith the supply.

4.02 The manufacturer shall give clear 15 days notice informing readiness of the valves at manufacturer's works.

4.03 The vendor shall permit the authorised representative of OWNER to inspect the manufacture and assembly of the valves in various phases in compliance with approved drawings, standards and specifications.

4.04 The vendor should make available to the authorised inspector the results of all the checks/calibrations conducted before presenting for Owner's inspection.

4.06 The vendor to provide all necessary facilities free of cost to Owner's inspector for carrying out the checks/calibration as per standard/approved quality assurance plan. In no condition inspection can be waived off without the written permission of Owner.

4.07 No assembly shall be shipped until all the required tests are successfully completed and certified "Cleared for despatch" by the inspection authority.

4.08 The following tolerances are permitted for calibration:

a) For valve calibration < 5 kg/cm^2, +/- 2.8% of the calibrated value.
b) For valve calibration > 5 kg/cm^2, +/- 3% of the calibrated value.

4.09 The following tests shall be carried out as a minimum for safety valves

(i) Verification of cold differential test pressure 100% for all valves

(ii) Hydraulic pressure tests for primary parts (Refer ANSI B 96.1 for terminology) shall be tested at 1.5 times the set pressure.

(iii) Pneumatic shell test for closed bonnet valves on secondary side shall be at 1.5 times back pressure (or) 2 kg/cm^2 whichever higher when back pressure is zero or not stated. For positive back pressure test pressure shall be 1.5 times the back pressure.

(iv) Seat leakage test for metal to metal seated safety valves shall be done in accordance with API-527. For steam, soft seat, pilot valves and special cases where leakage test is not covered in API-527, the procedure for testing in such cases shall be mutually decided and recorded in the Quality assurance plan.

(v) Foundry /forge shop test certificate to be provided for verification of body, bonnet, nozzle for conformance to standards.

(vi) Vendor's test certificate for material conformance and pressure test to be provided.

(vii) IBR certificate wherever applicable. Refer clause no. 3.03

(viii) Radiography/Ultrasonic inspection. Refer clause no. 3.06

(xi) NACE certificate wherever applicable. Refer clause no. 3.04

(xii) Corrosion test (Huey test) wherever applicable. refer clause no. 3.05

(xiii) Sealing test on bellows (as per manufacturer's standard)

4.10 Test certificate verification for coefficient of discharge

5.00 Packing

Each safety / relief valve and its accessories wherever applicable shall be suitably packed and protected from damage due to transportation, loading and unloading.

The safety / relief valves alongwith their spares shall be despatched as a single consignment.

6.00 Identification and Marking

6.01 Each safety / relief valve shall be fitted with a stainless steel permanently fixed name plate with the following minimum information:

- Complete tag no of the valve as per inst. data sheet.
- Manufacturer's name
- Valve model and serial no.
- Inlet and outlet sizes with ratings
- Body and trim material
- Bellows material wherever required
- Designated orifice with area in sq. cm.
- set pressure in kg/cm^2.

All valves are applied two coats of red oxide metal primer, prior to applying two final coats of synthetic enamel paint. The second coat of synthetic enamel paint is applied just before despatch.

7.00 Spares

Spares shall be as per enclosed spares list separately attached.

8.00 Documentation

The following documents (Technical) are required to be submitted by the vendor alongwith bid, after placement of order for approval purposes and final documentation before despatch of consignment.

SL.	DESCRIPTION OF	ALONGWITH	AFTER PLACEMENT OF ORDER

NO.	DOCUMENT	BID	FOR APPROVAL/ INFORMATION WITHIN SIX WEEKS	FINAL DOCUMENTS BEFORE DESPATCH OF CONSIGNMENT
1.	Consolidated list of drawing & documents.	Yes	Yes(I)	Yes
2.	Catalogue & technical literature of safety valves alongwith sizing calculation.	Yes	Yes(I)	Yes
3.	Deviation if any, from the technical spec. giving justification for the same.	Yes	X	x
4.	Dimensional and sectional drawing against each tag showing material of construction of each part.	Yes	Yes(I)	Yes
5.	Capacity chart for safety/thermal relief valves showing set pressure effective area/for air capacity, water capacity against models offered.	Yes	X	Yes
6.	Chemical analysis and material test certificates from an approved laboratory.	X	X	Yes
7.	Certificates showing chemical analysis, corrosion test (Huey test), Ferrite content on finished product, where applicable from an approved laboratory.	X	X	Yes
8.	NACE certificate (wherever applicable) from an approved laboratory.	X	X	Yes
9.	Weight of safety / relief valves.	Yes (approx. weight)	Yes(I)	Yes
10.	Instruction Manual for maintenance.	X	X	Yes
11.	Calibration and performance test certificates including calibration curve & Cold diff. test pressure values.	X	X	Yes

SL. NO.	DESCRIPTION OF DOCUMENT	ALONGWITH BID	AFTER PLACEMENT OF ORDER	
			FOR APPROVAL/ INFORMATION WITHIN SIX WEEKS	FINAL DOCUMENTS BEFORE DESPATCH OF CONSIGNMENT
12.	IBR certificate for valves for steam, BFW and condensate services from	x	x	Yes

	statuary bodies wherever applicable.			
13.	Ultrasonic test certificates for steel forgings and bars wherever applicable	x	x	Yes
14.	Liquid diepenetrant test certificate for steel castings and forgings.	x	x	Yes
15.	List of routine tests performed on standard valves and suggested on special ones.	Yes	x	x
16.	Radiography inspection certificate for steel castings and forgings wherever applicable.	x	x	Yes
17.	Impact test results for LT steel castings and forgings wherever applicable.	x	x	Yes
18.	Installation, operating and maintenance manual (12 sets) including parts lists.	x	x	Yes
19.	Transparency for each tag no. dimensional drawings.	x	x	Yes
20.	Quality Assurance Plan	x	Yes(A) (within 2 weeks)	x

(A) for Approval (I) for information.

Sl. no. 1 to 19 shall be forwarded to OWNER as per details outlined in Enquiry / order.
Sl. no. 20 shall be mutually finalised with Inspection Authority specified in the order.

Number of sets alongwith bid for approval and as final documentation shall be supplied as stipulated in the purchase order.

GENERAL SPECIFICATION FOR

RUPTURE DISC

0	05.12.2016	05.12.2016	**For Tender**	**Ritu Agarwal**	**Sanjay Kr Tripathi**	**Sanjay Kr Tripathi**
REV	**REV DATE**	**EFF DATE**	**PURPOSE**	**PREPD**	**REVWD**	**APPD**

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SECTION NUMBER	DESCRIPTION
1.0	GENERAL
2.0	GENERAL REQUIREMENT
3.0	INSPECTION, FACTORY TESTS AND APPROVAL
4.0	PACKING
5.0	IDENTIFICATION AND MARKING
6.0	SPARES
7.0	DOCUMENTATION

LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS

1.00 **GENERAL**

1.01 This Engineering specification together with the Instrument specification attached herewith define the technical requirement for the supply of rupture disc its spares, documentation, and testing.

1.02 In the event of any conflict between Engineering specification and Technical specification of the Rupture disc, the latter shall prevail.

2.00 **GENERAL REQUIREMENT**

2.01 All rupture disc shall be sized in accordance with API RP 520 or ASME codes section I & VIII as specified in the individual specification sheet. In cases, where exponent of the isentropic expansion has not been stated in the data sheets 1.4 shall be used for calculation purpose. Any restriction in the discharge area caused by the disc holder assembly shall be considered in the calculations. Vendor must submit orifice calculations and corresponding selected body sizes for approval.

2.01.1 CONTRACTOR shall provide rupture disc assembly wherever shown in P&ID. The assembly shall consist of
A) The rupture disc fitted in a pre torqued holder assembly.
B) J bolt for proper installation
C) The Rupture disc experiences vacuum, shall be provided with vacuum support as recommended by manufacturers.

Disc material shall be compatible with the vessel contents and shall be consistent with the bursting requirements. Inconel discs shall be used above 100ºC if compatible with the process fluid.

2.01.2 When rupture disc is used upstream of a pressure relief valve, a pressure gauge, pressure switch and excess flow check valve / safety relief valve as recommended by manufacturers. (Tell-tale assembly) shall be provided on the downstream of the disc to indicate any rupture of the disc. In addition derating capacity factor for the safety valve – rupture disc assembly as recommended by ASME section VIII shall apply. Tell –tale assembly as above must be provided irrespective of P&ID representation. For plugging toxic service pressure gauges shall be diaphragm seal type.

2.01.3 Each rupture disc must be supplied with minimum **3 number of additional discs**. This is in addition to discs required for carrying out burst testing at factory.

2.01.4 The indication of leaky rupture disc (i.e. the disc with a pen hole) or burst rupture disc shall be provided in the main control room.

2.01.5 The bursting tolerance of the rupture disc shall be ±5% of the specified bursting pressure or less. Unless otherwise specified.

2.02 Rupture disc devices shall be supplied as a complete unit i.e. disc holder and the required number of discs. The scope shall also include pre-assembly screws, jack screws, companion flanges, studs, nuts & gasket.

2.03 Flow direction, flange size and rating, burst pressure and temperature shall be marked on the disc holder.

2.04 The type and material of rupture disc shall be selected in accordance with service conditions, like pressure, temp., process media, vacuum or pulsating service.

2.05 Reverse buckling and non-fragmenting discs are preferred.

2.06 Disc holders shall be suitable for mounting between flanges. The design shall prevent wrong installation of the disc.

2.07 Rupture disc used at inlet of safety valves shall have fragmentation free burst. The stamped capacity of safety valves shall be derated by 20%, unless the combined capacity of the rupture disc and safety relief valve is established by the disc manufacturer.

2.08 The space between safety valve and rupture disc shall be vented during normal operation. The disc holder shall be supplied with 4" telltale pressure gauge with SS body, wetted parts, pipe nipple, excess flow valve. The excess flow valve and pressure gauge shall have 1/2" NPT connections.

3.00 INSPECTION, FACTORY TESTS AND APPROVAL

3.01 All instruments and accessories shall be inspected & tested to ascertain that the supply is in accordance with approved specification. The inspection & tests shall not relieve the supplier/ manufacturer from his responsibilities for materials and the performance of the instrument supplied.

Within two weeks of receipt of the Letter Of Intent (LOI) /order, vendor must contact the Inspection Agency specified in the order and finalise with them the Quality Assurance Plan (QAP) for carrying out Inspection and test.

In absence of any Inspection Agency the vendor must submit the Quality Assurance Plan for PDIL/OWNER's approval. All tests, in such cases, shall be conducted by manufacturer's quality department and the results of tests shall be forwarded alongwith the supply.

Procedure and extent of tests shall be governed by QAP mutually agreed between the vendor and PDIL/OWNER's inspection authority.

No instrument / accessory shall be shipped until all the required tests are successfully completed and certified "Cleared for dispatch" by the inspection authority.

4.00 Packing

Each rupture disc and its accessories wherever applicable shall be suitably packed and protected from damage due to transportation, loading and unloading.

The rupture disc alongwith their spares shall be despatched as a single consignment.

5.00 IDENTIFICATION AND MARKING

5.01 Self adhesive tapes or signs are not permissible for permanent marking of any instrument.

5.02 Each rupture disc shall be fitted with a SS tag plate and shall contain the following information:

- Complete tag no of the assembly as per inst. Data sheet.
- Manufacturer's name
- Disc and holder model and serial no.
- Inlet and out sizes with ratings
- Holder and disc material.
- Burst pressure in kg/cm2g.

Besides the above each instrument shall have a separate circular tag number plate in stainless steel with engraved tag number and range and attached securely to the instrument with a soft stainless wire. The size of letters and figures shall be minimum 4mm and the plate should be 25mm diameter with 1-2 mm thick. Also each instrument shall have corrosion resistance nameplate with 6 mm minimum size black letters on white background and identified with their relevant loop number.

5.03 All spare parts shall be fitted with identification plate having following data clearly printed and easily readable.

- Spare parts name/model no. as per purchaser's Instrument specification sheet
- Serial no.

6.0 SPARES

Spares for rupture shall be supplied as per spares list separately enclosed

7.0 DOCUMENTATION

SL. NO.	DESCRIPTION OF DOCUMENT	ALONGWITH BID	AFTER PLACEMENT OF ORDER	
			FOR APPROVAL/ INFORMATION WITHIN SIX WEEKS	FINAL DOCUMENTS BEFORE DESPATCH OF CONSIGNMENT
1.	Consolidated list of drawing & documents.	Yes	yes (I)	yes
2.	Catalogue & technical literature of rupture discs and accessories.	Yes	x	yes
3.	Sizing calculation for rupture disc.	Yes	Yes(A)	Yes
4.	Deviation if any, from the technical spec. giving justification for the same.	Yes	x	x
5.	Dimensional and sectional drawing for each rupture disc indicating weight and showing material of construction of each part.	x	Yes(I)	Yes
6.	Material test certificates / Mill Certificate from independent recognised agency showing chemical analysis, physical analysis, Ferrite content on finished products.	x	x	Yes
7.	List of routine tests performed on rupture discs	x	x	Yes
8.	Manuals for installation, operation & maintenance	x	x	Yes
9.	“As supplied” data sheet signed by qualified engineer	x	x	Yes
10.	Quality assurance plan	x	yes (A)	x

NOTES:

1. (A) for Approval (I) for information

2. Sl. No. 1 to 9 shall be forwarded to principal as per details outlined in enquiry/order.
3. Sl. No. 10 shall be mutually finalised with Inspection Authority specified in the order.

   Number of sets alongwith bid for approval and as final documentation shall be supplied as stipulated in the purchase order.

GENERAL SPECIFICATION

FOR

CLOSED CIRCUIT TELEVISION (CCTV)

SYSTEM

Abbreviations:

BIS : Bureau of Indian Standard

CCOE : Chief controller of Explosives

CIF : Common Image Format

CMRI : Central Mining Research Institute

ERTL : Electronics Regional Testing Laboratory

DGMS : Director General of Mine safety

IEC : International Electrotechnical commission

Ip **:** Internet Protocol

MPEG : Motion Picture Experts Group

PAL : Phase Alteration by Line

TCP : Transmission Control Protocol

UDP : User Datagram Protocol

CCD : Charge Coupled Device

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1.0 GENERAL

1.1 Scope

1.1.1 This specification, together with the data sheets attached herewith, covers the requirements for the design, materials, nameplate marking, inspection, testing and shipping of Closed Circuit Television (CCTV) system.

1. 1 .2 The related standards referred to herein and mentioned below shall be of the latest edition prior to the date of purchaser's enquiry;

ANSI/ASME	American National Standards Institute/American Society of Mechanical Engineers.
	B 1.20.1 Pipe Threads General Purpose (Inch)
	B 16.5 Steel Pipe Fittings and Flanged Fittings, NPS 1/2” through NPS 24
EN-I 0204	Inspection Documents For Metallic Products
IEC-60079	Electrical Apparatus for Explosive Gas Atmospheres
lEC- 60529	Degree of Protection Provided by Enclosures (IP Code)
rs- 13947	Specification for Low Voltage Switchgear and Control gear
lS- 2148	Electrical Apparatus for Explosive Gas Atmosphere - Flameproof enclosures 'd'

1.1.3 In the event of any conflict between this standard specification, data sheets, statutory regulations, related standards, codes etc., the following order of priority shall govern:

a) Statutory Regulations
b) Data Sheets
c) Standard Specification
d) Codes and Standards

1.1.4 In addition to compliance to purchaser's specification, Vendor's extent of responsibility shall include the following:

a) Purchaser's data sheets indicate the minimum requirements of camera, video encoders, video management system, video recorders etc., however, this does not absolve the vendor of the responsibility for proper selection with respect to the following:

i) Selection of lens focal length, camera, encoding techniques, selection of hardware and appropriate software for video management, selection of video recorder and its sizing to meet the storage requirements mentioned In the datasheets, accessories etc for proper monitoring and control.
ii) Selection of equipment suitable for the environmental conditions.

b) Carryout complete application engineering so as to achieve the desired objectives with the stated performance requirements.

c) Provide all hardware and software, as necessary, to meet functional requirements specified in the purchaser's specification.

1.2 Bids

1.2.1 Vendor's quotation shall be strictly as per the bidding instructions to vendor attached with the material requisition.

1.2.2 Vendor's technical offer shall include the following:

a) Compliance to the specifications.

b) Detailed specification sheet for each item providing all the details regarding make and model, type, construction, Maximum and minimum viewable distance, Maximum tilt or pan angle possible, Pan and tilt speed, Allowable Voltage and frequency variations, Interconnecting cable and transceiver module specifications, utility requirement, Network Bandwidth requirements and calculations to support the same considering bus loading as' 50% maximum, Hardware, software and licensing requirements, Storage calculations for video recorders.

c) Detailed dimensional and sectional drawings including mounting details for all the units offered. All dimensions shall be in millimeters.

d) Block-diagram showing all units with model numbers

e) Interconnection wiring diagram between the various components of CCTV system, including location of each item. The diagram shall show the size of cable and brief specification of the cable

f) Proven references for the offered model of CCTV system in line with clause 1.2.3 of this specification

g) A copy of approval from local statutory authority, as applicable, such as Petroleum and Explosives Safety Organization (PESO)! Chief Controller of Explosives CCOE), Nagpur or Director General of Mines Safety (DGMS) in India, for the electronic instruments installed in electrically hazardous area along with:

i) Test certificate from recognised test house like CIMFR/ERTL etc. for flameproof enclosure, as specified in the data sheet, as per relevant standard for all Indian manufactured equipments or for items requiring DGMS approval.

ii) Certificate of conformity from agencies like LCIE, Baseefa, PTB, CSA, FM, UL,CE etc. for compliance to ATEX directives or other equivalent standards for all equipments manufactured outside India.

h) Power consumption for the complete CCTV system including accessories.

i) Deviations on technical requirements shall not be entertained. In case vendor has any valid technical reason, they must include a list of deviations clausewise, summing up all the deviations from the purchaser's data sheets and other technical specifications along with the technical reasons for each of these deviations

j) Catalogues giving detailed technical specifications model decoding details and other information related to hardware and software for the items covered in the bid.

1.2.3 The integrated CCTV system comprising of Cameras, encoders, video management system, video recorder etc, as offered, shall be field. proven and should have been operating satisfactorily individually for a period of minimum 4000 hours on the bid due date in the conditions similar to those as specified in the purchaser's data sheets. Items with proto-type design or items not meeting proveness criteria specified above shall not be offered.

1.2.4 Vendor's quotation, catalogues, drawings, installation, operation and maintenance manuals shall be in English language.

1.2.5 Vendor shall also quote for the following:

a) All associated accessories and cables.

b) Two years operational and maintenance spares for all items including their accessories as per vendor's recommendation which shall include the following as a **minimum:**

i) Each type of electronic module
ii) Fuses

h) Any special tool or test equipment needed for calibration and maintenance work.

1.3 Drawings and Data

1.3.1 Detailed drawings, data, catalogues and manuals required from the vendor are indicated by the purchaser in vendor data requirement sheets. The required number of reproducible, prints and soft copies shall be dispatched to the address mentioned, adhering to the time limits indicated.

1.3.2 Final documentation consisting of design data, installation manual, operation and maintenance manual etc. shall be submitted by vendor after placement of purchase order shall include the following as a minimum:

a) Specification sheet for each camera and its accessories.

b) Certified drawings for the CCTV system which shall provide the following information:

i) Overall dimensions in millimetres

ii) Detailed interconnection diagram identifying each component with terminal number, cable type, cable size and cable entry details. The interface details shall be clearly identified in the drawing

iii) Grounding detail of each item

iv) Power supply distribution details

v) Clearance space required for maintenance work

vi) Weight of camera and other accessories

c) Configuration data.

d) Power consumption.

e) Installation procedure of camera and other accessories.

f) Maintenance procedure including replacement of its parts/ internals.

g) Copy of type test certificates.

h) Copy of the test certificates for all the tests indicated in clause 4.0 of this specification.

2.0 DESIGN AND CONSTRUCTION

2.1 The Closed Circuit Television (CCTV) system shall consist of the following units as a minimum:

a) Camera Unit.

b) Composite Video Baluns for Video Transmission

c) Video encoders

d) Video management ,Video analysis system along with LCD monitors

e) Video Recorder

f) CCTV System cabinet

g) Power supply distribution board

h) Cables, cable glands, connectors and other accessories

i) Network switches

2.1.1 CAMERA UNIT

Camera unit shall consist of Video Camera, camera unit enclosure, remote controlled pan and tilt unit, remote controlled washer and wiper assembly, sun shield -and thermostatically controlled heaters, receiver units, junction boxes etc.

2.1.1.1 Video Camera

a) Unless otherwise specified, the video camera shall be colour type 1/3" CCD/CMOS sensor with wide dynamic range with resolution of 540 TVLs (TVL: TV lines) as a minimum.

b) The camera shall have Automatic Gain Control (AGC) facility with gain adjustment of typically up to 18dBA. The video amplifier shall ensure a signal to noise ratio of 50.

c) The camera shall be able to operate satisfactorily under varied light intensity levels. The light sensitivity of the CCTV camera shall be 2.5 lux and shall be able to view objects in illumination level of 45 lux at the distance of 50 m as a minimum.

d) Automatic lens iris control facility shall also be provided as pel' the background light levels.

e) The focal length of the camera shall be based on the distance of the objects from the camera. The lens adjustment for focus control and zoom control shall be motorized and remote controllable.

f) The camera shall have feature of backlight compensation.

2.1.1.2 Camera unit enclosure

Camera unit enclosures in safe areas shall be weather proof to IP-65 as per IS-13947. Camera unit enclosures in hazardous areas shall meet the following requirements, as a minimum:

Weather-proof : IP-65 as per IS-13947

Camera unit enclosure shall be suitable for the area classification indicated in the datasheets.

21.1.3 Pan and Tilt Unit

The pan and tilt arrangement shall be able to adjust camera within an angle of 0° to 335° horizontally (i.e. pan range) and a minimum of 180° (±900) vertical (i.e. Tilt range). The movement of the device shall be smooth. Pan speed shall be 6 degrees /sec and tilt speed shall be 3 degree/second as a minimum. Pan and tilt action shall be operable from video management system in control room. Pan and tilt unit shall be suitable for area classification as indicated in the datasheets. Pan and tilt units shall also be weatherproof to lP-65 as per IS13947.

2.1.1.4 Wiper and Washer

Whenever camera is for outdoor installation or the application necessitates. the glass window shall be provided with a wiper and washer unit. The washer unit shall comprise of washer tank, motor & pump and associated tubing. The washer tank shall be placed in an FRP enclosure near the camera and shall be easily accessible. The tank shall have a water inlet connection, a valve along with ball float actuator, a water outlet connection, necessary tubing & connectors between the water outlet connection, water pump, and nozzle at the camera. The rising water level in the tank shall raise the lever which will close the valve. The pump shall either be located in the explosion proof housing of the camera or placed inside the FRP enclosure of the washer tank. Whenever the pump is placed in the FRP enclosure, it's motor shall be explosion proof certified for the area classification. Vendor shall indicate the media to be used for actual washing with requirements like flow, pressure etc. Whenever specified, the washer tank shall have a capacity of 10 litres as a minimum and the minimum flow rate of the pump shall be 0.5 litres per minute.

2.1.1.5 Space Heater

For outdoor applications and where there is a possibility of condensation on the glass window, the camera unit shall be provided with a thermostatically controlled anti-condensation heater.

2.1.1.6 Junction Box

The junction boxes for housing the accessories shall be suitable for outdoor installation with minimum IP-65 weatherproof protection and shall be certified for the specified area classification as per datasheets.

2.1.1.7 Camera Mounting

Cameras shall be provided with suitable mounting accessories for mounting on structures, roofs, poles as indicated in the datasheets. Whenever specified, the height of the support poles shall be as per the datasheets. The pole shall have ladder for camera maintenance.

2.1.2 VIDEO ENCODER

a) The video encoder shall digitize and compress the video signal using MPEG-4 & MJPEG compression technique. The operator shall have the option of changing the frame rate

from I to 25 frame per second (fps)/camera and also change the resolution to CIF,2CIF and 4CIF (PAL).

b) The video encoder shall be capable of TCP/UDP, unicast and Multicast transmission of live video. If connected over an IP network, then each video encoder shall be !P addressable and shall be able to connect to networking devices such as switches/ routers. Encoder shall be single/ multi channel as specified in the datasheets. Multi channel encoder shall have 4 channels maximum.

c) The video encoder shall be capable of receiving camera control commands from video management system and relay them to cameras on RS485.

d) The encoder shall be capable of detecting the loss of video signal from the camera video output.

e) Encoder shall have motion detection.

f) The encoder shall be abie to send alarm signals (e.g., on motion detection or loss of video signal) over the network to the respective video management system. The video management system at the control room shall receive the alarm signals over the network and shall drive outputs such as an audible alert or a visual indication on a monitor to alert an operator.

g) It shall be possible to upgrade the video encoder software remotely.

2.1.3 VIDEO MANAGEMENT SYSTEMIVIDEO RECORDINGNIDEO ANALYSIS

2.1.3.1 The system shall support the virtual matrix capability (i.e., software based matrix) to allow the operator to assign any camera to any local or remote monitor on the network. Also it shall be possible to Control and monitor any camera on the network.

2. 1 .3.2 The video management system shall be able to permit online selection of:

a) Camera Units

b) Monitors

c) No. of views on one monitor

d) Recording Commands

e) Pan-tile Control

f) Sequential Switching of image on monitors

g) Focus, wiper, wash and zoom operating for each camera unit.

2.1.3.3 The monitors shall be 26" colour LCD monitors with necessary controls like colour brightness, contrast adjustment and monitor ON/OFF control. These functions shall be possible from the monitor front.

2.1.3.4 The camera views on the monitor shall be populated based on the operator request. The operator shall be able to view 1/4/9/16 views per monitor. The operator shall be able to enlarge the views.

2.1.3.5 The operator shall be able to view cameras through simple drag and drop commands.

2.1.3.6 The system shall be equipped with the web based client software to allow users to view the cameras on the Microsoft explorer browser from any PC on the network, provided if they are given the permission and password.

2.1.3.7 The user interface shall present the operator with a camera tree that shall show the list of all the cameras and camera sequences that are available to the operator. The Vendor shall present the hierarchy of the camera tree together with the grouping of cameras and the way in which the user! operator shall interact with it.

2. 1.3.8 The NVMS user interface shall have a map to allow viewing the graphical representation of the area together with allowing the operator to place camera icons on the map. The Vendor shall present the full features and operations of the map and shall present the way in which the user/ operator shall interact with the map.

2.1.3.9 The operator shall be able to perform pan/ tilt! zoom/ washer and wiper unit control for PTZ **cameras.**

2.1.3.10 The operator shall be able to enable/ disable Motion detection for cameras.

2.1.3.11 The operator shall be able to write macros/scripts for the cameras to do the following as a minimum:

(i) To define the sequence of cameras to be viewed on a given monitor

(ii) To define the period and start/ stop time for viewing a camera on a monitor

2.1.3.12 The viewing and control of cameras shall be controlled by use of passwords. Two levels of password shall be provided:

a) The operator level in which the operator shall be able to perform PTZ controls, viewing, recording and playback.

b) The supervisor level in which the supervisor shall be able to make configuration changes in addition to the PTZ controls, viewing, recording and playback.

2.1.3.13 VIDEO RECORDER

a) Whenever specified the system shall also supplied with video recorder to record video images automatically or on manual demand. The recorder shall meet the following requirements as a minimum.

b) The video recorder shall have disk space to store on-line video storage for duration as specified in the datasheets and access to high capacity archiving mechanisms for removal of stored video to off-line storage media.

c) The vendor shall size the video recorder hard disc space based on the number of cameras, number of days (minimum 30 days) for which the recording has been done, the resolution of recording and the number of frames per second to be recorded, as indicated in the datasheets. Vendor shall submit calculations/ equations for storage requirements. Use of software without supporting calculations shall not be acceptable.

d) The system shall mark the events with time and date stamping during monitoring and recording. The system shall allow the operator to view stored information with respect to time and date of recording with scan and search of the marked events/ timing.

e) The operator shall be able to playback the recorded events in slow and fast motion with variable speed.

f) It shall be possible for the operator to schedule recordings for each individual camera taking place in the future. The operator shall be able to configure the Start and Stop time for the scheduled recording.

g) The operator shall be able to exports previously stored video to DVD or latest storage option as specified in the datasheets.

h) The exported video shall be able to retrieve archived video from DVD or the latest storage option as specified in the datasheets.

i) Captured images or videos shall be easily distributed to any remote locations through the LAN/WAN environment, if required. The operator shall be able to export previously stored video from a recorder to any other network storage devices including a network drive. An exported file must be in MPEG-4/ MJPEG format and, as such, should be readable using any MPEG-4/MJPEG compliant decoding software.

j) Each video recorder shall be of 19" rack mountable type.

k) Video recorder shall support RAID 0 +I as a minimum.

2.1.3.14 VIDEO ANALYSIS

a) System shall generate alarm on motion detection in areas where no motion is expected.

b) System shall generate alarm on no motion detection in areas where motion is expected.

c) System shall generate alarm on flare flame failure.

d) System shall generate alarm in case fire is detected.

e) System shall generate alarm when toxic cloud is observed.

2.1.4 ALARMS & EVENTS

a) The operator in the control room shall be able to get an indication of the faults occurring in any of the devices connected over the network. This includes faults occurring in the

cameras, video encoders, computers, and video recorders. Faults occurring in each of these devices shall generate an alarm in the operator console.

b) The operator shall be able to view the chronology of events by device, date, time and description.

c) The system shall support logging of events for reviewing and analysis in the future.

d) Upon detecting a fault, the system shall be able to automatically send an E-mail alert.

2.1.5 CONFIGURATION

The following facilities shall be provided for configuration of the CCTV system as a minimum:

a) Assign an ID or name to each camera.

b) Add/delete cameras.

c) Change the camera details (e.g. Camera location, Camera ID, Camera number, etc)

d) Configure the camera encoding parameters in terms of number of frames per second.

e) Configure the camera encoding resolution in terms of setting it to CIF, 2ClF, or 4CIF.

f) Creation of schedules for recordings.

g) Configure recording either on demand, continuous recording or based on motion detection.

h) Add/ delete monitors to the system.

i) Add/ delete computers to the system.

j) Creation of a camera group, view a camera group, view a camera sequence, and view a multiple view screen.

k) For an IP based system, assIgn IP addresses to video encoders, computers of video management system, video recorders, video wall controllers as applicable.

I) Program external outputs based on certain events.

2.1.6 INTERFACING WITH DCS

Wherever specified, interfacing with DCS shall be done to allow DCS operators to view live

video along with DCS graphics on the DCS operator consoles. Hardware required for the same shall be provided by vendor. Software required in video management system and DCS shall be provided by vendor.

2.1.7 CCTV CABINETS

2.1.8.1 The CCTV cabinet(s) shall house the following components: (i) Computer(s) (ii) video encoder(s), (iii) video recorder(s), (iv) control unit (v)network switches (vi) Transceiver modules, if any (vii) indoor fibre patch panel, if any (viii) VGA boosters, if any(ix) Line drivers, if any (x) Miniature circuit breakers etc. as applicable.

2.1.8.2 The cabinet(s) shall be fitted with lockable doors and shall have front and rear access. All system cabinets shall be completely wired.

2.1.8.3 The cabinet shall be free standing, enclosed type and shall be designed for bottom cable entry. Cabinet structure shall be rigid and shall be provided with removable lifting lugs to permit lifting of the cabinets.

2.1.8.4 Cabinets shall be fabricated from cold rolled sheet steel of minimum 2 mm thickness suitably reinforced to prevent warping and buckling. Doors shall be fabricated from cold rolled steel sheet of minimum of 1.6 mm thickness. Cabinets shall be thoroughly de-burred and all sharp edges shall be grounded smoothened after fabrication.

2.1.8.5 Each cabinet shall be of maximum 2100 mm height and 1200 mm width. Construction shall be modular preferably to accommodate 19" standard electrical racks. Maximum swing out for Pivot card racks, doors and drawers shall be limited to 600 mm. Doors of the cabinet shall be equipped with lockable handles and concealed hinges with pull-pins for each door removal.

2.1.8.6 In order to effectively remove dissipated heat from the cabinets, vent louvers backed by wire-ply screen shall be provided on the cabinet doors. Ventilation fans shall be provided in each cabinet along with fan failure alarm contact.

2.1.8.7 Fluorescent lamps shall be provided in each cabinet for each cabinet for internal illumination along with door operated micro switches. All lighting shall be on 230v 50Hz normal power supply.

2.1.8.8 All wiring within the cabinet shall be neatly laid and shall be accessible. Clamping rails shall be provided for incoming cables to present excessive stress on the individual terminals. All metal parts of the cabinet including doors shall be electrically continuous and shall be provided with common grounding lug.

2.1.8.9 The color of the CCTV cabinets shall be matched with the existing cabinets at control room.

2. 1.8.10 Cable glands shall be provided for cable entry into the CCTV cabinet. Spare cable entries shall be plugged.

2.1.8 OPTICAL FIBER CABLE

The Optical Fiber Cable (OFC) used for the CCTV system shall conform to the following specification as a minimum:

a) The OFC shall be CSTA (corrugated steel tape armored, electrolytically chrome plated low carbon steel) armored cable.

b) The OFC shall have FRP strength member, loose tubes for single mode optical fibers filled with moisture resistant jelly, moisture barrier of polymer coated Aluminum tape or water swellable tape, inner sheath of HOPE and outer sheath of PVc.

c) Optical fibers shall be single mode fibers compliant to ITV-T G 652 and fibers colours shall correspond to IEC 793-2 and 304. Optical fibers shall be coated with UV cured double acrylic resin. It should not have any reaction with cladding or core material. The coating should provide maximum resistance to micro-bending & abrasion and ensure mechanical & optical strength. The coating shall be easily stripped with mechanical tools.

d) The number of fibers in the OFC shall be decided depending upon the requirement with 8 fibers as a minimum.

e) The cabled fiber attenuation shall be -S 0.37 dB/km for 13] 0 nm wavelength range and 0.22 dB/km for 1550 nm wavelength range.

f) The tensile performance shall be as per IEC-794-IEI and with tensile load of9.81 W Newton with attenuation change -S 0.05 dB/km at 1310 nm. W is weight of OFC/km.

2.1.9 NETWORK SWITCH

The network switch used for the CCTV system shall conform to the following specification as a minimum:

The network Switch shall be configured to provide communication paths and provide the facility for adaptive packet and message routing through any available communication link. The network Switch shall provide the facility of multiple protocol router and bridge that provides high bandwidth connections into backbone networks for remote sites.

The hardware design shall be based on distributed processing architecture with packets forwarding to be performed on the network interface modules. It shall be based on the modular design and architecture and shall allow new network interface cards to be added in the racks without powering down the unit and ensuring no disruption of service to the network users.

The network Switch shall support both intra-area and inter-area routing for transporting messages between nodes and shall support the network routing! bridging services for OSI, TCP/ IP, X.25, LAT and other industry standard wide area networks/ protocols. The network switch shall be adaptive 10/100/1000 Mbps interface port, supporting pass through! Crossover adaptation of port. The network switch shall be provided with optical fiber module interface suitable for long distance transmission.

2.1.10 POWER SUPPLY

2.1.10.1 The system shall operate on I 10 VAC/ 230VAC (as specified in the datasheets) with the following specifications:

Voltage variation	± 10%
Frequency	50 Hz± 3 Hz

Any other power supply required shall be derived from this power supply by the vendor.

2.1.10.2 Power Supply distribution for all items related to closed circuit television system shall be carried out from the system cabinet itself. Vendor shall supply any hardware required for

conversion/ distribution. Power supply for each item shall be provided with a separate switch and fuse for isolation and protection of the system.

2.1.10.3 The CCTV camera unit shall be capable of withstanding plant vibration level of 2. 1 G (within the frequency range of 5 Hz to 200 Hz) and sudden shocks of level 5 G (with frequency of 2 Hz).Any vibration pads required to meet this requirement shall be in vendor's scope of supply.

2.1.10.4 The CCTV system shall have the capability for future expansion to add cameras and additional storage in video recorders.

2.1.10.5 All cable glands, as required, for camera enclosure, pan! tilt unit, junction boxes, CCTV cabinet etc. shall be Nickel plated brass, dual compression type, suitable for area classification specified in datasheets.

3.0 NAMEPLATE

3. 1 Each camera shall have a SS label name plate attached firmly to it at a visible place furnishing the following information:

a) Manufacturer's model no. and serial no.

b) Manufacturer's *name* / trademark.

c) Type and Resolution of Camera

d) Lens Focus Length

e) Pan and Tilt Range

f) Type of explosion protection and certificate number

g) Power Requirement.

3.2 Each item of Close Circuit Television and its accessory shall have SS labels attached firmly to it at a visible place, furnishing the following information:

a) Manufacturer's model no. and serial no.

b) Manufacturer's *name* / trademark.

c) Type of explosion protection and certificate number

d) Power Requirement.

4.0 INSPECTION AND TESTING

4.1 Unless otherwise specified, purchaser reserves the right to test and inspect the system at vendor's works. Vendor shall provide facilities like competent manpower, equipment and utilities required for the purpose to Purchaser's representative for inspection. Vendor shall test and demonstrate integrity of the system hardware and software. No material or equipment shall be transported until all required tests are successfully completed and certified 'Ready for Shipment' by the Owner / Consultant.

4.2 The Purchaser reserves the right to get involved and satisfy himself at each and every stage of project execution. The purchaser shall be free to request any specific test considered necessary by him although not listed specifically .The cost of performing all tests shall be borne by the vendor.

4.3 Vendor shall submit the following test certificates and test reports for purchaser's review:

a) Dimensional verification certificate
b) Manufacturer's test reports as per Type 3.1 of EN 10204

c) Minimum light intensity testing

d) Power supply variation check

e) Certificate from Statutory authority for flame proof and weather proof enclosure, as applicable

4.4 Witness Inspection

4.4.1 All items shall be offered for pre-dispatch inspection for following, as a minimum, unless otherwise specified:

a) Physical dimensional verification and workmanship.

b) Bill of material check

c) Effect of variations in power supply, voltage and frequency

d) Performance testing and verification of integrated CCTV system.

e) Review of all certificates and test reports.

4.4.2 In case, the witness is waived off by the owner / Consultant, the test report of test carried out by vendor as indicated shall be forwarded by vendor for review. The equipment shall be dispatched only after it is cleared by owner / Consultant for dispatch.

5.0 SHIPPING

5.1 All threaded openings and cable entries shall be suitably protected to prevent entry of foreign material.

5.2 Any glass item shall be protected with foam sheet to protect against damage during transportation.

5.3 Each panel and accessory shall be suitably packed and protected from damage due to transportation, unloading and loading.

5.4 Each component part requiring identification for proper assembly at site shall be piecewise marked.

6.0 REJECTION

6.1 Vendor shall submit their offer in detail, as per clause 1.2 of the specification and shall attach these documents, which are specifically indicated in the material requisition. Vendor shall make offer w.r.t every clause of this specification.

6.2 Any offer not confirming to the above requirements shall be summarily rejected.

INSPECTION AND

TEST REQUIREMENTS

FOR INSTRUMENTATION

CONTENT

Sl. No.	DESCRIPTION
1.0	Inspection and Tests
1.1	General
1.2	Visual Inspection
1.3	Dimensional Inspection
1.4	Material Inspection
1.5	Non-Destructive Examination
1.6	Pressure Test
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1.9	Performance Test
1.10	Steam Test
1.11	Insulation Resistance Test
1.12	High-voltage Test

ATTACHMENT

Sl. No.	DESCRIPTION
Table-A	Table-A- Table of Inspection and Test Items

1. INSPECTION AND TESTS

1.1 General

1.1.1 All instruments and system-oriented items shall undergo factory testing and inspection by authorized Third party representatives / Owner and PMC unless specified otherwise.

1.1.2 Wherever inspection at manufacturer's shop is waived because of any reason, the sub vendor's own testing reports shall be verified before despatch. In no case items shall be released without proper inspection verification.

1.1.3 The inspection and testing shall be carried out as per related specifications, international codes and practices/standards, approved documents and/or any other documents attached along with specifically suggesting testing to be carried out at manufacturer' works.

1.1.4 Items, for which 'Witness Inspection' is specifically exempted, manufacturer shall forward the test certificates as desired for review. The material shall be despatched only after obtaining written despatch clearance.

1.1.5 No system or system oriented item shall be despatched without integrated factory testing witnessed by representatives of / Third party inspector / Owner /PMC. The testing procedures shall be detailed out, based on testing requirements indicated in individual system specifications and shall be approved by Owner/ PMC. It must certify that the system is actually ready before calling the Owner/PMC for FAT. Also all the necessary documents and literature are to be submitted before calling for FAT.

1.1.6 Testing and inspection for all items shall be carried out as per approved factory testing procedures.

1.1.7 Performance specifications must be detailed out on each time which shall be verified by third party agency / by Owner / PMC during factory testing.

1.1.8 Acceptable criteria for Radiography and other NDT requirements for the instruments / instrument castings shall be inline with those specified in 'Piping Specifications' have been attached elsewhere in this package.

1.1.9 IBR certifications shall be provided by in the appropriate format duly signed by IBR authority or their authorised agency.

1.1.10 Verification of setpoint of rupture disc shall be part of witness inspection. Testing shall be carried out on the rupture disc, which are part of the actual rupture disc batch of manufacturer. This shall be in addition to the 3 numbers of spare rupture discs already indicated in the requirements. The testing, in general, shall be as per ASME section VIII.

1.1.11 Inspection and test items, witness inspection items for each kind of instrument at FAT (Factory acceptance test) shall be as shown in Table A.

1.1.12 Inspection and acceptance standards

Inspection and acceptance standards shall be as follows.

1.2 Visual Inspection

1.2.1 Conformation items

1. Type and model
2. Tag no.
3. Rating
4. Range, Scale and symbol of unit
5. Set pressure and capacity of safety valves
6. Valve characteristics and CV value of control valves
7. Name of materials
8. Nameplate
9. Colour of painting
10. Die Marking (nominal size, material of flange and direction of flow)
11. Accessories
12. Quantity

1.2.2 Harmful defects

- Defect such as cracks, deformation and flaws shall not be found in the casting, forging and machined surface of the pressure rating part.
- Defect such as inside surface weld protrusion; lack of fusion and incomplete penetration shall not be found in welded places of pressure retaining part.

1.2.3 The instrument shall be in rugged design and assembly of all components within the enclosure fixed firmly to avoid loosening or falling-off of any parts.

1.2.4 Painting of instrument's surface shall be such that there is no defect or lack of uniformity.

1.3 Dimensional Inspection

[X] Main parts
[ ]
[ ]

Check and conform to the requirement of Purchaser's Spec, approved drawings or applicable code and standards.

1.4 Material Inspection

1.4.1 Mill test certificates

Manufacturer shall submit the mill test certificates for the following parts.

1. ANSI class 900 or above (ALL material used at the P.T. ratings)

2. The following parts made of steel for :
   - High temperature service (Alloy steel above C-Mo steel used at temperature of 400ºC or over)
   - Low temperature service (Iron and steel material of design temperature bellow minus 11ºC containing Al-killed steel)
   - Corrosion-resistant materials

I.	Temperature detective parts	: **[X]**	Flange and Thermowell
II.	Orifice assembly	: **[X]**	Flange
III.	Venturi tube, Flow nozzle and Low-loss tube	: **[X]**	Body
IV.	Positive displacement flow meter and	: **[X]**	Body, Strainer and

	Turbine meter		Straightner
V.	Area type flow meter	: **[X]**	Body and Flange
VI.	Displacement type liquid level meter	: **[X]**	Chamber and Flange
VII.	Glass Gauge	: **[X]**	Body and Flange
VIII.	Control valve	: **[X]**	Valve body, Bonnet, Plug, Seat and Vane
IX.	Safety valve	: **[X]**	Valve body, Nozzle and Disc
X.	Condensate pot	: **[X]**	Body
XI.	Gas eliminator	: **[X]**	Body

1.4.2 Material grade 316SS or 316L SS of stainless steel, Purchaser may require Vendor to carry out the qualitative analysis for molybdenum.

1.5 Non-Destructive Examination

1. Control valve and safety valve
   Following Par. 1.5.2 and 1.5.3

2. Other instruments
   Shall be carried out in accordance with manufacture's standards approved by Purchaser

1.5.1 Ultrasonic Examination

1. Forging material on Orifice flange and Flow nozzle
   [X] ANSI class 900 or above
   [ ]

1.5.2 Radiography Examination

[ ] The pressure retaining casting parts

1. Applicable material and quantity (refer table VI)
   - Welded parts : [ ] JIS Z 3104, Z 3106
     [X] ASME VIII Division 1 uw-51 "Radiographic & Radioscopic Examination of Welded Joints"

2. Acceptant standards and grade
   - Casting : [ ] JIS G 0581
     [X] ASTEM E 446-9 or 186-93

Table VI Radiography Examination

Materials			Quantity
Casting	class 1500 or over	C-steel	One out of total quantity of the same type, size and rating for pressure retaining critical parts(a)
	class 900 or over	C-Mo steel	
	class 600 or over	Cr-Mo steel Stainless steel	
	class 300 or over	Al-killed steel 2.5 Ni steel 3.5 Ni steel	
Pressure retaining welded parts	class 1500 or over	C-steel C-Mo steel	One spot on each welded parts per same material and same welder. All welded crossing parts
	class 300 or over	Cr-Mo steel Stainless steel	
	class 150 or over	Al-killed steel 2.5 Ni steel 3.5 Ni steel	

a. Following parts are Critical parts.
- Groove-welded parts of cast body
- Flangeneck and valve seat's vicinity of cast body
- Other welded parts included in pressure retaining parts

Note: 1. In case of practical difficulty to perform Radiography Test, Manufacture shall notify Purchaser in advance, and for such case, magnetic particle or liquid penetrant examination may be used in accordance with Par. 1.5.3 with Purchaser's approval.

2. For the welded parts having nominal size of 1-1/2 in. or below, magnetic particle or liquid penetrant examination in Par. 1.5.3 may be used.

1.5.3 Magnetic Particle or Liquid Penetrant Examination

[X] For the pressure retaining parts

Table VII Magnetic particle / Liquid penetrant examination

Materials			Quantity
Casting	class 900 or over	C-steel	20% of total quantity of the same type, size and rating for pressure retaining critical parts (a)
	class 600 or over	Cr-Mo steel Cr-Mo steel Stainless steel	
	class 150 or over	Al-killed steel 2.5 Ni steel 3.5 Ni steel	
Pressure retaining welded parts (b)	class 150 or over	All materials	20% of total welded parts

a. Refer to Par. 1.5.2(1).
b. Including butt groove-welded parts at site.

1.6 Pressure Test

1.6.1 Control Valve

1. Body and Bonnets

[X] Hydrostatic test with Applicable codes and standards

2. Body of special type

[X] Hydrostatic test

Test pressure and Hold time

[X] 1.5 times of max. Operating pressure / min. 2 kgcm2g
[X] Minimum 5 minutes.

3. Permanent distortion or Leakage

[X] shall not be found

1.6.2 Safety Valve or Safety Relief Valve

1. Pressure retaining parts

[X] Hydrostatic test before assembling

i. Test pressure and Hold time

[ ] 1.5 times of Max. Operating pressure / min. 2 kgf/cm2g.
[X] 2.2 times of Max. Operating pressure.
[X] Minimum 5 minutes.

ii Distortion or leakage
[X] shall not be found

2. The out side parts of enclosed type
[X] Hydrostatic test after assembling

i. Test pressure and Hold time
[X] 1.5 times. Nominal pressure of flange
[ ] 2.2 times. Nominal pressure of flange
[X] Minimum 5 minutes.

ii. Defects
[X] Shall not be found

3. Special type valves

[X] Hydrostatic test with the manufacturer's standards approved by purchaser, where Par. 1.6.2(1) and (2) are not applicable

1.6.3 The pressure retaining parts of instrument

[X] Hydrostatic test or Pneumatic test as per applicable codes and standard

I Test pressure and Hold time
[X] 1.5 time of Max. Operating pressure / Min. 2 kg/cm2g
[X] Min. 5 minutes

ii Permanent distortion or Leakage
[X] Shall not be found

If the above mentioned test is technically difficult, the test shall be carried out in accordance with the manufacturer's standards approved by purchaser.

1.7 Pneumatic Test

1.7.1 The pneumatic test for instrument

I Test pressure & Hold time

[X] Max. Operating Pressure. (Design press.)
[X] Minimum 5 minutes

ii Permanent distortion or Leakage

[X] Shall not be found

1.8 Seat Leakage Test

1.8.1 Control Valve

Allowable leakage valve / (code):

[X] ANSI B16.104 (FCI 70-2)

Unless other wise specified, butterfly valves shall not require the seat leakage test.

1.8.2 Safety valve

Seat leakage test (closing property) as follows.

1. Safety valve for Steam

   i. Test pressure

      [X] 90% of set pressure

   ii. Leakage

      [X] Shall not be found

2. Safety valve for Gas

   i. Test pressure

      [X] 90% of set pressure

   ii. Allowable leakage value (Refer Table – VIII)

Table VIII - Allowable leakage value of Safety valve

Type	Orifice Area (mm)	Number of Bubbles (min)	Leakage Value (cm3/min)
General	16.0 and less 20.5 and over	40 20	11.80 5.90
Balance bellows	16.0 and less 20.5 and over	50 30	14.75 8.85

3. Relief safety valves, Vacuum breakers and atmospheric valve
   [X] Manufacture's standard (approved by Purchaser)

1.9 Performance Test

For each instruments, the performance test shall be carried out in accordance with procedure approved by Client / PMC.
Acceptance standard shall be in accordance with applicable codes & standard, All specification, and manufacture's standard shall be approved by Client / PMC.

1.10 Steam Test

Steam test shall be performed as follows:

[ ] Valves used for steam service Temperature of 450°C or more, and the body ratings of class 600 and above.

[ ] After attaining the steady surface temperature same as temperature of the service with the pressure of service condition.

In the case, when steam test has been performed and the report is submitted for the valve of same type, same bore size and material from the same lot, the steam test for the other valves may be omitted.

1. Leakage

   i. Body : [ ] Shall not be found
   ii. Seat : [ ] As per specified leakage value

2. Operation

   [ ] To be smooth

   After the steam test, the test of Par. 1.6 and Par. 1.8 shall be carried out.

1.11 Insulation Resistance Test

1. Power supply circuit & alarm circuit : 10M Ω or over (instrument panel: 3 MΩ or over/each panel)

2. Signal circuit : 5M Ω or more (instrument panel: 3 MΩ or More per panel)

The test shall be carried out in accordance with the applicable codes & Standards. Due to any technical constraint to measure, this test can be omitted

1.12 High-voltage Test

1. A-C power supply and alarm circuits

   i. Voltage level less than 250 V : **[X]** A-C 1500 V

   ii. Voltage level 250 V and above : **[X]** A-C 2E + 1000V

   'E' is the rated voltage.

2. D-C power supply circuits : **[X]** A-C 500V

   Test can be omitted in case of any technical constraint.

Table A : Table of Inspection and Test Items

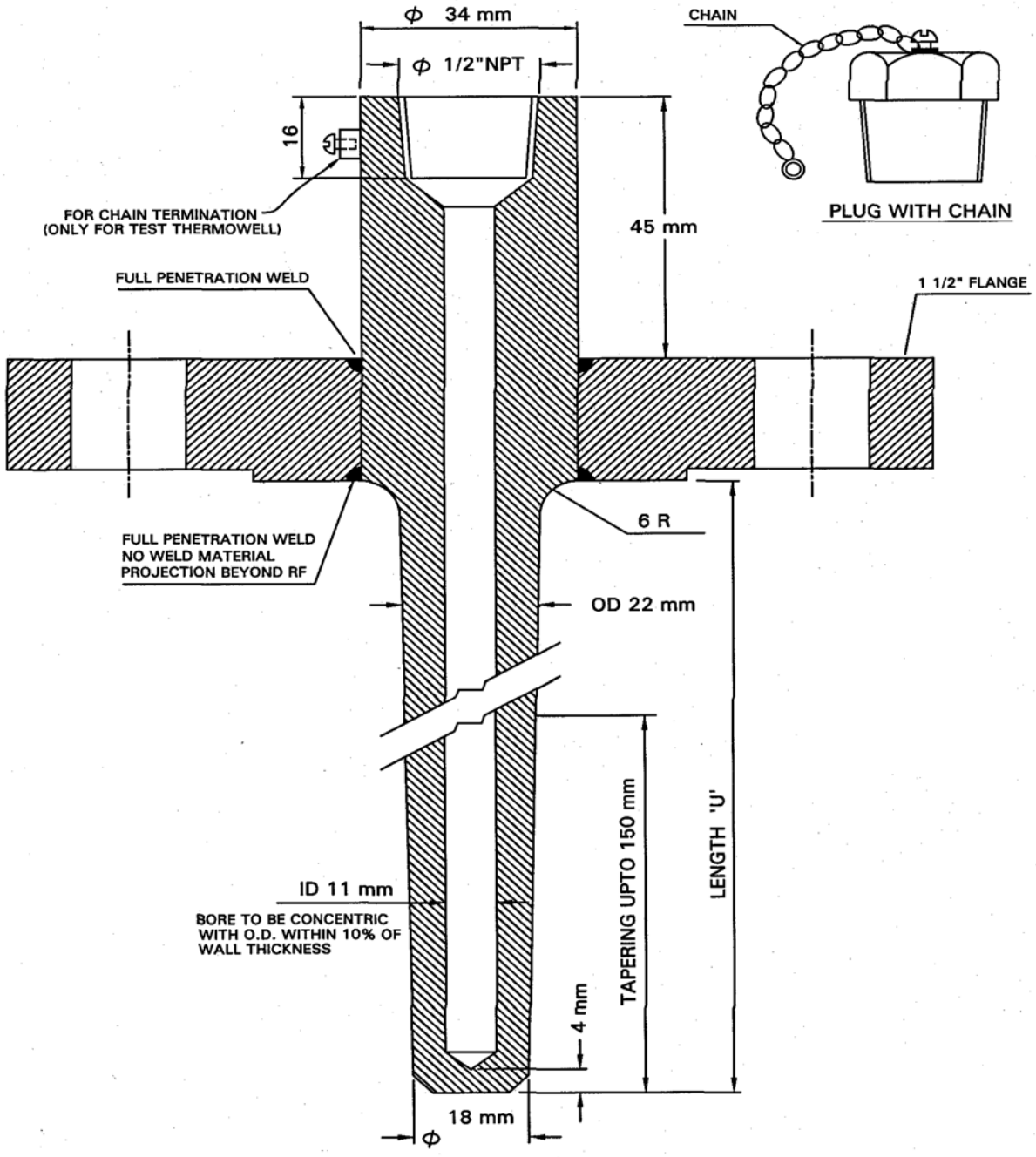
Kind of Instrument	Inspection and Test Items										
	Visual insp.	Dimensional insp.	Material insp.	Non-destructive exam	Pressure test	Pneumatic test	Seat Leakage test	Performance test	Insulation resistance test	High voltage test	Steam test
1 Thermocouple	○ ●T	○●T	—	—	—	—	—	□●T	□●T	□●T	—
2 Resistance thermometer bulb	●T ○	●T ○	—	—	—	—	—	●T □	□●T	□●T	—
3 Compensating lead wire	○●T	○●T	—	—	—	—	—	□●T	□●T	□●T	—
4 Bimetallic thermometer	○●T	○●T	—	—	—	—	—	□●T	—	—	—
5 Gas or liquid-filled thermometer	○●T	○●T	—	—	—	—	—	●T □	—	—	—
6 Thermowell	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
7 Orifice plate	○●T	○ □●T	○●T	—	—	—	—	—	—	—	—
8 Orifice flange	○●T	○●T	○ □●T	○ □●T	—	—	—	—	—	—	—
9 Restriction orifice	○●T	○ □●T	○●T	—	—	—	—	—	—	—	—
10 Flow nozzle low-loss tube	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
11 Venturi tube	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
12 Positive displacement flow meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
13 Area type flow meter	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
14 Thermal mass flow meter	●T ○	●T ○	●T ○	—	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
15 Turbine meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
16 Differential pressure flow meter	●T ○	●T ○	—	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
17 Differential pressure transmitter	●T ○	●T ○	—	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
18 Magnetic flow meter	●T ○	●T ○	●T ○	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
19 Bourdon gauge	○●T	○●T	—	—	○ □●T	—	—	○ □●T	—	—	—
20 Draft gauge	○●T	○●T	—	—	—	—	—	○ □●T	—	—	—
21 Differential pressure gauge	○●T	○●T	—	—	○ □●T	—	—	○ □●T	—	—	—
22 Pressure transmitter	○●T	○●T	—	—	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
23 Displacement type level indicator, controller	●T ○	●S ○ □	●T ○	●T ○	●S ○ □	—	—	●S ○ □	●S ○ □	●T ○ □	—
24 Chamber for displacement type level meter	○●T	○ □●T	○ □●T	○ □●T	○ □●T	—	—	—	—	—	—
25 Glass gauge	○●T	○ □●T	○ □●T	○ □●T	○ □	—	—	—	—	—	—

Kind of Instrument	Inspection and Test Items										
	Visual insp.	Dimensional insp.	Material insp.	Non-destructive exam	Pressure test	Pneumatic test	Seat Leakage test	Performance test	Insulation resistance test	High voltage test	Steam test
26 Float type level meter,	●T ○	●S ○	●T ○ □	●T ○ □	●S ○ □	—	—	●S ○ □	●S ○ □	●T ○ □	—
27 Differential pressure type level meter	○●T	●T ○	●T ○	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
28 Purge type level meter	○●T	○●T	—	—	—	—	—	○ □●T	—	—	—
29 Capacitance type level meter	○●T	●T ○ □	●T ○	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
30 Conductivity type level meter	○●T	●T ○	●T ○	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
31 Conductivity type level meter	●T ○	●S ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
32 Weight sounding type level meter	●T ○	●S ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
33 Radiation type level meter	●T ○	●S ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
34 Pneumatic type control valve	●T ○	●S ○	●T ○ □	○ □●T	●S ○ □	—	●S ○ □	●S ○ □	●T ○ □	●T ○ □	
35 Hydraulic type control valve	●T ○	●S ○	●T ○ □	●T ○ □	●S ○ □	—	●S ○ □	●S ○ □	●T ○ □	●T ○ □	
36 Motor-operated control valve	●T ○	●S ○	●T ○ □	●T ○ □	●S ○ □	—	●S ○ □	●S ○ □	●S ○ □	●S ○ □	
37 Self-acting control valve	○●T	○●T	○ □●T	○ □●T	○ □●T	—	—	○ □●T	—	—	—
38 Indicator	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
39 Recorder unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
40 Controller unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
41 Integrator unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
42 Alarm setting unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
43 Computing unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
44 Converter unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
45 Limiter unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
46 Power source unit	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
47 Instrument panel	●T ○	●S ○	—	—	●T ○ □	●S ○ □	—	●S ○ □	●T ○ □	●T ○ □	—
48 Instrument desk	●T ○	●S ○	—	—	—	—	—	●S ○ □	●T ○ □	●T ○ □	—
49 Gauge board	●T ○	●S ○	—	—	●T ○ □	●S ○ □	—	●S ○ □	●T ○ □	●T ○ □	—
50 Safety valve	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
51 Pilot operated safety relief	●T	●S	●T	●T	●T	—	●S	●S	—	—	—

Kind of Instrument	Inspection and Test Items										
	Visual insp.	Dimensional insp.	Material insp.	Non-destructive exam	Pressure test	Pneumatic test	Seat Leakage test	Performance test	Insulation resistance test	High voltage test	Steam test
valve	○	○ □	○ □	○ □	○ □		○ □	○ □			
52 Vacuum breaker	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
53 Atmospheric valve	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
54 Gas chromato-graph	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
55 Mass spectro-meter	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
56 Infrared type gas analyzer	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
57 Magnetic type gas analyzer	●T ○	●T ○	—	—	—	●T ○ □		●S ○ □	●S ○ □	●T ○ □	—
58 Thermal conductivity type analyzer	●T ○	●T ○	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
59 Combustion type gas analyzer	●T ○	●T ○ □	—	—	—	●T ○ □	—	●S ○ □	●S ○ □	●T ○ □	—
60 Density type gas analyzer	●T ○	●T ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
61 Photo-electric type analyzer	●T ○	●T ○	—	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
62 Moisture analyzer	○●T	●T ○	—	—	—	—	—	●T ○ □	●T ○ □	●T ○ □	—
63 pH meter	○●T	○●T	—	—	—	—	—	○ □●T	○ □●T	○ □●T	—
64 Turbidity analyzer Water quality analyzer	●T ○	●T ○	—	—	●T ○ □	—	—	●T ○ □	●T ○ □	●T ○ □	—
65 Density meter	○●T	○●T	—	—	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
66 Electric conductivity meter	○●T	○●T	—	—	○ □●T	—	—	○ □●T	○ □●T	○ □●T	—
67 Flame detector	●T ○	●T ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—
68. Mass Flow meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
69. Vortex Flow Meter	●T ○	●T ○	●T ○ □	●T ○ □	●T ○ □	—	—	●S ○ □	●T ○ □	●T ○ □	—
70 Gas detector	●T ○	●T ○	—	—	—	—	—	●S ○ □	●S ○ □	●T ○ □	—

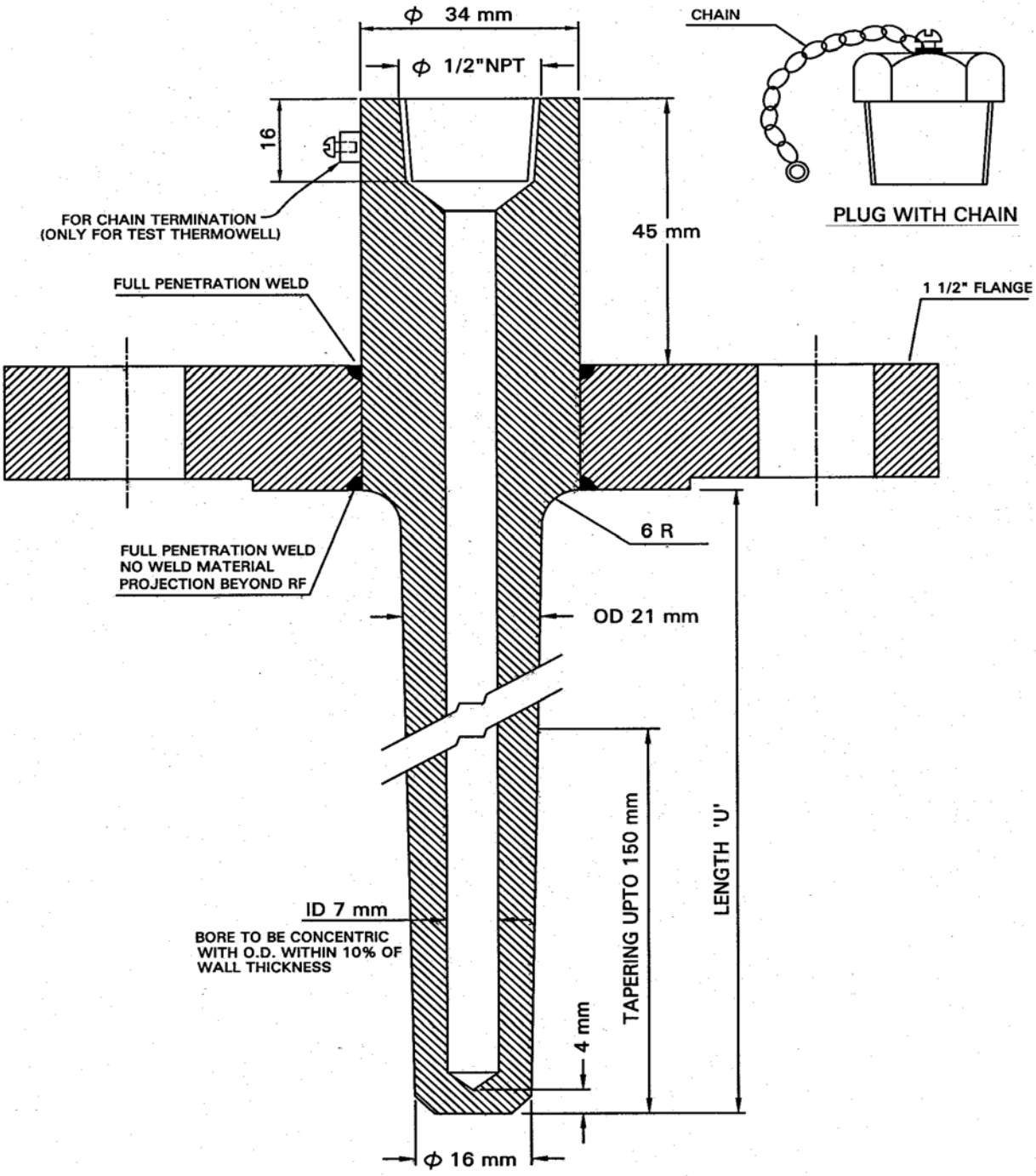
○ : Tested by Manufacturer.
● : Tested by manufacturer & witnessed by 3rd party inspector(TPI).
□ : Manufacturer will submit Inspection & test records.
T : Total Inspection by TPI.
S : Sample inspection by TPI.(10% of total quantity of the same type & rating.

Notes: PMC/OWNER may witness any or all testing in stages during manufacturer or at final stage before shipment.



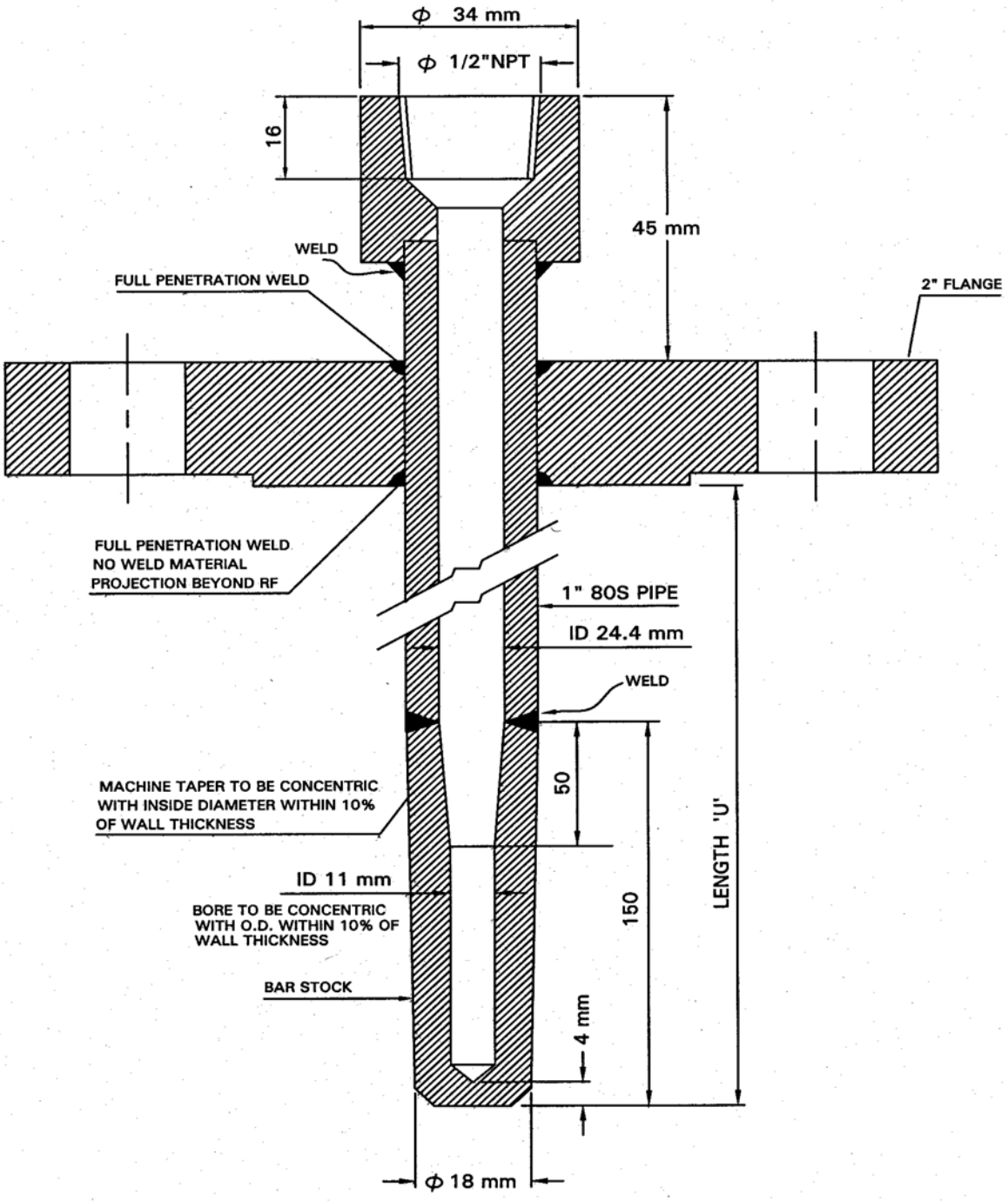
NOTES -

1. THIS STANDARD IS APPLICABLE FOR ;
   a) TEMPERATURE GAUGES, BEADED TEMPERATURE ELEMENTS AND DUPLEX TEMPERATURE ELEMENTS.
   b) *THERMOWELL UPTO 1500# ANSI RATING OR EQUIVALENT.*
2. TYPE OF FLANGE SHALL BE RTJ TYPE FOR ANSI RATING ≥ 600#.
3. DP TEST SHALL BE CARRIED OUT FOR ALL WELD JOINTS.
4. CHAIN AND PLUG SHALL BE APPLICABLE ONLY FOR TEST THERMOWELLS.



NOTES -

1. THIS STANDARD IS APPLICABLE FOR ;
   a) SINGLE TEMPERATURE ELEMENT.
   b) THERMOWELL UPTO 1500# ANSI RATING OR EQUIVALENT.
2. TYPE OF FLANGE SHALL BE RTJ TYPE FOR ANSI RATING $\geq$ 600#.
3. DP TEST SHALL BE CARRIED OUT FOR ALL WELD JOINTS.
4. CHAIN AND PLUG SHALL BE APPLICABLE ONLY FOR TEST THERMOWELLS.

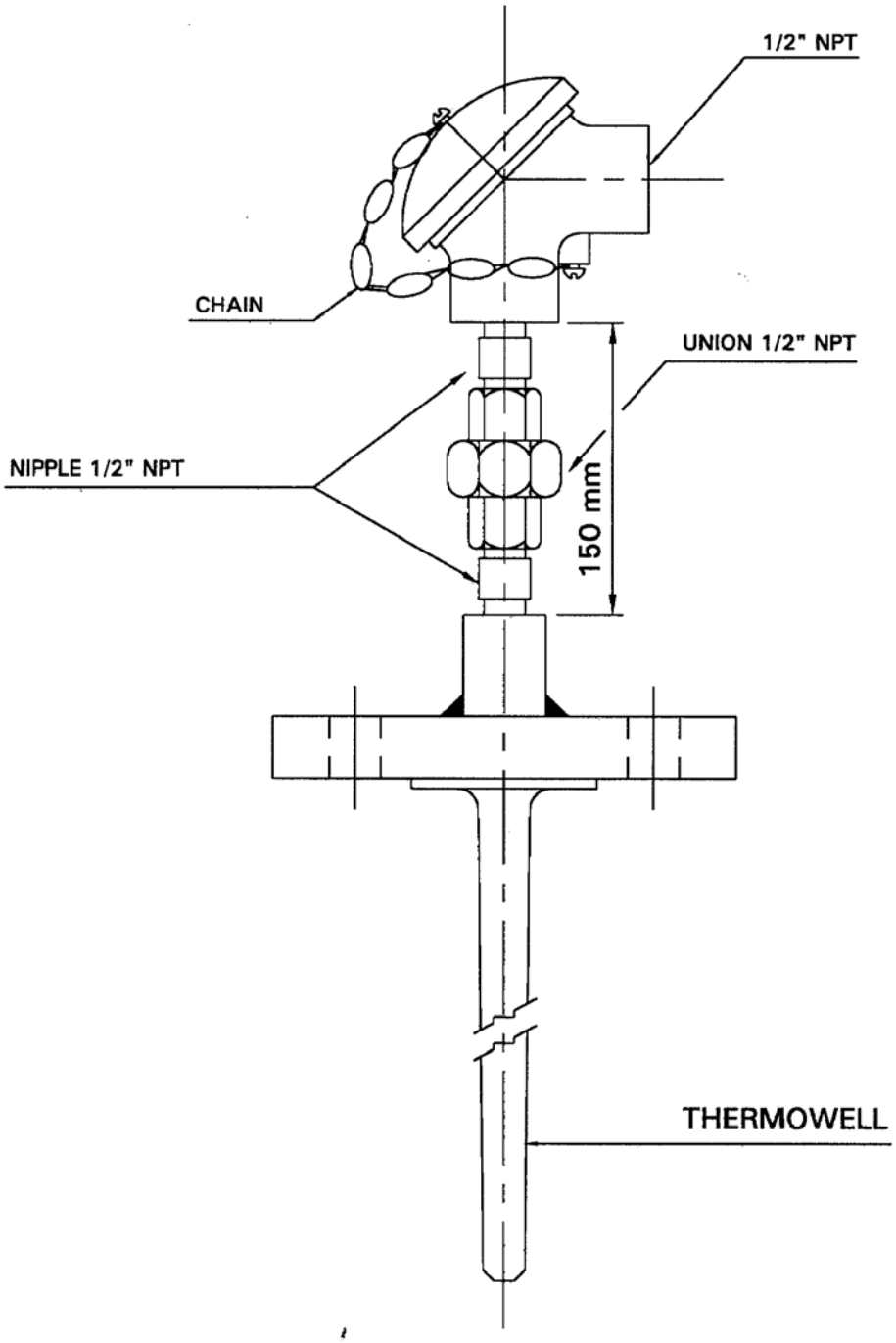


NOTES:-

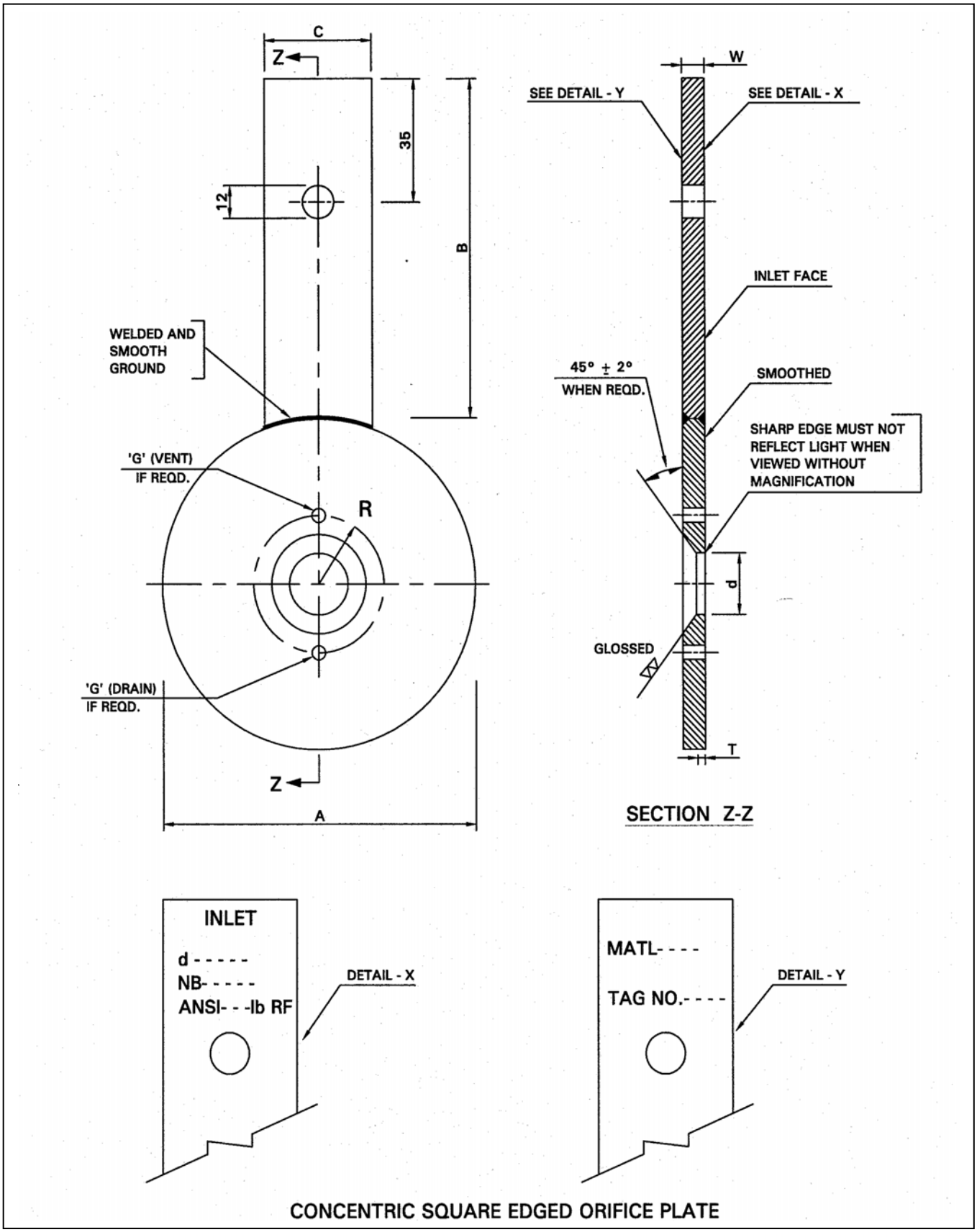
1. DP TEST SHALL BE CARRIED OUT FOR ALL WELD JOINTS.
2. TYPE OF FLANGE SHALL BE RTJ TYPE FOR ANSI RATING ⩾ 600#

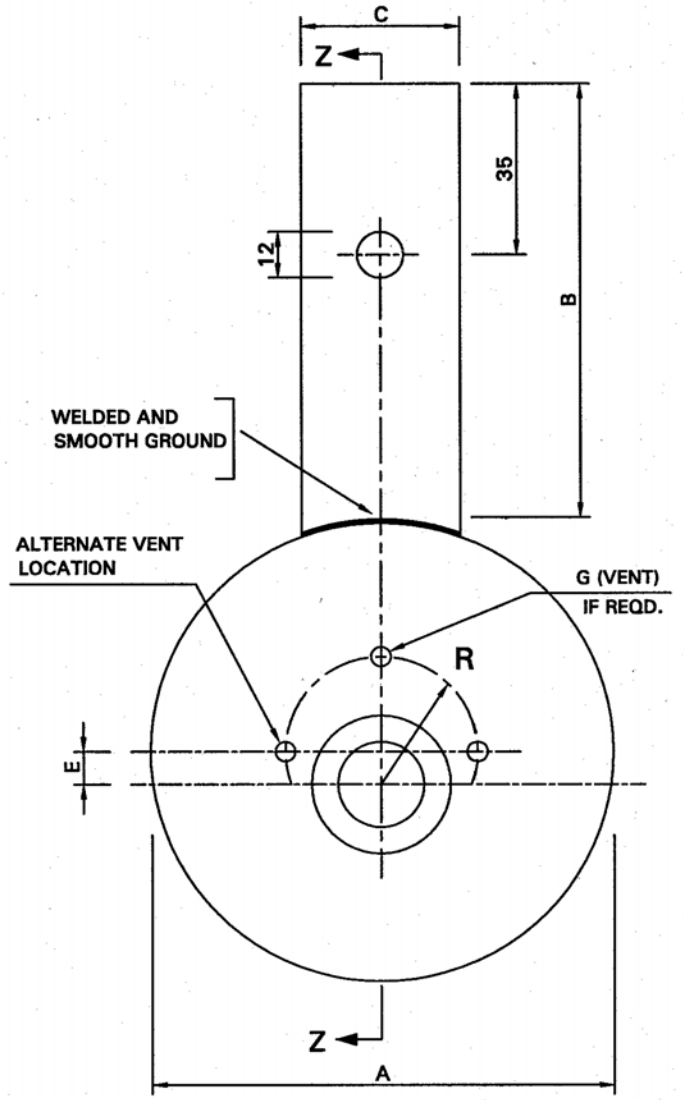
BUILT-UP THERMOWELL	

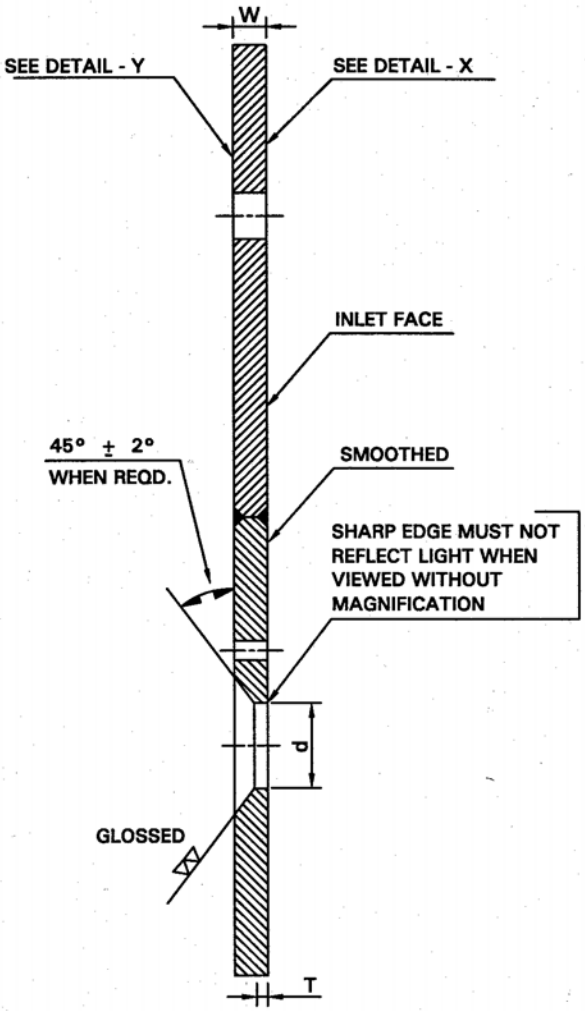
पी डी आई एल PDIL	**THERMOCOUPLE / RTD ASSEMBLY WITH THERMOWELL**		0
		DRG-0036	REV
		SHEET 1 OF **1**	



NOTE - IN THE CASE OF DUPLEX THERMOCOUPLE/RTD, TWO INDEPENDENT CABLE ENTRIES SHALL BE PROVIDED.

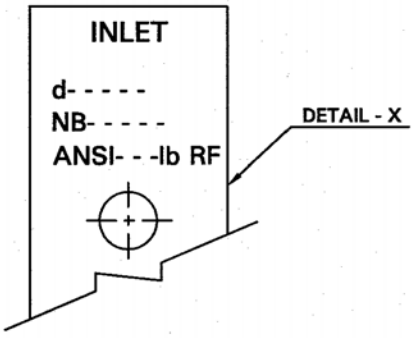


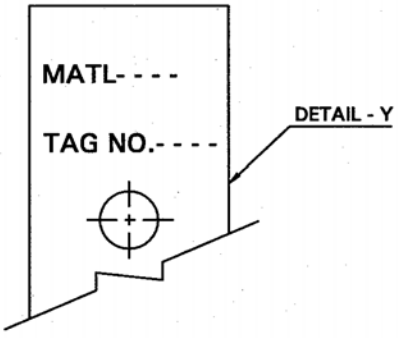




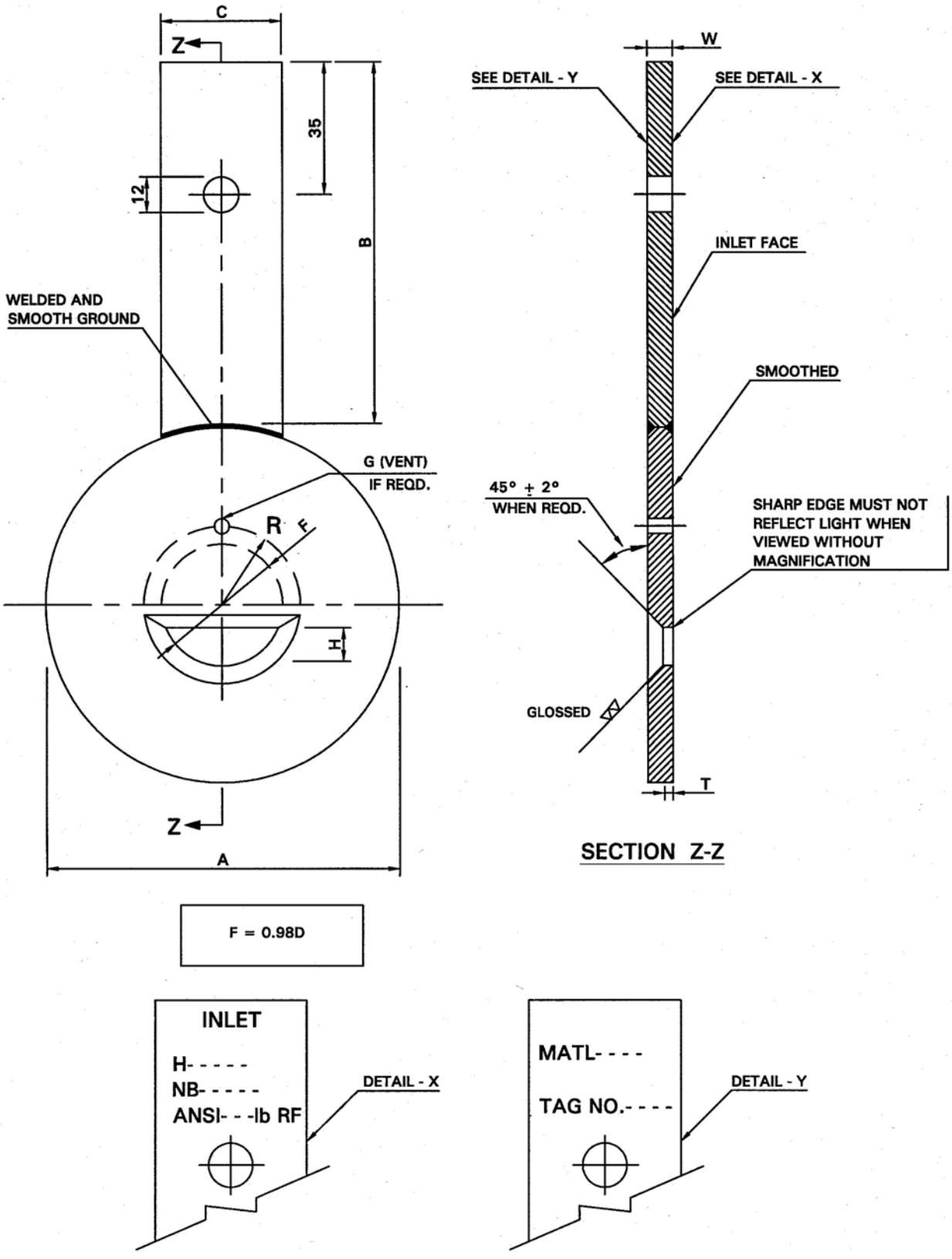
SECTION Z-Z

$$E = \frac{(D-d)}{2} - 0.01\,D$$

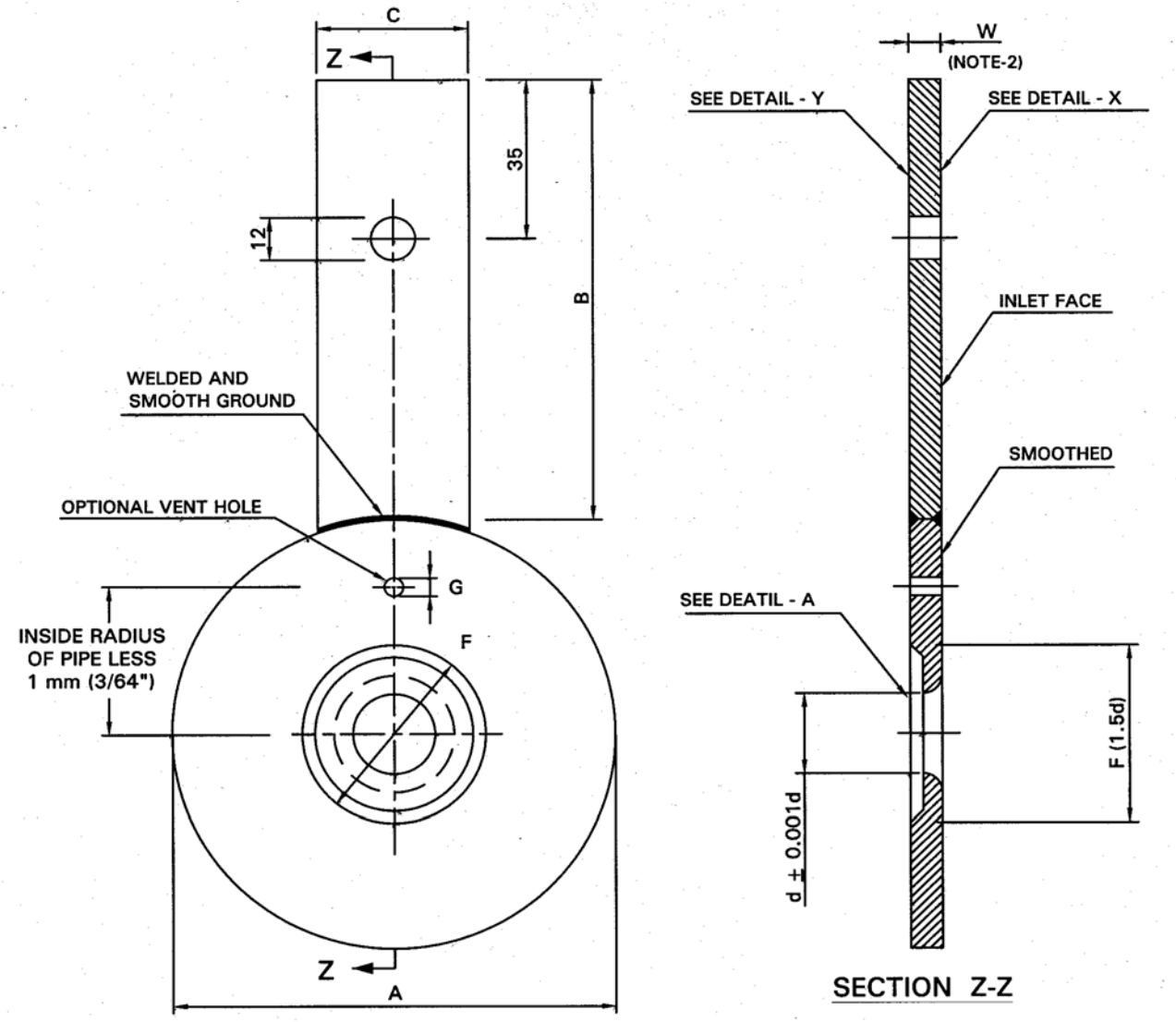




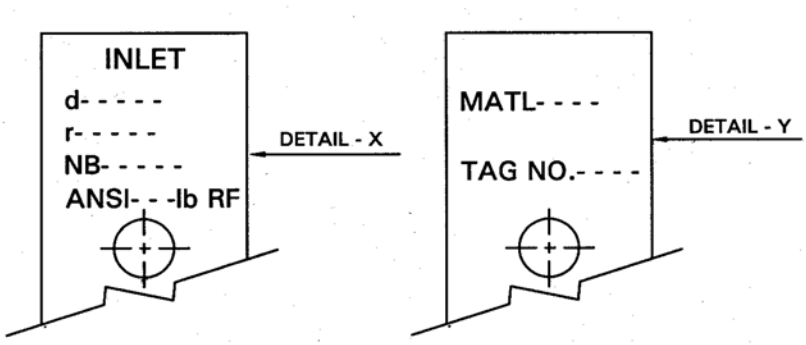
ECCENTRIC ORIFICE PLATE

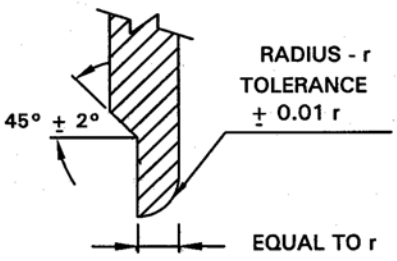


SEGMENTAL ORIFICE PLATE



F = 1.5d BUT NOT GREATER THAN INTERNAL PIPE DIA "D"



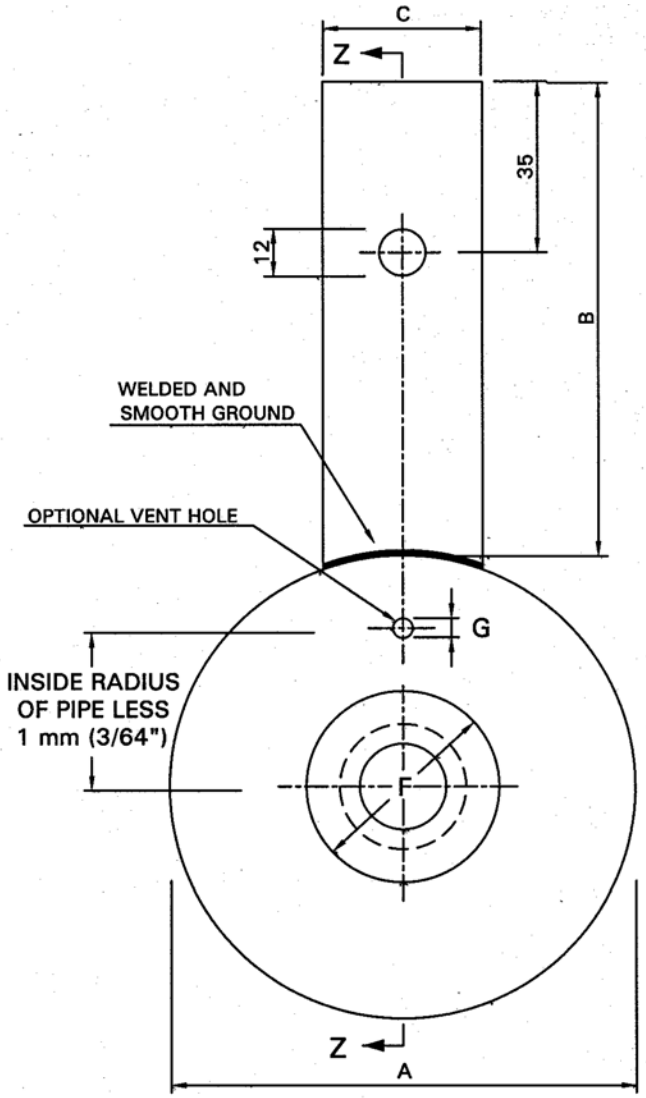


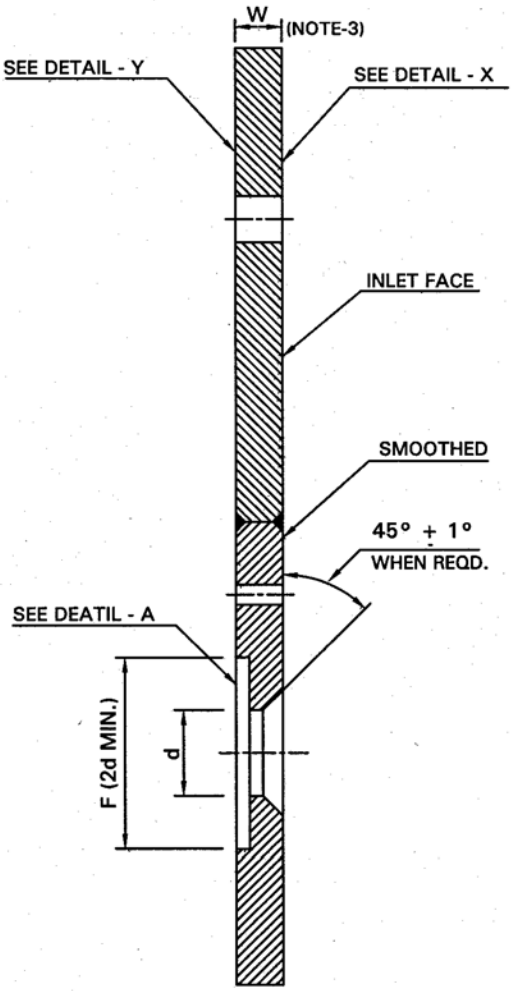
DETAIL - A

QUADRANT EDGE ORIFICE PLATE

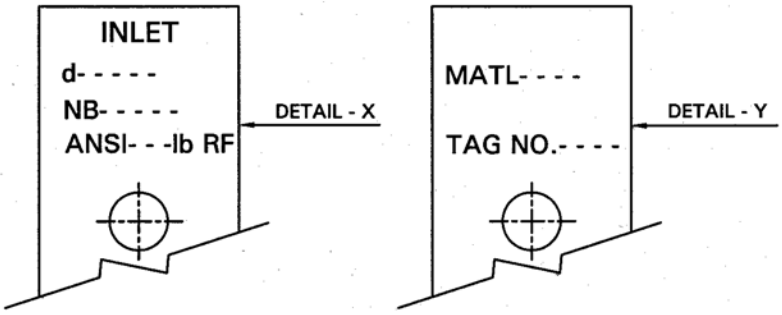
NOTES :-

1. DIMENSIONS A,B,C ARE SAME AS FOR SQUARE EDGE ORIFICE PLATES.
2. 'W' SHALL NOT BE LESS THAN 2.54 mm AND SHALL NOT EXCEED 0.1D WHERE THE RADIUS 'r' OF THE UPSTREAM PROFILE EQUALS OR EXCEEDS 0.1D (WHERE IS THE CASE WHEN $\beta \geq 0.571$ OR $m \geq 0.325$), 'W' SHALL BE REDUCED FROM 'r' TO 0.1D BY REMOVING METAL FROM THE UPSTREAM FACE.

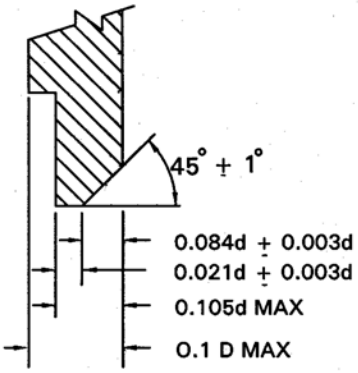




SECTION Z-Z



CONICAL ENTRANCE ORIFICE PLATE



DETAIL - A

NOTES :-

1. DIMENSIONS A,B,C ARE SAME AS FOR SQUARE EDGE ORIFICE PLATES.
2. DIMENSION-d SHALL NOT BE LESS THAN 0.25" AND NOT GREATER THAN 0.316D.
3. DIMENSION- W SHALL BE GENERALLY SAME AS FOR SQUARE EDGE ORIFICE PLATES AND SHALL NECESSARILY CONFORM TO FOLLOWING;

   'W' SHALL NOT EXCEED 0.1D WHERE D IS THE INTERNAL DIAMETER OF UPSTREAM PIPE LINE.

NB mm (")	A ±0.40 RATING 125#/150#	250#/300#	400 #	600 #	900 #	1500#	2500#	RATING 125 #TO 2500 # ≤315° C W	TOLER.	T +0 -0.25	>315° C W	TOLER.	T +0 -0.25
25 (1)	66.7	73.0	73.0	73.0	79.4	79.4	85.7	3.18		0.51	6.35		
40 (1 1/2)	85.7	95.3	95.3	95.3	98.4	98.4	117.5	3.18	+0.12	0.76	6.35		
50 (2)	104.8	111.1	111.1	111.1	142.9	142.9	146.1	3.18		0.79	6.35		
80 (3)	136.5	149.2	149.2	149.2	168.3	174.6	196.9	3.18	-0.25	0.79	6.35		
100 (4)	174.6	181.0	177.8	193.7	206.4	209.6	235.0	3.18		1.59	9.52		
150 (6)	222.3	250.8	247.7	266.7	288.9	282.6	317.5	3.18		1.59	9.52	±0.25	
200 (8)	279.4	308.0	304.8	320.7	358.8	352.4	387.4	3.18		3.18	12.7		
250 (10)	339.7	362.0	358.8	400.1	435.0	435.0	476.3	6.35		3.18	12.7		
300 (12)	409.6	422.3	419.1	457.2	498.5	520.7	549.3	6.35		3.18	12.7		
350 (14)	450.8	485.8	482.6	492.1	520.7	577.9		6.35	±0.25	3.18	12.7		
400 (16)	514.4	539.8	536.6	565.2	574.7	641.4		9.52		6.35	12.7		
450 (18)	549.3	596.9	593.7	612.8	638.2	704.9		6.35		6.35	12.7		
500 (20)	606.4	654.1	647.7	682.6	698.5	755.7		6.35		6.35	12.7		
550 (22)	660.4	704.9	701.7	733.4				6.35		6.35	12.7		
600 (24)	717.6	774.7	768.4	790.6	838.2	901.7		6.35		6.35	12.7		

SEE NOTE (T +0 -0.25)

SEE NOTE (>315° C T +0 -0.25)

NB mm (")	B -0 +10 RATING 125#/150#	250#/300#	400 #	600 #	900 #	1500#	2500 #	C ±0.4 RATING 125# TO 600#TO 400# 2500 #	R
25 (1)	88	88	88	88	100	100	100	30	$R = \frac{(D-G)}{2}$
40 (1 1/2)							114		
50 (2)						114	127		
80 (3)									
100 (4)		100	100	100	114		158	40	
150 (6)						127			
200 (8)				114		140	165		
250 (10)							177		
300 (12)		114	114		127	152			
350 (14)									
400 (16)				127	140	177		50	
450 (18)	100	127	127						
500 (20)	144								
550 (22)		40	140	140	165	203			
600 (24)									

d FROM	TO	TOLER.
<6.350		0.007
6.350	9.525	0.013
9.526	12.700	0.015
12.701	15.875	0.020
15.876	19.050	0.023
19.051	22.225	0.025
22.226	25.400	0.030
25.401	31.750	0.036
31.751	38.100	0.043
38,101	44.450	0.051
44.451	127.000	0.064
>127.000		0.0005 x d

G ≤ d FROM	TO	C ±0.05
< 25.400	-	-
25.400	88.900	2.38
88.901	104.775	3.18
104.776	127.000	3.97
127.001	152.400	4.76
152.401	171.450	5.56
171.451	190.500	6.35
190.501	212.725	7.14
212.726	234.950	7.94
234.951	254.000	8.73
254.001	276.225	9.53
276.226	295.275	10.32
295.276	317.500	11.11
317.501	336.550	11.91
> 336.550	-	12.70

ORIFICE PLATE DIMENSIONS

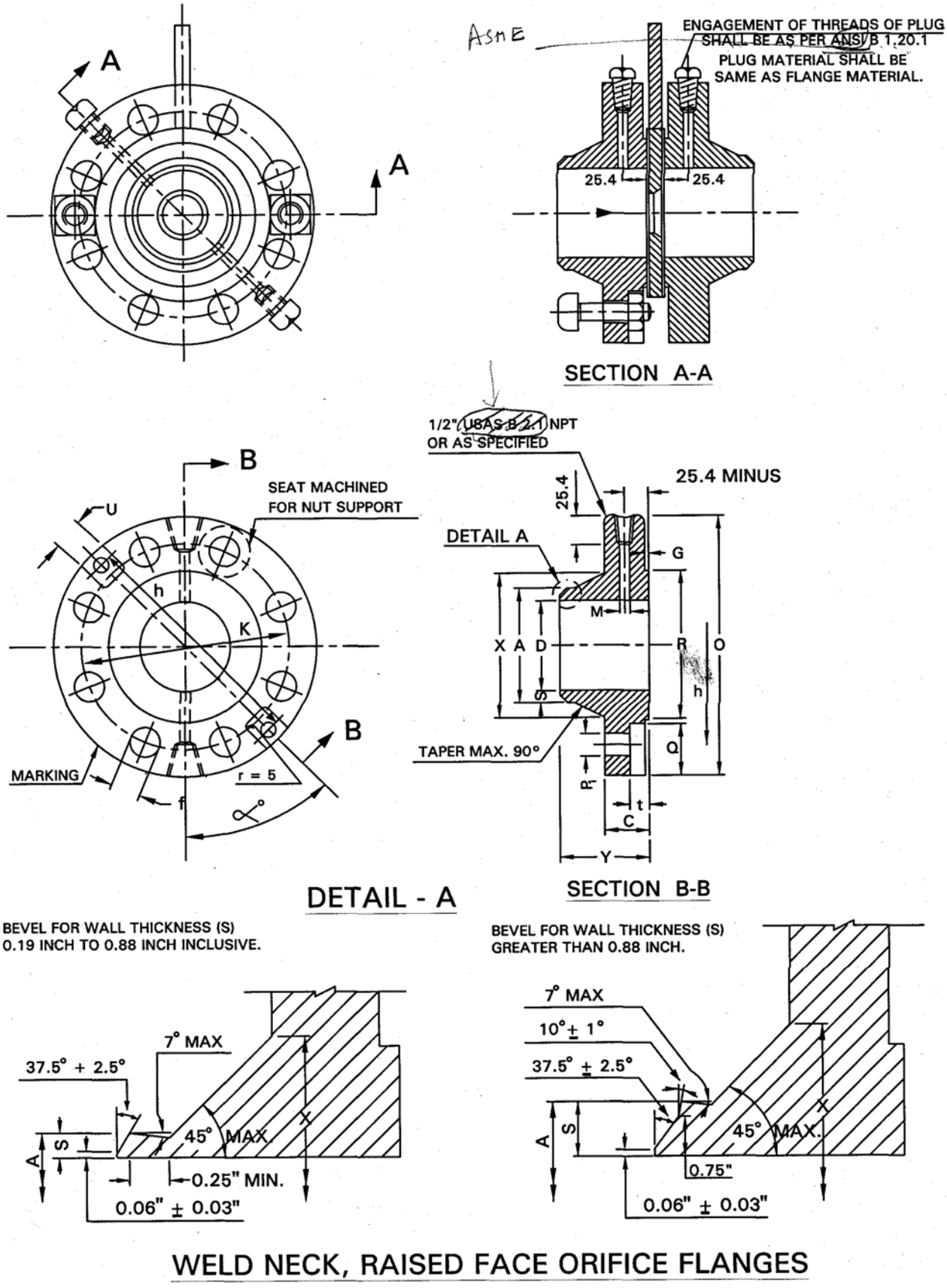
LEGEND :-

D - INTERNAL DIAMETER OF THE PIPE
NB - NOMINAL BORE.
d - ORIFICE BORE DIAMETER.
DIMENSIONS IN mm UNLESS OTHERWISE SPECIFIED.

NOTE :-

VALUES OF 'T' SHOWN IN THIS STANDARD ARE VALID FOR THE CORRESPONDING 'W' AND d/D (β) BETWEEN 0.25 AND 0.70 INCL WHEN THE VALUES ARE NOT SHOWN AND FOR β < 0.25 AND β>0.70, T SHALL BE CALCULATED EVERY TIME AND SHALL NOT BE HIGHER THAN THE SMALLER OF THE VALUES RESULTING FROM THE FOLLOWING RATIOS :-

$\frac{d}{8}$, $\frac{D}{50}$, $\frac{D-d}{8}$



DIMENSIONS (IN mm) - WELD NECK, RAISED FACE ORIFICE FLANGES

FLANGE RATING	FLANGE NB mm (")	A	X	O	K	C	Y	f	R	G	NO. OF BOLT HOLES	M	h	P_1	t	q	U	∝°	WEIGHT kg.
300#	25 (1)	33.5	54.0	124.0	88.9	38.1	82.6	17.5	50.8	1.6	4	6.4	102.2	12.7	9.5	21.8	19.1	82°30'	8
	40 (1.5)	48.3	69.9	155.6	114.3	38.1	85.9	20.6	73.2	1.6	4	6.4	133.8	12.7	9.5	21.8	19.1	82°30'	12
	50 (2)	60.5	84.1	165.1	127.0	38.1	85.9	17.5	92.1	1.6	8	6.4	141.3	14.3	12.7	23.8	20.6	45°	15
	80 (3)	88.9	117.5	209.6	168.3	38.1	88.9	20.6	127.0	1.6	8	9.5	185.7	14.3	12.7	23.8	20.6	45°	22
	100 (4)	114.3	146.1	254.0	200.0	38.1	92.1	20.6	157.2	1.6	8	12.7	230.2	14.3	12.7	23.8	20.6	45°	31
	150 (6)	168.4	206.4	317.5	269.9	38.1	100.1	22.4	215.9	1.6	12	12.7	293.7	14.3	12.7	23.8	20.6	60°	45
	200 (8)	219.2	260.4	381.0	330.2	41.3	111.2	25.4	269.9	1.6	12	12.7	351.6	15.9	15.9	29.4	25.4	60°	70
	250 (10)	273.1	320.7	444.5	387.4	47.8	117.5	28.6	323.9	1.6	16	12.7	411.6	19.1	19.1	32.9	28.6	67°30'	100
	300 (12)	323.9	374.7	520.7	450.9	50.8	130.2	31.8	381.0	1.6	16	12.7	482.2	22.2	22.2	38.5	33.3	67°30'	150
	350 (14)	355.6	425.5	584.2	514.4	54.0	142.9	31.8	412.8	1.6	20	12.7	545.7	22.2	22.2	38.5	33.3	72°	193
	400 (16)	406.4	482.6	647.7	571.5	57.2	146.1	35.1	469.9	1.6	20	12.7	603.6	25.4	25.4	44.1	38.1	72°	260
	450 (18)	457.2	533.4	711.2	628.7	60.5	158.8	35.1	533.4	1.6	24	12.7	667.1	25.4	25.4	44.1	38.1	75°	340
	500 (20)	508.0	587.4	774.7	685.8	63.5	162.1	35.1	584.2	1.6	24	12.7	730.6	25.4	25.4	44.1	38.1	75°	413
	550 (22)	558.8	641.4	838.2	743.0	66.7	165.1	41.3	641.4	1.6	24	12.7	783.4	31.8	31.8	54.8	47.6	75°	510
	600 (24)	609.6	701.7	914.4	812.8	69.9	168.3	41.3	692.1	1.6	24	12.7	854.1	34.9	31.8	60.3	52.4	75°	618

DIMENSIONS (IN mm) - WELD NECK, RAISED FACE ORIFICE FLANGES

FLANGE RATING	FLANGE NB mm (")	A	X	O	K	C	Y	f	R	G	NO. OF BOLT HOLES	M	h	P_1	t	q	U	α°	WEIGHT kg.
600#	25 (1)	33.5	54.0	124.0	88.9	38.1	82.6	17.5	50.8	1.6	4	6.4	102.2	12.7	9.5	21.8	19.1	82°30'	8
	40 (1.5)	48.3	69.9	155.6	114.3	38.1	85.9	20.6	73.2	1.6	4	6.4	133.8	12.7	9.5	21.8	19.1	82°30'	12
	50 (2)	60.5	84.1	165.1	127.0	38.1	85.9	17.5	92.1	1.6	8	6.4	141.3	14.3	12.7	23.8	20.6	45°	15
	80 (3)	88.9	117.5	209.6	168.3	38.1	88.9	20.6	127.0	1.6	8	9.5	185.7	14.3	12.7	23.8	20.6	45°	22
	100 (4)	114.3	152.4	273.1	215.9	44.5	108.0	25.4	157.2	6.4	8	12.7	234.6	22.2	14.7	38.5	33.3	45°	44
	150 (6)	168.4	222.3	355.6	292.1	54.0	123.8	28.6	215.9	6.4	12	12.7	311.5	25.4	21.1	44.1	38.1	60°	89
	200 (8)	219.2	273.1	419.1	349.3	61.9	139.7	31.8	269.9	6.4	12	12.7	375.0	25.4	21.1	44.1	38.1	60°	130
	250 (10)	273.1	342.9	508.0	431.8	69.9	158.8	35.1	323.9	6.4	16	12.7	463.9	25.4	21.1	44.1	38.1	67°30'	204
	300 (12)	323.9	400.1	558.9	489.0	73.0	161.9	35.1	381.0	6.4	20	12.7	514.7	25.4	21.1	44.1	38.1	72°	245
	350 (14)	355.6	431.8	603.3	527.1	76.2	171.5	38.1	412.8	6.4	20	12.7	559.2	25.4	21.1	44.1	38.1	72°	312
	400 (16)	406.4	495.3	685.8	603.3	82.6	184.2	41.2	469.9	6.4	20	12.7	636.2	28.6	21.1	49.6	42.9	72°	428
	450 (18)	457.2	546.1	743.0	654.1	88.9	190.5	44.5	533.4	6.4	20	12.7	693.3	28.6	21.1	49.6	42.9	72°	525
	500 (20)	508.0	609.6	812.8	723.9	95.3	196.9	44.5	584.2	6.4	24	12.7	763.2	28.6	21.1	49.6	42.9	75°	650
	550 (22)	558.8	666.8	870.0	777.9	101.6	203.2	47.6	641.4	6.4	24	12.7	820.3	28.6	21.1	49.6	42.9	75°	797
	600 (24)	609.6	717.6	939.8	838.2	108.0	209.6	50.8	692.1	6.4	24	12.7	890.2	28.6	21.1	49.6	42.9	75°	926

DIMENSIONS (IN mm) - WELD NECK, RAISED FACE ORIFICE FLANGES

FLANGE RATING	NB mm (")	A	X	O	K	C	Y	f	R	G	NO. OF BOLT HOLES	M	h	P_1	t	q	U	∝°	WEIGHT kg.
900#	25 (1)	33.5	52.4	149.2	101.6	44.5	89.0	25.4	50.8	6.4	4	6.4	116.3	19.1	14.7	32.9	28.6	82°30'	12
	40 (1.5)	48.3	69.9	177.8	124.0	44.5	95.3	28.6	73.2	6.4	4	6.4	144.9	19.1	14.7	32.9	28.6	82°30'	16
	50 (2)	60.5	104.8	215.9	165.1	44.5	108.0	25.4	92.1	6.4	8	6.4	183.0	19.1	14.7	32.9	28.6	45°	29
	80 (3)	88.9	127.0	241.3	190.5	44.5	108.0	25.4	127.0	6.4	8	9.5	208.4	19.2	17.9	32.9	28.6	45°	34
	100 (4)	114.3	158.8	292.1	235.0	50.8	120.7	31.8	157.2	6.4	8	12.7	253.6	22.2	17.9	38.5	33.3	45°	57
	150 (6)	168.4	235.0	381.0	317.5	61.9	146.1	31.8	215.9	6.4	12	12.7	336.9	25.4	24.2	44.1	38.1	60°	118
	200 (8)	219.2	298.5	469.9	393.7	69.9	168.3	38.1	269.9	6.4	12	12.7	420.3	28.6	24.2	49.6	42.9	60°	190
	250 (10)	273.1	368.3	546.1	469.9	76.2	190.5	38.1	323.9	6.4	16	12.7	496.5	28.6	24.2	49.6	42.9	67°30'	277
	300 (12)	323.9	419.1	609.6	533.4	85.7	206.4	38.1	381.0	6.4	20	12.7	560.0	28.6	24.2	49.6	42.9	72°	345
	350 (14)	355.6	450.9	641.4	558.8	92.1	219.1	41.3	412.8	6.4	20	12.7	591.7	28.6	24.2	49.6	42.9	72°	441
	400 (16)	406.4	508.0	704.9	616.0	95.3	222.3	44.5	469.9	6.4	20	12.7	655.2	28.6	24.2	49.6	42.9	72°	545
	450 (18)	457.2	565.2	787.4	685.8	108.0	235.0	50.8	533.4	6.4	20	12.7	732.6	31.8	27.4	54.8	47.6	72°	761
	500 (20)	508.0	622.3	857.3	749.3	114.3	254.0	54.0	584.2	6.4	20	12.7	802.5	31.8	27.4	54.8	47.6	75°	927
	600 (24)	609.6	749.3	1041.4	901.7	146.1	298.5	66.7	692.1	6.4	20	12.7	986.6	31.8	27.4	54.8	47.6	75°	1697

DIMENSIONS (IN mm) - WELD NECK, RAISED FACE ORIFICE FLANGES

FLANGE RATING	NB mm (")	A	X	O	K	C	Y	f	R	G	NO. OF BOLT HOLES	M	h	P_1	t	q	U	∝ °	WEIGHT kg.
1500#	25 (1)	33.5	52.4	149.2	101.6	44.5	89.0	25.4	50.8	6.4	4	6.4	116.3	19.1	14.7	32.9	28.6	82°30'	12
	40 (1.5)	48.3	69.9	177.8	124.0	44.5	95.3	28.6	73.2	6.4	4	6.4	144.9	19.1	14.7	32.9	28.6	82°30'	16
	50 (2)	60.5	104.8	215.9	165.1	44.5	108.0	25.4	92.1	6.4	8	6.4	183.0	19.1	14.7	32.9	28.6	45°	29
	80 (3)	88.9	133.4	266.7	203.2	54.0	123.8	31.8	127.0	6.4	8	9.5	228.2	22.2	17.9	38.5	33.3	45°	55
	100 (4)	114.3	161.9	311.2	241.3	60.3	130.2	34.9	157.2	6.4	8	12.7	272.7	22.2	17.9	38.5	33.3	45°	82
	150 (6)	168.4	228.6	393.7	317.5	88.9	177.8	38.1	215.9	6.4	12	12.7	349.6	25.4	24.2	44.1	38.1	60°	184
	200 (8)	219.2	292.1	482.6	393.7	98.4	219.1	44.5	269.9	6.4	12	12.7	433.0	28.6	24.2	49.6	42.9	60°	286
	250 (10)	273.1	368.3	584.2	482.6	114.3	260.4	50.8	323.9	6.4	12	12.7	534.6	28.6	24.2	49.6	42.9	60°	498
	300 (12)	323.9	450.9	673.1	571.5	130.2	288.9	54.0	381.0	6.4	16	12.7	623.5	28.6	24.2	49.6	42.9	67°30'	760
	350 (14)	355.6	495.3	749.3	635.0	139.7	304.8	60.3	412.8	6.4	16	12.7	694.5	31.8	27.4	54.8	47.6	67°30'	1053
	400 (16)	406.4	552.5	825.5	704.9	152.4	317.5	66.7	469.9	6.4	16	12.7	765.2	34.9	27.4	60.3	52.4	67°30'	1406
	450 (18)	457.2	596.9	914.4	774.7	168.3	333.4	73.0	533.4	6.4	16	12.7	854.1	34.9	27.4	60.3	52.4	67°30'	1836
	500 (20)	508.0	641.4	984.3	831.9	184.2	362.0	79.4	584.2	6.4	16	12.7	923.9	34.9	27.4	60.3	52.4	67°30'	2324
	600 (24)	609.6	762.0	1168.4	990.6	209.6	412.8	92.1	692.1	6.4	16	12.7	1108.1	34.9	27.4	60.3	52.4	67°30'	3749

TOLERANCES ALLOWED ON FLANGES ACCORDING TO ASME B16.36 / B16.5

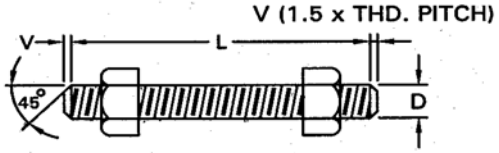
DIMENSIONS			TOLERANCES
O		≤ 609.6 mm	± 1.59 *
		> 609.6 mm	± 3.18 *
C	NB	≤ 450 (18)	+ 3.18 - 0
	NB	> 450 (18)	+ 4.76 - 0
X		≤ 609.6 mm	± 1.59 *
		> 609.6 mm	± 3.18 *
A	NB	≤ 125 (5)	+ 2.38 - 0.79
	NB	≥ 150 (6)	+ 3.96 - 0.79
Y	NB	≤ 250 (10)	± 1.59
	NB	≥ 300 (12)	± 3.18
DRILLING	K		± 1.59
	CENTRES BETWEEN HOLES		± 0.79
R		FOR G = 1.6 mm	± 0.79
		FOR G = 6.4 mm	± 0.40
ECCENTRICITY BETWEEN K AND R DIAMETERS			± 0.79
ECCENTRICITY BETWEEN K AND D DIAMETERS			± 0.79 *
ECCENTRICITY BETWEEN R AND D DIAMETERS			± 0.79 *
D	NB	≤ 150 (6)	± 0.12 *
	NB	200 & 250 (8 & 10)	+ 0.12 - 0.25 *
	NB	300 (12)	+ 0.12 - 0.38 *
	NB	350 & 400 (14 & 16)	+ 0.12 - 0.50 *
	NB	≥ 450 (18)	+ 0.12 - 0.76 *

* NOT COVERED BY ASME B16.5

WELD NECK RAISED FACE ORIFICE FLANGES

DIMENSIONS AS SHOWN — **THREAD : ANSI B 1.1**
FOR D" ≤1 - UNC - 2A
FOR D" ≥1 1/8 - 8 UN - 2A

CONSTRUCTION — **FORGED, BAR STOCK**



D		THREAD PITCH		V	2V *
15.9	(5/8)	UNC	2.309	3.46	7
19.0	(3/4)		2.54	3.78	7.5
22.2	(7/8)		2.822	4.23	8.5
25.4	(1)		3.175	4.76	9.5
≥28.6	(1 1/8)	8 UN	3.175	4.76	9.5

* APPROXIMATE VALUE OF THE TWO BEVELS

DIAMETER (NB,D) :mm (INCHES) &LENGTH - (L) IN mm											
RATING		300 #			600 #			900 #			1500#		
DIM.	N B	D		L	D		L	D		L	D		L
25	(1)	15.9	(5/8)	127	15.9	(5/8)	127	22.2	(7/8)	152	22.2	(7/8)	152
40	(1 1/2)	19.0	(3/4)	133	19.0	(3/4)	133	25.4	(1)	159	25.4	(1)	159
50	(2)	15.9	(5/8)	127	15.9	(5/8)	127	22.2	(7/8)	152	22.2	(7/8)	152
80	(3)	19.0	(3/4)	133	19.0	(3/4)	133	22.2	(7/8)	152	28.6	(1 1/8)	184
100	(4)	19.0	(3/4)	133	22.2	(7/8)	152	28.6	(1 1/8)	178	31.7	(1 1/4)	203
150	(6)	19.0	(3/4)	133	25.4	(1)	178	28.6	(1 1/8)	203	34.9	(1 3/8)	266
200	(8)	22.2	(7/8)	146	28.6	(1 1/8)	203	34.9	(1 3/8)	229	41.3	(1 5/8)	298
250	(10)	25.4	(1)	165	31.7	(1 1/4)	222	34.9	(1 3/8)	241	47.6	(1 7/8)	343
300	(12)	28.6	(1 1/8)	178	31.7	(1 1/4)	229	34.9	(1 3/8)	260	50.8	(2)	381
350	(14)	28.6	(1 1/8)	191	34.9	(1 3/8)	248	38.1	(1 1/2)	282	57.1	(2 1/4)	418
400	(16)	31.7	(1 1/4)	203	38.1	(1 1/2)	266	41.3	(1 5/8)	295	63.5	(2 1/2)	456
450	(18)	31.7	(1 1/4)	209	41.3	(1 5/8)	286	47.6	(1 7/8)	333	69.8	(2 3/4)	503
500	(20)	31.7	(1 1/4)	216	41.3	(1 5/8)	298	50.8	(2)	355	76.2	(3)	548
600	(24)	38.1	(1 1/2)	241	47.6	(1 7/8)	337	63.5	(2 1/2)	445	88.9	(3 1/2)	623

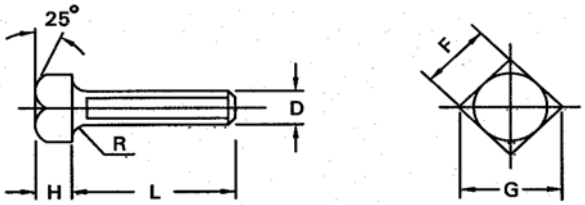
TOLERANCES ON 'L'

L-LENGTH mm	≤305	310 TO 455	≥455
TOLERANCE mm	- 0 + 1.6	- 0 + 3.2	- 0 + 6.4

STUD BOLT DETAILS FOR RAISED FACE FLANGES

DIMENSIONS : ANSI B 18.2.1
CONSTRUCTION : FORGED, BAR STOCK
TOLERANCES : ANSI B 18.2.1 ANSI B 1.1

THREAD : ANSI B 1.1
FOR D" ≤ 1 - UNC - 2A
FOR D" ≥ 1 1/8 - 8 UN - 2A



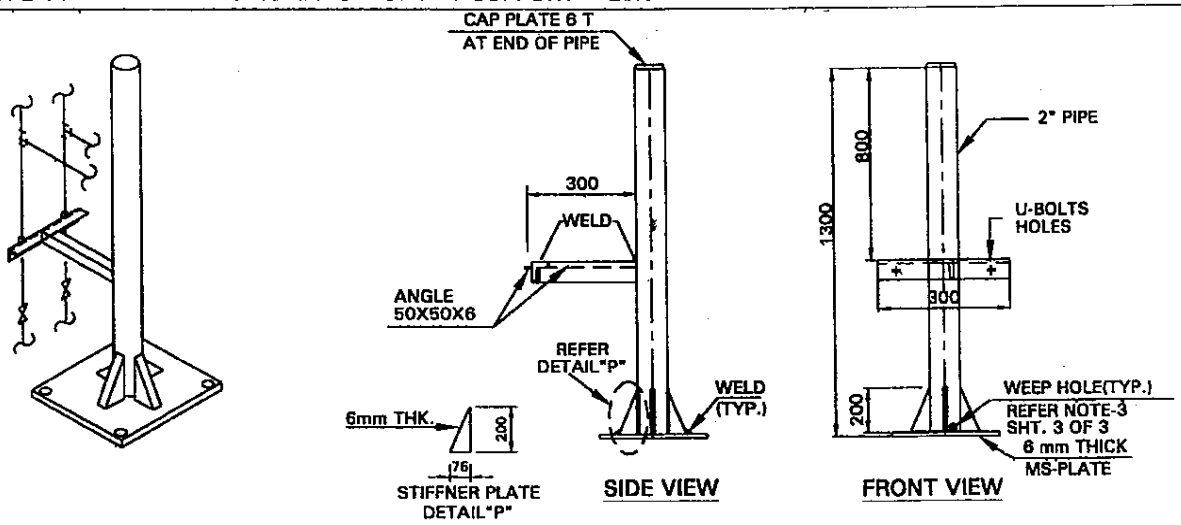
D	F	G		H	R
		MAX.	MIN.		
9.5 (3/8)	14.3	20.2	19.0	6.4	0.8
11.1 (7/16)	15.9	22.5	21.0	7.5	0.8
12.7 (1/2)	19.1	26.9	25.3	8.3	0.8
15.9 (5/8)	23.8	33.7	31.6	10.7	1.6
19.1 (3/4)	28.6	40.4	37.9	12.7	1.6
22.2 (7/8)	33.3	47.1	44.2	15.1	1.6
25.4 (1)	38.1	53.9	50.6	16.7	2.4
28.6 (1 1/8)	42.9	60.6	56.9	19.1	2.4
31.8 (1 1/4)	47.6	67.4	63.2	21.4	2.4
38.1 (1 1/2)	57.2	80.8	75.8	25.4	2.4

DIAMETER (NB,D): mm (INCHES) AND LENGTH - (L) IN mm

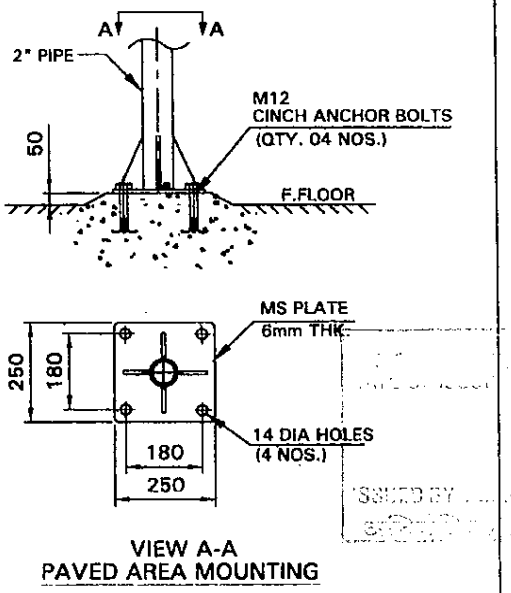
RATING	300#		600#		900#		1500#	
DIM. N B	D	L	D	L	D	L	D	L
25 (1)	9.5 (3/8)	75	9.5 (3/8)	75	15.9 (5/8)	90	15.9 (5/8)	90
40 (1 1/2)	9.5 (3/8)	75	9.5 (3/8)	75	15.9 (5/8)	90	15.9 (5/8)	90
50 (2)	11.1 (7/16)	85	11.1 (7/16)	85	15.9 (5/8)	100	15.9 (5/8)	100
80 (3)	11.1 (7/16)	85	11.1 (7/16)	85	15.9 (5/8)	100	19.1 (3/4)	115
100 (4)	11.1 (7/16)	85	19.1 (3/4)	100	19.1 (3/4)	110	19.1 (3/4)	120
150 (6)	11.1 (7/16)	90	22.2 (7/8)	115	22.2 (7/8)	130	22.2 (7/8)	160
200 (8)	12.7 (1/2)	100	22.2 (7/8)	130	25.4 (1)	140	25.4 (1)	170
250 (10)	15.9 (5/8)	110	22.2 (7/8)	135	25.4 (1)	145	25.4 (1)	190
300 (12)	19.1 (3/4)	115	22.2 (7/8)	140	25.4 (1)	155	25.4 (1)	215
350 (14)	19.1 (3/4)	120	22.2 (7/8)	140	25.4 (1)	165	28.6 (1 1/8)	235
400 (16)	22.2 (7/8)	130	25.4 (1)	155	25.4 (1)	170	31.8 (1 1/4)	255
450 (18)	22.2 (7/8)	130	25.4 (1)	160	28.6 (1 1/8)	200	31.8 (1 1/4)	275
500 (20)	22.2 (7/8)	140	25.4 (1)	165	28.6 (1 1/8)	205	31.8 (1 1/4)	295
550 (22)	28.6 (1 1/8)	155	25.4 (1)	180	- -	-	- -	-
600 (24)	31.8 (1 1/4)	160	25.4 (1)	185	28.6 (1 1/8)	240	31.8 (1 1/4)	315

SEMI-FINISHED, SQUARE HEAD, FULL THREAD, JACK SCREW

TYPE 11 SINGLE INSTRUMENT SUPPORT - GENERAL ARRANGEMENT

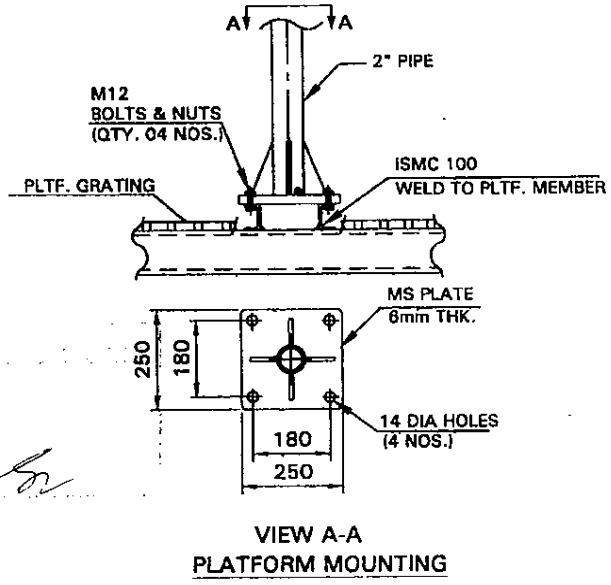


TYPE 11-1



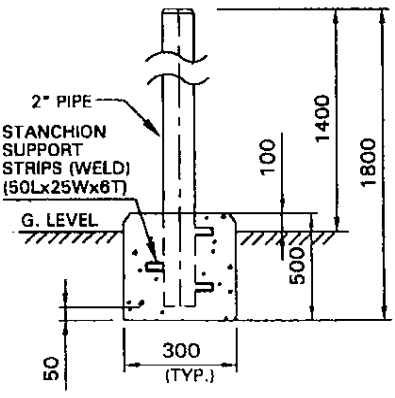
VIEW A-A
PAVED AREA MOUNTING

TYPE 11-2



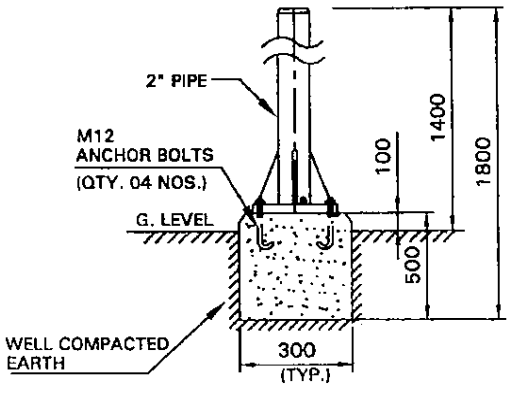
VIEW A-A
PLATFORM MOUNTING

TYPE 11-3



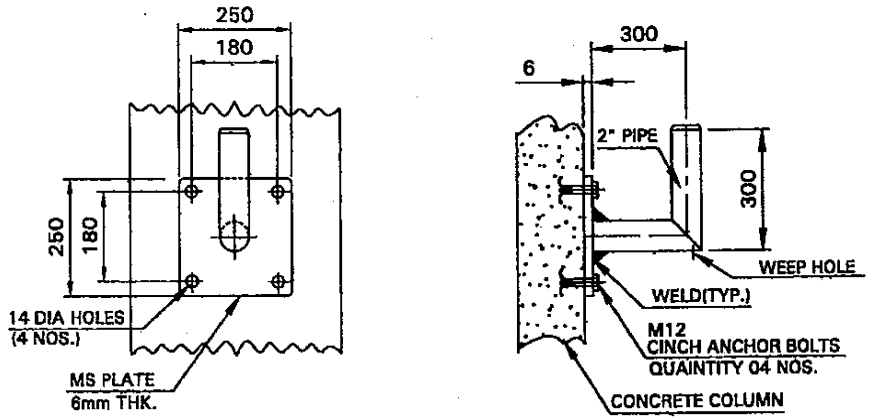
UNPAVED AREA MOUNTING
(WITH INTEGRAL CONC. BLOCK)

TYPE 11-4

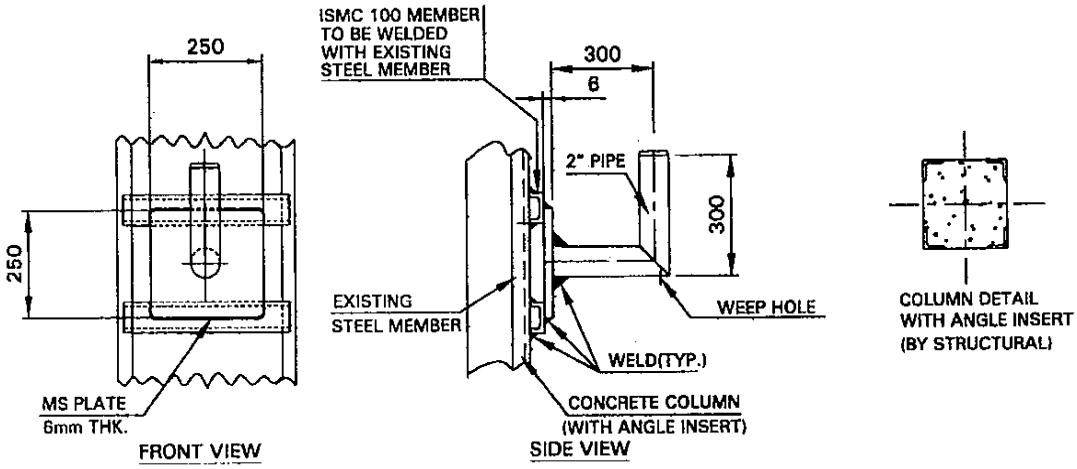


UNPAVED AREA MOUNTING
(WITH SEPARATE CONC. BLOCK)

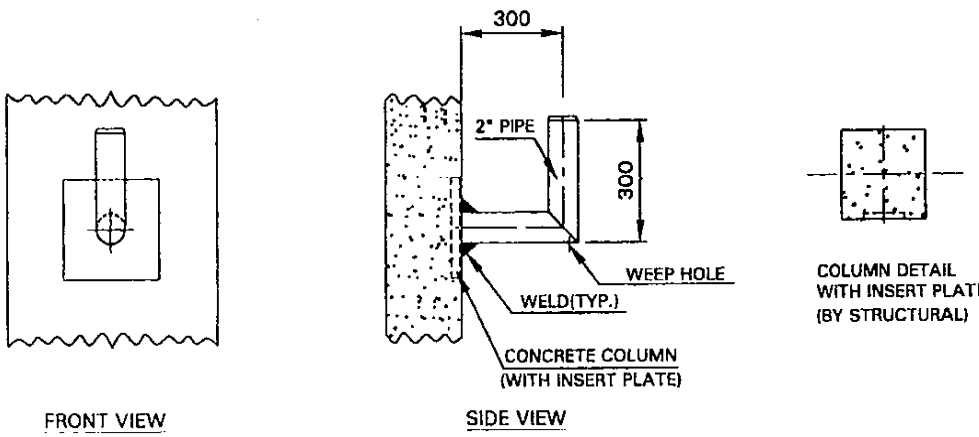
TYPE 12 CONCRETE COLUMN MOUNTING



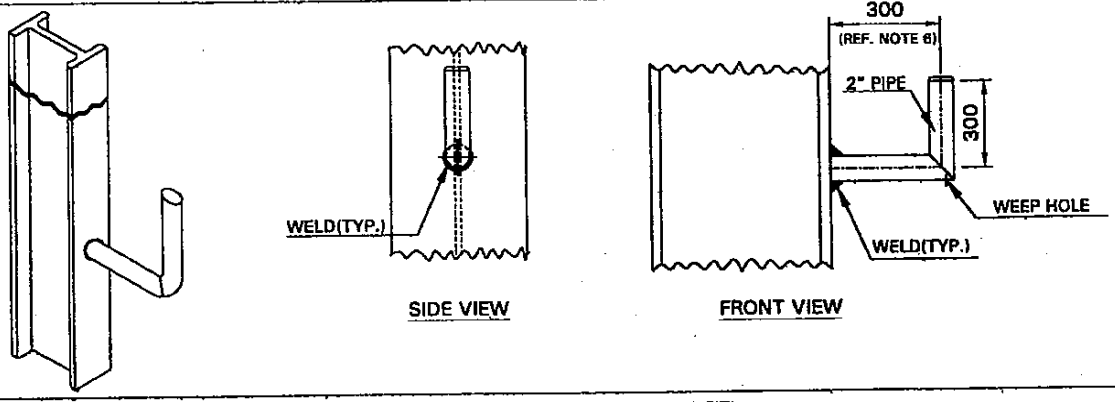
TYPE 13 CONCRETE COLUMN (WITH ANGLE INSERT) MOUNTING



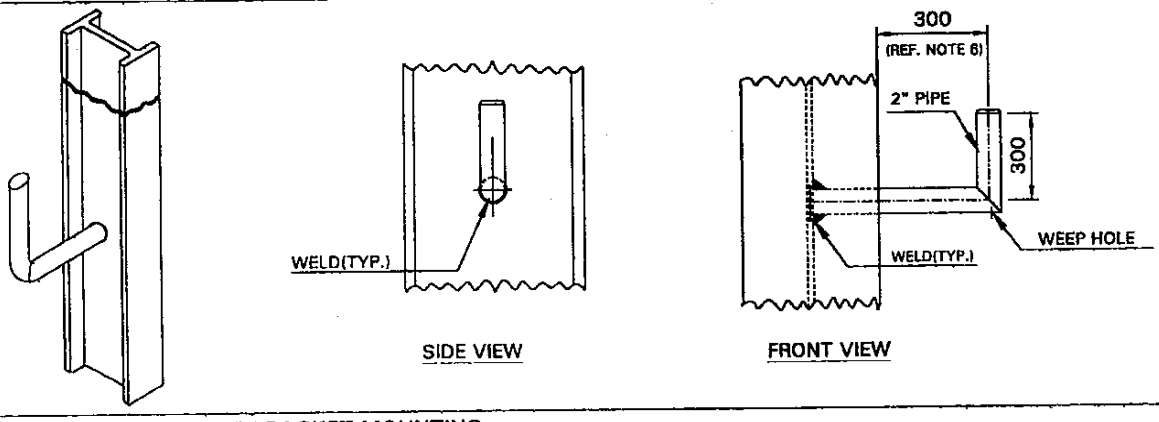
TYPE-14 CONCRETE COLUMN (WITH INSERT PLATE) MOUNTING



TYPE 15 STEEL COLUMN MOUNTING (FLANGE FACE)

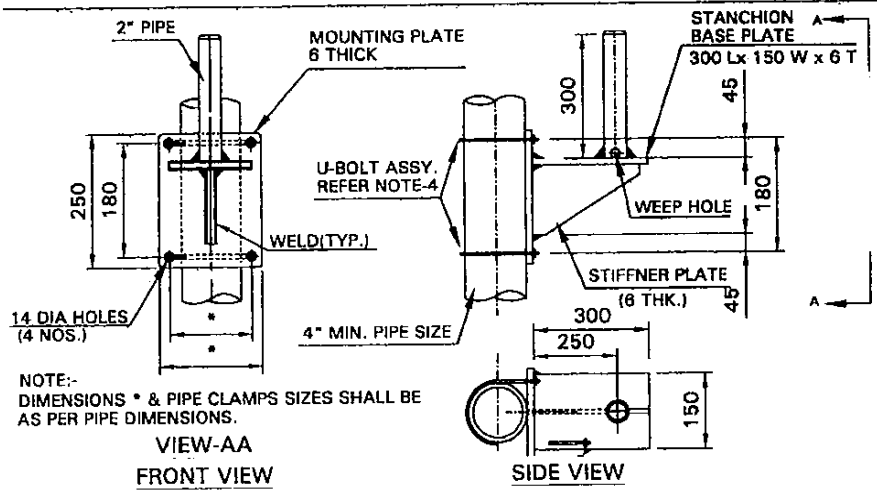


TYPE 16 STEEL COLUMN MOUNTING (WEB FACE)

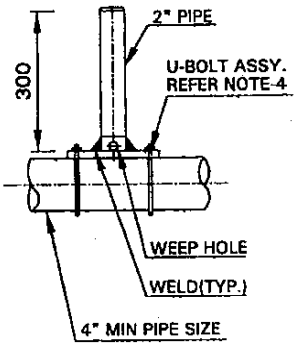


TYPE 17 PIPE BRACKET MOUNTING

TYPE 17.1 (VERTICAL PIPE)



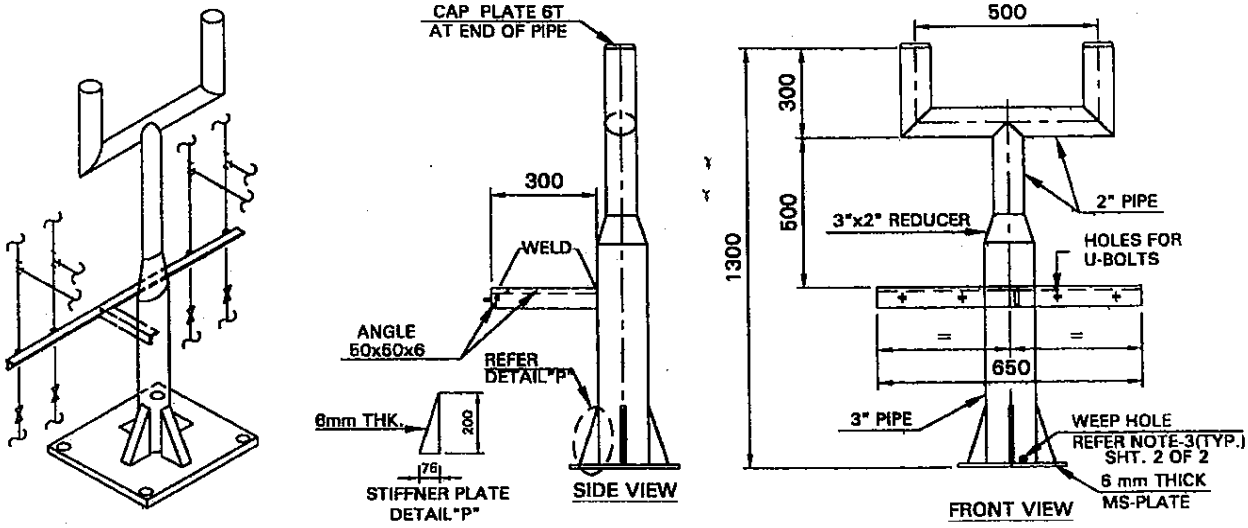
TYPE 17.2 (HORIZONTAL PIPE)



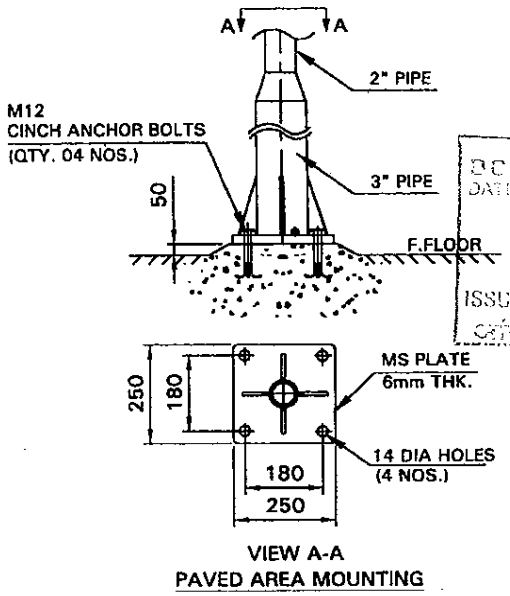
NOTES:-

1. ALL DIMENSIONS ARE IN M.M. UNLESS OTHERWISE SPECIFIED.
2. PIPE MATERIAL SHALL BE IS:1239 HEAVY GRADE AS A MINIMUM.
3. 6 mm DIA WEEP HOLE SHALL BE PROVIDED AT LOW POINT.
4. U-BOLT ASSEMBLY SHALL BE OF MINIMUM M12 SIZE WITH NUTS AND SPRING WASHERS.
5. ALL WELD SHALL BE 3mm FILLET WELD FULL STRENGTH.
6. ADD 50mm WHERE-EVER FIRE INSULATION IS PROVIDED.
7. BOLT SHALL BE TURNED FROM M.S. ROUNDS CONFIRMING TO IS : 432 GRADE 1.
8. NUTS AND WASHERS SHALL CONFIRM TO IS : 1363 AND IS : 3138.

TYPE 21 — TWO INSTRUMENTS SUPPORT - GENERAL ARRANGEMENT

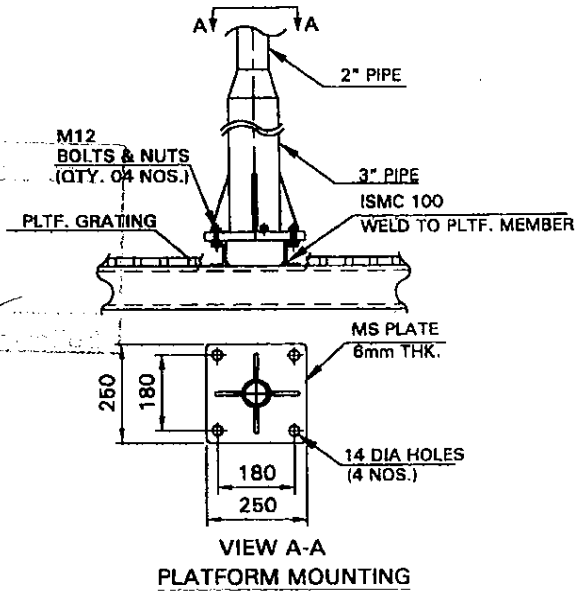


TYPE 21-1



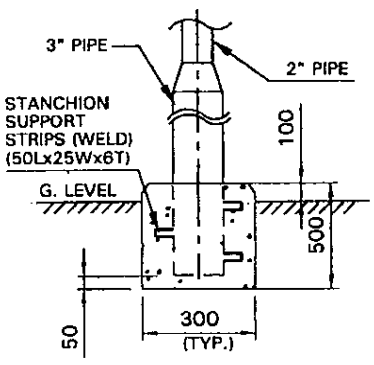
VIEW A-A
PAVED AREA MOUNTING

TYPE 21-2



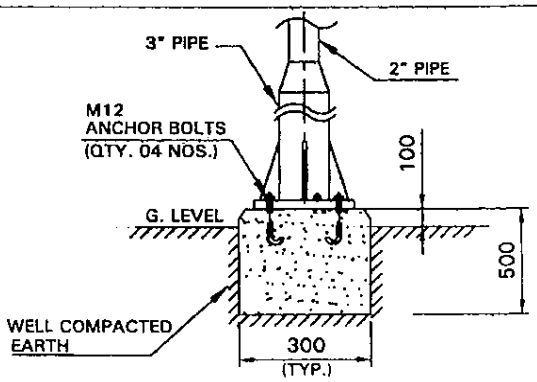
VIEW A-A
PLATFORM MOUNTING

TYPE 21-3



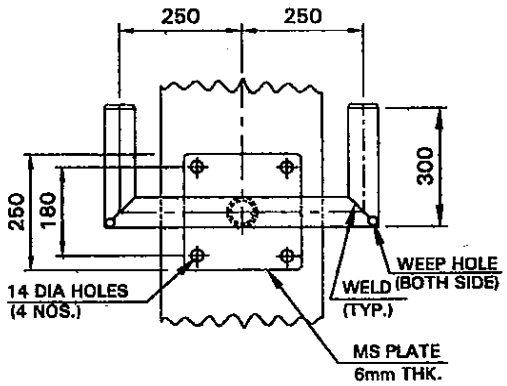
UNPAVED AREA MOUNTING
(WITH INTEGRAL CONC. BLOCK)

TYPE 21-4

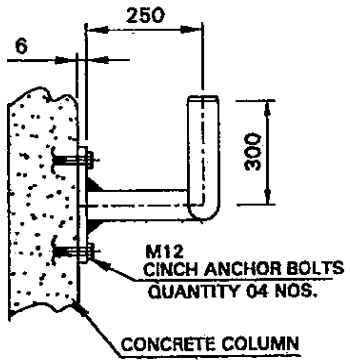


UNPAVED AREA MOUNTING
(WITH SEPARATE CONC. BLOCK)

TYPE 22 CONCRETE COLUMN MOUNTING

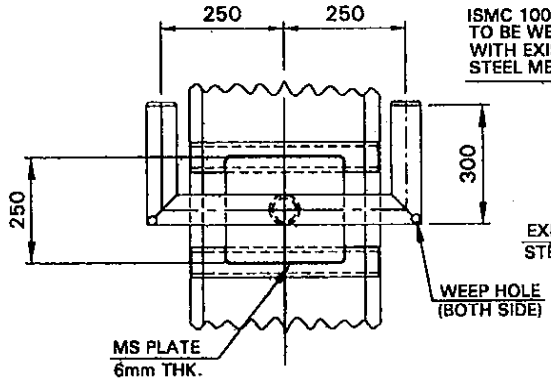


FRONT VIEW

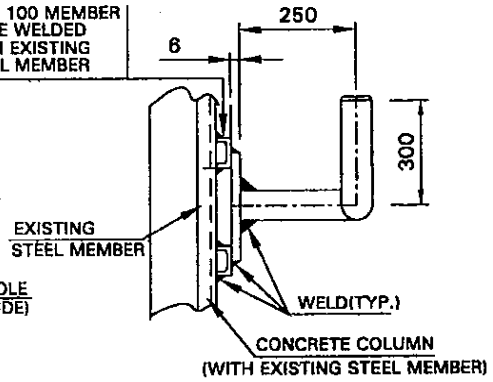


SIDE VIEW

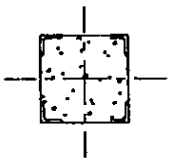
TYPE 23 CONCRETE COLUMN (WITH ANGLE INSERT) MOUNTING



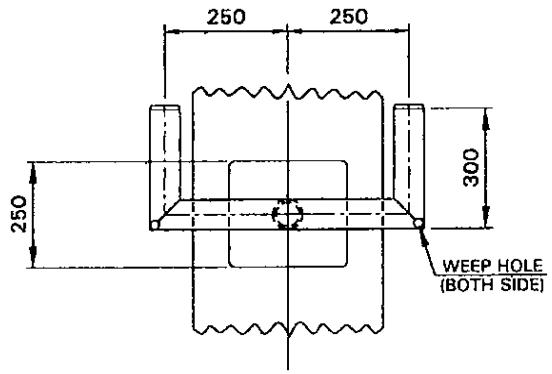
FRONT VIEW



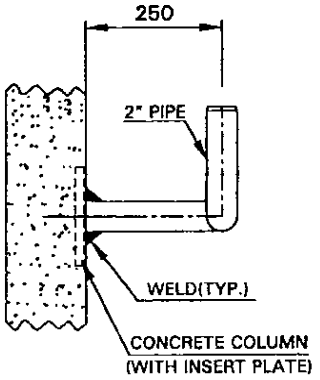
SIDE VIEW



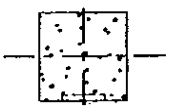
TYPE 24 CONCRETE COLUMN (WITH INSERT PLATE) MOUNTING



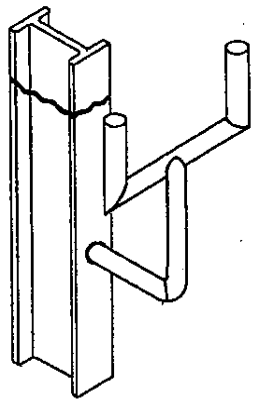
FRONT VIEW

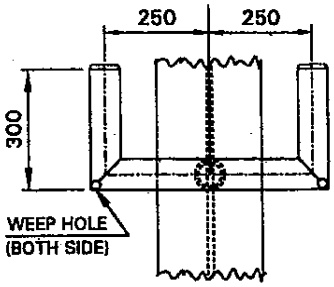


SIDE VIEW

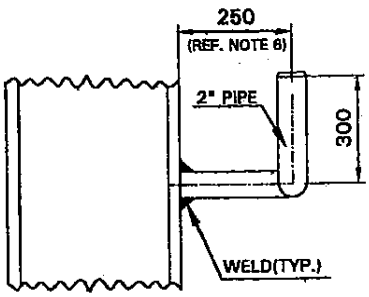


TYPE 25 STEEL COLUMN MOUNTING (FLANGE FACE)



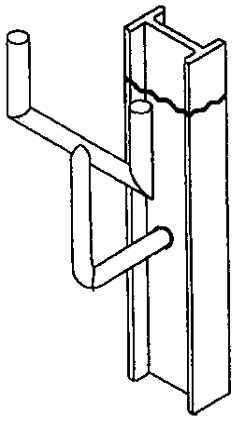


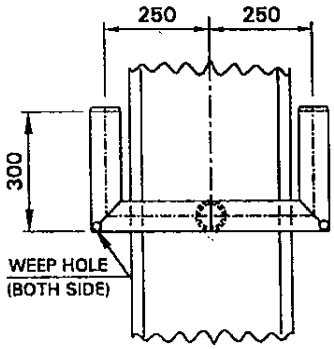
FRONT VIEW



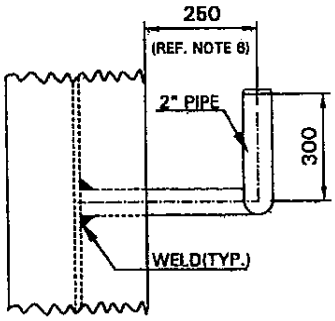
SIDE VIEW

TYPE 26 STEEL COLUMN MOUNTING (WEB FACE)





FRONT VIEW

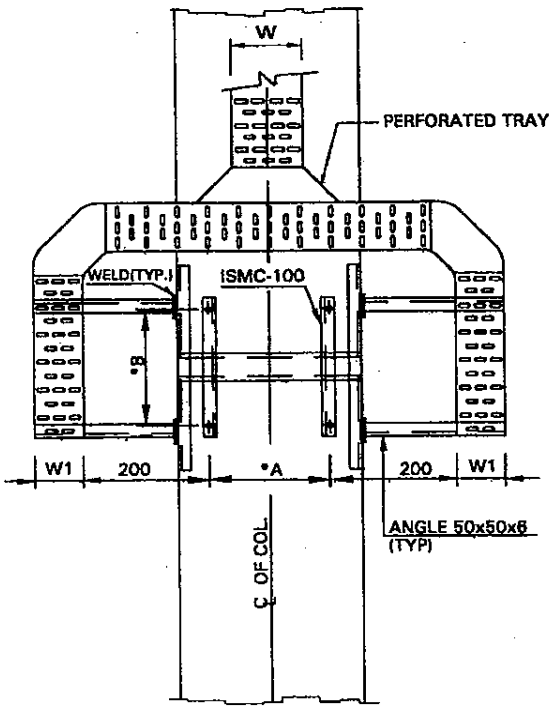


SIDE VIEW

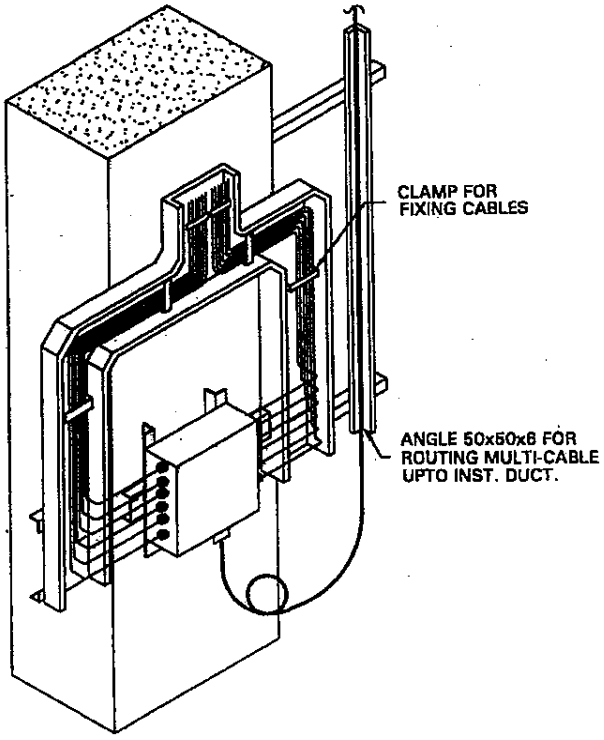
NOTES:-

1. ALL DIMENSIONS ARE IN M.M. UNLESS OTHERWISE SPECIFIED.
2. PIPE MATERIAL SHALL BE IS:1239 HEAVY GRADE AS A MINIMUM.
3. 6 mm DIA WEEP HOLE SHALL BE PROVIDED AT LOW POINT.
4. U-BOLT ASSEMBLY SHALL BE OF MINIMUM M12 SIZE WITH NUTS AND SPRING WASHERS.
5. ALL WELD SHALL BE 3mm FILLET WELD FULL STRENGTH.
6. ADD 50mm WHERE-EVER FIRE INSULATION IS PROVIDED.
7. BOLT SHALL BE TURNED FROM M.S. ROUNDS CONFIRMING TO IS : 432 GRADE 1.
8. NUTS AND WASHERS SHALL CONFIRM TO IS : 1363 AND IS : 3138.

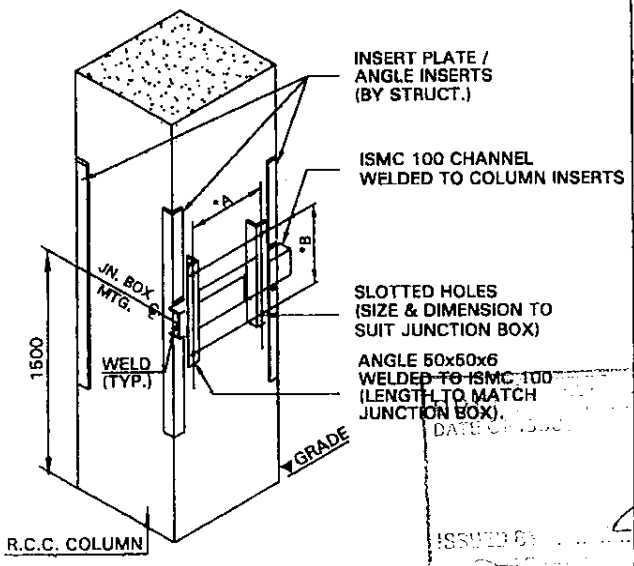
TRAY ARRANGEMENT FOR JUNCTION BOXES



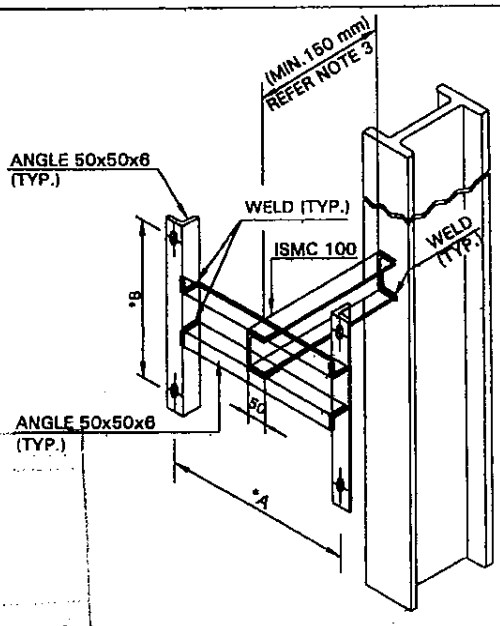
CABLE ROUTING FOR JUNCTION BOXES.



JN. BOX MOUNTING FRAME (R.C.C. COLUMN)



JN. BOX MOUNTING FRAME (STEEL COLUMN)

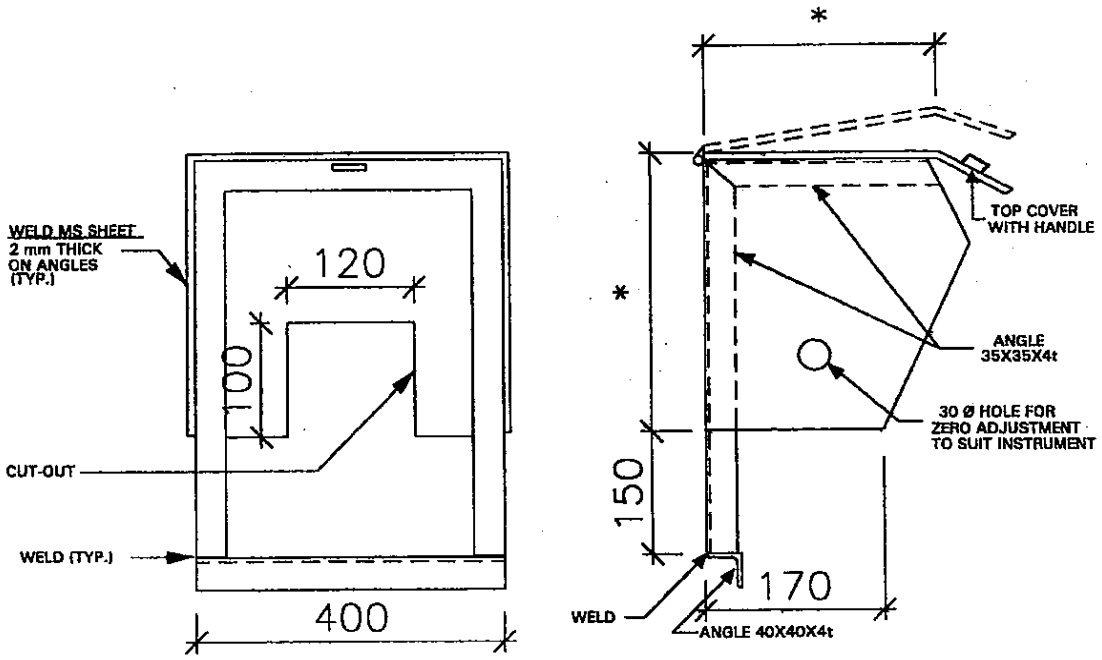


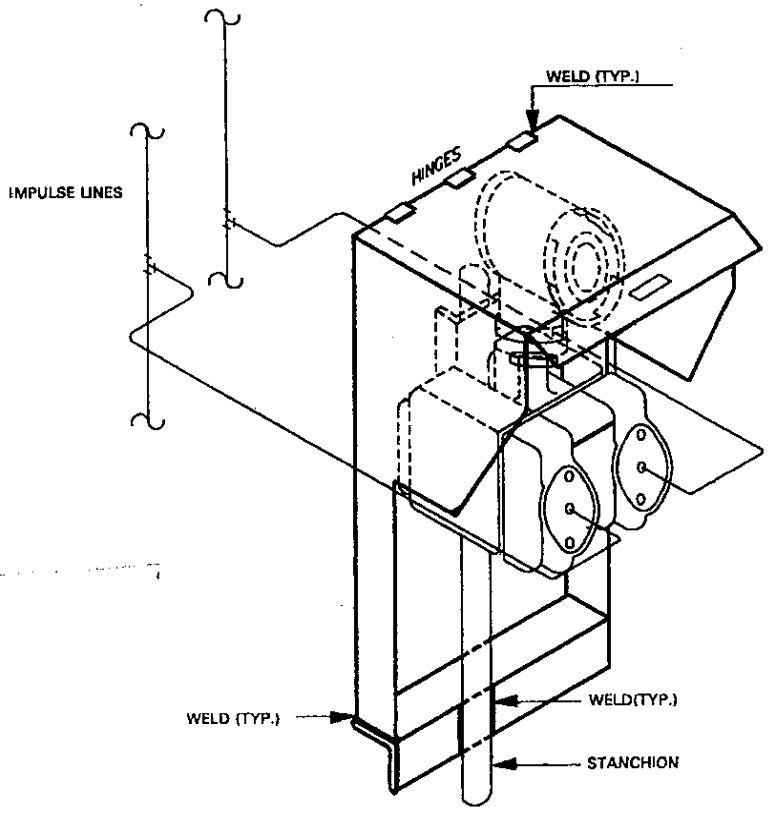
* DIMENSION `A and B' TO SUIT JUNCTION BOX.

NOTE:
1. ALL DIMENSIONS ARE IN mm.
2. CLAMP MULTICABLE ON ANGLE WITH 25mm WIDE PVC COVERED ALLUMINIUM STRIP.
3. ADD 50 mm WHERE-EVER FIRE INSULATION IS PROVIDED.

TRAY WIDTH

JN. BOX	W	W1
12 PAIR	300	150
8 TRIAD	300	150
6 PAIR	150	100
6 TRIAD	150	100



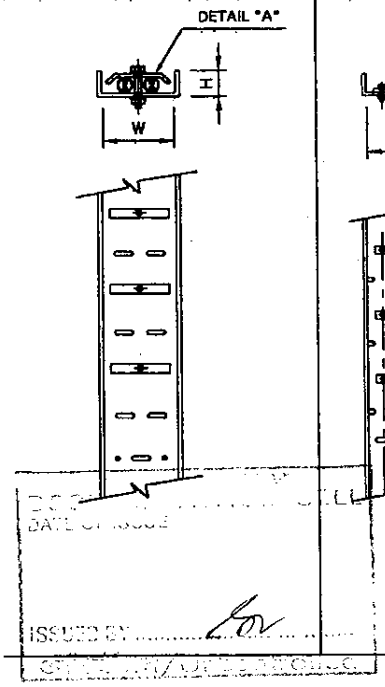


NOTES :

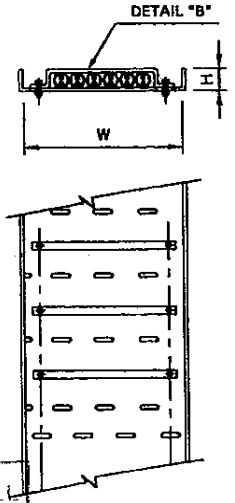
1. ALL DIMEN...
2. * - TO SUIT INSTRUMENT DIMENSIONS
3. HINGES SHALL BE OF STAINLESS STEEL.
4. A MINIMUM OF TWO COATS PAINTING SHALL BE CARRIED OUT AFTER A MINIMUM OF ONE COAT OF RED OXIDE ZINC CHROMATE PRIMER. THE COLOUR OF THE PAINT SHALL BE AS PER IS-5.

CABLE CLAMPING ON PERFORATED TRAYS

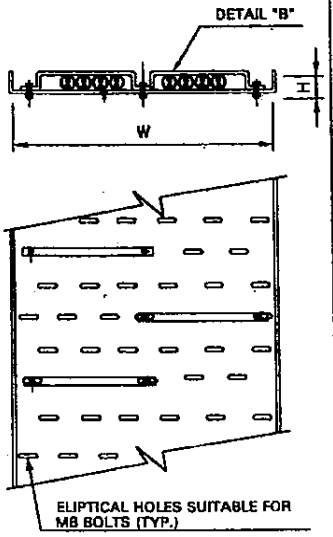
SINGLE CLAMPING FOR TWO CABLES



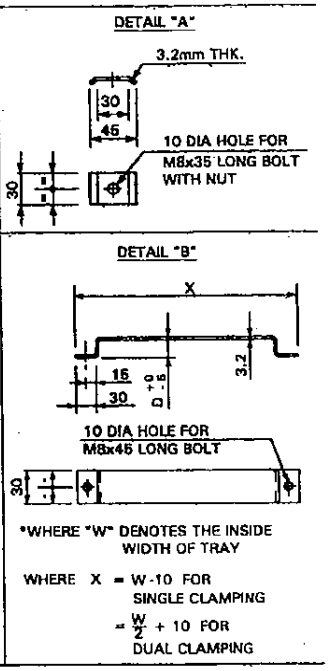
SINGLE CLAMPING FOR MULTIPLE CABLES



DUAL CLAMPING FOR MULTIPLE CABLES



CABLE CLAMPS DETAIL



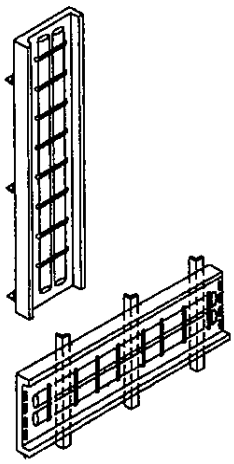
*WHERE "W" DENOTES THE INSIDE WIDTH OF TRAY

WHERE X = W-10 FOR SINGLE CLAMPING

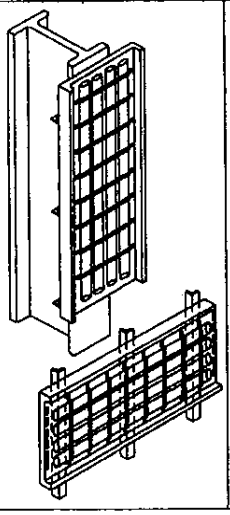
= $\frac{W}{2}$ + 10 FOR DUAL CLAMPING

PERFORATED TRAY - SUPPORTING DETAILS

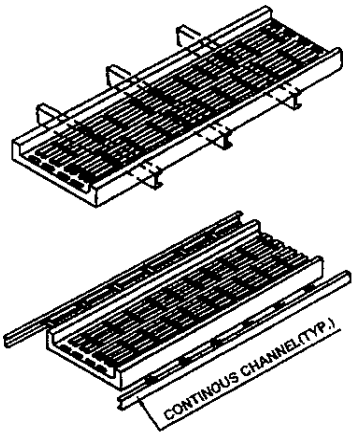
TRAY ROUTING EDGEWISE HOR. / VER. RUNS



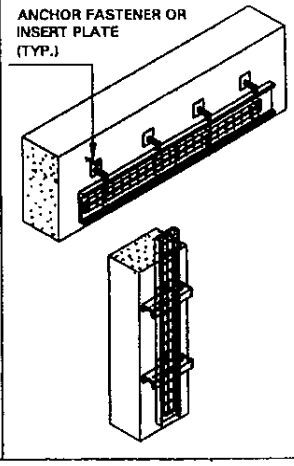
TRAY ROUTING EDGEWISE IN HOR. / VER. RUNS



TRAY ROUTING WIDTHWISE IN HORIZONTAL RUNS



TRAY ROUTING CONCRETE BEAM/COLUMN IN HOR. / VER. PLANE

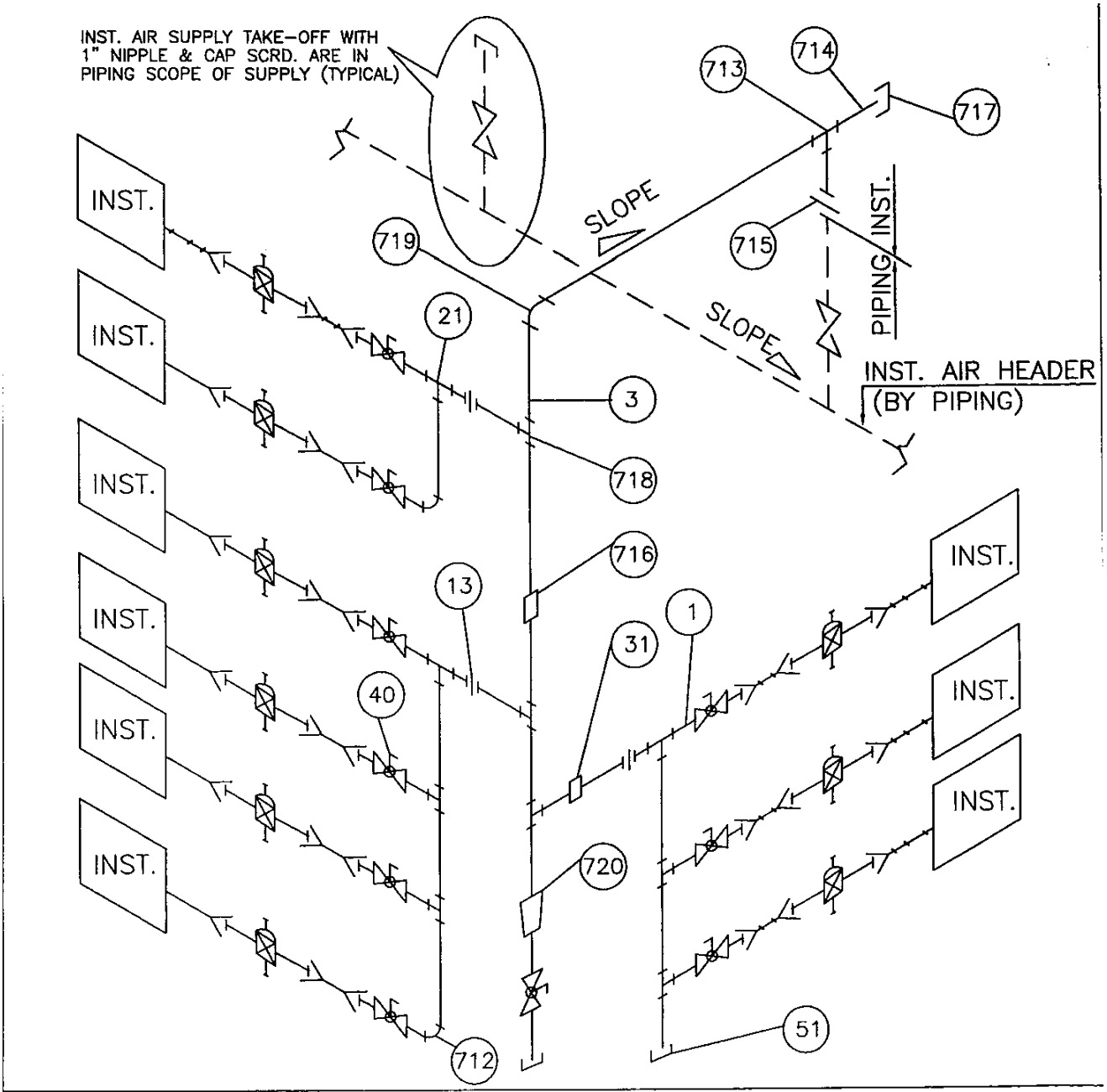


NOTES :-

1. ALL DIMENSIONS ARE IN mm.
2. PERFORATED TRAYS SHALL BE SUPPORTED AT EVERY 1000 mm (TYP.) INTERVAL FOR HORIZONTAL AS WELL AS VERTICAL RUNS USING MINIMUM ANGLE SIZE AS 40x40x5 OR CONTINOUS CHANNEL SUPPORT MC50
3. CLAMPING OF CABLES ON PERFORATED TRAYS SHALL BE AT EVERY 500 mm ON VERTICAL RUNS AND EVERY 1000 mm ON HORIZONTAL RUNS.
4. PERFORATED TRAYS SHALL BE SUPPLIED WITH CLAMPS, BOLTS / NUTS AND WASHERS OF GALVANISED MILD STEEL.
5. GALVANISING SHALL BE AS PER IS 4759 (66 μm / 460 g / m2)
6. THE PERFORATED TRAY THICKNESS SHALL BE 2 mm.

CAPACITY OF PERFORATED TRAYS

TRAY WIDTH (W)	FLANGE HEIGHT (H)	NO. OF CABLES		
		1 PAIR/ 1 TRIAD	6 PAIR/ 6 TRIAD	12 PAIR/ 8TRIAD
60	20	2	1	1
100	30	4	2	1
150	30	6	4	3
200	30	10	6	4
300	30	15	8	6



LIST OF MATERIAL

QTY.	ITEM	DESCRIPTION	SIZE	QTY.	ITEM	DESCRIPTION	SIZE
25M	3	PIPE	1"	36	721	ELBOW SCRD	1/2" X 1/2"
2	713	EQ. TEE SCRD.	1"	10	21	EQ. TEE SCRD.	1/2"X1/2"X1/2
4	714	NIPPLE	1" X 4"LONG	1	40	BALL VALVE	1/2"
2	715	UNION SCR'D	1"	4	13	UNION SCRD.	1/2"
3	716	COUPLING SCRD.	1"	A/R	1	PIPE	1/2"
2	717	CAP SCRD.	1"	12	8	NIPPLE	1/2"
4	718	UNEQUAL TEE	1"X1"X1/2"	4	31	COUPLING SCRD.	1/2"
4	719	ELBOW SCRD.	1" X 1"	2	51	CAP SCRD.	1/2"
1	720	REDUCER SCRD.	1" X 1/2"				

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

NEW AMMONIUM NITRATE MELT PLANT

AT

RASHTRIYA CHEMICALS FERTILIZER COMPLEX,

CHEMBUR, MUMBAI, MAHARASHTRA – INDIA

P	02.11.2020	TENDER ISSUED FOR REVIEW	GC	GC	UPT
REV	**DATE**	**PURPOSE**	**PREPD**	**REVWD**	**APPD**

CONTENTS

SL.NO.	DESCRIPTION	DOCUMENT NO.
1	DESIGN PHILOSOPHY & SCOPE FOR CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS	PC185/E-1/P-II/12
	ANNEXURES	
2	CIVIL ENGINEERING DESIGN BASIS (CIVIL & STRUCTURAL WORKS)	(ANNEXURE-A) (60 PAGES)
3	CIVIL ENGINEERING DESIGN BASIS (GENERAL CIVIL WORKS)	(ANNEXURE-B) (18 PAGES)
4	CIVIL ENGINEERING DESIGN BASIS (ARCHITECTURAL WORKS)	(ANNEXURE-C) (31 PAGES)
5	TECHNICAL SPECIFICATION (ES -2516) • FOR CIVIL, STRUCTURAL & ALLIED WORKS • FOR BORED CAST- IN - SITU PILES	(ANNEXURE-D) (85 PAGES)
6	QUALITY ASSURANCE PLAN	(ANNEXURE-E) (5 PAGES)
7	CIVIL & STRUCTURAL ITEM VENDOR LIST	(ANNEXURE-F) (9 PAGES)
8	TOPOGRAPHICAL SURVEY DRAWING	(ANNEXURE-G) (2 PAGES)
9	SOIL INVESTIGATION REPORT	(ANNEXURE-H) (54 PAGES)

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1.0 GENERAL

1.1 The scope of Civil, Structural and Architectural Works under this Contract given hereunder establish the minimum basic requirements for Civil, Structural and Architectural Works for Lump-sum Turn-key (LSTK) contracts. This standard specification shall be read in conjunction with the Design philosophy documents from other department (Process, Mechanical & Electrical.etc) issued for the Job and Standard Specification for Material & Construction requirements.

1.2 This document defines the design philosophy & Brief scope of works under this Contract for Civil, Structural and Architectural Works for the "***AMMONIUM NITRATE MELT PLANT AT RCF FERTILIZER COMPLEX, CHEMBUR***" and associated allied services within battery limit.

1.3 The scope of Civil, Structural and Architectural Works under this Contract shall include carrying out Micro-Grading & Leveling, Detailed Design, Drawings, Supply, Procurement of all materials, Construction, Demolitions, Supervision of all relevant Civil and Structural Works including providing all labour, supervision, material, scaffolding, construction equipment, tools, tackles and plants, supplies, transportation, all incidental items though not indicated or specified but reasonably implied or necessary for successful completion of the project.

1.4 This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

1.5 Compliance with this design basis and / or review of any of the contractor documents shall in no case relieve the contractor at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed, abiding all relevant Indian Standards (Latest Revisions).

2.0 SCOPE OF CIVIL, STRUCTURAL AND OTHER ALLIED WORKS

The scope of work under this contract includes the complete civil, structural and other allied works associated with the ***"AMMONIUM NITRATE MELT PLANT AT RCF FERTILIZER COMPLEX, CHEMBUR"*** and associated allied services within battery limit.

The general description of structures / facilities shall be read in conjunction with the technical requirements & specifications given elsewhere in this document. The tentative sizes of various process units, utilities, storage facilities and Plant structures / building and non-buildings with demarcated with areas on the plot plan is provided for reference.

Scope of the CONTRACTOR shall include but not limited to the following:-

a) Engineering related to site leveling, Micro-grading & preparation.

b) Soil Investigation, if required for specific design.

c) Structural Analysis and design calculations as per specifications laid down in Civil Engineering Design Basis, enclosed in the tender. For all **Civil, structural and other allied works** including but not limited to foundation, underground RCC structure, pile, pile-cap, plinth beam, RC superstructure, steel super structure, trenches, drains, pits etc.

d) Architectural design and drawings including details for doors, windows, partitions, false floor, false ceiling, toilet, finishes etc.

e) General Arrangement and construction drawings for foundations, underground structures, plinth/tie beams, pile, pile-cap, slab and sumps /pits etc.

f) General Arrangement and construction drawings at grade level showing foundations, extent of paving, trenches, drains, pits etc.

g) General Arrangement and construction drawings for superstructure (RCC and structural steel) at all levels.

h) RCC drawings showing all necessary details, such as opening, recess, embedment parts such as anchor bolts, sleeves and insert plates, etc. if any, for foundations and structures

i) General Arrangement and detail drawings for access roads, storm water drains, effluent drains, cable trenches, sewerage, manholes, pits, sumps with all necessary details.

j) Bar Bending Schedules for all RCC works.

k) Structural steel detail construction drawings for all steel structures.

l) Fabrication drawings with all details for all steel structures.

m) Coordination with OWNER / PMC for various activities including approvals of design basis, drawings, material samples, laboratory test results etc.

n) Procurement of all items necessary for completion of scope of work.

o) Construction of all units / structures, items of work included in scope of work.

p) As built drawings & final documentation.

q) Obtaining Statutory Approvals.

r) Adherence to Quality Assurance Plan

2.1 DETAILED SCOPE OF WORK

The dimensions & elevations of various units shall be furnished by LSTK contractor. All dimensions shall be finalized by the contractor during detail engineering phase & shall be get approved by Owner / PMC.

It is the contractor's responsibility to design safe, sturdy and robust structures, foundations etc. to withstand all static and dynamic forces in accordance with design specifications and engineering specifications laid down in the document.

The following plants and facilities shall be under the scope of the LSTK CONTRACTOR shall include but not limited to the following:-

2.1.1 The work shall have to be carried out both below and above ground level and shall be involving, basements, equipment foundations, slabs, beams, columns, footings, rafts, walls, steel frames, brick walls, stairs, trenches, pits, finishes, complete architectural aspects, drainage, sanitation, water supply (from terminal points to various buildings, conveyor galleries), and all other ***civil, structural and architectural works associated with the Ammonium Nitrate Melt Plant.***

2.1.2 The work to be performed under this specification for civil, structural and architectural items include works for sub-structures and super structures for the entire ***Ammonium Nitrate Melt Plant*** including auxiliary systems/services as per approved drawings and specification, including supply of materials and labours etc. for the following :

Consists of mainly but not limited to the followings:

a) Detailed design, engineering of all concrete foundations.

b) Pump foundations and associated civil facilities etc.

c) Foundation for tanks, Dyke wall and paving

d) Trenches/cable rack/cable trays for laying out cables

e) All Civil, Structural and Allied works along with foundation works required for the supporting structural platforms and various equipments as defined in Process and Mechanical Scope of work shall be under bidder scope.

f) Re-installation/Restoration of original structure / trench / roads etc. If effected/damaged during implementation of work.

g) To make trenches/Cable Rack/Cable trays for laying out cables from the cells to MCC. - Electrical substation if any.

h) Sumps/pit and waste water channel shall be of RCC construction with acid proof brick lining.

i) Area around acid alkali handling shall be lined with acid proof brick.

j) Remaining area shall be properly paved with provision of suitable storm water drain.

k) Control room

Control room shall be located at Ground floor for complete view of operation.

All sub and super structures and auxiliaries' works including cable trench/cable etc. with toilet facilities complete.

All civil, structural and architectural works associated with Control room including finishing works complete.

l) Miscellaneous Civil & Structural works

- Miscellaneous Fixtures / Stairs / Ladders. Etc. Providing and fixing embedment e.g. inserts, bolts, embedded plate, edge protection angles, ladders, railing, toe guard etc. complete for all structures wherever required as per approved system requirement.
- Miscellaneous local platforms, handrails, stairways, pipe sleepers, local foundations, local supports etc. as per requirement.
- False flooring as per latest specifications, as approved by Owner, to be provided.
- Doors to be used shall be of glazed aluminum sections or structure steel
- Blasting with explosive inside plant area is not permitted.

2.2 SITE RELATED INVESTIGATION & WORK

2.2.1 SOIL INVESTIGATION

a) The Soil Investigation Report carried out for urea plant within complex area is enclosed with the tender. This is indicative only and is enclosed purely for information / guidance purpose to the bidder. However Bidder shall make his own assessment for the type of foundations envisaged based on his site visit and data collected from site during the site visit.

b) In any case, the Bidder has to carryout detailed Soil investigation after the award of contract and submits Soil investigation report with recommendations for Owner's review and approval. The recommendation given in approved final report becomes binding on the contractor. The Bidder is not eligible to increase his cost or demand any extension of time because the final report is in variance from preliminary report furnished by Owner.

c) The Soil Investigation Report for Urea plant complex area is attached with this document as Annexure-H. This is indicative only and is enclosed for reference to the bidder for bidding purpose only.

2.2.2 TOPOGRAPHICAL / CONTOUR SURVEY

a) The OWNER has carried out a preliminary topographical survey of the proposed plant area. However the proposed plant site was developed. The Topography survey drawing for plant complex area is attached with this document as Annexure-G. This is indicative only and is enclosed for reference to the bidder for bidding purpose only.

b) Graded site shall be handed over to the contractor. However, The CONTRACTOR shall carry out his own topographical survey. For the purpose of surveying the Contractor's scope is not limited only up to Battery Limit, but shall extend up to the adjacent roads around the unit.

c) Before commencement of work / Contour Survey, the CONTRACTOR shall clear the site from all the debris lying on the site if any.

d) At bidding stage, the CONTRACTOR shall visit the site and study the existing site conditions & existing structures, etc.

2.2.3 SITE CONDITIONS

Levels like Finished Ground Level (FGL) and Highest Point of Paving (HPP) shall be finalized by the CONTRACTOR in consultation with OWNER / PMC based on contour survey of the unit, levels of adjacent units and levels of adjacent roads.

2.2.4 GRADING

a) The entire plant area has been developed during initial stage of plant construction. Fairly graded site area is available within complex area. Proposed site area shall be handed over to the contractor as in where is basis. However, the CONTRACTOR shall visit the site and study the existing site conditions & existing structures, etc.

b) The CONTRACTOR shall establish the finished grade levels of buildings after studying the existing site conditions, high flood level so as to maintain proper

efficient drainage of the plant area at no extra cost to OWNER / PMC. These grade levels shall be approved by the OWNER / PMC.

c) The LSTK Contractor shall be responsible for planning, designing, reshaping and contouring the Site to final grade elevations after study and verification of existing site conditions in consultation with OWNER / PMC.

d) The LSTK Contractor shall perform earthwork, excavation and filling to arrive at finished grade level. For the purpose of grading the Contractor's Scope is not limited only to the unit battery limit, but to be extended upto the adjacent roads around the unit.

e) Required grading and filling with sand, removing extra stuff shall be in contractor's scope. Micro grading works shall be in COTRACTOR's scope.

2.2.5 TRANSFER OF BENCHMARK

The Benchmark will be made available inside plant premises. However, it may be verified at CONTRACTOR's side. All Bench Mark (BM) levels of the survey shall be established with reference to the nearest GTS benchmark available. Precision leveling shall be carried out for establishing the BM at site by carrying levels from GTS BM adopting double circuit leveling. Precision theodolites used shall be of one-second accuracy.

2.3 DETAILED ENGINEERING

2.3.1 GENERAL

a) The CONTRACTOR shall carryout Analysis and Design of the structures required for this document and shall prepare all the required Architectural, Civil and Structural drawings needed for correct and accurate construction as per the Design Specifications given in this document.

b) The CONTRACTOR shall submit a Detailed Schedule for release of documents and drawings for review / approval to PMC / CLIENT, within 2 weeks / or mutually agreed period in writing from date of award of the Contract. Such a schedule shall be made in line with the overall Project Schedule given in the document.

c) The CONTRACTOR shall strictly adhere to the approved schedule. The Format of Submission of the above mentioned schedule shall be mutually discussed and finalized after award of the job.

d) Construction of various structures / facilities, whose designs and / or drawings are specially identified in the document submission requirements for approval by PMC, shall not be taken up for construction at site till they are approved by PMC and comments given by PMC are incorporated.

e) For other structures / facilities, the CONTRACTOR shall directly submit the Approved for Construction (AFC) drawings to PMC for information before, taking up construction.

f) It shall be the responsibility of the CONTRACTOR to accommodate all the functional requirements such as access, cutouts, clearances, interference etc. while designing / detailing of various structures / facilities.

g) Complete analysis, design and all drawings of each independent structure / facility shall be submitted in one lot so as to facilitate overall systematic review by PMC.

h) Only after the necessary architectural drawings are approved by the OWNER / PMC to their satisfaction, then the design drawings shall be reviewed and approved by the PMC.

i) The CONTRACTOR shall keep the OWNER / PMC informed of any major design revisions simultaneously in progress.

j) Approval of construction drawings prepared by the contractor shall not relieve the Contractor of his responsibility regarding the adequacy of design and correctness of the drawing, Engineering and Construction. The sole responsibility of the correctness of Design, Engineering & Construction shall lie with the Contractor irrespective of the fact that the Drawings/Documents submitted are reviewed or not reviewed by Owner/PMC. The Contractor shall correct all faulty design & construction detected at any stage of work without any cost & time implication to PMC or the Owner.

2.3.2 DESIGN CALCULATIONS

a) The CONTRACTOR shall prepare the design calculations based on the standard accepted practice and guidelines from PMC / OWNER.

b) All design calculations shall be written systematically, legibly and submitted for approval as per standard accepted practice.

c) For structures, analysis and design shall be done on latest version of **Staad Pro Software** only**.**

d) For other miscellaneous works, latest software's as necessary shall be used. Design calculations shall be done on A4 size sheet only.

2.3.3 DRAWINGS

a) The CONTRACTOR shall prepare

- Drawings for statutory approvals.
- Civil & structural design & construction drawings, architectural drawings based on the standard accepted practice and guidelines from PMC / OWNER.
- Bar bending schedules.
- Fabrication drawings.
- As-built drawings.

b) Detailing / drafting shall be done on AUTOCAD Latest Version only. Drawing size used shall be preferably of A1 size only. For foundation layout, drainage plans, paving plans and revised contour plans. A0 size drawings can be used if necessary.

2.4 CONSTRUCTION

a) Construction of all civil and structural works including all material, labour, supervision, tools and tackles etc. shall be carried out by the CONTRACTOR

b) Procurement and supply of all materials viz. cement, reinforcement, structural steel etc. shall be in the scope of CONTRACTOR.

c) All materials shall be procured in consultation with the Owner or as per the approved vendor list given elsewhere in this document. All materials of construction must be of ISI approved brand.

d) All materials and construction shall confirm to the specification given elsewhere in this document.

e) Materials of construction, construction methodology etc. shall be such, so as to protect the structures and foundations against the harmful effect of chemical, fumes etc. present in the plant, its vicinity, in ground and / or subsoil water.

f) The CONTRACTOR shall be responsible for obtaining the statutory approval from local authorities such as Inspector of Factories, Development Authorities, Municipal Corporation and other concerned authorities before starting the work.

g) The CONTRACTOR shall ensure that the facilities are constructed in accordance with the APPROVED FOR CONSTRUCTION drawings and specifications.

h) The CONTRACTOR shall maintain and operate an adequate system of control of availability of latest drawings and specifications, at all the places where work is performed.

i) Construction shall include excavation in all types of soils / rock inclusive of necessary dewatering as applicable.

j) The CONTRACTOR shall redo / repair all the existing facilities viz. roads, paving, drainage etc. which are damaged during transportation, construction and erection activities performed by him.

2.5 TEMPORARY SITE BUILDINGS & FACILITIES

a) The Contractor shall provide for at his cost the following buildings & facilities for proper execution and quality control of the job, while meeting the provision stipulated by Factory Rules regarding staff welfare facilities.

- Site office
- Store room
- Temporary Workshop and Garage shop
- Fabrication yard
- Quality Control / Testing Laboratory

b) All temporary work shall be so constructed as not to interfere with any permanent work or with the work of other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or work of other agencies, such removal and re-erection if required, shall be carried out by the Contractor, at the discretion of the Engineer without any delay and any extra cost on this account shall be borne by the Contractor.

c) Contractor has to make his own arrangement for making access/ roads/ approaches to the site for transportation of his men material and equipment. Nothing extra will be paid to contractor for this.

2.6 ROADS, PAVING AND HARD STAND

2.6.1 ROADS

a) The CONTRACTOR shall be responsible for complete planning and construction of the roads for access to all buildings and units of the plant from the existing roads within the battery limit including necessary tie-in connections. All works associated with shifting of Roads and related services (e.g. all type of drainages, culverts etc.) as required, for the proposed site, shall be in the scope of contractor.

b) Contractor shall provide Footpaths (as applicable) for maintenance and operational requirement of plant as per the equipment layout and as per detailed engineering requirement. Any additional approach roads around unit, substation, and other areas to facilitate crane movement or any other vehicle movement during construction shall be in contractor's scope of work. Crossings for all services shall be in the scope of contractor. Additional WBM layer and premix carpeting of damaged road during construction shall be in the scope of contractor.

c) All roads around each facility shall be made good while handing over after completion of construction activity. Any culverts, pipe way bridges, cable crossings, electric road crossings, road crossings for Caustic sewer system, fire water lines, drinking water lines, etc. coming below the main roads and approach roads shall be in Contractor's scope of work and shall be designed for crane

loads. The design of road cross section shall be in the scope of contractor based on the CBR values, to be obtained by the contractor during survey.

2.6.2 PAVING

a) The CONTRACTOR shall provide RCC pavement in entire process unit area and in associated facilities as per design requirements. For the purpose of paving the Contractor's scope is not limited only up to Battery Limit, but shall extend up to the adjacent roads around the unit.

b) RCC pavement of suitable type shall be designed and provided for areas where vehicle movement is envisaged for operations & maintenance requirements and rest of the areas shall be provided with lighter RCC pavement as per design requirements.

c) The contractor shall design the pavement sections taking care of the geo-technical recommendations and get approval from PMC during detailed engineering. The contractor shall ascertain extent of heavy-duty RCC pavement and heavy-duty pavement shall be designed / provided for required crane weight or any other heavier crane proposed to be used by the contractor for erection and maintenance. Hardstand for erection of heavy equipments by cranes shall be ascertained by the contractor & provided as required. Demarcation shall be clearly shown on drawing. The contractor shall design hardstand required for the erection of heavy equipment as per erection loads. The contractor shall carry out dismantling of hardstand, if required as per directions of Engineer-in-charge, disposal of material outside compound wall after completion of erection wherever required.

2.6.3 HARD STAND

Based on soil data, the hard stand required for erection of heavy equipments to be Designed and provided as per equipment erection philosophy / type of cranes to be used inside and outside the battery limit of units. Dismantling of hardstand if required, as per directions of Engineer-in-Charge, disposal of material outside the boundary wall shall be in the scope of contractor.

2.7 SURFACE DRAINAGE, STORM WATER DRAINS AND CULVERTS

The Contractor's scope work includes providing all internal services such as water supply, sanitary sewerage, drainage and storm water drains etc. and connecting the same to nearest external prevailing facilities complete in all respects in around and within the Unit battery limit.

2.7.1 STORM WATER DRAIN SYSTEM

a) The CONTRACTOR shall study the existing drainage system as per actual site conditions and ensure proper drainage system around and within the battery limit for all roads. The Storm Water Drains shall be connected to the existing drainage system at suitable tie-in points to be decided in consultation with OWNER / PMC during detailed engineering.

b) For the purpose of drainage the Contractor's scope is not limited only up to the Unit Battery Limit but shall extend up to the adjacent drainage network around the unit. Construction of storm water drains in around and within the Unit battery limit and connecting the same to nearest main storm water drain including providing cross drainage facilities (i.e. RCC Box culverts and RCC pipe culvert) for drainage of storm water of the area shall be carried out strictly in accordance with the "Technical specification (ES-2516)" provided with tender.

c) The drainage system shall be by gravity. Storm water drains shall be sized for the peak discharge arising discharge arising out of either rain water or fire fighting water.

2.7.2 SANITARY AND PLUMBING SYSTEM

d) The CONTRACTOR shall provide proper underground drainage system for sewage disposal and its connection to common sewage treatment plant. These shall be connected to existing sewerage system at suitable tie-in points to be decided in consultation with OWNER / PMC during detailed engineering.

e) The CONTRACTOR's scope work includes Supply and fixing of building plumbing for sanitary system, drinking water, sanitary sewer system including disposal facility i.e. connecting to nearest sanitary sewer manhole complete as per standards, specifications and direction of Engineer-in-charge.

f) All plumbing and sanitary works within new buildings and disposal of sanitary waste up to nearest manhole available is in contractor's scope of work. All the sanitary fixtures and fittings shall be as per approved Architectural drawings/ specifications and relevant Indian / International Standards.

2.7.3 DRINKING WATER SYSTEM

a) The CONTRACTOR shall study the existing drinking water distribution piping system as per actual site conditions and ensure proper drinking system inside the building and facilities within the battery limit at suitable points to be decided in consultation with OWNER / PMC during detailed engineering.

b) Providing HDPE drinking water storage tank (min.1 day storage Capacity) over building roof with distribution piping system inside the building up to different user points including taking tapping from external feeder supply line from the main headed running outside the package unit battery limit up to storage tank inlet with an isolation valve (in valve pit) at ground level.

2.7.5 CABLE CROSSING

For all electrical / instrument cables crossing the main / approach roads, suitable road crossings either by PVC pipes encased in concrete or RCC ducts / culverts shall be provided as per Electrical / Instrumentation requirements. Crossings shall be designed crane loads required for erection

2.7.6 RCC TRENCHES / CHANNELS

a) CABLE TRENCHES

RCC Electrical / Inst. cable trenches with pre-cast RCC covers shall be provided as per structural standards and electrical / instrumentation requirements. Trenches and covers in crane movement area shall be designed to withstand crane movement required for erection. Cable trenches within scope limit shall be filled with sand before placing of precast cover.

All trenches for electrical cables for other purposes shall be of RCC. The trench cover shall be of precast concrete with edge protection angle and lifting devices. Suitable inserts and opening shall be provided as per service requirement. Suitable drainage and walking arrangement inside trench shall be provided.

b) PIPE TRENCHES

RCC trenches sand filled with pre-cast RCC cover shall be provided for all U/G firewater headers in paved areas. Trenches and their covers in crane movement area shall be designed to withstand crane movement required for erection.

2.8 STRUCTURES & BUILDINGS

Contractor's scope shall include various technological/ Process structures steel & R.C.C. structures, pipe rack, buildings, equipment foundations, pits, cable trench, sheds, etc. as per the approved Plot Plan or mentioned in this tender document, required for the complete execution and commissioning of the plant.

2.9 SIZING OF VARIOUS FACILITIES

Sizing, nos., location etc. of various facilities viz. buildings, pipe rack, structures, equipments, etc. shall be in the scope of the bidder. Any change of sizing, addition of any structure / facility, indicated by Owner/PMC, based on functional requirements and as well as local rules and regulations, etc, shall be in the Contractor's scope, at no extra cost to OWNER / PMC.

2.10 SURFACE FINISHING'S

The CONTRACTOR shall be responsible for complete planning and detailing of all surfaces finishes viz. painting, flooring etc as per specifications given in the Tender. Also same shall be mentioned in respective architectural / civil drawings issued by the contractor.

2.11 ACID / ALKALI PROOF LINING

The CONTRACTOR shall be responsible for surface treatment of floors, exposed portion of foundations, pits and basins against acid / alkali as per process requirement.

2.12 ANTI-TERMITE TREATMENT / DAMP PROOF COURSE / WATER PROOFING

The CONTRACTOR shall provide anti-termite treatment, damp proof course and water proofing as per design basis. Water proofing (for all open terraces) of all

buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make.

2.13 SITE CLEANING

During construction and on completion of construction (inclusive all internal and external finishes), cleaning all the debris, waste materials scattered in and around the site and disposal of the same shall be in the scope of the CONTRACTOR with the consent of the OWNER/ PMC.

2.14 DISPOSAL OF SURPLUS EARTH

The CONTRACTOR shall dispose-off all surplus and unserviceable earth (if any), outside the plant in accordance to local Governing authority, at his own cost with the consent of OWNER/ PMC.

Disposal shall be done at a place outside the plant, with the consent of the OWNER/ PMC. Location of disposal area shall be decided by the CONTRACTOR and the required necessary approvals from the local bodies shall be the CONTRACTOR‘s responsibility.

2.15 REMOVAL OF UNDERGROUND AND ABOVE GROUND STRUCTURES

All above ground structures will be demolished by Owner. Proposed site area shall be handed over to the contractor as in where is basis after demolition. All underground facilities /structures shall be demolished /removed by the Contractor provided removal of former will not disturb the functions of existing plant. Rerouting of cables / pipes etc. encountered during excavation in the plot shall be in CONTRACTOR’s scope of work.

Existing underground installations found, if any, such as foundations and pipelines, which fall /obstruct the construction activities, shall have to be removed by The Contractor. Existing piles if any, needs to be adjusted while making new piling / foundations.

2.16 STATUTORY REQUIREMENT, RULES AND REGULATIONS

CONTRACTOR shall comply with all the applicable statutory rules pertaining to Factory act, Fire safety rule of Tariff Advisory Committee, Water act of Pollution

control board, Explosives act, local civil authority including building use permission etc. Provisions of Safety, health and welfare according to Factories act shall also be complied with. Statutory clearances and norms of State Pollution Control Board shall be followed.

CONTRACTOR shall obtain approval of Civil / Architectural drawings from OWNER/ PMC before taking up the construction work.

All the facilities shall conform to all Local Rules and Regulations, Factory Inspector, Rules, TAC rules etc. whichever is more stringent.

Getting the approval of the various documents through the various authorities shall be in the Contractor's scope at no extra cost to OWNER / PMC.

2.17 CONSTRUCTION METHOD & EQUIPMENT

The Contractor shall submit drawings and write-up indicating his construction methodology for execution of work with elaborate explanation for construction work e.g. deep underground structures for Wagon Tipler, Reclaim Hopper, TTs, tunnels building and trestle foundation, preventive arrangements to avoid damage to existing structures (if any).

2.19 OTHER MISCELLANEOUS WORKS

2.19.1 SCOPE OF WORK IN OUTSIDE BATTERY LIMIT (OSBL) AREA

Scope work includes in outside battery limit area, if any civil & structural work required for completion of work

2.19.2 It is not the intent to specify herein all the works in the scope of this contract. The scope also includes all other buildings, structures and works necessary which are not specifically mentioned here but required for construction, operation and maintenance of the "***AMMONIUM NITRATE MELT PLANT AT RCF FERTILIZER COMPLEX, CHEMBUR***"" are deemed to be included in the scope of the Contractor. All works shall conform to the specification. The works shall conform to high standards of design, engineering and workmanship. Design and construction shall conform in every respect to all local and state regulations governing such works and to stipulations of Indian Standards unless stipulated otherwise in detail specification.

3.0 GENERAL DESCRIPTION OF STRUCTURES & SERVICES

Some of the salient features for structures involving major civil & Architectural works are furnished below for guidance. The requirement furnished in design specification from other department (Process, Mechanical & Electrical.etc) shall also be read in conjunction to this general description.

It includes the Civil, Structural and Architectural works related mainly to the following areas (but not limited to):

3.1 CONTROL ROOM

a) Control Buildings shall be RCC framed structures with columns, beams, slabs and foundations etc. Cladding shall be of brickwork with plastering on both sides. Roof shall be provided with roof water proofing treatment, as specified elsewhere in the technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations.

b) All air - conditioned areas, shall be provided with the suspended permanently colour coated aluminium false ceiling system with under deck insulation. Roof shall be provided with roof water proofing treatment with Roofosol or equivalent. 50mm thick average thickness Foam concrete insulation shall be provided conforming to IS: 13205.

c) Control panel room for control room near wagon tippler shall be provided with thick wired glass (min. 5.5 mm thick) on all sides so as to permit operators to have full view on operation of wagon tipper.

d) Adequate aluminium doors and aluminium glazed windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing. All outer face of brick wall shall be finished with cement paint and inside surface shall be white/colour wash except for control room which shall have acrylic emulsion paints over plaster of paris.

4.0 QUALITY ASSURANCE PLAN

Contractor shall ensure the quality of civil works by engaging a third party supervision /inspection and provide test results to Owner / PMC for information.

The Quality Assurance Plan is attached for reference as Annexure – D and the contractor is obliged to follow it.

5.0 COMPLETENESS OF WORK/CONTRACT

a) The scope of work mentioned in the contract / NIT is not the comprehensive one, but gives total idea/outline of the scope of work; however contractor shall be responsible for completeness of the job for the purpose indicated elsewhere to make the system fully functional, operational and durable as per latest IS standards.

b) The work furnished shall be complete in every respect with all mounting, fittings, fixtures and standard accessories etc. normally provided for such item/equipment and or needed/required for erection, completion and safe operation of the item/equipment/system as required by applicable codes though they may not have been specifically detailed in the respective specifications, unless included in the list of exclusions.

c) Any additional items and materials which are not specifically mentioned but are required to complete the system offered, in every respect in accordance with the technical specifications and required for safe operation and guaranteed performance shall also be deemed as included in the scope of work of this tender. Contractor shall not be eligible for any extra payment in respect of such mountings, fittings, fixtures, and accessories etc. which are needed/ required for safe operation of the item / equipment/system, as required by applicable codes of the country though they may not have been explicitly spelt out in the NIT/Contract.

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE-A

CIVIL & STRUCTURAL DESIGN BASIS

(CIVIL AND STRUCTURAL WORKS)

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1.0 GENERAL

1.1 SCOPE

This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

Compliance with this design basis and / or review of any of CONTRACTOR documents shall in no case relieve the CONTRACTOR at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed.

1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards
Owner	RCF
Consultant	PDIL
LSTK contractor	Successful LSTK Bidder of The Tender

1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

1.4.1 The main codes and standards and statutory regulations considered as minimum requirements are as follows Latest revision of these shall be followed.

a) National Building Code of India : 2005

b) IS: 875 (Part 1) – Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 1 – Dead Loads).

c) IS: 875 (Part 2) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 2 – Imposed Loads).

d) IS: 875 (Part 3) - Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures (Part 3 – Wind Loads).

e) IS: 1893 (Part 1):2002 –Criteria for Earthquake Resistant Design of Structures (Part 1 – General Provisions and Building).

f) IS: 1893 (Part 4):2005 –Criteria for Earthquake Resistant Design of Structures (Part 4 – Industrial Structures including Stack-Like Structures).

1.4.2 STRUCTURAL STEEL

a) IS: 800 – Code of Practice for General Construction in Steel

b) IS: 802 – Code of Practice for use of structural steel in overhead transmission line towers.

c) IS: 1161 – Code of Practice for Circular hollow sections/pipes.

d) IS: 4923 – RHS & SHS sections.

e) IS: 2629 – Recommended practice for hot dipped galvanizing on iron and steel.

f) IS: 2633 – Methods for testing uniformity of coating of zinc coated articles.

g) IS: 6533 – Code of Practice for design and construction of steel chimney.

h) IS: 6745 – Method for Determination of mass of zinc coating.

i) IS: 814 – Covered Electrodes for manual metal arc welding of Carbon and carbon manganese steel.

j) IS: 816 – Code of Practice for use of Metal arc welding for General Construction in mild steel.

k) SP-06 – (Part 1 to Part 7) - Handbook for Structural Engineers.

1.4.3 REINFORCED CONCRETE AND MASONRY WORK

a) IS: 456 – Plain and Reinforced Concrete – Code of Practice

b) SP:16 - Design Aids for Reinforced Concrete to IS: 456

c) SP: 34 – Handbook of Concrete Reinforcement and Detailing.

d) SP:24 – Explanatory Handbook on Indian Standard Code of Practice for Plain and Reinforced

e) SP: 20(S & T) – Explanatory Handbook on Masonry Design and Construction.

f) IS: 2911 (Part 1 to Part 4) – Code of Practice for Design and Construction of Pile Foundation.

g) IS: 2950 (Part 1) – Code of Practice for design and construction of Raft foundation.

h) IS: 2974 (Part 1 to Part 5) – Code of Practice for design and construction of Pile Foundations.

i) IS: 3370 - Code of Practice for Concrete Structures for storage of liquids.

j) IS:4326 – Code of Practice for earthquake resistant design & construction of buildings

k) IS: 13920 – Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces.

l) IS:1172 - Code of basic requirements for water supply, drainage & sanitation

m) IS:1742 - Code of practice for building drainage

n) IS:1905 - Code of practice for structural use of unreinforced masonry

o) IS: 2212 - Code of practice for brick work

1.4.4 ROADS AND SANITARY WORKS

a) IS: 2065 - Code of practice for water supply in buildings

b) IS: 8835 - Guidelines for design of surface drains.

c) IRC: 6 - Code of practice for road bridges, Section-II Loads and stresses

d) IRC: 19 - Standard Specifications And Code of Practice for Water Bound Macadam

e) IRC: 37 - Design of flexible pavements

f) IRC: 58 - Design of rigid pavements

Note: The above list is suggestive and not exhaustive. Apart from these basic codes any other related codes shall also be followed wherever required.

In case of any difference between Codes provision and this design basis, the stringent one should govern the design.

1.4.5 In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

a) Statutory Regulations

b) Job Specifications

c) Engineering Design Basis

d) Standard Specifications

2.0 MATERIALS OF CONSTRUCTION

Type of Structure	Materials of Construction
Piperacks Technological Structures/Platforms Shed type structures (e.g. compressor shed, Pump shed)	Structural Steal (unless required otherwise from process requirement or operation considerations)
Opening Platforms in steel structures	Steel gratings
All buildings (except blast-proof control-	RCC frames with hollow/solid concrete block
Blast proof control room building	RCC
Gratings	Steel

3.0 DESIGN LOADS & COMBINATIONS

The following design loadings shall be considered

- Dead loads including self weight
- Live load

- Wind load
- Seismic load
- Equipment load
- Dynamic load
- Load from lifting appliances
- Erection loads / maintenance loads
- Thermal load
- Earth pressure / Hydrostatic Loads
- Any other load not mentioned above, but applicable

These loadings shall be applicable to all structures irrespective of the material employed for construction.

3.1 BASIC LOADS

3.1.1 DEAD LOAD (DL)

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways and fixed services.

The unit weight of materials in general, shall be in accordance with IS: 875-1987.

Unless noted otherwise following unit weights shall be adopted.

Reinforce Concrete	:	2500 kg/m³
Plain Concrete	:	2400 kg/m³
Structural steel	:	7850 kg/m³
Backfill Soil	:	1800 kg/m³
Operating floor with grating	:	100 kg/m²
Staircase (steel)	:	140 kg/m²
Ladder	:	40 kg/m²
False ceiling	:	60 kg/m²
Heavy duty tar felting	:	30 kg/m²
6/8 mm Thick. Raised Pattern Chequered plate	:	55 kg/m²
25 mm Thick Grating	:	40 kg/m²

Hand Rail	:	150 kg/m
Ladder	:	40 kg/m
Operating floor with grating	:	100 kg/m²
Electrical Panel Load	:	As per Actual panel loads
Instrumentation Panel Load	:	As per Actual panel loads

3.1.2 LIVE LOAD (LL)

Live loads shall, in general, be as per IS: 875. However, the following minimum live loads shall be considered in the design of structures to account for maintenance and erection phases; if equipment layout / vendor drawings indicate loads of greater magnitude, the same shall be adopted.

(1) Live Loads on locations other than roofs

The Design Live Loads shall be those appropriate to the actual situations but shall not be less than the following values:

a) Process Building / Technological Structure (Open / Enclosed type)

- Operating area : 5.0 kN/m²
- Maintenance area : 7.5 kN/m²
- Ground floor : 10.0 kN/m²

b) Compressor House/TG House

- Operating area : 7.5 kN/m²
- Maintenance area :7.5 kN/m² or as specified by Machine vendor whichever is more
- Ground floor : 10.0 kN/m²

c) Service Platform

- Vessel / Tower : 3.0 kN/m²
- Isolated platform (for valve operation) : 2.5 kN /m²
- Access way : 2.5 kN/m²
- Cross over : 2.0 kN/m²
- Pipe rack walkways : 2.5 kN/m²
- Gantry girder walkway : 3.0 kN/m²

d) Storage Areas

- Light Storage Areas : 5 KN/m²
- Heavy Storage Areas :- 12 KN/m²

e) Substation / Control Room

- Panel floor : 10.0 kN/m² (Minimum) or Subjected to actual panel load Whichever is more.
- Battery Room : 5 KN/m2
- Lobby : 5 KN/m2
- Exit way : 5 KN/m2
- Miscellaneous partition : 1.0 kN/m²
- Other areas : 5.0 kN/m²

f) Office building

- Office area : 3.0 kN/m²
- Entrance lobby : 5.0 kN/m²
- Exit way : 5.0 kN/m²
- Miscellaneous partition : 1.0 kN/m²
- Document Storage area : 10.0 kN/m²

g) Laboratory

- Upper floors : 4.0 kN/m²
- Ground floor : 5.0 kN/m²

h) Cooling Tower

- Operating platform / Hot water Basin cover slab : 3 kN/m²

i) GT Building / DM Plant / ETP

- Operating platforms : 3.0 kN/m²
- Ground floor : 5.0 kN/m²

j) Ware House & Work Shop

- Light : 5 kN/m^2
- Medium : 7.5 kN/m^2
- Heavy : 10 kN/m^2

k) Staircase

- Process Building : 5.0 kN/m²
- Technological structure : 5.0 kN/m²
- Office : 5.0 kN/m²
- Substation / Control Room : 4.0 kN/m²
- Laboratory : 4.0 kN/m²
- Service platform : 2.5 kN/m²

(2) Live Loads on roof

a) Flat Roof, sloping roof with slope < 10 degree

- With Access : 1.5 kN/m²
- Without Access except for maintenance : 0.75 kN/m²

b) Sloping roof with slope > 10 degree

- For roof membrane sheet or purlins : 0.75 kN/m² less 0.02 kN/m² for every degree increase in slope over 10 degrees subject to minimum of 0.40 kN/m²

Loads on account of equipment and incidental loads shall be taken over and above the loads indicated in the table.

For all other buildings not covered in above Table, the imposed loads shall be taken as specified in IS: 875 (Part II)

1 kN/m² allowance shall be made for services supported from below the floor.

Live load on various types of roofs shall be as per the requirements given in IS: 875.

3.1.3 WIND LOAD (WL)

Definition of basic wind speed shall be peak gust velocity averaged over 3 second time interval at 10 m height above mean ground level with 50 years mean return period. The design life span of all structures, except temporary structures, and boundary wall shall be taken as 50 years. Life span of temporary structures and boundary wall can be lesser and shall be as per IS: 875.

The Wind forces on buildings / structures and equipments due to effects of wind shall be calculated as per IS 875 (Part-3) except for switchyard structures and transmission towers for which IS: 802 shall be applicable

To account for surface area of piping, platforms and other attachments fixed to the equipment, the surface area of the equipment (vessel/column) exposed to wind shall be increased by 20% or as specified in the mechanical data sheets of the equipment.

Basic wind Speed (Vb) = 44 m/s upto 10 m height.

Risk Coefficient (k1) = Refer Table 1, IS 875 (Part-3)

Factor (k2) = Refer Table 2, IS 875 (Part-3)

(Coefficient K2 shall be worked out based upon structure height, structure class and terrain category)

Terrain = Category 1 (Open Sea Coasts)

Topography Factor (k3) = 1.0

Importance factor for Cyclonic Region (k4) = 1.15 (Industrial structure)

Design Wind Speed (V_Z) = Vb*k1*k2*k3*k4 m/s

Design Wind Pressure (p_Z) = $0.6*V_Z^2$ N/m^2

Wind force on structural elements shall be calculated using design wind pressure multiplied by elements frontal area, normal to wind direction multiplied by force coefficient as per Table 26, IS 875 Part-3.

In calculation of wind force frictional drag shall be considered where applicable.

3.1.4 SEISMIC LOAD (SL)

All buildings, structures, foundations shall be designed to resist the effects of earthquakes in accordance with IS: 1893 (Part 1):2002 and IS: 1893(Part 4):2005. Seismic loads shall be as per IS: 1893 (Latest Revision).

3.1.4.1 DESIGN SITE CONSIDERATION

The Project site falls in seismic zone III that indicates that Site has moderate probability for occurrence of earthquakes.

SEISMIC PARAMETERS

Seismic design forces shall be determined based upon the following parameters. Buildings of different materials of construction and lateral force resisting systems shall be investigated separately.

Item	Value	Reference
Seismic Zone	Zone -III	Fig.1 Map Showing Seismic Zones of India (IS:1893-Part 1)
Zone Factor	0.16	Table 2 (IS:1893-Part 1)
Response Reduction Factor (R)	As per table 3 of IS1893 Part 4	
Importance Factor	As per table 2 (IS:1893-Part 4)	
Damping	5% for RCC Structure	Clause 7.8.2.1 (IS:1893-Part 1)
	2% for Steel Structure	

3.1.5 EQUIPMENT LOAD (EQ)

3.1.5.1 EQUIPMENT CATEGORY

a) EQUIPMENT CATEGORY-I

The weight of equipment category I such as pumps, compressors, motors etc., shall be derived as far as possible from Manufacturer's data and shall include controls, auxiliary machinery, piping etc. The equipment load shall be categorized if required for use in various loading combinations as empty and operating.

b) EQUIPMENT CATEGORY-II

This category consists of loads from equipments such as vessels, columns, heat exchangers, condensers, settlers, filters and the like, complete with their piping.

In accordance with the various load combinations for the category of equipment, the following weights/loads shall be included in the calculations.

3.1.5.2 EQUIPMENT WEIGHTS

a) Empty Weight (Ee)

This is the dead weight of vessels, columns, etc. completely installed) including platforms and ladders, piping, insulation and fireproofing) and ready for operation, however, without liquid filling. Weights will be derived from manufacturer's data.

b) Operating Weight (Eo)

This is the empty weight plus the maximum weight of contents of vessels, columns, etc. during normal operation of the plant, Weight of pipes full of product (liquid/gases) plus the weight of insulation and anchor loads if any.

c) Hydrostatic Test Weight (Et)

When Hydrostatic pressure testing of equipment is required at site and is done after installation, the weight of equipment, completely filled with water shall be incorporated in the design of the supporting structure. Only one biggest system shall be considered to be tested at a given time.

The empty / operating / test weight of process equipment including contents and all fixtures, platforms, ladders and attached piping etc, shall be considered. If piping weight is not indicated separately or not included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

3.1.5.3 EXCHANGERS / FABRICATED EQUIPMENTS

When exchangers are supported on structures, the supports shall be designed for vertical and horizontal forces (bundle pulling force or friction forces). The vertical loads shall be categorized into empty weight, operating weight and test weight.

Weight distribution over two (2) saddles of an exchanger shall normally be as follows:

Exchanger Type	Channel Side	Shell Side
Floating head type	60%	40%
Fixed tube sheet type	50%	50%
Kettle type	45%	55%
U-tube and other type	67%	33%

3.1.5.4 SPECIAL CONSIDERATIONS

a) Bundle Pull

Bundle pull forces for different types of exchangers shall be taken as under :-

Fixed type - Nil

Kettle type - 0.30 x Bundle weight

All other types - 0.86 x Bundle weight or 30 N/mm of diameter whichever is greater.

Total Bundles Pull shall be considered on fixed pedestal alone

b) Thermal Expansion

Horizontal force due to thermal expansion of horizontal vessels / exchangers shall be relieved by using slotted holes and slide plates and remaining force derived from the product of the sliding saddle 'gravity load' and the coefficient of friction shall be applied to each support. The coefficient of friction shall be as under:

i) Teflon to Teflon : 0.08
ii) stainless steel to Teflon : 0.10
iii) steel to steel : 0.30
iv) steel to concrete : 0.45

c) Non-Static Loading

Foundations and structures supporting vessels subject to surge loading, such as Deaerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal forces of 10% of those derived from the Vessel's operating weight or the given surge load whichever is the greater. The forces shall be applied at the vessel's centre of gravity and act longitudinally OR transversely. Consideration shall be given to bracing these structures.

The design of foundations and structures supporting agitated vessels, centrifuges, reactors and other variable load equipment shall take full account of all the loading data provided by the equipment vendors. Where no loads are available, consideration shall be given to applying force at 10% of operating weight. In addition, for dynamic effect loads will be increased by 50% of steam agitated equipment and 25% for mechanical agitated vessels.

Where two or more similar items of such equipment are supported on a common foundation or structure, the design must be based on the assumption that these items will resonate in phase.

3.1.5.5 ROTATING EQUIPMENT

Comprehensive loading data of mechanical equipment, such as, fans, blowers, pumps, compressors, D.G. Sets, turbines, motors engines etc., as furnished by the equipment vendor shall be considered.

3.1.6 PIPE RACK LOADS

For designing the pipe rack superstructure and foundation the following loads shall be considered.

a) PIPING LOADS FOR ERECTION/ EMPTY (P_E):

Empty loads of pipes coming at each tier shall be considered. Pipe empty weight shall comprise only empty weight of pipes excluding the contents but includes the insulation weight wherever applicable. These loading shall be as per piping loading data.

b) PIPING LOADS FOR OPERATION (PO):

This shall mean, the load of piping during normal operating conditions, including the weight of internals fluids & insulation.

In case of gas/steam carrying pipes, the material content shall be taken as 1/3rd volume of pipe filled with water.

Piping Loads shall be calculated considering the pipe diameters and piping arrangement (as per Piping Stress Analysis report) subject to minimum of 150 Kg/m2 over entire span.

c) PIPING LOADS FOR TESTING (PT):

Test loads shall comprise of the maximum design loads i.e Empty weight of the pipe plus the weight of test medium contained in a set of simultaneously tested piping systems. Unless otherwise specified a minimum specific gravity of 1.0 shall be used for the test medium.

Vertical Loading

Actual weights of pipes coming at each tier shall be calculated. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. Insulation density shall be taken as 2600 N/m³ minimum. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. The total actual weight thus calculated, shall then be divided by the actual extent of the span covered by the pipes to get the uniformly distributed load per unit length of the span. To obtain

the design uniformly distributed load, over the entire span, the u.d.l. obtained as above, shall be assumed to be spread over the entire span. However, minimum loading for any piperack shall not be less than 1.25 kN/m². In case, the calculated loading is higher than 1.25 kN/m², this shall be rounded off to the nearest multiple of 0.25 (i.e., 1.50, 1.75 kN/m²)

Vertical loads of flare pipe shall be taken as one third full of water for piping within units & one sixth full for outside unit battery line. All flare line independent support shall be of four legged braced open lower type construction.

In addition to piping load, gravity loads due to encasement, if any, shall be considered.

d) FRICTION FORCE (LONGITUDINAL & TRANSVERSE)

i) Pipe rack and supports shall be designed to resist the friction induced by the piping. Where the pipes are of similar diameter and service condition, the friction force at each tier on every portal, both in longitudinal and transverse directions shall be 10% of the design vertical loading of the pipes for four or more pipes supported on a tier, and 30% of the design vertical loading of the pipes for single to three pipes supported on a tier.

ii) Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level. Friction forces on T-supports and trestles shall be taken as 30% of the vertical loading. Both longitudinal and transverse friction forces shall be considered to be acting simultaneously.

iii) For two-phase fluid flow/transfer lines frictional force shall be minimum 50% of the weight of pipe including contents & insulation, acting simultaneously in transverse & longitudinal direction.

e) ANCHOR AND GUIDE FORCE (AL)

The Anchor or Guide Forces in longitudinal and transverse directions shall be as per piping stress analysis results. These loads shall be considered for local / global design of members / structure as appropriate. In absence of information of

anchor force it shall be considered as 10 % of Operating weight of pipe per pipe tier.

f) LOADING ON INTERMEDIATE BEAM AT TIER LEVEL

Intermediate beam at tier level shall be designed for 25% of load on main portal beams in transverse direction. A reduction of 10% in vertical loading shall be considered for main portal beams, if intermediate beams are provided.

g) LOADING ON LONGITUDINAL BEAMS

Longitudinal beams connecting portal columns shall be sufficiently strong to sustain 25% of the load on the transverse beams. The total load shall be assumed as two equal concentrated loads acting at 1/3rd span. Other longitudinal axial forces coming on it from the design of the supporting system shall also be simultaneously taken into account in the design of the longitudinal beam. Friction & anchor forces, if specifically given by the Piping Specialist, shall also be catered for in the design. Loads from monorails, when supported from these beams, shall also be considered to be acting simultaneously along with all other loads mentioned above.

h) CABLE TRAY AND WALKWAY LOADS

The estimated actual load from electrical, instrumentation trays shall be considered at the specified locations, together with walkways, platforms for valve operation, wherever provided.

i) PIPE WIND FORCE

Transverse wind loading shall be calculated depending on the width of the piperack as per the following table. This force shall be considered irrespective of the height between two tiers.

Width of Piperack	Wind Force at each Tier level(N)
Upto 4 m	1.25 x p x s
Above 4 m but upto 6 m	1.50 x p x s
Above 6 m but upto 10 m	2.00 x p x s

Above 10 m projected height x p x s

Where p = Horizontal wind pressure as per IS:875 (N/m²)

s = Spacing of portals (m)

For pipe racks of width greater than 10 m, the projected height shall be lesser of the following two:

i) 0.8 x (diameter of largest pipe including insulation (m) + tan 10º x (width of rack (m).

ii) height between consecutive tiers

For flare header or any other line supported on extended leg of piperack, the wind force shall be considered separately.

j) PIPE SEISMIC LOADS

Seismic loads shall be as per IS: 1893 (latest version).Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

Limiting permissible horizontal deflection for piperack shall be height / 325.

3.1.7 IMPACT AND VIBRATORY LOADS

Structures subjected to impact or vibratory loads shall be designed as per the provision of IS: 875 & IS: 2974. Requirements for monorails and overhead cranes shall be as per IS: 800, IS: 875 or manufacturer's data, whichever is more stringent.

3.1.8 EARTH PRESSURE (EP)

Earth Pressure shall mean pressure of the soil acting on the underground structures and / or foundations of retaining walls, dikes etc. Earth pressure to be considered for design shall be due to earth pressure at rest (Ko) condition only.

3.1.9 HYDROSTATIC / LIQUID PRESSURE (LP)

Hydrostatic / Liquid Pressure shall mean pressure of the liquid acting on the underground structures Pit/Basin walls etc.

3.1.10 TRAFFIC LOADS (TR)

Traffic Loads for plant engineering and construction shall be defined as the following loads according to the governing condition at construction, operation and maintenance. Unless otherwise specified, appropriate IRC Loading (Class A-A) shall be applied to the design of road crossing constructions such as drainage pipes and cable trench.

3.1.11 CONTINGENCY LOADS

3.1.11.1 RCC STRUCTURES

All floor slabs and beams shall be designed for a concentrated load of 10 KN acting simultaneously with the uniform live load, but not with actual concentrated loads from equipment, piping etc. This load shall be placed to result in maximum moment and / or maximum shear.

This load shall not be considered for the design of columns, foundations and in overall frame analysis. For floor slabs, the load shall be considered to be distributed over an area of 0.75 m x 0.75 m.

3.1.11.2 STRUCTURAL STEEL

For process plants, the following contingency additional loading shall be applied to individual beam elements, these shall be applied as point loads to produce worst shear and bending stresses:

- Platform Walkways 3 kN
- Secondary Floor Trimmers 5 kN
- Primary / Grid beams 10 kN

3.1.12 MISCELLANEOUS LOADS

Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design Job specifications and shall also be referred to, for any specific loading.

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.

All the handrails, parapets, parapet walls, balustrades shall be designed for horizontal load mentioned in Table 3 of IS-875 (Part-2).

3.2 LOAD COMBINATIONS

Structural analysis and design shall take into consideration, worst combination of the above loads under different phases, such as, Erection, Operation, Hydro-test, Shutdown, Maintenance, and Blast for control room, as applicable.

3.2.1 FOR FOUNDATION DESIGN

LOAD CONDITION	LOAD COMBINATION
OPERATING	$DL + LL + E_O$
	$DL + LL + E_O \pm WL$
	$DL + E_O \pm WL$
	$0.6 X (DL + E) \pm WL$
	$DL + E_O + LL \pm SL$
	$DL + E_O \pm SL$
	$0.6 X (DL + E_O) \pm SL$
ERECTION	$DL + E_e \pm WL$
	$0.6 X (DL + E_e) \pm WL$
TESTING	$DL + E_t \pm WL$
	$0.6 X (DL + E_t) \pm WL$

3.2.2 FOR CONCRETE DESIGN

LOAD CONDITION	LOAD COMBINATION
OPERATING	$1.5 X (DL + LL + E_O)$
	$1.2 X (DL + LL + E_O \pm WL)$
	$1.5 X (DL + E_O \pm WL)$
	$0.9 X (DL + E_O) \pm 1.5 X WL$
	$1.2 X (DL + E_O + LL \pm SL)$
	$1.5 X (DL + E_O \pm SL)$
	$0.9 X (DL + E_O) \pm 1.5 X SL$
ERECTION	$1.5 X (DL + E_e \pm WL)$
	$0.9 X (DL + E_e) \pm 1.5 X WL$
TESTING	$1.5 X (DL + E_t \pm WL)$
	$0.9 X (DL + E_t) \pm 1.5 X WL$

3.2.3 FOR STRUCTURAL STEEL DESIGN

LOAD CONDITION	LOAD COMBINATION
OPERATING	DL + LL + E_O
	0.75 X (DL + LL + E_O ± WL)
	0.75 X (DL + E_O ± WL)
	0.75 X (DL + E_O + LL ± SL)
	0.75 X (DL + E_O ± SL)
ERECTION	0.75 X (DL + E_e ± WL)
	0.8 X (DL + E_e)
TESTING	0.75 X (DL + E_t ± WL)
	0.8 X (DL + E_t)

The design shall be governed by worst load combinations.

4.0 DESIGN CRITERIA FOR FOUNDATIONS

4.1 DESIGN BASIS FOR FOUNDATION

This document defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures/building foundations, equipment foundation, misc. support foundation, etc. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

Soil Investigation report attached with the bid is only indicative. However, the contractor is required to carry out confirmatory soil investigation, through the party approved by PMC / OWNER, and submit the report for Review / Approval. The report should contain all necessary details about suitable foundation system(s) for Project area.

Foundations shall be designed to permit field hydro test for all vessels and towers in operating position, excluding those vessels that are not designed for hydro test.

Type of foundations and other pertinent details thereof to be adopted shall be as per Soil Investigation report recommendations which are more stringent among the two.

Following clauses describe the general guidelines to be followed while designing the foundations; these clauses do not per se stipulate the type of foundations to be followed.

4.2 SHALLOW FOUNDATIONS

Foundation sizing for shallow foundations shall be based on working loads, not on loads which may have been increased by factors for the purpose of concrete design.

For load combinations including seismic forces, the Safe Bearing Pressure of Soil and the Safe Bearing Load of piles shall be increased as permitted in IS: 1893.

Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. However, minimum cement content, type of cement, and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document.

Permissible settlements of Foundations

For open foundations, the total permissible settlement and differential settlement will be governed by IS: 1904/ IS: 13063 respectively and from functional requirements whichever is more stringent. However total settlements of foundation resting on soil will be restricted to following:

Foundation Type	Allowable settlement (mm)
Shallow Foundations in unit areas, utility areas and foundations for plant buildings including substation, compressor house, control room, technological structures	25
Shallow Foundations Supporting non-plant buildings	25
Continuous Raft Foundation	40
Pipe Racks	25
Pump House	25

Note: for all other foundation settlement criteria shall be as per IS code requirements

4.2.1 GROUND WATER TABLE

The ground water table (GWT) and other pertinent details thereof to be adopted shall be as per Soil Investigation report recommendations.

The ground water table (GWT) within project limit varies from 0.6~2m* (Approx.) depth from existing ground level. However, the Ground water levels shall be considered at ground level while checking stability against uplift.

4.2.2 UPLIFT ON FOUNDATIONS

In the design of foundations, the upward pressure of water, where applicable, shall be taken as the full hydrostatic pressure applied over the whole area. Ground water table shall be assumed to be at ground level for calculating the hydrostatic pressure. Any other upward load shall also be included in the design.

Partial contact between the foundation and soil strata shall be considered wherever applicable. The footing will be checked for minimum contact area and maximum bearing pressure will be calculated for the actual contact area only.

Allowable loss of contact area between underside of foundation and soil (due to resultant overturning moment) under different loading conditions shall be as given below.

Load Combination description		Allowable % Loss of Contact Area
A	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 10%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 25%
	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 20%

B	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 30%

Where A = Foundations on Soil B = Foundations on Rock

4.2.3 SOIL AND HYDROSTATIC PRESSURE ON WALLS BELOW GRADE

In the design of walls below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or whole of the adjacent soil is below a free water surface, computations shall be based on the weight of the soil diminished by buoyancy, plus full hydrostatic lateral pressure.

The lateral pressure from surcharge loads shall be taken in addition to the lateral earth pressure loads.

4.2.4 STABILITY OF FOUNDATIONS/ SUB-STRUCTURES

Foundations shall be checked for stability against overturning, sliding & uplift. While checking stability, the following shall be considered;

a) Stability against Overturning

Minimum Stability Ratio i.e. Factor of safety required against overturning (M_R/M_O) both being calculated at the leading edge of the foundation considering all forces and moments.

M_R = Resistant moment and M_O =Over turning moment

b) Stability against Sliding

The resistance to sliding shall be calculated from the following, where applicable:-

1) Foundation / soil friction

2) Passive soil resistance to the side of the foundation

3) Passive soil resistance of soil bearing against keys

c) Stability against Uplift

Ground water levels shall be considered at ground level while checking stability against uplift. Beneficial load of backfill can be included only in circumstances where it will never be removed.

d) Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like under ground storage tanks, pits, trenches, basements, etc. Minimum factor of safety of 1.25 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For purpose of calculating downward load due to any overburden, the mass located vertically above and the inclined portion depending on the θ angle of soil. the projected area of the base slab shall be taken in to consideration.

e) Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

f) In cases where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

g) All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS: 456 and other latest relevant IS codes. However following minimum factor of safety shall be followed.

h) Foundations shall be checked for stability against overturning, sliding & uplift. While checking against uplift, the following shall be considered.

FOUNDATION DESIGN – FACTORS OF SAFETY

Type of Structures	Minimum factor of safety against overturning		Minimum factor of safety against Sliding		% Weight of Overburden over projected plan area of footing
	With wind or seismic	Without wind or seismic	With wind or seismic	Without wind or seismic	

All Buildings/ Structures / Eqpt. In Units	1.5	2.0	1.5	1.5	100
Pipe Rack (Offsite)	1.5	2.0	1.5	1.5	50
Flood Light Mast	1.5	-	1.5	1.5	50**
Retaining Wall	1.5	2.0	1.5	1.75	100
Over Head water tank	1.5(empty) 2.0(full)	-	1.5	-	50**
Blast Resistant Structures	1.5	2.0	1.5	1.5	100
Flare supporting Structures	1.5	-	1.5	-	50**

** In case area is paved, overburden shall be based on NGL (for area under filling) or 600 mm below HPP, whichever is lower. In case of unpaved area, it shall be w.r.t. FGL.

Buoyancy from high ground water levels shall be taken into account in investigating stability against uplift.

4.2.5 FOUNDATION ON SOILS

The bearing capacity used in design shall be based on both shear strength of soil as well as settlement.

Footings shall be embedded into a sound, non-degradable surface having sufficient depth to provide adequate bearing resistance.

Piping failures of fine materials through rip-rap or through drainage backfills behind abutments shall be prevented by properly designed, graded soil filters or geotextile drainage systems.

4.3 PILE FOUNDATIONS

a) Piling shall be considered when footings cannot be founded on granular soil or stiff cohesive soils within a reasonable depth. Piles shall also be used where the spread footings shows an unacceptable amount of settlement.

b) Piles shall be designed as per IS: 2911. However, pile capacity shall be proven by a sufficient number of initial load tests before preparing piling plans.

c) The increase in Safe Working Load permitted as per codal provisions, under load combinations including wind / earthquake shall apply equally to uplift and sheer conditions, subject to confirmations by the piling Contractor with respect to the particular piling system. Pile capacity may be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

d) Design capacity shall be established by conducting sufficient number of initial load tests. Routine pile load tests shall also be carried out as per IS 2911 (Part 4) on working piles. When any major machinery is to be supported on piles, behaviour of the piles under dynamic loading conditions as established by necessary field tests shall be considered.

e) The capacity of pile groups shall be obtained by applying appropriate group efficiency factors. Where piles pass through filed ground, the available pile safe working load shall be suitably reduced to account for negative skin friction caused by settlement of fill. Where suitable, consideration shall be given to reducing drawdown effects by slip coating the piles

f) When any major machinery is to be supported on piles, behavior of the piles under dynamic, loading conditions, as established by necessary field test, shall be considered.

g) While computing horizontal capacity, piles shall be treated as fixed head or free head depending on the degree of fixity at the top.

4.4 FOUNDATIONS

a) Foundation shall be proportioned in such a way that the allowable soil bearing capacity is not exceeded and the resulting settlement is within the acceptable limit in case of shallow foundation. For pile foundations, load on pile shall not exceed acceptable limit.

b) Foundation sizes and depths shall be planned considering subsurface conditions and surrounding underground constructions such as adjacent foundations,

underground pipes and cables, trenches, pits, roads as well as the slope of ground.

c) Isolated footing shall be planned for each foundation. However, where adjacent footings interfere with each other, combined footing may be provided.

d) Where applicable the elevation of foundation top shall be in accordance with the process, mechanical and piping requirements.

e) For structures supported on strip footing of width one meter or less, suitable tie beams shall be provided connecting all the footings at foundation level.

f) Masonry walls shall be supported on continuous plain cement concrete mats / plinth beams. Top of plinth beams shall be located at least 300 mm below the finished grade level. Fouling of plinth beams with cable trenches, drains, pipe ducts etc shall be avoided by suitably lowering the beam levels.

4.4.1 FOUNDATIONS FOR ROTATING AND RECIPROCATING EQUIPMENTS

a) Foundations and structures supporting rotating machinery shall satisfy the requirements of IS: 2974 and any other parameters as per machine vendors. Foundation block extensions supporting auxiliary equipment's requiring rigid positioning with respect to the main equipment shall be detailed to act integrally with the block.

b) Generally, foundations and structures supporting rotating machinery shall be so proportioned that their natural frequency shall not fall within the range of 0.8 to 1.2 of normal operating speed of the equipment.

c) Foundation for rotating and reciprocating equipment's such as turbines, engines, compressors and generators shall be designed to secure the dynamic stability of the foundation system, as well as the static stability.

d) Dynamic stability for foundation supporting heavy vibrating equipment's like the following shall be secured by dynamic analysis in general:

- Heavy vibrating equipment,

- Equipment sensitive to vibration,

- Equipment causing large dynamic force

e) All foundations for dynamic equipment's shall be isolated from floor or any other static foundation by providing filler board all around foundation. Clear air gap shall be provided in Superstructure to avoid transmission of vibration to adjacent structures. Special note shall be given on the drawing in this respect, and suitable details be shown as required.

4.4.2 GENERAL REQUIREMENTS FOR DESIGN

Following minimum requirements shall be taken into account for foundation design in principle.

a) Further, design shall be carried out such that amplitude of vibration during normal operation or other critical conditions shall not exceed the allowable amplitude specified by the equipment manufacturer or IS: 2974,whichever is more stringent. The above design criterion may be omitted for centrifugal pumps and fans and other minor rotating equipment weighing less than 1 ton or if the mass of the rotating parts are less than 1/100th of the mass of foundation installed directly on concrete foundation provided that the weight of foundation is not less than 3 times of the equipment weight. In such cases, dynamic analysis is not necessary.

b) Foundation for heavy vibrating equipment shall be kept independent of building floors/ foundations and other adjacent foundations.

c) Foundation weight shall be at least three times the weight of the rotating equipment and five times the weight of the reciprocating equipment.

d) The weight of foundation slab shall not be less than the combined weight of the structure and the machine.

e) Foundation shall be of uniform rectangular/ square shape. Beams and columns of foundations shall be of uniform rectangular/ square shape.

f) The horizontal eccentricity, in any direction, between the center of gravity of the machine - foundation system and the center of base contact area or centroid of the pile group, shall be within 5% for block foundations and 3% for frame foundations. However, in highly compressible soils no eccentricity shall be permitted.

g) The geometric layout of the foundation and structure shall be basically symmetric with respect to the vertical plane passing through the rotational axis of the equipment.

h) Minimum reinforcement as per requirements of IS: 2974 shall be provided unless required otherwise by design.

i) Soil stress below foundations under dead loads shall not exceed 80% of the allowable soil bearing capacity for static loading.

j) It shall be ensured that there is no transfer of vibrations from machine foundations to any part of the adjoining structures. In case such machine is sitting on building floors, approved damping pads shall be used with prior approval of OWNER / CONSULTANT.

4.4.3 DYNAMIC ANALYSIS

Dynamic analysis shall be performed by suitable and approved method so that dynamic feature can be evaluated correctly:

Following effects shall be taken into account:

- Dynamic features of subsoil
- Dynamic features of supporting foundation system
- Dynamic effect of the foundation system
- Dynamic forces of equipment

Data of dynamic load to be used for the dynamic analysis shall be supplied by Equipment Supplier and shall state unbalanced force due to:

- Eccentricity of dynamic mass of rotating equipment
- Different crank arrangement of reciprocating equipment

4.4.4 EVALUATION OF DYNAMIC ANALYSIS

a) Foundations shall be so designed that natural frequency of the foundation system shall not resonate with the following:

i) Operating speed of the motor.

ii) Operating speed of the machine.

iii) 2 times operating speed of the machine

(This condition shall be complied only when the manufacturer has furnished the unbalanced forces related to 2 times the operating speed of the machine)

iv) Critical speed of the machine (for centrifugal machines).

Natural frequency of the foundation shall be ±20% away from the above mentioned frequencies. However, amplitudes of vibration of the foundation block shall always be checked to be within permissible limits

Where deviations (resulting from inaccuracies in soil parameter measurements, approximations in design method, etc.) from calculated natural frequencies, leading to amplitudes in excess of specified limits, are foreseen, provisions for increasing foundation mass without removal of the machine and without affecting surrounding space availability or connected piping shall be made, if possible.

b) Allowable amplitude due to dynamic load

Amplitude of the foundation systems for vibrating equipment shall be calculated through dynamic analysis by using dynamic load supplied by supplier and the allowable amplitude shall conform to supplier's requirement.

If supplier's requirement on amplitude is not specified, following criteria shall be applied:

The amplitude of vibration of the foundation in any direction, at any point in the foundation or structure shall be such that, it will fall down the zone ACC' for the specific exciting frequency as given in IS: 2974 (Part I)-1982 figure 3 "Amplitude Limits of foundation block ".

4.4.5 COMPRESSER FOUNDATIONS

Each structure and foundation supporting a compressor, pump or other machinery having significant dynamic unbalance shall be designed to resist the peak loads specified by the manufacturer. Vibration amplitudes of the supporting

structure or foundation shall be kept within acceptable limits for dynamic forces that occur during normal machine operation.

For the foundation supporting minor rotating equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary.

The design of machine / equipment foundation shall be as per ISO 1940-1/ ISO-10816-2, IS: 456 and IS: 2974. The provisions of DIN 4024 shall also be followed for machine foundations.

All machine / equipment foundations and structures subject to vibrations shall be suitably proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

Analysis and design of the COMPRESSER foundation shall be carried out in accordance with relevant codes IS: 2974 Part-3 and IS: 456 and/or manufacturer's requirements. Dynamic analysis shall be carried out using finite element software. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Unbalanced loads for normal operating condition as given by machine manufacturer and/ or ISO-1940 whichever is more shall be used for calculating dynamic response.

The static analysis shall include all operating conditions, load cases and abnormal loads like loss of blade, unbalance and seismic forces.

Natural frequencies and amplitude of vibrations of COMPRESSER foundation shall be as per relevant applicable code of practices as indicated above and/or as per manufacturer's requirements. Amplitudes calculated shall be ensured to be within the permissible limits as specified by the manufacturer. In the absence of specified criteria, amplitude shall be limited to alarm limit specified in ISO 10816–2. The Compressor foundations shall also be designed to meet the manufacturer's static deflection criteria, if any.

The minimum reinforcement in Compressor base raft shall be 0.12% on top face and 0.2% on bottom face Shrinkage reinforcement due to thermal expansion/connection shall be provided in 3D grid pattern in the base raft. .

The number of construction joints in the pedestal will be kept to minimum to achieve the monolithic behaviour of the structure. The base raft shall be cast in a single pour with construction joints at the top of the raft. The subsequent construction joints shall be provided in columns at the top of mezzanine floor and below the top deck. Continuous concreting shall be done for top deck/ beam portion. Special care shall be taken during concreting of pedestal to avoid cold joints and to ensure proper compaction and curing of concrete.

The pedestals supporting Compressor shall be completely isolated from Compressor building at all the floors by suitable gaps to prevent the transfer of vibrations. All foundations of major equipment subject to heavy vibrations shall be separated from adjoining part of building and other foundations. Joints at floor / slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitable to ensure integral action.

4.5 TANK PAD FOUNDATIONS

Tanks shall be supported on compacted sand filling contained within ring walls. The ring walls will be designed for hoop tension resulting from side pressure exerted by sand fill due to surcharge of storage tank full with water. The ring foundations shall be designed as per the provisions of IS: 456 and IS: 11089.

4.6 LIQUID RETAINING R.C.C. STRUCTURES AND BASEMENTS

4.6.1 All liquid retaining / storage R.C.C. structures shall be leakpoof and designed as uncracked section in working stress method as per IS:3370. However, the parts of such structures not coming in contact with the liquid, shall be designed according to IS:456 except ribs of beams of suspended floor slabs and counterforts of walls (located on the side remote from liquid) and roof of liquid retaining structures which shall be designed as uncracked section. Hot/cold water basin, and other primary framing members of Cooling Towers and similar liquid retaining structures, which remain constantly in contact with water (stored / sprayed) shall be designed as

uncracked sections. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.

4.6.2 RCC water storage tanks and other water retaining structures like clarifier, water storage tank, water treatment structures like filter house, underground tanks, cooling tower basin, cooling water channels and also substructure of pump houses shall be designed in accordance with IS: 3370-2009.

4.6.3 All liquid retaining / storage structures shall be designed assuming liquid up to the full height of wall, irrespective of provision of any overflow arrangement. Pressure relief valves or similar pressure relieving devices shall not be considered in underground water retaining RCC structures. Hot water basin in cooling tower shall be designed for the weight of water up to top of parapet wall.

4.6.4 Base slab and columns of the pump houses will also be designed for the condition of different combination of pump sumps being empty during maintenance stages with ground water level at formation level.

4.6.5 Intermediate dividing pier of pump sumps and partition wall in channel will be designed considering water on one side only and other side being empty for maintenance.

4.6.6 Storm water drains shall be designed as per IS: 456 using Limit State method.

4.6.7 Earth pressure for all underground structures will be calculated using coefficient of active earth pressure or at rest depending upon the boundary condition.

4.6.8 The walls and base slabs of liquid retaining storage structures shall be provided with reinforcement on both faces for thicknesses greater than 150 mm.

4.6.9 In all liquid retaining structures, PVC water bars (230 mm wide, 6 mm thick) shall be provided at each construction/ expansion joint. PVC water bars shall be of minimum 150/230 mm width and 6 mm thickness, and generally shall be riffed/serrated type with a central bulb Kicker type PVC water bars shall be used for the base slab and in other areas where it is required to facilitate concreting.

5.0 DESIGN CRITERIA FOR REINFORCED CONCRETE STRUCTURES

5.1 GENERAL

a) All buildings, structures, foundations, machine equipment foundations, liquid retaining storage structures, trenches, pits etc. shall be of RCC and designed based on the following IS codes (latest revision with all amendments, issued there to) in general, and other relevant IS codes applicable : IS:456, 875, 1893, 1904, 2911, 2950, 2974, 3370, 4326, 4991, 4998, 5249, 6403, 8009, 13920.

b) Only limit state method as per IS: 456 shall be followed for the design unless otherwise specified elsewhere in this document for special structures.

c) All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS: 13920.

d) Where the specified design depth of groundwater table so warrants, all underground pits, tunnels, basements, etc. shall be leak-proof R.C.C. construction using water proofing compounds.

5.2 RCC FRAMED STRUCTURES

All reinforced concrete framed structures will be rigid/moment resisting frames along both longitudinal & transverse directions.

The suspended floor slab will be considered as continuous over secondary beams and will not form part of framing system. However, it will be considered to transfer shear to the framing system and also assumed to act as diaphragm element to resist lateral forces.

The concrete frame members will be designed by Limit state method in accordance with IS-456.

The effective length of concrete pedestals supporting structural members shall be 1.5 times the actual length. The reinforcement for column shall be as per the design requirement. However the minimum reinforcement shall be 0.8% of the effective sectional area or 0.15% of the gross cross sectional area or as per the requirement of IS: 13920 whichever governs. The floor beam/roof beam & wall beams shall not be designed for compression. Minimum reinforcement criteria / minimum and maximum reinforcement for various structural elements such as beams, columns, footings, slabs, walls, pedestals etc as per relevant IS code.

5.3 DESIGN BASIS AND REQUIREMENTS

5.3.1 Framing Systems shall be arranged so that the stiffness of structure can be well balanced and the structural stability can be secured.

5.3.2 Structural analysis and section design shall be made in accordance with the applicable codes, standards and specifications and by using the validated software's and approved methods.

5.3.3 In case of heavy and/ or tall equipments installed on the reinforced concrete structure, the floor beam and framing column arrangement shall be so planned that the firm anchoring and structural stability shall be assured.

5.3.4 Pits and basins shall be designed to withstand the water pressure, earth pressure, buoyancy and surcharge where required. Pits and Basins containing liquids shall be designed for both full and empty conditions and partition walls between compartments shall be designed for alternative liquid pressure on either side. Dykes shall be designed to withstand the pressure of containing liquid for both full and empty conditions.

5.3.5 Minimum Dimensions of Concrete Members

a) Member sizes shall be as per Design Requirements. However, minimum dimensions of structural members shall be as given below:

Pile cap……. : 500 mm

Levelling concrete……... : 50 mm

Grade slabs……. : 150 mm

b) Underground Pit/Reservoir (Below ground Water table) – Walls & Base Slab… : 150 mm

c) Underground Pit/Reservoir (Above ground Water table) – Walls & Base Slab… : 150 mm

d) Liquid retaining / Leak-proof structures

- Walls & Base Slab…….. : 150 mm
- Columns & Pedestals……. : 300 mm width

e) Beams…….. : 300 mm width,

f) Floor / Roof slab…….. : 150 mm

g) Walkway…… : 1500mm wide, 100 mm thick

h) Parapet/Chajjas/Cantilever canopy slab. ……..: 100 mm

i) Cable/Pipe trench Walls & Base slab…… : 100 mm

j) Precast Trench Cover / Precast Floor Slab…. : 125 mm

k) Louvre/Fin (not in contact with liquid) ……. : 100 mm

l) Louvre (in contact with liquid) …….. : 125 mm

m) Base slab with beams …….. : 200 mm

n) Base slab without beams…….. : 300 mm

a) Insert plate…….. : 10 mm

b) Corner angle…….. : 6 mm

c) Footings (All types with or without beams) . : 300 mm

Note: Tapered footings shall not have thickness less than 150 mm at the edges. Minimum average thickness shall not be less than 300 mm

5.3.6 Minimum Height of Pedestals above Finished Grade Level

The minimum height of outdoor and indoor pedestals (supporting equipment / structures) above the highest paving level/finished floor level shall be:

Building plinth : 450 mm above finished ground level

Pedestals for structural columns:

Open paved area : 300 mm (min.) OR as indicated in Equipment layout drawing

Open unpaved area : 300 mm

Covered area(building etc.): 300 mm (min.) OR as indicated in drawing

Storage tank foundation : As per equipment layout

All equipment supporting foundations / pedestals

Open area : As required but not less than 300 mm

Covered area : As required but not less than 150 mm

Stair Pedestals : 300 mm (min.) OR as indicated in equipment Layout drawing.

Ladder pedestals : 300 mm

5.3.7 Minimum Clear Cover to Main Reinforcement

For structural elements which are exposed to fire (i.e. structures which are designed for fire resistance), consider nominal cover criteria as per IS 456 table 16 and as per relevant fire rating. Reinforcement shall have concrete cover not less than twice the diameter of bar at end. Minimum cover to main bar shall be:

a) Slab (roof & floor)…….: Free face…... 30 mm or dia of bar whichever is greater.

Canopy, Chajjas, Waist Slab..: Face in contact with earth…….: 30 mm

b) Beam…… : Top & Bottom…….. : 45 mm

: Side…….. : 45 mm

: Face in contact with earth……. : 50 mm

c) Column and pedestal…….. : Super Structure…….. : 50 mm

: Face in contact with earth……. : 50 mm

d) Retaining wall,…….. : Face in contact with earth……. : 45 mm

Basement and Pit wall : Free face…… : 45 mm

e) Liquid retaining…… : Face in contact with liquid……. : 45 mm

Structure: : Face in contact with earth……. : 45 mm

: Free face…… : 45 mm

f) Plinth beam…….. : Top ……..…….. : 50 mm

: Bottom…….. : 50 mm

: Sides……: 50 mm

g) Foundation…… : Top …….. . : 50 mm

: Bottom…….. ……. : 50 mm

: Sides…… : 50 mm

h) Pile…… :Sides…… : 75 mm

i) Pile cap…… : Bottom…….. : 100 mm

: Top & Sides…… 75 mm

j) The above requirements shall not be applied to concrete construction of trench, local foundation, minor platform foundation, sump pit/ manhole, paving and other miscellaneous concrete construction, for which minimum clear cover shall be 25 mm.

5.3.8 Minimum Bar Diameter (Except for Blast Proof Construction)

Piles – Main Bars…….. : 12 mm

Piles – Ties…… : 8 mm

Major Foundation…….. : 10 mm

Block Foundation - Main Bars…… : 10 mm

Block Foundation - Tie Bars…… : 8 mm

Minor Foundation (Local foundation etc.)…….. : 8 mm

Column, Pedestal - Main Bars…… : 12 mm

Column, Pedestal – Ties…….. : 8 mm

Beam - Main Bars…… : 12 mm

Beam - Anchor Bars…… : 10 mm

Beam – Stirrups…… : 8 mm

Slab - Main Bars…… : 10 mm

Slab - Distribution Bars…… : 8 mm

Wall - Main Bars…… : 10 mm

Wall - Distribution Bars…….. : 8 mm

Minor Elements such as Chajjas, Lintel Beams, etc…….. : 8 mm

Slab and Wall for Blast proof building ……..…: 12 mm

5.3.9 Bar Spacing

Minimum and maximum bar spacing for Foundations, Slabs, Stirrups for Beams, and Ties for Columns, Pedestals, Walls etc. shall be as per IS 456 & IS:13920. Bar spacing shall be provided in multiples of 25 mm.

5.3.10 Expansion Joints

Concrete structures

Expansion points in concrete structures shall be provided at 30-35 m centers. The expansion joint shall be provided preferably by way of twin columns on a common foundation. Sliding joints shall be avoided as far as possible.

5.3.11 Deflections

Deflections in concrete structures shall in general be limited by adherence to the limits on span by depth ratio for beams and slabs and length to lateral dimension ratios for columns as prescribed in IS: 456. Where special functional / serviceability requirements or large spans demand actual deflections and / or crack widths shall be calculated and the following limits adhered to:

- Total deflection due to all loads including the Effects of temperature creep and shrinkage : Span/250
- Crack width (for non-liquid retaining structure) : 0.3 mm
- Total horizontal deflection between two floors : Storey height/200

5.4 BUILDING SLABS ON GRADE

The specifications given in Table-1 shall be followed.

Sl. No.	DESCRIPTION		FLOORING TYPE		
			I	II	III
1.a	Sub Grade	Earth fill base compacted to 95% dry density	Yes	Yes	Yes

1.b		Rubble soling	230 Thick	230 Thick	150 Thick
2.a	Structural Grade Slab	Lean concrete 1:5:10 over 1.b layer	50 Thick	50 Thick	50 Thick
2.b		Stable in Grade M20 concrete (Reinforced with 8 mm dia bars @ 200 c/c both ways) over lean concrete	150 Thick	150 Thick	100 Thick
			R/F placed centrally	R/F placed in two layers at top & bottom	No reinforcement required
3	Finish	Floor finish	As/Architectural detail	As/Architectural detail	As/Architectural detail

TYPE I: Plant buildings such as Sub-stations, Control Rooms, Process Operators' Room, Pump Houses, Utility Compressor Houses, D.M. Plant, E.T.P., Parking Areas, Stores, Porches.

TYPE-II : Warehouses, Workshops, Cement Godowns, Fire Stations, Process Compressor House.

TYPE III: Non Plant Buildings (viz. Administration, Laboratory, Canteen, Time Office, Gate House, Training Centre, Guest House, Residential Building)

5.5 RCC AND STEEL CHIMENY

RCC and steel chimneys shall be designed as per IS: 4998 and IS: 6533 respectively.

5.6 CULVERTS

Culverts shall be designed as per the following IRC codes of practices and manual. Where crane access is specified, the culverts shall be designed for the crane loads.

a) Standard specifications and code of practice for Road Bridges (Section – I - General features of design) IRC 5

b) Standard specifications and code of practice for Road Bridges (Section-II – Load and Stresses) IRC 6

c) Guidelines for Evaluation of Load Carrying Capacity of Bridges SP 37

6.0 CRITERIA FOR MASONRY WORKS

6.1.1 GENERAL

All masonry works shall be designed in accordance with IS:1905, IS:1597, IS:2185, IS:4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. ES 2516, enclosed with the tender may be referred for details. Masonry shall be plastered with CM 1:6, 12 mm thick on inside surfaces and 20 mm thick on outside surfaces.

6.1.2 CEMENT MORTAR

All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with 2 nos.8mm dia. M.S bars provided at every fourth course properly anchored with cross walls or pillars.

6.1.3 MASONRY WALL

a) All masonry walls from ground floor shall be placed on R.C.C. grade beams. However, light internal partitions may be placed on ground floor slab.

b) All brick masonry (M 7.5 grade) walls shall be considered as 230mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.

c) All in-filled brick (M7.5 grade) panels shall be designed to transfer horizontal loads from wind and seismic to the structural frameworks without damage and the extent of brick panel dimensions shall be as per the recommendations in IS. All half masonry wall shall be provided with reinforcement consisting of 2 Nos. of 8mm diameter bars at every fourth layer.

6.1.4 FIRE WALLS

Thickness of all masonry firewalls shall be as per Electricity Rules but not less than 345 mm.

7.0 DESIGN CRITERIA FOR STEEL STRUCTURES

This Specification covers the Requirements for the Design of Steel Structures such as Steel Buildings (Shelters & Sheds), Pipe Rack, Local Pipe Supports, Cable Racks, Equipment Supporting Structures, Platforms & Walkways, Staircase, Ladders, Handrails, Crane Gantry, Girders and Monorails flare stack, etc.

Excluded from the scope of this Specification are the Design Requirements for Platforms / Stairs / Ladders / Handrails directly attached to equipment and Stacks including Support Structures.

7.1 GENERAL / DESIGN METHODS

7.1.1 Design fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz, IS:800, 801, 802, 806, 814, 816, 875, 1893, 6533, 9595, etc. Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy, satisfying relevant Indian Standard Codes of Practice. Steel structures adequately braced in vertical and horizontal planes, consistent with functional requirements, shall be preferred over structure having moment connections. Moment connections, if adopted, shall be fully rigid as per IS:800. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member. Flare stack supporting structure shall be adequately braced on all four faces.

7.1.2 Structural elements, continuously exposed to temperatures above 200º C, shall be designed for reduced stress as per Table-4 of IS: 6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400 º C. The structures connected to column, heater vessels working at high temperatures shall not be rigidly connected with staircase and adjoining structures, which are on ambient temperatures.

7.1.3 Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.

7.1.4 Monorails shall be provided for all pumps and motors located in buildings, sheds and in open areas having rating more than 55 KW. For pumps and motors of smaller ratings, monorails shall be provided if directed by Owner / PMC.

7.1.5 Steel staircases shall have channels provided as stringers with minimum clear width of 750 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 m wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 200 mm. If relevant local by-laws or applicable Factory Act Rules stipulates more stringent requirements in this regard, the same shall be adhered to.

7.1.6 Hand rails, 1000 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 5 mm) shall be provided for all hand railing (except for staircases). Spacing of uprights shall be 1500 mm (maximum). Two types of hand railing shall be provided.

a) For walkways, platforms (except platform around/on circular & horizontal vessels), and staircases: Top rail, mid rail and upright shall be 32 mm dia. (NB) galvanized MS tubes.

b) For platforms around circular vessels : Top rail shall be 32 mm dia. (NB) galvanized MS tubes, but mid rail and upright shall be of structural steel.

7.1.6 Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30 mm x 55 mm. The minimum thickness of galvanizing shall be 120 microns. Gratings shall be suitable for the operation and maintenance loads for the floors.

7.1.7 Welded connections shall be adopted as far as practicable, except for cases where bolted connections are required viz. (Galvanized) electrical switchyard structures and transmission towers. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members.

7.1.8 Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.

7.1.9 Minimum two nuts shall used for all anchor bolts except for ladder, stair and hand rail

7.2 DESIGN BASIS FOR STEEL FRAMED STRUCTURES

7.2.2 DESIGN CONSIDERATIONS

Design of steel structure will be carried out by Limit state method in accordance with IS-800-2007code with specific reference to other relevant IS codes wherever required.

The distance between point of lateral restraint shall form the basis for finding out the allowable stress in axial compression and bending.

Concrete floors where the compression flange of beam embedded to a minimum of 10mm into RCC shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However where large cut outs are provided in the floor slabs horizontal floor bracing shall be provided.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimise vibration, avoid resonance and maintain alignment and level.

Horizontal plan bracings shall be of angle / tee section located at the upper portion of framing secondary beams so as to make lateral strain effective in compression zone.

Interaction ratio shall be restricted to 0.9.

7.2.3 DESIGN BASIS AND REQUIREMENTS FOR SPECIFIC APPLICATIONS

a) Framing and bracing shall be planned so that the stiffness of the structure can be well balanced with the loads and the structural stability can be secured.

b) Vertical & Horizontal bracings shall be arranged properly, considering the following requirements:

- Plant Layout
- Equipment / Piping arrangement
- Structural Layout
- Construction, operation & maintenance requirement.

c) Expansion joints shall be provided at 80 – 100 m centres, where possible, column bracing shall be provided at the center of a longitudinal frame, rather

than at the ends so as to avoid constraints on free expansion. An expansion joint for the structure shall be as per clause 3.10 of IS: 800-2007.

d) Structural analysis and members selections shall be made in accordance with the applicable codes, standards and specifications and by using the validated software and approved methods.

7.2.3.1 PIPE & CABLE RACK STRUCTURES

a) The pipe and cable rack structures will be of structural steel construction and will accommodate the pipes/cables trays with proper access, walkways, operating platforms, and adequate working space for erection and maintenance.

b) The size and no. of tiers will be finalised during detailed design depending upon the size and number of pipes and cable trays.

c) All transverse frames will generally be braced below the pipes with head room for personnel movement to transmit the lateral forces to foundation level and the lateral forces in longitudinal direction will be taken care through vertical bracing in longitudinal direction. However, the detail framing shall be decided based on General arrangement & load data during detailed engineering.

d) The structural frames will be designed to become adequately rigid to carry the forces from the pipelines at anchor points without undue deflection. The pipe and cable rack structure will be designed for longitudinal thrust forces arising out of friction between pipe and support point by provision of suitable vertical bracing in longitudinal direction.

e) In case the pipe is routed on the ground on sleepers, the height of the pipe above ground shall be 300mm.

f) Longitudinal beams are required to support piping entering or leaving the pipe rack and to support intermediate transverse beams. Longitudinal beams may also be required for structural continuity, and in braced bays, for structural stability. The spacing of transverse beams depends on the diameter of the piping and the type of cable trays to be supported.

g) The positions of anchor bays shall be determined as per the requirement of Piping stress and support. During the structural arrangement finalization, special consideration shall be given to take care of the torsion in the structural members arising due to cable supports.

h) When buildings are situated alongside pipe racks (e.g., compressor buildings), care shall be taken to line up the pipe rack frames with the building frames. This will facilitate the piping runs. For the same reason, anchor bays with vertical diagonal bracing shall be located away from compressor buildings.

i) A continuous longitudinal tie/strut member may be provided at the center of span and suitably framed with the horizontal bracing system at the anchor bays to reduce the horizontal span of transverse beam at each tier.

7.2.3.2 TECHNOLOGICAL STRUCTURES

a) These are mainly for supporting Horizontal Heat Exchanger & vessels installed on steel structures. Preferred method of structural arrangement is, bracing in one direction (longitudinal) and moment connection in other direction (transverse). For structure configuration, due considerations to be given for erection/ installation/ operation and maintenance requirements.

b) Platforms are provided around the equipments and hence head room clearance to be critically checked.

7.2.3.3 FLOORS, PLATFORMS AND WALK WAYS

a) Platform and Maintenance walkways shall be minimum 1000 mm wide and shall be made of grating flooring unless otherwise specified. Platforms below the airfin coolers shall be provided with GI grating/ RCC platform. Space for piping, conduits, lighting fixtures shall be above the headroom.

b) The minimum clear headroom over platforms and walkways shall be 2500 mm to the lowest point of overhead structural framing or equipment.

c) Chequered plates shall be minimum 6 mm thick.

7.2.3.4 STAIRS & LADDERS

a) Stairs / Cage Ladders shall be provided from grade level to highest operating level. All buildings with flat roof shall be made accessible. All stairs shall have not more than twelve (12) risers in one flight. Height of risers shall be 150mm to 166mm (maximum 180mm for fire escape stairs) and width of treads shall be 250 mm (minimum). Minimum width of stairs shall be 1200 mm. Minimum headroom of 2500 mm to be maintained in all staircases.

b) All staircases shall be in structural steel unless otherwise noted.

c) Escape staircase shall be provided in plant and non-plant buildings as per Fire Regulation Rules in suitable locations.

d) No ladders shall be permitted, except for large field erected tanks and secondary means of egress from isolated areas where placement of stair is not practical, ladder may be used. Platforms shall be connected with walkways where necessary. All platforms shall have kick plates at edge of platform. Operating platforms shall not be less than 1000 mm wide Emergency escape ladders shall be provided for platforms with dead ends. All Platforms from the elevator lobby shall extend to main staircases.

e) Ladders shall be 450 mm wide and shall be made of stringers with 20 mm diameter M.S. rungs at 300 mm (max.) intervals.

f) The flight of Ladder without the intermediate platform shall not exceed 6000 mm. However, wherever feasible, staircase shall be provided.

g) Ladders over 4500 mm in height or originated from a point which is 4500 mm or more above grade, shall be provided with safety cages, originating 2500 mm from the bottom.

h) Ladder access openings shall be provided with the safety chain.

i) Ladders shall preferably be vertical; however in no case the angle with the vertical shall exceed 5 degrees

j) Preferably side step Ladders shall be provided & all ladders shall be installed “facing the equipment”.

7.2.4 GENERAL CONSIDERATION IN STEEL STRUCTURE

7.2.4.1 PERMISSIBLE STRESSES

a) The permissible stress will be as per relevant IS Code.

b) Permissible stresses in bolts shall be as specified in IS: 800 and IS4000.

c) Appropriate increase in allowable stresses as per relevant IS Code.

d) Limiting Permissible Stresses

Permissible stresses in structural members shall be as specified in various codes.

IS:800 - Hot rolled sections (excluding transmission towers and Switchyard structures).

IS:801 - Cold formed light gauge sections

IS:802 - Transmission towers & switchyard structures

IS:806 - Tubular Structures

Permissible stresses in bolts shall be as specified in:

IS:800 - Hot rolled sections

IS:801 - Cold formed light gauge sections

IS:802 - Transmission towers & switchyard structures

IS:806 - Tubular Structures

Permissible stresses in welds shall be as specified in:

IS:801 - Cold formed light gauge sections

IS:806 - Metal Arc Welding

7.2.4.2 PERMISSIBLE DEFLECTION

a) PIPE RACK AND EQUIPMENT SUPPORTING STRUCTURE

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

Allowable deflection of beams and columns, to support Pipe and / or Equipment directly during normal operation, shall be as stated below for unfactored load.

i) Pipe Rack Beams : Span / 240, but not more than 30 mm

ii) Equipment Supporting Structure

Static Equipment Supporting Beams : Span / 300, but not more than 30mm

Vibrating Eq't/hoist Supporting Beams : Span / 300, but not more than 30mm

Other Beams : Span / 300, but not more than 30mm

iii) Horizontal sway at top of Column of Each

Storey for Open framed structures :Height / 300

For Cladded structures :Height / 300

Pipe Rack :Height / 300

iv) Cantilevers : Span / 150 but not more than 20 mm at end

b) CRANE GIRDERS

- Allowable Vertical and Horizontal deflection of girders for traveling cranes during normal operation, depending on types, shall be as stated below

i) Gantry girder for manually operated crane : Span / 500

ii) Electric overhead traveling crane upto 50 T : Span / 750

iii) Electric overhead traveling crane over 50 T : Span / 1000

iv) Other moving loads such as charging cars, etc. : Span / 600

Crane gantry girder due to surge : Span / 400

Building main columns at crane rail : Height/400

Gantry girder (to be checked as per the requirement of crane)

Open gantry columns at crane: as per the requirement of crane gantry girder rail level due to action of Crane surge load only

- Monorails and Hoist Beams : Span / 500
- Joists : Span / 300
- Purlins supporting any type of roofing material : Span / 200

  Under (dead load + live load) or (dead load + wind Load) conditions
- Other structural components : As specified in relevant IS

v) Gratings / Chequered Plates : Span / 200 or 6 mm whichever is minimum

vi) Minimum capacity of monorail shall be: 3 MT or 1.5 times weight of concerned equipment's whichever is higher.

The limiting permissible horizontal deflection for multistoried steel structure/ building including flare stack shall be Height/325.

7.2.4.3 MINIMUM THICKNESS & SIZES OF ELEMENT

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

Trusses, purlins, girts and bracing : 6 mm

Columns and beams : 8 mm

Flare Trestles, Stiffeners : 8 mm

Base plates :10 mm & above

Chequered plates : 6mm o/p & above

Grating flats :5 mm

COLUMN BASE PLATE

For major Structure : 16 mm thick.

For minor Structure : 12 mm thick.

Stiffeners : 8 mm thick.

GUSSET PLATE

Thickness of Gusset Plate required in trusses & girders shall be maximum of the followings:

(a) Up to and including 12 m span : 8 mm

(b) Above 12 m : 10 mm

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

For cold formed sections which may be used for purlins & girts the minimum thickness criteria shall be relaxed.

7.2.4.4 SLENDERNESS & DEPTH RATIO

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800.

The following limiting ratios of depth to span shall be considered as a general guide.

a) Truss 1 / 10 ~ 1/12

b) Rolled beams and girders for Ordinary floors and rafters 1 / 24

c) Supporting floor beams for vibrating Machines / equipment's 1 / 15

d) Roof purlins and girts 1 / 45

e) Gable columns 1 / 30

7.2.4.5 MINIMUM COVER TO FOUNDATION BOLTS

a) Minimum distance between a Standard Holding down Bolt or Anchor Sleeve and the face of Foundation/pedestal shall not be less than 6 x (dia of bolt) mm.

b) Minimum distance between the inside surfaces of the anchor boxes and the outside surface of the foundation shall be 75 mm.

c) Clear distance between the edge of the base plate or base frame to the outer edge of the pedestal shall be minimum 50 mm.

d) In general, anchor bolts for structural steel columns are embedded into the pedestal. Clear distance from the edge of the sleeve or anchor plate to the edge of the pedestal shall be minimum 75 mm or the distance from center of

anchor bolt to the edge of pedestal shall be 6 times bolt diameter or 125 mm, whichever is greater.

7.2.5 CLADDING AND RAINWATER GUTTERS

All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage.

8. 0 MATERIALS

Unless otherwise specified in the drawings, material specifications shall conform to the following.

8.1 CEMENT

Cement used for all concrete works both above and below ground shall be as follows:

- For Foundation & Sub-structures - Ordinary Portland cement (OPC) type confirming to 53 grade
- For Super structures - Ordinary Portland cement (OPC) type confirming to 53 grade
- Cement shall be procured from Owner's approved Vendor List only.

8.2 AGGREGATES

Aggregates used in the concrete works shall be locally available gravel or crushed stone conforming to IS: 383.

Unless otherwise specified, the maximum size of aggregates shall be as follows:

For large foundations and mass concrete

: 40mm graded down (provided the pitch of reinforcement is more than 100mm).

For others: 20mm graded down.

8.3 REINFORCEMENT

High yield strength deformed TMT steel bars of grade Fe500D conforming to IS: 1786 shall be used. The Minimum dia. used shall be 8mm.

Binding wire used for tying the reinforcement shall conform to IS: 280 unless specifically mentioned herein or in engineering drawings or other engineering design basis prepared for the individual units/structures.

All reinforcement bars shall be procured from SAIL / TISCO /RINL or Owner's approved Vendor List.

8.4 CONCRETE GRADE

8.4.1 REINFORCED CEMENT CONCRETE (RCC)

8.4.1.1 Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. However, minimum cement content, type of cement and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document.

8.4.1.2 All R. C. C. works to the done under this specification, unless specified otherwise shall be design mix concrete. Minimum grade of concrete for various structures shall be as follows:

a) M30: For major machine foundation, underground & water-retaining structures such as, manholes, cooling tower etc. For all other underground / sub structural R. C. C. work.

b) M30: For R. C. C. superstructure works

c) M25: For R. C. C works including ground floor slabs, trenches & drains.

d) The minimum grade of reinforced concrete shall be M25.

e) Pre-cast concrete shall be of minimum grade M35.

8.4.1.3 From durability consideration the minimum cement content, exposure Condition and maximum water-cement ratio for Plain concrete and Reinforced concrete shall be as per IS:456. However, if soil investigation report recommendations require higher cement content and / or specified type of cement, the same shall have precedence.

8.4.1.4 Maximum cement content shall not exceed 450 kg/m³.

8.4.1.5 For concreting of underground structures requiring water tightness, plasticizer cum water proofing admixture shall be added to the concrete mix.

8.4.1.6 Both coarse and fine aggregates shall conform to IS: 383 for concrete, shotcreting etc. unless otherwise mentioned.

8.4.2 PLAIN CEMENT CONCRETE (PCC)

8.4.2.1 75mm thick lean concrete of grade M10 shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100mm thick lean concrete of grade M15 shall be used. The lean concrete shall extend 75 mm beyond the foundation for normal foundations and 100mm under liquid retaining structures.

8.4.2.2 Plain Cement Concrete (PCC) of grade M20 of minimum 150mm thickness shall be provided under all masonry wall foundations.

8.4.2.3 Concrete for encasing, if used, shall be M20 with 10 mm down aggregates.

8.4.2.4 Plain cement concrete of grade M20 of minimum 40mm thickness shall be provided as damp proof course at plinth level of all masonry walls and to be coated with 3mm thick bitumen emulsion or minimum 100 mm thk RC band of M20 grade admixed with approved integral waterproofing compound as DPC in all the RCC frame structure building.

8.4.2.5 Lean concrete of grade M7.5 shall be used as filler material wherever loose sub grade exists by removing loose soil / fill or where the levels are made up to the desired founding level; however making-up of levels for placing the foundation at a shallower depth from NGL / FGL (from that as specified in the soil investigation report) by means of filling of lean concrete shall not be resorted to.

8.4.2.6 In addition to conducting various tests as mentioned in IS: 456, Contractor shall also to check workability of fresh concrete at site, slump test to be performed. Any specific requirement regarding grade and thickness of PCC to be provided shall be incorporated in the drawing.

8.5 FOUNDATION / ANCHOR BOLTS

8.5.1 Anchor Bolts shall be of mild steel bars of grade E 250 Grade A conforming to IS: 2062. Preferably limit state method to be followed for working out strength of anchor bolts.

8.5.2 All equipment foundation bolts / templates shall be designed and supplied by equipment vendor. Foundation bolts for steel structures shall be designed and supplied by contractor as per standard drawings or approved equivalent.

8.5.3 In case of no tension loads in the anchor bolts of equipment such as small towers, tanks, heat exchangers, pumps, blowers, compressors, etc. anchor bolts shall generally be set in anchor boxes unless embedment is required.

8.5.4 Anchor bolts for heavy towers, which are subject to pull out force, shall be embedded into the foundation at the time of placing concrete using templates.

8.5.5 All anchor bolts shall also be provided with additional lock nut.

8.6 INSERT PLATES AND EMBEDDED ITEMS

8.6.1 Insert plates shall be of structural steel quality grade E 250 Grade A conforming to IS: 2062 and shall be provided with mild steel lugs and /or TMT bar lugs as per drawings/ standards.

8.6.2 Mild steel bars shall conform to IS: 432.

8.6.3 Unless otherwise specified, all structural steel shall be weldable structural steel “Standard Quality” (Fe 410 WA), in accordance with code IS: 2062.

8.6.4 All embedded steel items (exposed to atmosphere) shall be hot-dip galvanized in accordance with IS: 2629, except if noted otherwise on the design drawings.

8.6.5 All inserted and embedded items shall be accurately placed or template in and be securely anchored prior to placing concrete.

8.7 STRUCTURAL STEEL

8.7.1 **Mild Steel**

a) Rolled sections shall conform to grade designation E250, Quality A and shall be semi killed/killed conforming to IS: 2062.

b) Plates shall be of grade designation E250, Quality BR, killed, tested for impact resistance conforming to IS 2026. Plates beyond 20mm and up to 40 mm thickness shall be controlled rolling. Plates beyond 40mm thickness shall be normalizing rolling and shall also be ultrasonically tested as per ASTM-A578 level B.

c) Pipes for handrail shall conform to medium grade of IS: 1161

d) Chequered plates shall conform to IS: 3502 and steel shall conform to grade A of IS 2062.

e) Seal plates shall conform to IS : 1079 (semi - skilled quality)

8.7.2 Medium & High Tensile Steel

a) Rolled section and plates shall be of minimum grade designation E350, Quality B0, conforming to IS 2062. Plates beyond 20 mm and up to 40 mm thickness shall be controlled rolling. Plates beyond 40 mm thickness shall be normalizing rolling and shall also be ultrasonically tested as per ASTM-A578 level B.

b) All plates up to and including 40mm thickness shall be ultrasonically tested on audit basis to check the laminations.

c) Steel Pipe shall conform to IS: 1239 (Medium)

- Ordinary Black Bolt shall conform to IS: 1367 Class 4.6
- High Strength Bolt shall conform to IS: 1367 Part 3 Class 8.8
- Steel Grating :IS: 2062 (Grade A) with Hot-dip Galvanized with coating 900 gms/m2
- Rail :IS: 3443.

All Structural steel material shall be procured from Owner's approved Vendor List.

8.8 GROUTING

8.8.1 Unless otherwise specified by equipment manufacturers, top of foundations except for local foundations shall be provided with an allowance for grouting as specified below:

(a) Foundation for large heavy duty compressors, generator, etc…….: 50 mm

(b) Foundation for big towers (>20 m) ……..: 50 mm

(c) Other foundation bases for columns, trusses, etc…….. : 25 mm

8.8.2 Grouting under the column base plates/ shoe plates including sleeves and pockets shall be done with non-shrink cementations grout (Min. M40) as per manufacture specification.

8.8.3 The thickness of grout shall not be less than 25 mm and shall not be more than 50 mm.

8.8.4 For all grouting work below equipment bases and for anchor bolt pockets for equipment foundations grout shall be non-shrink grout as per manufacture specifications.

8.8.5 For grouting work for anchor bolt pockets & base plates of major equipment's (compressors, turbines, etc. of weight over 2500 kg or above 300 kw rating, or surface over 3 m) a non-shrink epoxy grout shall be composed as per the specifications of the equipment manufacturer as per the approved list / as per the decision of EIC. At the time of detailed engineering, grouting system / material shall be specifically mentioned in drawings issued for construction.

8.8.6 Ordinary grout consisting of 1 part of OPC and 2 parts of clean, dry well graded sand mixed with water to obtain the required consistency shall only be used under the base plates of cross-overs, short pipe supports (not exceeding 1.5 m height) and small operating platforms (not exceeding 2 m height) not supporting any equipment.

8.9 ANTI-TERMITE TREATMENT

8.9.1 No anti –termite treatment shall be provided inside the unit areas. Offsite and utility buildings shall be provided with anti –termite treatment as per IS: 8944 and IS: 6313.

8.9.2 Chloropyrifos emulsifiable concentrates (1%) confirming to IS: 8944 shall be used for treatment of soil for protection of buildings attack by subterranean termites.

8.10 MISCELLANEOUS APPLICATIONS

8.10.1 ADMIXTURES

Admixtures shall conform to IS: 9103 and to be mixed with concrete (if required) strictly as per manufacturer's recommendations.

8.10.2 PLINTH PROTECTION

Each building shall be provided with 1.0 m wide concrete M15, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 250 c/c both ways Reinforcement bars all round as plinth protection. A surface drain to be provided along-with plinth protection which shall be connected to the drainage system.

8.10.3 RAMPS

Ramps for building entrance shall be cast in situ R.C.C. designed as a grade slab and the slope of ramps shall not be less than 1 in 10. Minimum thickness of the slab shall be 150 mm.

8.10.4 HOT BITUMEN PAINT

All underground structures including top surface of foundations shall be painted with two coats of hot bitumen paint of grade 20/30 with quantity of bitumen at least 1.2 kg/m^2 per coat.

8.10.5 INSULATION

For equipment with temperatures over 200^o C, or sub zero temperatures, insulation shall be provided between equipment base / lugs and concrete / steel structure.

9.0 PAINTING

Paint system shall be adopted with type of environment envisaged in and around the plants as per requirements mentioned in separate document for painting specifications.

Painting of all steel structures, including seal plates, hand rails, steel doors & windows, ventilators, louvers, Rolling Shutters Stair Cases (except gratings), etc. shall be with paints as per requirements mentioned in separate document for painting specifications.

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE- B: CIVIL ENGINEERING DESIGN BASIS

(GENERAL CIVIL WORKS)

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1.0 GENERAL

1.1 SCOPE

This engineering design basis defines the design criteria that shall form the basis for carrying out design and engineering of items under general civil, viz. roads, paving, drainage, etc.

1.2 UNITS OF MEASUREMENTS

Units of measurement in design shall be metric system.

1.3 DEFINITIONS

CCE	Chief Controller of Explosives
TAC	Tariff Advisory Committee
NFPA	National Fire Protection Association
IS	Indian Standards
Owner	TFL
Consultant	PDIL
LSTK Contractor	Successful bidder of the tender

1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country.

1.4.1 The main codes, standards and statutory regulations considered as minimum requirements are as follows. Latest revision of these shall be followed.

IS:456	Code of practice for plain and reinforced concrete
IS:800	Code of practice for general construction in steel
IS:875	Code of practice for design loads (Other than earthquake for buildings & Structures
IS: 1172	Code of basic requirements for water supply, drainage & sanitation
IS: 1742	Code of practice for building drainage
IS: 1905	Code of practice for structural use of unreinforced masonry
IS: 2065	Code of practice for water supply in buildings
IS: 8183	Bonded Mineral wool

IS: 8835 Guidelines for design of surface drains

IS: 11134 Code of practice for setting out of buildings

IS: 8640 Recommendations for dimensional parameters for industrial building

IS: 2502 Code of practice for bending and fixing of bars for concrete reinforcement

IS: 2095 (Part-1) Gypsum Plaster Boards - Specification

IS: 2469 Glossary of terms relating to gypsum

IS: 2542 (Part -2) Methods of test for gypsum plaster

IS: 2547(Part-1) Gypsum building Plaster

IS: 4905 Methods for random sampling

IS: 12679 Specification for by –product gypsum for use in plaster, blocks and boards

IS: 4926 Code of practice for ready mixed concrete

IS: 9012 Recommended practice for shotcreting

IS: 10262 Guidelines for concrete mix proportioning

IS: 4971 Recommendations for selection of industrial floor finishes

IS: 3483 Code of practice for noise reduction in industrial buildings

IS: 2065 Code of practice for water supply in buildings

IS: 1641 Code of practice for fire safety of buildings (general): General principles of fire grading and classification

IS: 1642 Code of practice for fire safety of buildings (general): Details of construction

IS: 1644 Code of practice for fire safety of buildings (general): Exit requirements and personal hazard

IS: 12456 Code of practice for fire protection of electronic data processing installation

IS: 3935 Code of practice for composite construction

IS: 11384 Code of practice for composite construction in structural steel and concrete

IS: 15988 Seismic Evaluations and Strengthening of Existing Reinforced Concrete Buildings – Guidelines

IS: 1346 Code of practice for waterproofing of roofs with bitumen felts

IS: 9918 Code of practice for in-situ waterproofing and damp-proofing treatment with glass fibre tissue reinforced bitumen

IS: 1200 (Part 1 to 28) - Methods of measurement of building and civil engineering works.

IS: 13592 Unplasticized Polyvinyl Chloride (PVC-U) pipes for soil and waste discharge systems inside buildings including ventilation and rainwater system

IS: 14333 High density polyethylene pipe for sewerage.

IRC: 15 - Standard Specifications and Code of Practice for Construction of Concrete Roads.

IRC: 6 Code of practice for road bridges, Section-II Loads and stresses

IRC: 19 Standard Specifications and Code of Practice for Water Bound Macadam

IRC: 37 Design of flexible pavements

IRC: 58 Design of rigid pavements

Factory Rules for State

Note: The above list is suggestive and not exhaustive. Apart from these basic codes, any other related codes shall be followed wherever required.

1.4.2 In case of any conflict / deviations amongst various documents, the order of precedence shall as follows:

a) Statutory regulations

b) Job specifications

c) Engineering design basis

d) Standard specification

2.0 DESIGN CRITERIA –GENERAL

2.1 SITE GRADING

2.1.1 The work area shall be cleared and stripped completely of all bushes, roots, trees, Shrubs and other vegetation, organic matter and other objectionable materials. All these should be completely uprooted and removed, and not merely scraped at the surface.

2.1.2 The grading of the area shall be done by cutting and filling with the following:

a) Cutting Area : Thoroughly rolled and compacted.

b) Filling Area : Compacted in layers not exceeding 20cm to achieve minimum 95% of maximum dry density

2.1.3 Site grading philosophy shall be based on following:

FFL of the adjacent paved area is .....m above Mean Sea Level (To be decided later).

However, levels like Finished Ground Levels (FGL) and Highest Point of Paving (HPP) shall be finalized by the CONTRACTOR, in consultation with OWNER / PMC, based on contour survey of the Unit, levels of adjacent units and levels of adjacent Roads.

2.1.4 Slope in Graded Areas

a) General Site Grading : 1 in 500 to 1 in 1000

b) Micro grading, after completion of major Construction (for road corridors) : 1 in 200

c) Tanks Farms : 1 in 200 to 1 in 300

2.2 ROADS

2.2.1 Contractor shall design cross section of roads, including roads for crane access, as per IRC 37. However, the minimum section to be adopted shall be as given in clause 2.2.7 Ruling gradient shall not exceed 1 in 20. If existing roads are to be used for erection purposes, the same should be strengthened to cater for erection

loads. It should be ensured that use of existing roads does not hinder normal activities in existing plants.

All roads surface shall be prepared in accordance with Section-16 of CPWD Specifications & designed in accordance with IRC 37 (Latest revision) for crossing of drains, pipes, cable trenches etc; suitable culverts shall be provided. The culverts shall be designed for class `AA' loading and also checked for class `A' loading in accordance with IRC.

2.2.2 Road Width

Category	Width*	Carriageway Width
I. Road around unit and its Primary access	12.5 m	10.5 m (three lane road or width to suit crane type)
ii. Roads for high lifts crane	2.0 m+ c.w. width	3 m + outer width of crawlers of required Capacity crane.
iii. Plant approach road	9. 0m	7.0 m (two lane)
iv. Roads around tank farm	7.5 m	5.5 m
v. Patrolling roads (along boundary wall)	6.0 m	4.0 m
vi. Access to building	5.5 m	3.5 m
vii. Foot path	1.0 m	…….

* Width of the road to be finalised as per site condition in consultation with client / PMC.

2.2.3 Camber : 1 in 50

2.2.4 Radius of curve: 12 m for 8 m wide carriage way roads, 8 m for 5.5 m wide Carriage way width & 15 m for roads of higher carriageway width.

2.2.5 Pavement Type: Concrete pavement at all roads to be used for crane movement (Requirement of crane movement route and its specification to be finalised in consultation with client /PMC)

2.2.6 Extents: As per Plot Plan / Equipment Layout drawing / scope drawing.

2.2.7 Clearance: Minimum 8.0 m to underside of pipe racks.

2.2.8 Minimum Cross Section

i) Sub base: The sub base shall be 300 mm layer of crushed / broken size stones on well compacted earth or approved fill.

ii) Base course: The base course shall be 225 mm stone size thick water bound Macadam consisting of 3 layers of 75 mm each.

iii) Bituminous wearing course / RCC: The wearing course shall be 75 mm thick for roads with crane duty and 50 mm thick for roads without crane duty. However, roads for crane movement, concrete pavements shall be provided.

2.2.9 Crossings

a) Pipe Ways under roads & rails : RCC Box Culverts

b) Storm Water Culverts Under road / rail. : RCC Box Culverts

c) Electric / Instruments Cable : RCC duct bank with PVC Pipe lass – 1 (IS 4985)

2.2.10 Finished Road Top Levels Above FGL.

When box culverts for pipe ways : 1.05 m (minimum)

Ways are provided : 1.6 m at box culvert location with a slope from 1.05 m to 1.6 m above FGL

When overhead bridges are : 1.05 m around hazardous units

Provided for pipe ways : 0.40 m to 0.60 m for others areas

Other areas : 0.40 m to 0.60 m

2.3 CONCRETE PAVING (WITHIN PLANT AREAS)

2.3.1 GENERAL

RCC paving to be done for entire battery limit and extend up to extend up to the adjacent roads around the unit. The contractor's scope is limited to all round the peripherical roads. Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

Concrete paving shall be laid in cast-in-situ panels of 3.0 meter X 3.0 meter size, with expansion joints spaced approximately 15.0 m c/c, each panel being cast in a single pour.

Hard stands should be designed and provided by contractor, based on required crane capacity, here called for by Owner, the same shall be demolished after erection, and surface made good.

Provision of trenches, drains, sealing of trench covers, inserts, thickening for pipe / equipment supports etc. shall be made while construction pavements, as detailed in drawings.

Acid / alkali / chemical resistant coating as required shall be applied in areas where such corrosive materials are likely to come in contact with concrete.

Suitable drainage arrangements will be provided within curbed areas around pumps, for drainage leaks. Similarly, suitable drainage arrangement shall be provided at streaming points also.

2.3.2 JOINTS

Expansion joint of 20 mm shall consist of 20 thick impregnated fibre boards. Filled at top with joint sealing compound 20 x 25

Equipment / column pedestals will be separated from paving with 20 thick sand fill and Sealing compound 20 x 25.

Contraction joints will be sealed by sealing compound 10 x 40.

2.3.3 Slope: 1 in 100 (minimum)

2.3.4 Minimum requirements of paving in various areas

a) Paving within Process & Utility areas for maintenance compatible to crane movements / dropout / : Type – 1 (200 mm thk. RCC)

Loading / Unloading areas /

Vehicular movement areas

b) Non vehicular movement areas

i) Unit : Type –II (150 mm thick RCC)

ii) Offsite pump station : Type –II (100 mm thick RCC)

iii) Bullet Area : Type –II (100 mm thick RCC)

iv) Utilities : Type –II (150 mm thick RCC)

c) Pipe rack : PCC 1:3:6 (100 mm thick)

Paving and trenches including covers in process units shall be suitable for Hydra crane movement. Where movement of bigger cranes for maintenance is envisage paving and trenches including covers shall be designed for the loads arising from the same.

2.4 SURFACE TREATMENT

The surface treatment for the various areas shall be provided as enumerated in the table below.

AREA	RC CONCRETE PAVING	ASPHALT PAVING	50 thick PCC 1:3:6 ON 115 thick brick soling	GRAVEL	100 THK PCC 1:3:6	ACID / ALKALI PROOF COATING
Operating Areas of Process units (including crane movement roads)	X (Type I /II Paving as per cl. 2.3.4)					
Around Transformers In substation						
Roads (excluding roads having crane movement)		X				
Approaches to units		X				
Tank farms			X			
Acid / alkali / storage / handling area						X
Parking		X				
Hardstands	X					

Pathways	X					
Pipe ways					X	
‘ X ’ Indicating applicable option						
Notes: 1. Existing services where interfering with the new construction should be located and rerouted as instructed by Owner / Consultant. 2. Micro-grading shall be carried out by the Contractor over graded areas to bring the FGL to indicated levels including provision of required slopes and finishes.						

2.5 STORM WATER DRAINAGE

2.5.1 Storm water drains shall be sized for the higher discharge arising out of either rain water or fire fighting water.

2.5.2 Rain water run-off shall be computed by the formula:-

Q = KIA / 360

K is run-off coefficient given below.

A is area (hectares) contributing to the drain

I is rain fall intensity (mm / hr.)

Q is the discharge.

2.5.3 Design of drains shall be based on Manning’s formula:-

$V=R^{2/3} S^{1/2} / n$

V is velocity of flow m/s,

R is hydraulic radius,

S is slope,

n is roughness coefficient taken as 0.013 for plaster surface, 0.015 for cast-in-situ concrete, 0.017 for brick lined.

The following parameters are to be ensured to be within limits specified while sizing

Minimum velocity of drains	:	0.6 m/s
Maximum velocity of drains	:	2.4 m/s
Minimum depth of drains	:	300 mm
Minimum width of rectangular drains	:	300mm (for depth<500mm)
Minimum width of drains	:	500 mm (depth > 500mm)

Run off coefficient 'K'

a.	paved area	concrete	-	1.0
		Bituminous	-	0.9
b.	unpaved areas		-	0.7
c.	unusable areas like Green belt		-	0.4

2.5.4 DRAINS WITHIN PROCESS UNITS

Rain water falling on such portion of paved areas of process unit where it is not likely to get contaminated, shall be collected in open rectangular RCC drains. These drains shall be covered by gratings, and shall be generally connected to periphery drains, which at battery limit shall have a double valve chamber. This will permit discharging the rain water either to storm water network, or to the battery limit CRWS manhole. Drains shall be designed for the maximum of rainwater / firewater on same principles as storm water drains.

2.5.5 CULVERTS AND ROAD / RAIL CROSSINGS

Road / Rail and storm water drain crossing shall by RCC box culverts, designed for the Relevant IRC loads for roads, and track loads for rail. The relevant lateral loads due to wheel / track loads on the soil adjacent to wall on crossing shall be considered on the walls. Approval from the rail authorities on culvert design shall be in the scope of LSTK contractor.

Drain to adjacent to roads / pavement where heavy crane movement is anticipated shall be Concrete drains, designed to resist the lateral thrust due to wheel loads.

Pipe culverts, if instructed to use by Owner/PMC, shall comprise of R.C.C. pipes (class NP-3, IS: 458) under roads; and R.C.C. pipes (class NP-4, IS: 458) under rail lines

2.5.6 TANK FARM DRAINAGE

Tank farm drainage system should be provided in such a way that the storm water discharge shall be either sent to storm water open ditch or to the oily water sewer by providing valve pit outside the dyke wall depending on its contamination.

2.5.7 DISPOSAL OF STORM WATER

Storm water drains shall not be combined with oily waste sewer / CRWS/combined sewer system, etc. For disposal of storm water references shall be made to the 'scope' document.

2.5.8 OIL CATCHER

An oil catcher with baffle wall type arrangement shall be provided a storm water ditch before it leaves the battery limit of the unit, & tank farm.

2.6 WATER SUPPLY

Existing drinking water piping shall be extended to new facilities. Adequacy of header branch line etc. shall be ensured; else additional lines shall be run.

2.7 SANITARY SEWERS

2.7.1 GENERAL

Sanitary sewerage will not be combined with storm water.

Building drainage shall be designed as a dual pipe system with separate soil & waste pipe.

Sewers shall be designed for discharging 3 times average flow flowing half full in case of lateral sewer, and flowing 2/3 full in case of Main sewer. The minimum and maximum clearing velocities shall be 0.75 m/s and velocity 2.4 m/s respectively. Velocity shall be calculated by Manning's formula with n=0.015

Minimum pipe size shall be 100 mm and all pipes shall preferably be salt glazed stoneware unless abnormal soil conditions or high velocity dictates otherwise.

2.7.2 Sanitary sewer shall be led into the existing sewerage system leading to waste water treatment plant (WWTP). Where system is not available, septic tank/soak pit shall be provided.

2.7.3 Cover for Sewer Line shall be minimum 600 mm.

Under road, sewer shall be protected by concrete encasement or minimum cushion shall be 1200 mm.

Under railway, the sewer shall be protected as per railway standards.

2.7.4 MATERIAL OF CONSTRUCTION

a. Material of Construction for Manholes shall R.C.C. M30.
b. Material of Construction for Sewer

Sanitary Sewer

i.	Toilet block to inspection chamber	- CI pipes as per IS: 3486/1729) or UPVC, as directed.

ii. Gravity main & lateral - Salt glazed stoneware / C.I./ R.C.C. Class P1 (as per IS:458)

iii. Pressure main - C.I. pipes (as per IS: 1536 an IS: 1537)

iv. Offsite Pumping, if any - CPVC pipes/GI as per PMS J2A(as directed)

v. Manholes - R.C.C. M30

2.8 CONTAMINATED EFFLUENT SEWERS

2.8.1 PROCESS UNIT

Contaminated rain water / floor wash / fine water shall be collected through catch basins located in the contaminated areas of the process unit and shall be send to the oil catcher / CRWS pit / CRWS header. The continuously contaminated area of all pumps shall be segregated by kerb wall; discharge from such kerbed areas shall be collected in OWS network and not in CRWS network.

CRWS shall be designed for contaminated water due to rain water or Fire water, whichever is more.

The quantities of contaminated rain water shall be worked out based on the contaminated process area in the unit block.

Sewer shall be sized flowing full with peak flows taking future requirements or 2/3 full without future requirements.

CRWS manholes shall be R.C.C. (M30) construction. For trapping of gas or prevention of spread of fire through CRWS from one area to another, a liquid seal of minimum 150 mm shall be provided in manhole along with suitable vents. Location of sealed manholes should be decided accordingly. The vents on the manholes should extend minimum 2.0 m above the pipe rack or 1.0 m above buildings, or if in open areas extending min 3.0 m above FGL with frame arresters.

CRW sewers in process units and tankage areas shall be of mild steel /Carbon steel conforming to IS: 3589

2.8.2 TANK FARM AREA

Tank farm areas, not containing tanks for corrosive materials, shall be drained by surface drains. Waste water shall be led to a sand trap and then to a valve chamber which shall either drain the water to storm water drain or oily water drain. Waste water from tank farm areas containing corrosive / hazardous materials shall be drained by chemical sewers to neutralization tank / ETP.

2.9 OTHER PROCESS DRAINS

Other process drains shall be oily water sewers, closed blow down sewers or chemical Sewers. Sizing, layout, material specification, corrosion protection etc will be as per u/g piping design Basis.

Oily water sewer convey water contaminated with oil, e.g. from reflux drums, separators, Cooling / quench water for compressor / pump, process wash water, floor and paving Drains in oily areas etc. These are conveyed either to WWTP or oil separator by means Of U/G steel pipes through sealed manholes.

Blow down are liquid streams containing water / oil / chemicals that are required to be drained from process equipment under different operating situations like start-up, shutdown etc. Blow down systems are closed piped systems in which streams are collected in underground blow down drums and then pumped to respective slop / field tanks.

Chemical sewers carry effluents containing chemicals which require separate treatment from oily water streams. These are generally corrosive and require pipe of materials resistant to corrosion or lined pipes.

Closed blow down sewers shall be closed piping systems as shown in piping drawings. These will lead to underground blow down drum / drums which shall be protected by a concrete pit as detailed in drawings. Before entering the blow down drum, a valve chamber shall be provided for the sewer .Sewer cleanouts will be provided at start / end charges in direction and at 45 m intervals on straight length.

Other aqueous blow downs within process areas will be collected by funnels and routed through oily water sewers to sealed manholes. A common oily water header will route these streams to the plant oily water sewer network leading to waste water treatment plant.

Small neutralization pits hall be provided near battery rooms to treat floor wash in battery rooms. Water from these pits will further be routed to storm water drains.

Dyked areas around emergency booths shall drain into a gully trap which shall be connected to the chemical sewer network.

Oily water & contaminated rain water catch pits / manholes shall be of reinforced concrete to the chemical sewer network with internal coal tar epoxy lining.

Manhole for acid / alkali sewer shall be of reinforced concrete (M30). Exposed steel work shall be provided with coal tar epoxy coating.

2.10 STORAGE TANK FOUNDATION AND DYKE WALLS

2.10.1 Proposed Ammonia Storage tank shall rest on the deck slab at the required level above ground which in turn shall be supported by short columns over the pile cap.

The storage tank foundations shall be designed to sustain the forces at the tank bottom within permissible settlement, under operating and hydro-test conditions.

Tanks less than 2.5m dia. may rest directly on a concrete pedestal with anti corrosive layer.

Tanks greater than 2.5m dia. but less than 10.0 m dia. may be supported on RCC ring all with sand / murrum fill.

For tanks greater than 10m dia, Tank Pad Foundations shall be provided as per relevant design Codes.

2.10.2 Anticorrosive layer shall be provided as per specifications for tank pads of 50 thick premix Carpet over 50 thick bitumen sand mixed with additions of kerosene / oil as required.

2.10.3 STORAGE TANK DYKE WALLS / FIRE WALLS

Dyke walls / Fire walls shall be provided. Walls shall be plastered brick work conforming to standard relevant Codes. DYKE walls shall be designed for retaining liquid in case of rupture of the largest tank in the farm. It shall be minimum 600mm thick to enable persons to walk on the wall top. If space permits, Dyke walls shall be provided with ramps on both sides at suitable places, for movement of vehicles for tank cleaning purpose. Fire walls shall only be 600 mm high (min.) or as shown in drawings / as instructed. They shall only retain spillages, to prevent fire spread.

2.11 BARRICADE

Contractor shall design a suitable barricading system for protection of existing facilities. Barricade shall be of G.I. sheet cladding with suitable supporting system of height and extent shown in drawings or as instructed by Owner / Consultant. Water spray system shall be incorporated where felt necessary by Owner / Consultant. Localized G.I. sheet barricading shall be provided from operational constraint requirements as directed by Owner / consultant.

2.12 TRENCHES

Trenches shall be of RCC with inserts or other suitable arrangement required to support Cables pipes etc. Pre-cast concrete covers with lifting arrangement shall be provided on top. In paved areas, the top will be flush with finished floor level. Covers shall overlap walls and joints with paving shall be sealed to prevent water entry. In unpaved areas, walls shall be raised above ground level by 100 mm. Trench floors shall be provided with a nominal slope to drain pits, where any water entering trenches can collect and be detained to the nearest contaminated rain water sewer / storm water sewer. Trench covers shall be designed for the vehicle load relevant to the area where the trench is located. Cable trench shall be of leak proof construction.

2.13 HARD SURFACES

Hard surface of PCC 1:3:6, (100 mm thick) over suitable bedding (brick / stone soling) Shall be provided below all new pipe tracks and / or extended potion of existing pipe Tracks. This shall extend 600 mm on one side for track width less than 6 m, and 900mm On either side for pipe track having width 6 m or more, end it shall have approach @ 500 M c/c from nearest road.

Hard surface of PCC 1:3:6 (100 mm thick) over suitable bedding (brick / stone soling) of approximate size 1 m x 1 m shall be provided with proper approach near drain point of offsite piping, near drinking water installations, at washing facilities, etc., with suitable curbing and drainage arrangements as required for the fluid being handled.

3.0 REMOVAL / REROUTING OF OBSTRUCTIONS

All underground structures / foundations which will cause obstruction to new structures / foundations, and which can be removed without disturbing any functions of the existing plant, shall be removed by the Contractor.

All existing underground facilities requiring rerouting due to fouling with new facilities shall be rerouted by the Contractor in such a manner that rerouted facilities keep on functioning as before.

NOTE:

Before finalizing the route connection to existing system, adequacies of existing system shall be checked by the contactor.

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE- C: ARCHITECTURAL WORK DESIGN BASIS

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1.0 GENERAL

1.1 SCOPE

The design philosophy defines the minimum design requirements and procedures for carrying out architectural design, Interior design, Furniture design and engineering of buildings covered under this project. Relevant criteria shall be taken into consideration to achieve satisfactory and trouble free performance of the facilities.

1.2 UNITS OF MEASUREMENT

Units of measurement in design shall be in metric system.

1.3 DEFINITIONS

CCE	:	Chief Controller of Explosives
TAC	:	Tariff Advisory Committee
NFPA	:	National Fire Protection Association
IS	:	Bureau of Indian Standards
Owner	:	RCF
PMC	:	PDIL
LSTK Contractor	:	Successful LSTK bidder of the tender (To be selected)

1.4 CODES AND STANDARDS

The design shall be in accordance with established codes, sound engineering practices and shall conform to the applicable statutory regulations.

The main codes, standards and statutory regulations considered as minimum requirements are as follows:

a) National Building Code of India

b) Factories Act of State

c) Local Municipality or any other Authority's Bye-laws as applicable.

d) Bye-Laws applicable of Town & Country Planning Organization.

e) Code of practice for building bye-laws IS : 1256

f) TAC (Tariff Advisory Committee) Rules

g) Indian Electricity Rules

h) Bureau of Indian Standards

Note: The above list is suggestive and not exhaustive. Apart from the basic codes any other related codes shall also be followed wherever required.

1.5 ORDER OF PRECEDENCE

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

a) Statutory Regulations

b) Job Specifications

c) Engineering Design Basis

d) Standard Specifications

2.0 DESIGN PHILOSOPHY / CRITERIA – GENERAL

2.1 ARCHITECTURAL DESIGN

Architectural design of buildings / sheds shall be in accordance with this design basis and references as stated herein, to facilitate the intended functions. The various types of requirements to be considered are described further.

2.2 BUILDING REQUIREMENTS

2.2.1 SPATIAL REQUIREMENTS

Spatial requirements inside a building / shed shall be decided based on activities to be performed in the building and consequent occupancy pattern, equipment layout etc. Spaces can be generally classified as functional spaces, circulation spaces, amenity spaces, utility spaces. They are elaborated further.

2.2.1.1 FUNCTIONAL SPACES

Functional areas of any building / shed shall be constituted by the main activity for which the building is required. Various spaces/rooms shall be judiciously sized and shall be integrated logically to generate the total building plan taking into account the following parameters:

a) Activities, group of activities and consequent work-flow pattern.

b) Site conditions i.e., dimensions, contours etc.

c) Climatic conditions vis-à-vis orientation.

d) Safety regulations.

e) Lighting and ventilation.

f) Acoustics.

g) Services

h) Security

i) Economy

j) Aesthetics

k) Green building Concept as per Govt. Guidelines for the state

l) Specific requirement pertaining to particular buildings, if any

m) All other established architectural design parameters in practice.

The objective of spatial arrangement shall be to satisfy functional requirements and physical comfort and safety regulations as well as aesthetics which has significant role in creating a favourable working environment.

2.2.1.2 CIRCULATION SPACES

Following spaces are classified as circulation spaces. These spaces shall be provided as per required building services, for integrating various types of spaces and as means of access / exit / escape.

a) Corridors & passages.

b) Staircases

c) Elevator

d) Entrance lobby / Foyer including Reception & waiting

e) Gangway / walkways

f) Equipment loading / unloading platforms

g) Emergency Exits

2.2.1.3 AMENITY SPACES

Following spaces are classified as amenity spaces:

a) Toilet (Gents & Ladies)

b) Drinking Water Facility

c) Locker & Change Room

d) Rest room / Lunch Room / Pantry

e) First-Aid Room

Out of the above mentioned areas, a) Toilet, b) Drinking water, c) First Aid enclosures shall be mandatory requirement for occupied buildings / sheds. Other facilities shall be provided as required.

2.2.1.4 UTILITY SPACES

Utility spaces are space requirements which materialize due to provision of services like air-conditioning, pressurization, fire fighting, electrical, telephone, LAN etc. These spaces shall be provided as per required building services. Following are examples:

a) Air-conditioning plant room

b) Air handling rooms

c) Pressurization blower plant room

d) Electrical distribution panels rooms

e) Telephone exchange equipment room.

f) Firefighting equipment room.

g) UPS room

h) Battery room

i) Service ducts

j) Store Room

2.2.1.5 SIZES OF SPACES

Sizes of various types of spaces shall be decided based on occupancy / equipment / Panel / furniture layout, clearance, maintenance & safety requirements & ventilation requirements.

However, following are the limiting sizes / dimensions for various purposes, which shall be adhered to:

a) Minimum area of any habitable room = 9.5 m^2 with minimum dimension restricted to 2.5 m

b) Minimum ht of any habitable room = 3 m which may be reduced to 2.75 m for air-conditioned areas. Due provision / clearance may be made for AC ducts above false ceiling if any. Headroom below beams should be min. 2.4 m.

c) Maximum ht of habitable rooms = As stipulated by the local bye-laws

d) Scale of accommodation for industrial work spaces = @ 14 m^3 per occupants. Minimum clear height of such workspaces shall be 3.6 m. Heights above 4.25 m shall not be taken into account.

2.2.2 DAY LIGHTING AND VENTILATION

2.2.2.1 DAY LIGHTING

Established level of illumination shall be maintained for all parts of the buildings by means of windows, ventilators, skylights, etc. Following references shall be adhered to in this regard:

a) National Building Code of India, Part-VIII, Section-1

b) IS:2440: IS 3646 (Part-II) : IS:7662 (Part-I)

c) State Factories Rules

d) Any other relevant rules / code etc.

Following architectural norms shall be adopted:

a) Direct solar illumination shall not be considered and only sky radiation shall be taken as contributing to illumination of the building.

b) Openings shall be provided with shading devices to avoid glare.

For the purpose of illumination, day lighting shall also be supplemented by artificial illumination.

2.2.2.2 VENTILATION

A. Natural Ventilation

Established level of ventilation in terms of air changes per hour shall be maintained for all spaces. Following references shall be adhered to for the purpose:

a) National Building Code of India, Part-III, Section-1

b) IS:3101 (Industrial Buildings), IS:3362 (Residential Buildings); IS:7662(Part-I)

c) State Factories Rules

d) Any other relevant rules / Codes etc.

Natural ventilation shall also be supplemented by mechanical or electrical means of ventilation in all areas of habitation. Sufficient no. of Glazed / Louvered windows / ventilators shall be provided and supplemented by exhaust fans.

Non- electrical Turbo ventilator of S.S. makes of required size shall be provided in sufficient numbers over roof of all sheds of the entire scope of work.

B. Mechanical Ventilation

In addition to natural ventilation, if required mechanical or electrical ventilation shall be provided depending on the type of building and its use. Other relevant design basis shall be referred for its requirement and applications.

2.2.3 ACOUSTICS AND SOUND INSULATION

Specified acceptable noise level and reverberation time shall be maintained inside a building / shed. Following references shall be referred to for the purpose:

a) National Building Code of India

b) State Factory Rules

c) Limitations on decibel level stated elsewhere, if any, in the bid document

Required noise level in any space shall be maintained by means of

d) Segregating noise sources by buffer zones

e) Dampening of noise levels by damping devices

f) Providing Acoustic treatment with acoustic material (on walls, ceilings, floors, as required).

2.2.4 SAFETY REQUIREMENTS

Safety from fire and like emergencies shall be taken into account in building / shed design. Buildings / sheds meant for human occupancy shall be provided with exits sufficient to permit safe escape of occupants in case of an

emergency. The exits shall be in terms of doorway, corridors, and passage ways to internal / external staircase or to areas having access to the outside. Following references shall be adhered to this regard. Max distance to an exit from any point in a building shall not exceed 30 m. Control Room building shall be provided with emergency exit on the other side of entrance.

A minimum of two staircases and two exits per floor shall be provided in each building. Width of passage / corridor shall not be less than 1500 mm. Following references shall be referred to for the purpose design of Control Room building.

a) National Building Code of India, Part-IV

b) State Factories Rules

c) Any other relevant rules / codes

2.2.5 SITE PLANNING & LANDSCAPING

Site planning of building shall take into account aspects like inter-relationship of the buildings with the whole system, movement pattern, traffic and road net-work, safety regulations, service network, fire safety, climatic and environmental aspects.

Main and service / maintenance entrances of buildings shall be provided with vehicular access. All exit points shall also be provided with footpath / vehicular access. Truck movement space in accordance with traffic pattern shall be provided for the building as per the location of hoisting bay / loading, unloading platform. Road network and open space around the buildings shall be designed considering movement and functioning of fire tenders and cranes, etc.

Suitable landscaping treatment shall also be done around Control Room. Such treatment shall generally consist of lawns, road side plantation and beautification of building entrance areas. Standard landscape elements such as earth contours, paving, flower beds, hedges, shrubs, ground cover and ornamental trees shall be incorporated in landscape treatment. Necessary water supply / sprinklers shall also be provided.

2.3 BUILDING SERVICES

Following services shall be provided for all building / sheds as essential services:

2.3.1 WATER SUPPLY, DISTRIBUTION AND DRAINAGE, SANITARY SERVICES

The service is essential for all habitable buildings / sheds. All buildings with human occupancy shall have toilet and drinking water facility and accordingly water supply, distribution and drainage, sanitary services as per following references:

a) National Building Code of India, Part-IX, Section 1 & 2

b) State Factories Rules

Drinking water provisions, including one number water cooler per area shall be provided within an enclosure separated from the toilets. Space for janitor shall be provided in the toilets. All service pipes showing on the external wall shall be suitably concealed or shall be provided within a shaft.

Each building shall be equipped with approved PVC overhead water tanks of capacity not less than 2000 litres.

2.3.2 ELECTRICAL SERVICES

This service shall be provided as essential service for all buildings / sheds. Electrical services for buildings shall consist of electrical supply and distributions, electrical lighting installations, telephone network, fans, exhaust fans, lighting protection system etc. including all accessories, cabling etc. including emergency power supply, all as per requirement. All electrical wiring should be concealed. All electrical switches / sockets shall be of modular type as per the approved makes given separately.

2.3.3 AIR CONDITIONING AND HEATING

Areas of control room, spaces housing equipment / machinery / panels etc. which required conditioned environment and certain specified areas like offices, specific office accommodation shall be suitably air-conditioned by split /

package / centrally air-conditioned type units, as per requirement with respect to other relevant Design Basis.

Accordingly, AC Plant / AHU etc. of the required capacity, whenever required, shall be provided and housed, suitably.

2.4 AESTHETICS

Apart from the fulfilment of functional & safety requirement, aesthetic requirement of the buildings / sheds shall be taken care of in the design. As specific guidelines for achieving required aesthetics are difficult to establish, following guidelines shall be followed:

a) Preliminary Drawings including perspective views indicating architectural treatment minimum three different alternative proposals shall be submitted for OWNER's approval.

b) Following elements shall be considered as contributory elements to aesthetics and their design etc. shall be subjected to the OWNER's approval. Any change / modifications sought for aesthetics improvements with regards to these elements shall be carried out. Any incidental elements like brick masonry, RCC work etc. required for such changes / modifications shall also be added.

i) Building / shed shape and features

ii) Canopies, overhangs & shading devices

iii) Gutters

iv) Entrance / exit steps, door

v) Window / Ventilator composition

vi) External wall location with respect to columns

vii) Colour scheme, grooves in plaster

viii) Spatial arrangement

ix) Aesthetic of the buildings should match with the surrounding existing facilities at the site.

2.5 BUILDING ELEMENTS

2.5.1 PLINTH PROTECTION

All the buildings & sheds shall be provided with minimum 1000 mm wide plinth protection around the building / shed. Level wise, it shall be 100 mm high above top of approach road level. In order to avoid accumulation of water outside the buildings, requirement of surface drains shall be examined on case to case basis for individual building and provided if necessary.

2.5.2 FINISHED FLOOR LEVEL (PLINTH FFL)

In general, Plinth FFL of the buildings, sheds shall be determined with respect to top of approach road or pavement. Unless noted otherwise on the reference drawings, following schedule shall be adhered to for FFL of various buildings & sheds.

a)	Sub Station Building		
-	Cable cellar floor	-	Top level of approach road + 450 mm
-	Transformer bay with pebbles	-	Top level of approach road + 150 mm
-	Single storey substation with trenches	-	F.G.L. (+) approx. 1000 mm high from top of road
b)	Transformer bay	-	Top level of approach road + 150 mm
c)	Vehicle, scooter, cycle shed including fire tender bays, repair shop	-	Top level of approach road + 300 mm
d)	False floor areas (Control Room)	-	As specified in the Instrumentation section of NIT
e)	Loading, Unloading bays, platforms	-	Top level of approach road + 1100 mm

f)	Electrical rooms	-	As specified in the Electrical section of NIT
g)	Other Buildings / Shed (Process Operator's Cabin)	-	Top level of approach road + 450 mm from surrounding ground level.

Notes:

a) In case of approaches with different top levels, the highest top level of approach road / pavement shall be considered.

b) FFL shall be same throughout in a building / shed. Split levels any be considered in exceptional cases due to ground terrain etc.

c) FFL of external loading / unloading bays / platforms, toilet, pantry, kitchen shall be 6 – 12 mm lower than that of the building / shed's FFL to check ingress / spillage of rainwater.

d) FFL of Warehouses, stores may be kept lower than loading / unloading bays / platforms where forklifts etc. are used for internal movement of items. Adequate arrangement for negotiating the level difference shall be provided in that case.

e) Where applicable, existing levels of building / sheds shall be followed.

2.5.3 STEPS / RAMPS

Steps / ramps shall be provided for access to the buildings / sheds for pedestrian /vehicles movement, equipment entry, etc. Minimum 1500 mm wide platform shall be provided in between entrance door and steps / ramps. Following dimensions of the steps / ramps shall be adhered to:

a) Tread	:	300 mm minimum
b) Riser	:	175 mm maximum
c) Slope of ramp	:	Not steeper than 1:10 slope

d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm
e)	Landing width	:	1500 mm minimum
f)	Flight width	:	1500 mm minimum

Edge of treads shall be provided with friction grip strips

2.5.4 WALL

Following schedule shall be adhered to for wall material and thickness

a)	Rain water duct / shaft	:	Min.230 mm thick hollow/ solid concrete block work
b)	External walls	:	Min.230 mm thick hollow/ solid concrete block work
c)	Fire wall (Around transformers)	:	240 thick RCC or 355 mm (including plastering) thick hollow/ solid concrete block work wall / OR as per Electrical requirements. (IER/TAC)
d)	Internal partition wall	:	230 / 115 mm thick. hollow/ solid concrete block work wall depending on the overall length and height of the wall (refer notes below)
e)	Blast Proof Wall	:	Min 230 mm thick.RCC wall

Notes:

a) 115 mm thick partition walls shall be provided with RCC transoms and mullions for suitability.

b) Wherever conduits or pipes are required to be concealed within partition wall, the local wall thickness shall be increased suitably.

2.5.5 DOORS

Doors shall be provided for access, security and safety to all rooms, functional areas in a building with all safety closures as per the requirement of OWNER. Air tight door shall be provided in pressurized area and in gaseous protection area. Emergency door shall be opened outwards. Sizes of the doors shall be determined on the basis of the following schedule:

a)	Equipment, Panel area	:	Maximum size of equipment including packing
b)	Other areas	:	Volume of movement through door
c)	Minimum door size at entrance	:	1500 mm x 2500 mm (masonry opening size)
d)	W.C. bath Cubicle door	:	800 mm x 2100 mm (masonry opening size)
e)	Minimum size of other doors	:	1000 mm x 2100 mm (masonry opening size)

Notes:

a) Entrance doors shall be provided covering full width of the entrance lobby. In that case the door shall be of composite type consisting of openable shutters & fixed panels. Entrance lobby shall be provided with elaborate canopy.

b) Rolling shutters min 2500 mm wide shall be provided for equipment entry for Switchgear room, Electrical room, A.C. Plant room etc. and also wherever size of opening exceeds 2500 mm x 2500 mm.

c) Mechanically operated rolling shutters shall be provided for main equipment entry opening, and also where opening size exceeds 8 m^2.

d) Fireproof door shall be with two hours fire rating as per statutory requirements.

e) Blast resistant Control room entry door shall be provided with blast resistant baffle wall in front of entry door and shall have 45 degree / 90 degree overlap on both sides as per relevant standard/codes.

2.5.6 WINDOWS / VENTILATORS

Windows / ventilators shall be provided in all areas for natural lighting, ventilation, and visibility of working level. For the purpose of ventilation, total openable area of the windows / ventilators shall be as per Factories Act subject to a minimum of 15% of the floor area to be ventilated. However, for control room and in office areas, etc. where visibility from inside is also important, increased window area (as per discussion with Owner/PMC) shall be provided. Areas accommodating panels / equipment shall be normally provided with ventilators at high level for uniformity distributed lighting.

Notes:

a) Requirements of window / ventilation area as stipulated above are for maximum room height of 4000 mm. For heights more than 4000 mm, additional window / ventilator shall be provided in the same manner at every work area / platforms at all levels.

b) Wherever due to limitation of external wall area or other reasons, stipulated area of window / ventilator cannot be provided, suitable mechanical / electrical system shall be employed.

c) Fly mesh shutters shall be provided for windows / ventilators in Kitchen, Pantry, Dining hall etc.

d) Ventilator shall be able to serve as smoke vents in the event of fire.

e) For structures like workshop / warehouse / compressor shed with pre-coated or G.I. roof sheeting, suitable monitor may be added to provide proper ventilation.

f) Fireproof windows shall be provided as per TAC, electrical, process, etc. statutory requirements.

g) External windows shall have P.C.C. (1:3:6) sills, 100 thick.

h) All glasses in windows & doors shall be toughened glass. Outside glasses shall be tinted toughened.

2.5.7 CANOPY / OVERHANG

RCC Canopy / Overhangs shall be provided at all entrances for rain / sun protection, accentuation of the entrances, and pedestrian movement as per the following schedule:

a) For all offices, control rooms, composite buildings / sheds accommodating offices, canopy shall be provided at all entrances. Size of the canopy shall be decided based on vehicle parking & pedestrian movement in addition to aesthetics of the building / shed. Bottom of canopy shall be minimum 2800 from top of drive way.

b) Overhangs shall be provided over all exits. Size of the overhang shall be decided on the aesthetics of the building / shed subjected to minimum of 1000 mm.

Blast proof Control rooms shall not have any projections on outer face of its walls except with false treatment for aesthetics of the building.

2.5.8 SHADING DEVICES

RCC Shading devices shall be provided over all windows, open able ventilators for rain & sun protection. These devices shall be in form of horizontal projections, vertical projected fins or combination of both as per building façade treatment. Minimum projection shall be 600 mm.

2.5.9 PARAPET

Parapets shall be of RCC for all buildings with minimum 500 mm high for non-approachable roof and 1100 mm high for approachable roof.

2.5.10 ROOF GUTTER

Gutter with rainwater pipes shall be provided for all the buildings / sheds for roof water drainage. Sizing of the gutter shall be based on areas to be

drained and number of outlets. Gutters shall be of RCC or sheet metal depending on type of structure

2.5.11 RAIN WATER PIPES, SPOUTS

PVC rain water pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity as per NBC-IX, Section-2. Rain water pipes shall be concealed as far as possible. RCC or GI spouts may be used for drainage of chajja / small canopies of ground floor. Dia of rain water pipe shall be 150 minimum.

2.5.12 ENTRANCE LOBBY

Entrance lobby shall be provided as a common entrance for all buildings / sheds accommodating separate functional spaces integrated together. Individual entries to such functional spaces shall be from this lobby by means of passages / corridors. Apart from common entry lobby, separate independent entries to these functional spaces shall also be provided if functionally required. Size of the entrance lobby shall be decided on the basis of volume of movement. Air lock lobby shall be provided for all entries with centrally air-conditioned spaces, and pressurized.

2.5.13 PASSAGE / CORRIDORS

Passage / corridors shall be provided to integrate various spaces. Width of the passage / corridors shall be as per statutory requirement, subject to a minimum width of 1500 mm.

2.5.14 SERVICE ENTRY

Separate service entry shall be provided for service areas such as kitchen, air-condition / pressurization plant room, electrical rooms. A common service entry may be provided depending on spatial arrangement.

2.5.15 EMERGENCY EXITS

Emergency exits shall be provided for all the building / sheds as per statutory requirements. Emergency exits for individual function spaces such as console area, cable cellar and switchgear hall shall also be provided. Emergency exits

shall be located in such a manner that escape route is unobstructed & without passing through any other function areas. Corridors / staircases shall be provided as escape route.

2.5.16 STAIRCASES

Staircases shall be provided in multi floor buildings for vertical circulation & emergency exits. Number of staircases shall be based on building / shed sizes, emergency exit requirements, and travel distances to exit points as per statutory regulations. More than 500 sq m ground covered area shall have at least two stairs in line with NBC-Part-IV. Emergency exit requirements shall be as per safety distance requirement. At least one staircase shall be provided for access to the flat roof tops for maintenance. Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 2.5 m for single flight. Following dimensions for staircases shall be adhered to:

a)	Stairs width	:	1500 mm minimum, (1000 mm minimum for emergency exit)
b)	Tread	:	250 mm minimum
c)	Riser	:	150 mm maximum
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm
Number of risers for single flight shall be restricted preferably to 12 depending on occupancy.			

2.5.17 RAILINGS

Railings shall be provided in roofs, stairs and in all unprotected openings in slabs as a safety device. Railings in high level loading / unloading bay of substations shall be of removable type. Parapets shall be given precedence over railings in roofs.

2.5.18 TOILETS

Toilets shall be provided for all habitable buildings / sheds. Gents & ladies Toilet, drinking water enclosure & janitor space, all shall be provided as required. The fittings / fixtures provided for bath / toilet shall be of luxury / coloured type.

2.5.19 PARTITIONS

Brick masonry partition wall shall be provided for control building. If required partitions shall be provided for flexible space arrangement in office spaces, Control room etc. The partitions shall be modular, dismantleable type of Godrej or approved equivalent make

2.5.20 FALSE CEILING

2.5.20.1 False ceiling shall be provided normally in air conditioned areas. False ceilings shall be provided for following purposes:-

a) To reduce room volume and hide ducting etc. for air conditioned spaces.

b) To maintain acoustic level inside any space.

c) To reduce habitable room, corridor, lobby, and toilet heights located in high ceiling building/shed to a reasonable and satisfactory height of minimum 3000 mm.

d) In fire rated areas where walls and doors are required to be fire rated, false ceiling shall also have complementing fire rating. It is appreciated that false ceiling have limitations in their fire performance due to openings in them for lighting and air-conditioning. Therefore alternative systems to prevent puncturing the ceiling must be employed.

2.5.20.2 Suitable space shall be kept to enable suitable arrangement of service duct cable, piping and lighting fixtures.

2.5.20.3 Providing and fixing thermal insulation with Resin Bonded Fibre glass wool conforming to IS: 8183. Density 16 kg/m³, 50 mm thick, wrapped in 200G

Virgin Polythene bags placed over existing false ceiling and held in position by criss-crossing GI wire.

2.5.20.4 False flooring as per latest specifications, as approved by Owner, to be provided

2.5.21 UNDER DECK INSULATION

Underdeck insulation below RCC roof and over false ceiling (both locations) shall be provided for air-conditioned office / space.

2.5.22 FALSE / CAVITY FLOORING

False / cavity flooring, consisting of cement filled flooring sheets with antistatic lamination on the top, of approved make / as directed by Engineer in charge, shall be provided to accommodate under floor cabling in all areas. Extent of false / cavity flooring shall be as per functional requirements.

False flooring shall be fire rated to the level of fire rating of the walls, doors and suspended ceiling in the compartment.

Cavity flooring for Control Room buildings, specifications given in Instrumentation section is to be followed.

2.5.23 WATERPROOFING ON ROOFS

Waterproofing on roofs shall be of either by membrane / chemical compound, as directed by engineer in charge

Dash fasteners, if used, shall be of approved make or as directed.

3.0 BUILDING STRUCTURE

The layout of the buildings shall be finalized within 3 months after the effective date of contract.

The design considerations, type of buildings and specifications of various buildings shall be as generally defined under this clause, unless stated otherwise as per plant requirements:

S. No.	Building	Design Consideration	Type of Building
1	Operators & Maintenance/ Control Room building	Rack layout, occupancy	RCC blast resistance structure as per specifications/ relevant standard/codal requirements including Hollow /Solid Concrete Block work infill walls
2	Sub station	Equipment layout, occupancy	RCC frame, hollow/solid concrete block work/ masonry infill walls
3	Compressor shed/ Technological structures/ etc	Equipment layout, occupancy	Structural steel Framed Structure

4.0 ARCHITECTURAL FINISHES / TRADES

(To be finalized in consultation with the client / PMC)

All the buildings shall be provided with Architectural finishes such as floor finishes, plastering & painting on walls & ceilings, doors / windows / ventilators, roof treatment, plinth protection, etc. pertaining to approved make/brand and best quality for industrial usage.

4.1 EXTERNAL FINISHES (To be finalized in consultation with the client /PMC)

4.1.1 EXTERNAL WALLS

a) Substation Room, Operator & Maintenance building

Cement Based paint of approved Quality.

b) Control Room

Sand Stone Cladding

4.2 INTERNAL FINISHES (To be finalised in consultation with the client/ PMC)

4.2.1 FLOOR FINISHES

a) Office area, & Sub station

Vitrified tiles in glazed or matt finish / Marbo-granite tiles

b) Toilet, Drinking Water area

Granite flooring

c) Circulation area (Corridor / Passage etc. except Entrance Lobby) of Sub station

Control room --Kota stone flooring

d) Switch Gear, Cable Cellar, A.C. Plant Room, storage area

Switch gear Room for substation will have Kota Stone Flooring. Rest of the buildings will have heavy Duty Decorative Ceramic Tiles. / Hardcrete Floor, as directed by E.I.C

e) Battery Room

Acid resistant epoxy coating over IPS-flooring & 2100 high dado.

f) Entrance lobby, corridor lobby of main building

Granite flooring

NOTE:

Skirting shall be provided in all areas, which shall be of same material as that of flooring. Glass strip panel shall be provided in cement concrete flooring.

4.2.2 INTERNAL WALL FINISHES

(To be finalized in consultation with the client /PMC)

a) Entrance lobby, Corridor lobby:

Granite stone cladding and plastic emulsion paint.

b) Office areas of Buildings:

Cement plaster, POP punning & plastic emulsion paint

c) Circulation areas (Corridor/Passage etc. excepting Entrance lobby) of Buildings

Cement plaster, POP punning & plastic emulsion paint

d) Rack Room, Office Rooms, Operators Room

Cement plaster, POP punning & plastic emulsion paint

e) Switchgear Room / Electrical Room

Cement plaster & Plastic Emulsion paint (Switchgear Room)

f) Battery Room

Acid resistant epoxy coating over cement plaster up to 2100 height. Plastic emulsion paint above 2100 height.

g) Toilet, Drinking water area

Granite stone cladding / Marble / Ceramic tiles as directed by E.I.C

4.2.3 INTERNAL CEILING FINISHES

(To be finalized in consultation with the client /PMC)

a) Toilet Electric Operator, Rack room, MCC panel room, UPS

As described in Instrumentation and Electrical specifications

b) Aluminum tray panel false ceiling.

c) Other areas which do not have false ceiling

Cement plaster & white / color wash, plastic emulsion paint etc., as in the case of wall finish.

4.2.1 DOORS, WINDOWS & VENTILATORS

4.3.1 DOORS

a) All doors in Toilet / WC / Bath

Pressed steel frame, block board flush shutter with lamination on the both sides.

35 mm flush door laminated with 01mm laminate from both sides

b) All doors of Electrical Room, A.C. Plant Room, Battery Room

Pressed steel frame with pressed steel shutter (or as specified in Electrical section).

c) Inside Control Room / Rack Room

Fire check door with 2 hours rating as required in perfect partition wall separating various fire zones (or as specified in Instrumentation section).

d) All other door of Control Room / Rack Room / Sub station

Glazed, powder coated Aluminum door with decorative etching (or as specified in Instrumentation section).

4.3.2 WINDOWS & VENTILATORS

Windows / ventilators

Glazed, powder coated aluminum window / ventilator.

4.3 SANITARY FITTINGS

(Make: Jaquar/Cera/Hindware/Perryware or equivalent)

a) Water Closet for Control Room

Wall hung type colored European designer type WC.

b) Water Closet for Sub Station.

Pedestal type white European designer type W.

c) Water Closet (Indian).

Orissa type (Indian) pan white WC.

d) Wash basins for Control Room.

Round wash basin white / colored housed in granite counter with electronic sensors for water control, approved quality mirror. Front portion below the counter shall be covered with shutters of laminated boards.

e) Wash basins for Sub Station /Control Room.

Wall hung wash basin with pedestal.

f) Plumbing fixtures.

Stainless steel bib cock, stop cock etc. fittings.

5.0 MISCELLANEOUS

5.1 ARCHITECTURAL DRAWING

5.1.1 Plant datum shall always be 100.00 metres and it's correspondence to the reduced level with respect to the mean sea level shall be indicated in the "NOTES" (Unless it is already established).

5.1.2 Location co-ordinates shall be indicated on grids.

5.1.3 Reference drawings, notes, holds list, schedule of finishes including painting, door and window schedules, area statement, notes on plastering, key plan, were necessary, shall appear in the first drawing sheet of a building. Subsequent sheets can cover them by a reference to the first sheet.

5.1.4 Elevations shall show physiographic to highlight features, human figures for scale, automobiles for headroom, trees and foliage for appearance.

5.1.5 False ceiling area shall be shown by hatching suitably.

5.1.6 False flooring area shall be shown by hatching suitably.

5.1.7 Air-conditioned rooms shall be identified suitably.

5.2 DESIGN

5.2.1 Entrances shall be elaborate and well sheltered to accommodate pedestrians and vehicles.

Provision for future extension, vertical and horizontal shall reflect in the work

5.2.2 Toilet, kitchen and pantry floors with waterproofing and sloped for drainage. The finished floor level shall be 25 mm below the general finished floor level.

5.2.3 Tile drops shall be indicated where required. For example from general floor to toilet floor, toilet floor to WC / Shower floor, general floor to pantry, general floor to entrance platforms and so on.

5.2.4 Plumbing works, external drainage, schematic, flow, shall be indicated.

5.2.5 AC plant, cooling tower, Chiller units etc., where required, shall be located on building roof as far as possible and it shall be positioned and supported to

transfer its load on to beams and columns and not to the slab. Such facilities should not be visible from outside. Suitable side cladding shall be provided for this purpose.

5.2.6 Access to all roofs via steel ladder. In case of accessible roofs at least one staircase shall go up to the roof.

5.2.7 Plinth beams level shall clear trenches if any.

5.2.8 Vertical ducts for running services must be examined.

5.2.9 Ventilator arrangement shall be provided unless situations strongly prevent or make it unnecessary. In addition to ventilation requirements, ventilators shall have the capacity to vent smoke in the event of fire.

5.2.10 Layout shall take into account the type of air-conditioning and built-in provisions shall be made to accommodate the equipment.

5.2.11 Walls on steel beams shall be constructed after wall below and up to the steel beam is constructed. This shall appear in the 'Notes' if applicable.

5.2.12 Gaps in floor cut outs shall be sealed with fireproof material for fire safety.

5.2.13 Openings in wall / cladding for pipes and cables from pipe rack / trays shall be made water tight primarily by means of design features.

5.3 BUILDING REQUIREMENTS

5.3.1 All free edges of chajjas and slab projections shall have drip mould in plaster 50 mm wide and 20 mm drop, unless the need is resolved in some other manner.

5.3.2 Floor slab in WC areas shall be sunk by 500 mm and toilet, pantry, kitchen floor slabs shall be sunk by 200 mm at all levels (including terrace, where future extension is envisaged).

5.3.3 All partition walls within toilet kitchen areas shall be 115 mm thick and 2200 mm high.

5.3.4 All supporting framework members of partition walls within false ceiling areas shall go up to roof level, partitions shall go up to false ceiling level except where there are fire compartment wall where it shall be from floor to ceiling.

5.3.5 Preferably all cut out in slab shall be provided with 200 high kerb.

5.3.6 Groove in plaster, 20 wide x 10 deep shall be provided aesthetically to break extensive areas of plaster.

5.3.7 Flooring shall be done in panels, preferably in 3000X3000 size. With expansion joints provided at 25000 c/c.

Flooring contraction joint shall be provided as per design.

5.3.8 Parapet walls shall be at least 1100 mm high.

5.3.9 Roofs of RCC buildings should have mild slope towards rain water gutters.

5.3.10 All Instrument / Electrical cables at the junction of the building (outside) shall be covered with pre-cast RCC slab. Sleeve pipes should be provided for the cable in the brick wall including its sealing.

5.3.11 All new buildings shall be designed for vertical extension in future

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE-D: TECHNICAL SPECIFICATIONS

FOR CIVIL, STRUCTURAL AND OTHER ALLIED WORKS

(ES-2516)

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1.0 GENERAL

1.1 Specifications of materials and workmanship shall be as described in the Central Public Works Department Specifications Vol. I & II (latest) include latest amendments, unless otherwise specified. These CPWD Specifications shall be deemed to form part of this contract. The **CONTRACTOR** shall procure and maintain copies of the latest CPWD Specifications at site for reference.

1.2 These technical Specifications shall be supplementary to the specifications contained in the CPWD specifications, wherever at variance, these Particular Specifications shall take precedence over the provisions in the CPWD Specifications.

2.0 CODES & STANDARDS

2.1 Wherever reference of IS Specifications/ or IS Codes of Practice are made in the Specifications/ Schedule of Rates or Preambles, reference shall be to the latest edition of IS (Bureau of Indian Standards).

IS - 383	Coarse & Fine aggregates from natural sources for concrete.
IS - 427	Distemper, dry, colour as required.
IS - 432	Mild Steel & Medium tensile steel bars.
IS - 456	Code of Practice for Plain and Reinforced Concrete.
IS - 515	Natural and Manufactured aggregates for use in mass concrete
IS - 730	Hook bolts for corrugated sheet roofing
IS - 800	Code of Practice for General Construction in Steel
IS - 1079	Hot rolled carbon steel sheets & strips
IS - 1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.

IS - 1161	Steel tubes for structural purposes.
IS - 1285	Wrought aluminium & aluminium alloy extruded round tube and hollow sections
IS - 1361	Steel windows for Industrial Buildings.
IS - 1363	Hexagon head bolts, screws & nuts of product grade C : Part - I Hexagon head bolts (size range M5 to M64)
IS - 1367	Technical supply conditions for threaded steel fasteners
IS - 1566	Hard - Drawn steel wire fabric for concrete reinforcement.
IS - 1786	High strength deformed steel bars & wires for concrete reinforcement.
IS - 2062	Steel for general structural purposes.
IS - 2116	Sand for masonry mortars.
IS - 2212	Code of practice for brickwork.
IS - 2386	Methods of test for aggregates.
IS - 2835	Flat transparent sheet glass
IS - 4021	Timber door, window and ventilator frames
IS - 4923	Hollow Steel sections for structural use.
IS - 4925	Concrete batching and mixing plant.
IS - 5410	Cement Paint
IS - 6477	Dimensions for wrought aluminium & aluminium alloys, extruded hollow sections.
IS - 7318	Fusion welding of steel.
IS - 10262	Recommended guidelines for concrete mix design.

IS - 14871 Products in Fibre Reinforced Cement – Long Corrugated or Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification

3.0 EARTHWORK

3.1 EXCAVATION

3.1.1 Excavation shall be carried out in soil of any nature and consistency, in the presence of water or in the dry, met on the site to the lines, levels and contours shown on the detailed drawings and **CONTRACTOR** shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed by the Engineer-in-Charge.

3.1.2 Surface dressing shall be carried out on the entire area occupied by the buildings including plinth protection as directed without any extra cost. The depths of excavation shown on the drawings are the depths after surface dressing.

3.1.3 The site around all buildings and structures to a width of 3 metres beyond the edge of plinth protection, ramps, steps, etc. shall be dressed and sloped away from the buildings.

3.1.4 Black cotton soil, and other expansive or unsuitable soils excavated shall not be used for filling in foundations, and plinths of buildings or in other structures including manholes, septic tanks etc. and shall be disposed off within the contract area marked on the drawings, as directed, levelled and neatly dressed.

3.1.5 In case of trenches exceeding 2 metres depth or where soil is soft or slushy, the sides of trenches shall be protected by timbering and shoring. The **CONTRACTOR** shall be responsible to take all necessary steps to prevent the sides of trenches from caving in or collapsing. The extent and type of timbering and shoring shall be as directed by the **Engineer-in-Charge.**

3.1.6 Where the excavation is to be carried out below the foundation level of adjacent structure, the precautions to be taken such as under pinning, shoring and strutting etc. shall be determined by **Engineer-in-Charge**. No excavation shall be done unless such precautionary measures are carried out as per directions of **Engineer-in-Charge.**

3.1.7 Specification for Earth work shall also apply to excavation in rock in general. The excavation in rock shall be done such that extra excavation beyond the required width and depth as shown in drawings is not made. If the excavation done in depth greater than required /ordered. The **CONTRACTOR** shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.

3.1.8 **CONTRACTOR** shall make all necessary arrangements for dewatering / defiling as required to carry out proper excavation work by bailing or pumping out water, which may accumulate in the excavation pit from any cause/ source whatsoever.

3.1.9 **CONTRACTOR** shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.

3.1.10 The **CONTRACTOR** is forbidden to commence the construction of structures or to carry out concreting before **Engineer-in-Charge** has inspected, accepted and permitted the excavation bottom.

3.1.11 Excavation in disintegrated rock means rock or Boulders including brickbats which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.

3.1.12 Excavations in hard rock - meant excavation made in hard rock to be done manually, or by blasting using only explosives and / or pneumatic hammers. In case of blasting, control blasting should be adopted depending on site conditions. For using explosives **CONTRACTOR** shall follow all provisions of Indian Explosives Act / Rules 1983, corrected / revised up to date.

3.1.13 In case of hard rock excavation to be carried out using explosives the, **CONTRACTOR** shall obtain the written approval in advance.

3.1.14 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.

3.1.15 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The **CONTRACTOR** shall take all measures required for ensuring stability of the excavation and safety of property and people in the vicinity. The **CONTRACTOR** shall erect and maintain during progress of work, temporary fences around dangerous excavations at no extra cost.

3.1.16 Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact moorum, or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50m^3.

3.1.17 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates, etc. or other rock which can be quarried or split with crowbars or wedges. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.25m^3.

3.1.18 Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete for which in the opinion of the Engineer-in-Charge, requires the use of compressed air, equipment, sledge hammer and blasting or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.

3.1.19 In case of any difficulty concerning the interpretation of type of soil as mentioned above, the Engineer-in-Charge shall decide whether the

excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the CONTRACTOR and without appeal.

3.2 FILLING

3.2.1 Back filling of excavations in trenches, foundations and elsewhere shall consist of one of the following materials approved by **Engineer-in-Charge.**

Soil

Sand

Moorum

Hard-core

Stone/gravel

All back filling material shall be approved by the **Engineer-in-Charge.**

3.2.2 Soil filling - Soil material shall be free from rubbish, roots, hard lumps and any other foreign organic material. Filling shall be done in regular horizontal layers each not exceeding 20 cm. depth.

3.2.3 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings.

3.2.4 Back filling around pipes in the trench shall be done after hydro testing is done.

3.2.5 Back filling around liquid retaining structures shall be done only after leakage testing is completed and approval of **Engineer-in-Charge** is obtained.

3.2.6 Sand used for filling under foundation concrete, around foundation and in plinth etc. shall be fine/ coarse, strong, clean, free from dust, organic and deleterious matter. The sand filling under foundation shall be rammed with Mech. compactor. Sand material shall be approved by **Engineer-in-Charge**.

3.2.7 Moorum for filling, where ordered, shall be obtained from approved pits and quarries which contain siliceous material and natural mixture of clay. Moorum shall not contain any admixture of ordinary earth. Size of moorum shall vary from dust to 10 mm.

3.2.8 Hard-core shall be of broken stone of 90 mm to 10 mm size suitable for providing a dense and compact sub grade. Stones shall be sound, free from flakes, dust and other impurities. Hard core filling shall be spread and levelled in layers, 15 cm thick, watered and well compacted with ramming or with mechanical / hand compacts including hand packing wherever required.

3.2.9 If any selected fill material is required to be borrowed, **CONTRACTOR** shall make arrangements and procure such material from outside borrow pits. The material of source shall be subject to prior approval of **Engineer-in-Charge**. **CONTRACTOR** shall make necessary access roads to borrow areas and maintain the same, if such access roads do not exist, at no extra cost.

3.2.10 Plinth filling shall be carried out with approved material as described earlier, in layers not exceeding 150mm, watered and compacted with mechanical compaction machines. **Engineer-in-Charge** may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at later stage. The finished level of the filling shall be trimmed to the level specified. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.

3.2.11 Whenever the fill material (earth or soil) is purchased, **CONTRACTOR** shall get the approval of Engineer-in-Charge. The CONTRACTOR shall arrange to determine the following properties of the soil and shall get the approval of **Engineer-in-Charge**.

1. Clay content : 15% to 20%
2. Laboratory dry density : Not less than 1600 kg/m³
3. Plasticity Index : Not more than 20

3.2.12 The fill shall be compacted using a vibrating compactor of not less than 1.5 tonne. The fill shall be thoroughly compacted in layers as directed but not more than 200 mm thick. Adequate water shall be used for compaction and the density after compaction shall be not less than maximum dry density obtained in test of IS: 2720 Part-8. Compacted surface shall have at least 90% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.

3.2.13 The Gravel fill shall be non plastic granular material, well graded, strong, with maximum particle size of 50 mm, with not more than 15% passing a 4.75 mm IS sieve, free of all debris, vegetable matter and chemical impurities.

3.2.14 All clods, lumps etc. shall be broken before compaction.

3.2.15 In case of grading/banking successive layers of filling shall not be placed, until the layer below has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within +/- 2% of the optimum moisture content as described in IS 2720 Part-7. The moisture content shall preferably be on the wet side for potentially expansive soil.

After adjusting the moisture content as described, the layers shall be thoroughly compacted by means approved by Engineer-in-Charge, till the specified maximum laboratory dry density is obtained.

General, fill shall be placed in layers not exceeding 300 mm thickness and shall be thoroughly compacted to achieve a compaction of at least 90% of laboratory maximum dry density up to a depth of 600 mm below finished

grade. Final fill of 600 mm thickness shall consist of preferably natural material in, as dug condition except that stones larger than 100 mm shall be removed. It shall be placed in layers not exceeding 150 mm thickness and compacted to achieve of at least 95% of laboratory maximum dry density. Each layer shall be tested in field for density and accepted by Engineer-in-Charge, subject to achieving the required density before laying the next layer. A minimum of one test per 250 sq meters for each layer shall be conducted.

If the layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction altered as directed by Engineer-in-Charge to obtain the required density.

The filling shall be finished in conformity with the alignment, levels, cross-section and dimensions as shown in the drawing.

Extra material shall be removed and disposed off as directed by the **Engineer-in-Charge.**

4.0 PLAIN AND REINFORCED CONCRETE WORK

This specifications deals with cement concrete, plain or reinforced, for general use, and covers the requirements for concrete materials, their storage, grading, mix design, strength & quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works.

4.1 MATERIALS

4.1.1 Cement: Any of the following cements may be used as required.

IS - 269	Ordinary Portland cement, 33 grade
IS - 8112	43 Grade ordinary Portland cement
IS - 12269	53 Grade ordinary port land cement

4.1.2 Water: Water used for mixing and curing concrete and mortar shall conform to the requirements as laid down in IS: 456. Sea water shall not be used for concrete work.

4.1.3 Aggregates: Coarse and fine aggregates for cement concrete plain and reinforced shall conform to the requirements of IS 383 and / or IS 515. Before using, the aggregates shall be tested as per IS: 2386.

Coarse aggregate: Coarse aggregate for all cement concrete work shall be broken or crushed hard stone, black trap stone obtained from approved Quarries or gravel.

Sand: Fine aggregate for concrete work shall be coarse sand from approved sources. Grading of coarse sand shall be within grading zones I, II or III laid down in IS: 383, table 4. If required the aggregates (both fine and coarse) shall have to be thoroughly washed and graded as per direction of **Engineer-in-Charge**.

4.2 MIXING

All cement concrete plain or reinforced shall be machine mixed. Mixing by hand may be employed where quantity of concrete involved is small, with the specific prior permission of the **Engineer-in-Charge**. 10% extra cement shall be added in case of hand mixing as stipulated in IS-456.

For large and medium project sites the concrete shall be sourced from ready-mixed concrete plants or from on site or off site batching and mixing plants (IS 4926)

4.3 WATER CEMENT RATIO, LAYING & CURING

Water Cement Ratio, Laying & Curing shall be done as per IS: 456.

4.4 CONCRETE

4.4.1 Concrete Grades lower than M 25 shall not be used in reinforced concrete.

4.4.2 A sieve analysis test of aggregates shall be carried out as and when the source of supply is changed without extra charge notwithstanding the mandatory test required to be carried out as per CPWD specification.

4.4.3 All tests in support of mix design shall be maintained as a part of records of the contract. Test cubes for mix design shall be prepared by the CONTRACTOR under his own arrangements and at his costs, but under the supervision of the **Engineer-in-Charge**.

4.5 DESIGN MIX CONCRETE

4.5.1 Design mix shall be allowed for major works where it is contemplated to be used by installing weigh batch mixing plant as per IS 4925. At the time of tendering, the CONTRACTOR, after taking into account the type of aggregates, plant and method of laying he intends to use, shall allow in his tender for the design mix i.e., aggregate/cement and water/cement ratios which he considers will achieve the strength requirements specified, and workability for concrete to be properly finished.

4.5.2 Before commencement of concreting, **CONTRACTOR** shall carry out preliminary tests for design mix on trial mixes proposed by him in design of mix to satisfy the **Engineer-in-Charge** that the characteristic strength is obtained. In this regard, CONTRACTOR may consult govt. approved/reputed institute to get design mix done as per IS 10262 at his own cost. The concrete mix to be actually used shall be approved by the **Engineer-in-Charge**.

4.5.3 Notwithstanding the above, the following shall be the maximum combined weight of coarse and fine aggregate per 50 kg of cement.

Grade of Concrete	Maximum weight of fine & coarse aggregates together per 50 kg of cement

		(for nominal mix only)
1.	M - 10	480 kg
2.	M - 15	350 kg
3.	M - 20	250 kg

4.5.4 The workability of concrete produced shall be adequate, so that the concrete can be properly placed and compacted. The slump shall be as per IS 456.

4.6 TESTING OF CONCRETE

4.6.1 Testing of concrete, sampling and acceptance criteria shall be in accordance with IS 456.

4.7 PROPORTIONING

Mixes of cement concrete shall be as ordered. Where the concrete is specified by grade, it shall be prepared by mixing cement, sand and coarse aggregate by weight as per mix design. In case the concrete is specified as volumetric mix, then dry volume batching shall be done, making proper allowances for dampness in aggregates and bulking in sand. Equivalent volume batching for concrete specified by grade may however be allowed by the **Engineer-in-Charge** at his discretion.

4.8 PRE CAST CONCRETE

The specifications for pre cast concrete will be similar as for the cast in situ concrete. All pre cast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soft former of the units, shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with

smooth neat cement finish or a layer of MS sheeting. The casting shall be over suitable vibrating tables or by using form vibrators as per directions of **Engineer-in-Charge**.

The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (Twenty Eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I .sheet metal. The yard shall preferably be fenced.

Lifting hooks, wherever necessary or as directed by **Engineer-in-Charge** shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drgs. and shall be burnt off and finished after erection.

Pre cast concrete units, when ready shall be transported to site by suitable means approved by **Engineer-in-Charge**. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the **Engineer-in-Charge**. The CONTRACTOR shall render all help with instruments, materials and staff to the **Engineer-in-Charge** for checking the proper erection of the pre cast units.

After erection and alignment the joints shall be filled with grout or concrete as directed by **Engineer-in-Charge**. If shuttering has to be used for supporting the pre cast unit they shall not be removed until the joints has attained sufficient strength and in no case before 14 (fourteen) days. The joint between pre cast roof planks shall be pointed with 1:2 (1 cement : 2 sand) mortar.

5.0 STEEL REINFORCEMENT

5.1 Steel reinforcement shall comprise:

Mild steel bars conforming to IS : 432 Part-I.

Cold twisted bars conforming to IS: 1786

CRS bars

TMT bars

Hard drawn steel wire fabric conforming to IS: 1566

5.2 All joints in reinforcement shall be lapped adequately to develop the full strength of the reinforcement as per provision of IS: 456 or as per instruction of **Engineer-in-Charge**.

6.0 FORM WORK

6.1 The shuttering or form work shall conform to the shape, lines and dimensions as shown on the drawings and be so constructed as to remain sufficiently rigid during placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete. The surface that becomes exposed on the removal of forms shall be examined by **Engineer-in-Charge** or his authorized representative before any defects are made good. Work that has sagged or bulged out, or contains honey combing, shall be rejected. All shuttering shall be plywood or steel shuttering.

6.2 The **CONTRACTOR** shall be responsible for sufficiency and adequacy of all form work. Centering and form work shall be designed & detailed in accordance with IS 14687 and approved by the **Engineer-in-Charge**, before placing of reinforcement and concreting.

6.3 STRIPPING TIME

Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of form work. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the form work shall be left longer as it would assist the curing.

Note 1: In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:

1.	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the **Engineer-in-Charge**
2.	Slabs (props left under)	3 days
3.	Beam soffits (Props left under)	7 days
4.	Removal of props under slabs 1. Spanning up to 4.5 m 2. Spanning over 4.5 m	 7 days 14 days
5.	Removal of props under beams & arches: 1. Spanning up to 6 m 2. Spanning over 6m	 14 days 21 days

For other types of cements, the stripling time recommended for ordinary Portland Cement may be suitably modified.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

7.0 CEMENT CONCRETE BLOCK

Cement concrete block shall be machined made in the proportion of such that mix shall not be leaner than one cement to twelve combined aggregates (by volume) but having minimum strength of 7.5 MPa. Combined aggregate shall be graded as near as possible to IS: 383. The fineness modules of combined aggregate shall be between 3.6 and 4. The concrete block shall be properly

cured as per IS-456. The surface of conc. block shall have even face without any honeycomb and free from cracks.

7.1 MORTAR

Cement and water shall confirm to the requirements laid down for cement concrete work.

7.1.1 Sand for concrete block masonry mortars shall be coarse sand generally conforming to IS: 2116. Maximum quantities of clay, fine dust, shall not be more than 5% by weight. Organic impurities shall not exceed the limits laid down in IS: 2116.

7.1.2 Mix of mortar for building concrete block shall be as specified in the item of work.

7.1.3 Mixing of the mortar shall be done in a mechanical mixer. When quantity involved is small hand mixing may be permitted by **Engineer-in-Charge**. Any mortar remaining unused for more than 30 minutes after mixing shall be rejected.

7.2 CONCRETE BLOCK MASONRY

The thickness of joints shall be 10 mm +- 3mm. Thickness of joints shall be kept uniform. In case of foundation and manholes etc. joints up to 15 mm may be accepted.

7.3 HALF CONCRETE BLOCK

All courses shall be laid with stretchers. Reinforcement comprising 2 nos. 6 mm dia MS bars shall be provided over the top of the first course and thereafter at every fourth course.

7.4 FIXTURES

All iron fixtures, pipes spouts, hold fasts of doors and windows which are required to be built into the wall shall be embedded in cement concrete blocks

1:2:4 mix (1 cement :2 coarse sand :4 graded stone aggregate. 20 mm nominal size) of size indicated in the item.

7.5 CURING

Concrete block masonry shall be protected from rain by suitable covering when mortar is green. Masonry work shall be kept constantly moist on all faces for a minimum period of seven days.

8.0 STRUCTURAL STEEL WORK

This specification covers the technical requirements for the preparation of shop drawings, supply, fabrication, protective coating, painting and erection of all structural steel rolled sections, built up sections, plates and miscellaneous steel required for the completion of the work.

Steel

All structural steel used in construction within the purview of this contract shall, comply with one of the following Bureau of Indian Standard Specifications, whichever, is appropriate or as specified.

IS – 2062 Hot rolled sections and plates

IS – 1079 Cold formed light gauge sections

IS – 1161 Tubular sections

IS – 4923 Hollow sections (rectangular or square)

Fabrication

Fabrication of steel structure shall be carried out in conformity with the best modern practices and with due regard to speed with economy in fabrication and erection and shall conform to IS-800. All members shall be so fabricated as to assemble the members accurately on site and erect them in correct positions. Before dispatch to site the components shall be assembled at shop and any defect found rectified. All members shall be free from kink, twist, buckle, bend, open joints etc. and shall be rectified before erecting in position. Failure in this respect will subject the defective members to rejection.

Fabrication Drawings:

Connections, splices and other details shall be suitably designed based on good Engineering practice.

Electrodes:

Electrodes used for welding shall comply with IS-814 or IS - 815.

8.1 MS BLACK/HIGH STRENGTH BOLTS AND NUTS

M.S.Black or high strength bolts, nuts and washers etc. shall be as per IS-800, IS-1363 and IS-1367. Manufacturer's test certificate shall be made available to the **Engineer-in-Charge**. For bolted joints, shanks and threaded bolts are to be used to ensure that threaded length do not encroach within the thickness of connected members of dimension beyond the following limit:-

a) 1.5 mm for connected members of thickness below 12 mm and

b) 2.5 mm for connected member of thickness 12 mm and above and that adequate shearing and bearing values required as per design are achieved.

Every portion work shall have its erection mark or numbers stencilled on the member for guidance in erection and bear all necessary marks of erections as directed by the Owner / Consultant.

8.2 No part of the work is to be oiled, painted (except contact surfaces) packed, bundled, crated or dispatched until it has been finally inspected and approved by the Owner / Consultant or his authorized representative. The whole steel work before being dispatched from the Contractor’s shop shall be dry and after being thoroughly cleaned from dust, mills scale, rust etc., and shall be given two coats of primer and one coat of final paint as per painting specification attached in this enquiry. Unless otherwise specified, all surfaces inaccessible after welding shall be given two coats of primer and two coats of paints as per painting specification attached in this enquiry.

8.3 The Owner / Consultant or his authorized representative shall have free access at all reasonable time to all places where the work is being carried out, and shall be provided by the Contractor at his own expenses all necessary facilities for inspection during fabrication and erection. The Owner / Consultant or his authorized representative shall be at liberty to reject the work in whole or in part if the workmanship or materials do not conform to the terms of the specifications mentioned herein. The Contractor shall remove, replace or alter any part of the work as ordered by the Owner / Consultant or his authorized representative.

9.0 PAINTING ON STRUCTURAL STEEL

The following specification shall be used for painting of structural steel work.

9.1 SCOPE

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of structural steelwork, plate work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.

9.2 DEFINITIONS

C.S - Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys

S.S - Stainless steel, such as 304,316, 321, 347,

Non-ferrous- copper, aluminium and their alloys.

High Alloy - Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.

DF - Dry Film thickness, the thickness of the dried or curved paint or coating film.

9.3 SAFETY REGULATIONS

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

9.4 MATERIAL SAFETY DATA SHEETS

The latest issue of the coating manufacturer's product datasheet, application instructions, and material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

9.5 MATERIALS

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

Specification number

Colour reference number

Method of application

Batch number

Date of Manufacture

Shelf life expiry date

Manufacturer's name or recognised trade mark.

9.6 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

9.7 INDIAN STANDARDS:

IS-5: 1994 Colors for ready mixed paints and enamels.

IS-2379: 1990 Color codes for identification of pipe lines.

IS-2629: 1985 Recommended practice for hot-dip galvanizing on iron and steel.

IS-2633: 1986 Methods for testing uniformity of coating of zinc-coated articles.

IS-8629: 1977 Code of practice for protection of iron and steel structures from atmospheric corrosion.

IS: 110 Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers

IS: 101 Methods of test for ready mixed paints & enamels.

9.8 OTHER STANDARDS:

9.8.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988

(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

9.8.2 DIN: 53151 Standards for Adhesion test.

9.9 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a) Instructions for storage to avoid exposure as well as extremes of temperature.

b) Surface preparation prior to painting.

c) Mixing and thinning.

d) Application of paints and the recommended limit on time intervals between coats.

9.10 SURFACE PREPARATION

9.10.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

9.10.2 Pre-Cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

9.10.3 Surface decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired. Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces. Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be

used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m^2 of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

a) Sodium chloride :- Less than 50 microgram / cm^2;

b) Soluble iron salts :- Less than 7 microgram / cm^2; and

c) pH :- 6 – 8

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

9.10.4 Abrasive blasting

All C.S materials shall be abrasive blast cleaned in accordance with relevant IS Codes. To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination).When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a

surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 Degree Celsius above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm^2 using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

9.10.5 Painting system to be used is indicated below:

1.Epoxy Painting:

Primer P 1-2 coats + finish paint FP1 (2 coats) where P1 is epoxy polyamide cured zinc chromate primer having DFT of 35 micron per coat and FP1 is epoxy polyamide cured finish paint having DFT (Dry Film Thickness) of 35 micron per coat.

Equivalent product chart for approved paint manufactures for primer P1 finish paint FP1 indicated above is enclosed.

2. For PU painting:

i) P1 – One coat of Ethyl silicate inorganic zinc primer having DFT of 70 microns per coat.

ii) IP1 – One coat of Epoxy MIO having DFT of 70 microns per coat.

iii) FP1 - One coat of finish epoxy paint using two pack Polyamide cured epoxy having DFT of 40 microns per coat.

iv) FP2 - One coat of Aliphatic Acrylic Polyurethane paint having DFT of 40 microns per coat.

Equivalent product chart for approved paint manufactures for P1, IP1, FP1 & FP2 indicated above is enclosed.

9.10.6 All the surfaces must be abrasive blasted and 2 coats of primer plus 1 coat of finish paint applied in the fabrication shop before the same are shifted to site for erection. All the members must be suitably match marked for facilitating proper assembly.

After erection is over all surfaces shall be washed up as follows:

Washing with clean water (pressure 7 kg/cm^2) using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matters.

Solvent washing if required to remove traces of oil grease etc.

After washing the surface as indicated above, the surfaces shall be suitably touched up to the extent required so that all the damages to the premiered surfaces caused during erection are done up.

a) The surfaces affected by welding and / or gas cutting during erection shall also be suitably touched up. Before touch up is taken up surfaces shall be prepared by mechanical means such as grinding, power brushing etc. to achieve surface finish to ST-3.

b) After touch up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

9.10.7 The following points must be observed for painting work:

a) Primer and paint shall be compatible to each other and should be from the same manufacturer.

b) The recommendation of the paint manufacturer regarding mixing, matching and application must be followed meticulously.

c) Technical representative of paint manufacturer should be available at site as and when required by Engineer-in-**Charge** for their expert advice as well as to ensure that the painting work is executed as per the instruction of paint manufactures.

d) Paints and primers shall be supplied at site in original container with factory seal otherwise such paints and primers shall not be allowed to be used. Mode of application i.e. by spray, brush or roller shall be strictly as per recommendation of paint manufacturer.

e) Painting materials must be used before the expiry date indicated on the containers.

f) Number of coats and DFT per coat must be strictly followed as indicated above. If the desired DFT is not achieved for primer and finish paints in two coats (each), CONTRACTOR shall be required to apply extra coat (s) to achieve the desired DFT without any extra cost to Engineer-in-Charge.

g) Color shade for each coat of primer and finish paint must be different to identify the coats without any ambiguity.

h) Shade for the final finish coat shall be decided by Engineer-in-Charge at site.

i) All painting materials must be accompanied by manufacturers test certificates. However, Engineer-in-Charge has any doubt regarding quality of materials, he shall have the right to direct CONTRACTOR to get the doubtful material tested or and provided (by CONTRACTOR) testing agencies for which no extra payment shall be made to the CONTRACTOR and the charges shall deemed to be covered in the unit rates quoted for fabrication and erection of structural work.

j) DFT for paint shall be measured at least 20 points and mean DFT shall not vary by more than 10% than specified in DFT.

k) Reliable and calibrated Instrument for measurement of DFT shall be arranged and provided by CONTRACTOR at his cost.

l) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.

9.10.8 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.

9.10.9 Equivalent Chart for Various Paint Manufacturers for Epoxy paint

	ASIAN	G & N	SHALIMAR	J & N	BERGER	BOMBAY
P1	APCODUR - Epoxy Zinc Chrome Primer	AMERCOAT-71	EPIGARD-4 Zinc Chromate Primer	EPILAC Zinc Chromate Primer	EPILUX-4 Zinc Chromate Primer	PENTADUR PRIMER 1532
FP1	APCODUR CF 692	NEROLAC TWO COMP EPOXY	EPIGARD XL FINISH	EPILAC 974 ENAMEL	EPILUX-4 ENAMEL	PENTADUR ENAMEL 5534 GRAY

9.10.11 Equivalent Chart for Various Paint Manufacturers for PU paint

CODE	ITEM	DFT PER COAT (MICRONS)	ASIAN	G & N	SHALIMAR	J & N	BERGER	BOMBAY
P1	ETHYL SLILICATE INORGA-NIC ZINC PRIMER	70	APCOSIL 601	DYMET - COTE - 9	TUFFKOTE ZILICATE	J&N INORGA-NIC ZINC SILICATE PRIMER	ZINC ANODE 304	HEAPELS GALVO-SIL 1570
IP1	EPOXY MIO	70	APCO-DUR MIO	AMER COAT 385	EPIGUARD HB MIO	EPILAC HB MIO	EPILUX-4 HB MIO	PENTA-DUR HB MIO 4567
FP1	TWO PACK POLYA-MIDE CURED EPOXY	40	APCO-DUR CF-692	NERO-LAC TWO COMP EPOXY	EPIGUARD XL	EPILAC 974	EPILUX-4 ENAMEL	PENTA-DUR ENAMEL 5534

FP2	ALIPHA-TIC ACRYLIC POLYURE-THANE PAINT	40	APCO-THANE 674	AMER-COAT 450 GL	SHALI-THANE	JN 992 PU FINISH PAINT	BERGA-THANE ENAMEL	PENTO-THANE 4513

10.0 STEEL / ALUMINIUM DOORS, WINDOWS AND VENTILATORS

10.1 The Steel doors, windows and ventilators shall be of the size and type as per IS-1361 and IS-1038. Fixing and glazing shall be done as per IS-1081 and as per manufacturer's instructions. The putty of approved make such as special gold size or equivalent conforming to IS-419 shall be used.

10.2 Aluminium doors, windows and ventilators shall be manufactured from wrought aluminium and aluminium alloy extruded round tube and / or hollow rectangular / square sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by **Engineer-in-Charge**.

11.0 ROOFING & CLADDING

All roof and cladding sheets should be galvalume sheet of 0.5 mm total coated thickness with 550 MPA grade steel confirming to AS 1397 with AZ150 grade coating.

Translucent sheets shall be provided, in non-process areas only, intermittently where day lighting is required.

12.0 FLOORING AND PAVING

12.1 SUB BASE OF FLOOR

12.1.1 The area to be paved shall be divided into suitable panels. Form work shall be provided. The boarding / battens shall be fixed in position with their toe at proper level, giving slope where required. Alternatively base concrete may be deposited in the whole area at a stretch.

12.1.2 Before placing the base concrete the sub-base shall be properly wetted and rammed. The concrete of the specified mix shall then be deposited between the forms where provided, thoroughly tamped and the surface finished level with the top edge of the forms. The surface of base concrete shall be spreader uniformly. The surface shall be finished rough to provide adequate bond for the topping. Two or three hours after concrete has been laid the surface shall be brushed with wire brush to remove any scum or Latinate and swept clean so that coarse aggregate is exposed.

12.2 CEMENT CONCRETE FLOOR FINISHES

12.2.1 The surface of base concrete shall be thoroughly cleaned by scrubbing with coir or steel wire brush. Before laying the toping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the toping is laid.

12.2.2 The forms shall be fixed over the base concrete dividing into suitable panels. Where glass dividing strips are provided, thickness of glass dividing strips shall be 4 or as indicated. Before placing the concrete toping, neat cement slurry at the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float to a fair and even surface shall be left for some time till moisture disappears from it. Junctions with skirting / dado or wall surfaces shall be rounded off using cement mortar 1:2 curing shall be carried out for a minimum of 7 days.

13.0 PLASTERING

13.1 Sand for plastering shall be 50% fine sand and 50% coarse sand from approved sources.

13.2 Preparation of surface shall be done as per CPWD specifications.

13.3 Cement mortar shall be of the mix as indicated in the items and shall be mixed as specified in the CPWD specifications.

13.4 Joints in walls etc. shall be raked to a depth of 12 mm, brushed clean with wire brushes dusted and thoroughly washed before starting the plaster work.

13.5 The surface shall be thoroughly washed with water cleaned and kept wet to saturation point before plastering is commenced.

13.6 Cement mortar as indicated, shall be firmly applied to the masonry walls in a uniform layer to the thickness specified and will be pressed into the joints. On concrete surfaces rendering shall be dashed to the roughened surface to ensure adequate bond. The surface shall be finished even and smooth. Hectoring wherever required shall be done as per directions of **Engineer-in-Charge.** Nothing extra shall be paid on this account.

13.7 All plaster work shall be cured for at least 7 days.

13.8 Integral water proofing compound shall be mixed with cement in the proportion recommended by the manufacturer. Care shall be taken to ensure that the water proofing material gets well and integrally mixed with cement. All other operations are the same as for general plaster work.

13.9 For sand face plaster undercoat of cement plaster 1:4 (1 cement : 4 sand) of thickness not less than 12 mm shall be applied similar to one coat plaster work. Before the under coat hardens the surface shall be scared to provide for the top coat. The top coat also of cement mortar 1:4 shall be applied to a thickness not less than 8 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.

14.0 EXTERIOR PAINTING OR APEX

14.1 Exterior painting shall be Apex.

14.2 Where shown on drawings for external surfaces of sand faced plaster, or any other surface, two coats of cement paint shall be applied of tint and shade as approved by the **Engineer-in-Charge**.

14.3 The surfaces shall be prepared as specified for white washing. Before applying cement paint the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet, when the paint is applied. Not less than 24 hours shall be allowed between the two coats. In hot weather the first coat shall be slightly moistened before applying the second coat.

14.4 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and concrete surfaces, apex weather proof paint shall be vigorously scrubbed on to work the paint into the voids and provide a continuous paint film free from pin holes and other openings.

15.0 GLAZING

15.1 Sheet glass glazing of doors, windows etc. shall be of selected quality glass conforming to IS: 2835. Toughened splinter proof industrial safety glass shall confirm to IS: 2553. No cracked chipped or disfigured glass shall be accepted Glass shall be in one piece for each pan.

15.2 Glazing shall be fixed with timber or steel / aluminium beading as called for. Glass shall be back puttied and fixed with beading for a water tight and rattle free installation. Sizes of timber/ steel / aluminium beading shall be as directed.

16.0 PROTECTIVE COATING AND LINING SYSTEM

16.1 ACID PROOF TILES:

MATERIAL

1) TILES

These tiles shall be made of clays, feldspar, quartz, talc and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from

slipperiness. Tiles shall not absorb more than 2% of their own dry weight when soaked in water. Compression strength: 700 Kg/cm2 Min. & Flexural strength: 200 Kg/cm2 Min. It shall not lose more than 1.5% of it weight when soaked in acid.

Chemical compositions of tiles:

- Al_2O_3 : 22-24%
- SiO_2 : 60-65%
- Fe_2O_3 : 1.0-2.0%
- Alkalise : 10-12%

2) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid tile linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

- Colour : White
- Density (lbs/Cub. ft.) : 130
- Water Absorption : 2-5 %
- Tensile Strength (Psi) : 400
- Compressive strength (Psi) : 2800
- Bond Strength (Psi) : 180
- Coefficient of thermal expansion : 6.0×10^{-6}

3) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

- Density (Kg/m^3) : 2200
- Water content by mass percent (max) : 0.5
- Flash point °C ,min. : 35

Consistency

a) Before setting (test after 1 hr) min. : 100

b) After setting (test after 24 hr) min. : 80

Mastic shall be heated to 150-300^{o}C and shall be applied in 5 mm layers after surface is cleaned and dried.

4) BITUMINOUS PAINT

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall confirm to the following requirements:

- Viscosity by standard tar viscometer, 4mm orifice at 25°C: 4 to 24
- Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50
- Water content percent (max) : 0.2

APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#

SL. NO.	DESCRIPTION	ITEM OR AREA
4.	10 mm thick Acid proof tiling	Over K-based Silicate

- Tiles should be fixed on bitumastic surface with the help of 5mm K-based silicate mortar.

16.2 EPOXY COATING

Characteristics of coated surfaces (after application)

- Compressive strength : min. 90 N/mm2
- Tensile strength : min. 10 N/mm2
- Abrasion resistance : as per Amsler 1.5 mm after 3000 revol.
- Bonding (joining) factor : 1

APPLICATION:

SL. NO	DESCRIPTION	APPLICATION
1.	One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 60 micron per coat	Primer coat on Concrete surface
2.	One coat of two pack interpenetration polymer (Epoxy Phenolic) Thickness 100 micron per coat	Intermediate Coat over Primer Coat
3.	One coat of two pack interpenetration polymer (Polyurethane)	Final Coat over Intermediate Coat

SL. NO	DESCRIPTION	APPLICATION
	Thickness 50 micron per coat	
4.	Sealing by polysulphide compound	This will be provided at all joints with foundation, pits & wall etc

16.3 ACID RESISTANT BRICK LINING

MATERIAL

These bricks are made of raw materials such as clay or shale of suitable composition with low lime and iron content, feldspar, flint or sand and vitrified at high temperature in ceramic kilns. Bricks shall not absorb more than 2% of their own wt. when soaked in water. Compression strength: > 700 Kg/cm^2. Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are

a) Al_2O_3 22-24%

b) SiO_2 60-65%

c) Fe_2O_3 1.0-2.0%

d) Alkalies 10-12%

1) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid brick linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

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- Colour : White
- Density (lbs/Cub. ft.) : 130
- Water Absorption : 2-5 %
- Tensile Strength (Psi) : 400
- Compressive strength (Psi) : 2800
- Bond Strength (Psi) : 180
- Coefficient of thermal expansion : 6.0×10^{-6}

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- Water content by mass percent (max) : 0.5
- Flash point °C ,min. : 35
- Consistency

  Before setting (test after 1 hr) min. : 100

  After setting (test after 24 hr) min. : 80

Mastic shall be heated to 150-300^{o}C and shall be applied in 5 mm layers after surface is cleaned & dried.

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The primer shall confirm to the following requirements:

Viscosity by standard tar viscometer, 4mm orifice at 25°C : 4 to 24

Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50

Water content percent (max) : 0.2

APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
.	Bituminous Paint (Primer)	Concrete surface
.	10mm Bitumastic Laying in two layers each shall not be more than 5 mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	One layer, 40mm Acid resistant Brick lining	Over K-based Silicate

#:- K-based Silicate mortar should be buttered on all sides of acid-resistant brick except the side facing the surface to be exposed to corrosives

17.0 CULVERT WORK

17.1 PIPE CULVERTS

17.1.1 Reinforced concrete pipes shall be provided between the drain pits of storm water drains to cross the roads. These pipes shall be non-pressure type conforming to IS: 458 and class as specified in the nomenclature of the item. The pipes shall be laid between the drain pits with a uniform slope and with proper bedding, if required, as per approved drawings. The reinforced concrete pipes shall be manufactured by centrifugal process. All pipes shall be true to shape, perfectly straight, sound and free from cracks. The pipes shall

be free from defects resulting from imperfect grading of the aggregate mixing or moulding.

17.1.2 Reinforced concrete pipes shall be laid, jointed and tested as per IS: 783. Pipes shall be laid true to alignment and gradients over cement concrete bed of 1:2:4 mix and / or encased, if required, as per approved drawings or as directed by Engineer-in-Charge. No deviations from the lines, depths of cuttings or gradients shall be permitted without approval in writing by Engineer-in-Charge. The joint between concrete drain pit wall and concrete pipe shall be done properly to make it water-tight. The pipe joints shall be spigot and socket joint (rigid type) for pipes of 600 mm. diameter and below and collar joint (rigid type) for pipes over 600 mm. diameter. For both types of joints, the annular space shall be filled up with cement and sand mortar 1:2 mix which shall be rammed with caulking tools. After the day's work, any extraneous matter shall be removed from inside of the pipes. Joints shall be cured properly as per IS: 783. Reinforced concrete pipes shall be tested hydraulically as per IS: 783. Refilling of trenches shall not be commenced until the entire length of the pipe has been tested and approved. The excavation of earth in trenches for laying the concrete pipes and refilling shall be done as per IS: 783.

17.2 BOX CULVERTS

17.2.1 The box-culverts are to be provided across the roads joining the storm water drains on both sides of the road. These box-culverts shall be of either complete reinforced cement concrete construction or brick masonry and reinforced cement concrete construction as specified in the schedule of items. The box-culvert construction shall be carried out as per the approved drawings.

18.0 TECHNICAL SPECIFICATION FOR WATER SUPPLY, DRAINAGE & SANITATION

18.1 SCOPE

a) The supply, laying and installation of pipes / open surface drains for draining off rain / surface water, fire water, sewage, plant effluent / blow down / floor washings etc., with all fittings and fixtures including jointing.

b) The supply, laying and installation of pipes for supply of water with all fittings and fixtures including jointing.

c) The supply and installation of sanitary fixtures like water closets, urinals, wash basins, sinks etc., with all fittings and fixtures.

d) The supply and installation of toilet accessories like mirrors, shelves, towel rails, liquid soap containers etc., with all fittings and fixtures.

e) The supply and installation of overhead water tanks with all fittings and fixtures.

f) The supply and construction of ancillary works like manholes, drop connections, gully chambers, oil traps, soak pits etc., with all fittings and fixtures.

18.2 GENERAL REQUIREMENTS

18.2.1 The Contractor shall furnish all skilled and unskilled labour, plant, equipments, scaffolding, men, materials, etc., required for complete execution of the work in accordance with the drawings and as described herein and / or as directed by the Engineer.

18.2.2 The Contractor shall make his own arrangements for locating the coordinates and positions of all works and reduced levels (RL) at these locations based on two reference grid lines and one bench mark which will be furnished by the owner. The

Contractor has to provide at site all the required survey instruments etc., to the satisfaction of the Engineer so that the work can be carried out accurately according to the specification and drawing.

18.2.3 The Contractor shall make good to the satisfaction of the Engineer all cuttings / damages resulting from his operations during the installation.

18.2.4 Only tentative Plant layout shall be furnished by the Owner. Detailed working drawings showing the layout, installation and other details will be prepared by the Contractor and got approved from the Engineer.

18.2.5 The Contractor shall dispose of all unserviceable materials at least 50 m away from the plant boundary, unless otherwise directed by the Engineer. All serviceable material shall be stacked within a lead of 500 m as directed by the Engineer.

18.2.6 In case of any contradiction between the provisions stipulated in this module of technical specification and those of other modules like Excavation and Filling, Cast-in-situ Concrete and Allied works etc., the former shall govern.

All works shall be carried out by qualified / licensed plumbers.

18.3 CODES AND STANDARDS

18.3.1 All standards, specifications, acts, and Codes of practice referred to herein shall be the latest edition including all applicable official amendments and revisions.

18.3.2 In case of conflict between this specification and those (IS Standards, codes etc.)

18.3.3 Some of the relevant Indian Standards, Acts and Codes referred to herein are given below:

IS : 458 : Precast concrete pipes.

IS : 554 : Dimensions for pipe threads, where pressure tight joints are made on threads.

IS	:	651	:	Salt glazed stoneware pipes and fittings.
IS	:	771 (Part-1 to 7)	:	Glazed fire clay sanitary appliances.
IS	:	774	:	Flushing cisterns for water closets and urinals.
IS	:	775	:	Cast iron brackets and supports for wash basins and sinks.
IS	:	778	:	Copper alloy gate, globe and check valves for water works purposes.
IS	:	781	:	Cast copper alloy screw down bib taps and stop valves for water services.
IS	:	782	:	Caulking lead.
IS	:	783	:	Code of practice for laying of concrete pipes.
IS	:	805	:	Code of practice for use of steel in gravity water tanks.
IS	:	1172	:	Code of basic requirements for water supply, drainage and sanitation.
IS	:	1239	:	Mild steel tubes, tubular and other wrought steel fittings.
IS	:	1536	:	Centrifugally cast (Spun) iron pressure pipes for water, gas and sewage.
IS	:	1703	:	Copper alloy float valves.
IS	:	1726	:	Cast iron manhole covers and frames.
IS	:	1729	:	Sand cast iron spigot and socket, soil waste and ventilating pipes, fittings and accessories.
IS	:	1742	:	Code of practice for building drainage.
IS	:	1795	:	Pillar taps for water supply purposes.
IS	:	2065	:	Code of practice for water supply in buildings.
IS	:	2326	:	Automatic flushing cisterns for urinals.

IS	:	2501	:	Solid drawn copper tubes for general engineering purposes.
IS	:	2548	:	Plastic seats and covers for water closets.
IS	:	2692	:	Ferrules for water services.
IS	:	2963	:	Copper alloy waste fittings for wash basins and sinks.
IS	:	3311	:	Waste plug and its accessories for sinks and wash basins.
IS	:	3438	:	Silvered glass mirrors for general purposes.
IS	:	3486	:	Cast iron spigot and socket drain pipes.
IS	:	3989	:	Centrifugally cast (spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
IS	:	4111 (Part-1 to 5)	:	Code of practice for ancillary structure in sewerage system.
IS	:	4127	:	Code of practice for laying of glazed stone-ware pipes.
IS	:	4764	:	Tolerance limits for sewage effluent discharged into inland- surface waters.
IS	:	4827	:	Electro plated coatings of nickel and chromium on copper and copper alloys.
IS	:	5219	:	Cast copper alloys traps.
IS	:	5329	:	Code of practice for sanitary pipe work above ground for buildings.
IS	:	5382	:	Rubber sealing rings for gas mains, water mains and sewers.
IS	:	5822	:	Code of practice for laying of welded steel pipes for water supply.
IS	:	6163	:	Centrifugally cast (spun) iron low pressure pipes for water, gas and sewage.

IS	:	7231	:	Plastic flushing cisterns for water closets and urinals.
IS	:	7740	:	Code of practice for construction and maintenance of road gullies.
IS	:	8931	:	Copper alloy fancy single taps combination tap assembly and stop valves for water services.
IS	:	8934	:	Cast copper alloy fancy pillar taps for water services.
IS	:	9762	:	Polyethylene floats for float valves.
IS	:	10446	:	Glossary of terms for water supply and sanitation.
IS	:	10592	:	Industrial emergency showers, eye and face fountains and combination units.
IS	:	12592	:	Specification for precast concrete manhole covers and frames.
SP	:	35	:	Hand book on water supply and drainage.

18.4 MATERIAL

18.4.1 All pipes, fittings, fixtures, appliances and accessories shall conform to the relevant Indian Standards as listed under Clause No. 3.0. These shall be obtained from an approved reputed manufacturer, and shall be approved, the Engineer. Wherever indicated by the Engineer, the Contractor shall submit samples of materials. These may be retained by him for subsequent comparison when bulk supplies are received at site. Ultimate choice of type lies completely with the Engineer.

18.4.2 The material brought to the site shall be stored in a separate secured enclosure, away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and item found damaged shall not be retained at site.

18.4.3 Chromium plating fittings and appliances shall be of grade-2. (10 micron thickness), conforming to IS: 4827.

18.4.4 Pipes

Unless otherwise specified, following types of pipes shall be used:

For water supply to buildings, fittings CPVC pipes conforming to IS 15778 shall be used.

For inlet connecting pipes to appliances / fittings, C.P. brass pipe of 15 mm N.B. with union of approved make shall be used. Standard length of 300 mm to 450 mm pipe shall be used to suit the site requirements.

For building sanitary work above ground, UPVC pipes, fittings and accessories conforming to IS: 13592/relevant IS Codes shall be used. Pipes shall be coated with coal-tar by hot dipping process for both inner and outer surfaces.

Glazed stoneware pipes used for sewer and drain shall conform to Grade A of IS: 651.

RCC pipe used for sewer and drain shall conform to IS: 458. Class NP2 pipe shall generally be used. However, for road or railway crossing higher class of pipe or concrete encashment shall be provided to take care of higher load.

For drain and sewer line work in bad or unstable ground condition and under building, centrifugally cast (Spun) iron pressure pipes conforming to IS: 1536 shall be used. Class LA pipe with spigot and socket ends shall be used. Pipes shall be coated with coal tar.

PVC rain water pipes shall be used for roof drainage.

18.4.5 Above Ground Level

a) Galvanised mild steel pipes for water supply

i) For work above ground level, the galvanised mild steel pipes and fittings shall run on the surface of the walls, ceiling or in chase as specified or shown on the drawing. The fixing shall be done by means of standard pattern holder bat clamps, provided at no more than 90 cm and keeping the pipes about 1.5 cm clear of the wall. To conceal the pipes, chasing may be adopted or pipes fixed in the ducts or recess etc. Provided there is sufficient space to work on the pipes with the common tools. The pipes shall not ordinarily be buried in walls or solid floors. Under unavoidable situations, pipes may be buried for short stretch after providing adequate protection against damage. Union joints shall be provided for all required locations to facilitate maintenance.

ii) Where directed by the Engineer, a M.S. tube sleeve shall be fixed at a place the pipe is passing through. In case the pipe is embedded, it should be painted with anti-corrosive bitumastic paints conforming to IS: 158. The pipes shall be oiled and rubbed over the white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench. All pipes and fittings shall be properly jointed and made complete water tight. Burr from the joint shall be removed after screwing.

iii) The pipes and fittings shall be checked under working pressure. Any joint found leaking, shall be rectified and all leaking pipes removed and replaced. The pipes and fittings shall be tested to a hydraulic pressure of 6 kg/sq.cm. All pipes used for water supply should be thoroughly and efficiently disinfected before being taken into use. The method of disinfection shall be subject to the approval of the Engineer.

iv) The storage tanks and downtake distribution pipes shall be disinfected together as specified under clause no. 13.2 of IS: 2065-1983, using disinfecting chemical.

b) UPVC pipe above ground for Buildings Sanitary work

i) For sanitary pipe work above ground for Buildings, 1S:5329 shall be followed for general guidance. Proper ventilation shall be provided in the piping system. The single stack system shall not generally be provided.

ii) Plain pipes shall be secured to the walls at all joints with M.S. holder bat clamps. The clamp shall be made from 1.6 mm thick M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semicircular pieces, hinged with 6 mm dia M.S. pin on one side and provided with flanged ends on the other side with holes to fit in the screw holt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long, 10mm diameter M.S. bar, riveted to the ring at the centre of one semicircular piece. C.I. brackets can also be used. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm (1:2:4 mix) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear of finished face of wall.

iii) All soil pipes shall be carried up above the roof and shall have sand PVC terminal guard. The pipes above parapet shall be secured to the wall by means of clamps.

iv) The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipes shall be properly fitted in the socket of the lower pipe such that here is a uniform annular space for filling with the jointing material. The interior of the socket and exterior of the spigots shall be thoroughly cleaned and dried. The spigot end shall be inserted into the socket right up to the back of the socket and carefully jointed using solvent as per recommendation of manufacturer.

v) Floor trap shall be 'Nahni' or ordinary type and shall conform to IS:1729. The floor shall be suitably lowered to accommodate the trap and the top of the floor shall be properly sloped towards the trap for effective drainage. A chromium plated/galvanised grating shall be provided on the trap. The sunken floor slab

shall be filled with light weight materials like cinder mixed with cement. Sunken slab shall be made watertight by means of Sika water proofing compound as recommended by the manufacturer.

c) Rain Water Down comers

i) Rain water downcomers and fittings shall be standard PVC rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer, these may have to be installed in chases cut out in the structure. All pipes shall be well secured to the walls and supported by adequately strong brackets. The brackets may be wrought iron clevis type, lip-ring type or perforated strap iron type, as approved by the Engineer. Suitable spacer blocks shall be provided against the vertical surface on which the pipe is fixed.

ii) All bends and junctions shall be supplied with water tight cleaning eyes. For improving the aesthetic appearance of the portion of building carrying rain water downcomers, the pipes may have to be concealed by encasing them with brick masonry, concrete, etc.

iii) Galvanised M.S. pipes shall be joined by using standard sockets or by welding. For welding of pipes, IS:11906 shall be followed. After welding, the welded area shall be coated with zinc rich paint after proper cleaning and preparation of the surface. Joints between successive lengths of pipe can be by collars according to provision of IS:1742-1983. All rainwater downcomers shall be provided with roof drain head of the shape and type as shown on the drawing. Unless otherwise specified, dome type drain head shall be used.

d) Khurras

i) The khurras shall be constructed before the brick masonry work in parapet wall is taken up, and it shall be 45x45cm in size, unless otherwise specified and be formed of cement concrete 1 :2:4 (1 cement: 2 sand: 4 graded stone aggregate of 20 mm nominal size).

ii) A PVC sheet 1 mx1 mx400 micron shall be laid under khurras and then cement concrete shall be laid over it to a minimum thickness of 3cm with its top surface lower than the level of adjoining roof surface by not less than 50mm.

iii) The concrete shall be laid to a size greater than the stipulated size of khurra in such a way that the adjoining terracing of brick tile overlaps the concrete on its 3 edges by not less than 7.5 cm. The concrete shall slope uniformly from the edges to the rainwater outlet. The concrete shall be continued at the same slope through the width of the wall into outlet opening to ensure a water tight joint.

iv) The khurras and the sides of outlet shall then be rendered with 12 mm coat of cement plaster 1:3 (1 cement: 3 sand). This shall be done when the concrete is still green and shall be finished with a floating coat of neat cement. The sides of khurras and the sides of openings shall be well rounded. The size of finished outlet opening shall be 10cm wide by 20cm high or as directed by the Engineer.

v) Iron grating shall be provided at the outlet to prevent chocking. The grating shall be 20×25cm with an outer frame of 15mm x 3mm MS flat, to which 4 nos. - 10mm dia MS bars shall be welded in vertical direction, keeping an equal clear spacing of 2.5cm.

e) Rainwater Spout

i) No spout shall be less than 80 mm in diameter. The spacing of spouts shall be arranged to suit the position of openings in the wall.

ii) The spouts shall be of PVC, 60 cm long. These shall be perfectly sound, free from cracks, imperfections of glazing etc. These must be straight, cylindrical and of Standard nominal diameter, length and depth of socket. Full length of pipes shall be used on the work. These must be salt glazed and shall generally conform to IS: 651.

iii) These shall be provided at the mouths of khurras and shall be fixed in cement mortar 1: 4 (1 cement: 4 sand) with the socket embedded in the masonry and the spigot end projecting outside. The masonry around the pipe and socket shall be thoroughly wetted and the hole shall be given a coat of cement mortar around. The pipe shall then be inserted and fixed with a surround of mortar. In case the hole is made much larger than the size of the pipe. Cement concrete 1: 2: 4I (1 cement: .2 sand: 4 graded. stone aggregate of 12.5 mm nominal size) shall be used to fill in the annular space. The spouts shall slope downward at a slope of 1 in 6. The projection outside the wall shall be uniform and not less than 40 cm. The entrance with the pipe shall be smoothly rounded to meet the internal bore of the pipe to facilitate easy flow. Care shall be taken to ensure that the vertical plane through the centre line of the spouts in a row shall be true to line.

18.4.6 below Ground Level:

a) Trenches and other Excavation:

i) Except as mentioned hereunder, all work for earthwork shall be done as specified in relevant chapter of Excavation and Filling. The trenches shall be so dug that the pipe may be laid to the required alignment and at required depth. The cover shall be measured from top soil or other surface of the ground. Turf, top soil or other surface material shall be set aside, turf being carefully removed and stacked for use in reinstatement. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions, if any, shall be properly filled with earth and consolidated in 20 cm layers.

ii) If the trench is extremely hard or rocky or loose stony soil, the trench shall be excavated at least 150 mm below the trench grade. Rocks, stone or other hard substances from the bottom of the trench shall be removed and the trench brought back to the required grade by filling with selected earth and compacted so as to provide smooth bedding for the pipe.

iii) The last 7.5 cm. of excavation shall be trimmed and removed as separate operation immediately prior to the laying of the pipe on their foundations. The width of the trench shall be such as to provide not less than 20 cm clearance on either side of the pipe. Excavation in road shall be so arranged as to cause minimum obstruction to traffic.

b) Laying of Pipes:

In no case, pipes shall be rolled and dropped into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe is carefully centered into the socket of the next pipe and pushed to the distance that it can go.

The pipe shall be laid with socket facing the direction of flow of water. The connection to an existing sewer shall as far as possible be done at the manhole.

c) Filling of Trench

Filling of the trench shall not be commenced until the length of pipes therein has been tested and passed. Special care shall be taken to pack under and sides of the pipes thoroughly with selected material. At least 300 mm over the pipe shall also be filled with selected earth.

18.5 MANHOLES

18.5.1 Wherever applicable manhole should be suitably designed & constructed.

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE-D

TECHNICAL SPECIFICATIONS

FOR BORED CAST- IN- SITU CONCRETE PILES

(ES-2516)

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1.0 SCOPE

1.1 This specifications cover the installation of bored cast-in-situ reinforced concrete vertical piles. Installation of bored cast-in-situ concrete vertical piles shall also conform to IS: 2911 (Part-1/Section-2).

1.2 This specifications also covers the technical requirements for load test (Initial and Routine tests) on reinforced concrete single vertical piles of to assess their vertical, horizontal and pull-out load carrying capacity.

1.2.1 Load tests on piles shall conform to IS: 2911 (Part-4).

2.0 GENERAL REQUIREMENTS

2.1 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work, load tests and submission of records / reports as per schedule.

2.2 The Contractor shall guarantee the "Safe Load" capacity of piles for various modes i.e., vertical, lateral and pull-out loads for piles installed by him.

2.3 Consequent upon award of work and prior to installation of piles, the Contractor shall submit design of piles in terms of allowable capacity, length, diameter, termination criteria, reinforcement, etc. for Owner's/ Consultant's approval. Owner's/Consultant's approval on pile design in no way absolve the Contractor for his responsibility to carry out all the initial (vertical, lateral and pull-out) load test of piles prior to installation of the job piles. The pile capacity to be used in design shall be arrived at from the initial load test of piles.

2.4 The Contractor shall make his own arrangements for locating the co-ordinates and position of piles shown in approved drawings and for determining the Reduced Levels (R.L) of these locations with respect to the single bench mark indicated by the Engineer-in-Charge. Two established reference lines in mutually perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site

all the required survey instruments to the satisfaction of the Engineer-in-Charge so that the work can be carried accurately according to specifications and drawings.

2.5 In case of working piles, if the pile rejected due to any reasons, attributable to contractor the Contractor shall install extra piles at no extra cost to the Owner / Consultant. Further, the extra cost due to the increase in the pile cap size, if any, on account of extra piles shall be borne by the bidder.

2.6 It is essential that all equipment and instruments are properly calibrated both at commencement and immediately after the tests so that they represent true values. Certificates to this effect from an approved institution shall be furnished to the Engineer-in-Charge. If the Engineer-in-Charge so desires the contractor shall arrange for having the instruments tested at an approved laboratory at his own cost and the test report shall be submitted to the Engineer-in-Charge. If the Engineer-in-Charge desires to witness such tests Contractor shall arrange to conduct the test in his presence.

2.7 The complete jacking system including the hydraulic jack, hydraulic pump and pressure gauge shall be calibrated as unit. The complete unit shall be calibrated over its complete range of travel for increasing and decreasing loads same as that of test loads. The calibration certificate shall be submitted to the Engineer-in-Charge.

2.8 The reaction load to be made available for the test shall be at least 25 % greater than the maximum jacking force. The reaction system as relevant shall be designed for the total reaction load. All reaction loads shall be stable and balanced during all operations of testing. During testing, stability of reaction system shall be ensured.

2.9 The load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack with a least count of not more than 10 % of the safe load.

2.10 The displacement of pile (In vertical, horizontal and uplift) shall be measured using dial gauges having a least count 0.01 mm.

2.11 Load test shall be conducted at pile cut off level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable dewatering methods.

2.11.1 In case of initial vertical load test where the water table level is higher than the COL Contractor may use reaction piles for testing purposes in each case. Engineer-in-Charge may at his discretion decide to rise the COL above water table.

2.12 Full details of the equipment proposed to be used and the test setup with detail sketches shall be submitted to the Engineer-in-Charge, before making arrangement to carry out the tests, for his approval. Approval of the Engineer shall also be obtained after the test set up is complete prior to commencement of loading.

2.13 All operations in connection with pile load test shall be carried out in a safe manner so as to prevent the exposure of people to hazard.

2.14 If any test has to be discontinued, which in the opinion of the Engineer-in-Charge interferes with the load test results, and he decides to abandon the test, the Contractor shall install another pile for the purpose and repeat the test after correcting the fault and the cost of all such operations, including the cost of test pile, shall be at the Contractor's expense.

2.15 After completion of piling work contractor shall submit four copies of the following documents for Owners record and future reference:

a. Initial load test data for all tests done along with the pile data and the analysis of the initial test results.

b. Pile data along with concrete mix design detail (note pile data shall contain details as per requirement of Annexure- A).

c. Routine load test data for all tests done.

d. A full record giving all details of test in the Performa shown in Annexure- B shall be submitted in triplicate to the engineer immediately on completion of each test. The record shall also include the plots of:

i. Load VS. Settlement

ii. Time VS. Settlement (for each increment of load)

iii. Characteristic of the piles and the interpretation of the pile load test curve as per the criteria for safe loads as mentioned in the specification.

2.16 Before commencement of the work, the Contractor shall submit Quality Assurance Plan to the Owner/Consultant for their approval.

3.0 CODES AND STANDARDS

3.1 All standards and codes of practice referred to herein shall be the latest editions including all applicable Amendments issued.

3.2 All works shall be carried out as per the relevant Indian Standard Codes. In case of conflict between the specification and the IS codes referred to herein, the former shall prevail. Some of the applicable Indian Standards and codes are referred to here below:

IS: 432(Part I&II)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
IS: 456	Code of Practice for plain and reinforced concrete.
IS: 1786	Code of practice for twisted steel high strength deformed bars for concrete reinforcement.
IS: 2911(Pr-I&II)	Code of practice for design and construction of pile foundations- Bored cast-in-situ concrete pile.
IS: 2911(Part-IV)	Code of practice for design and construction of pile foundation Load test on piles.

SP-34	Handbook on concrete reinforcement and detailing
IS: 5121	Safety code for piling and other deep foundations.
IS: 10262	Recommended guidelines for concrete mix design.
IS: 12330	Code of practice for Sulphate resistant Cement

4.0 MATERIALS

4.1 GENERAL

All materials vise cement, steel, aggregates, water etc., which are to be used for pile construction shall conform relevant IS codes specifications for properties, storage and handling of common building materials. However, aggregates more than 20 mm shall not be used.

5.0 CONCRETE

5.1 Enclosed Technical Specifications for cast-in-situ concrete and allied works along with IS: 2911 Part I/Sec.2 - Code of Practice for Design and construction of pile foundations (Bored cast-in-situ concrete pile) shall be applicable to concrete works for piles. Use of plasticizer to control the water cement ratio shall be permitted on specific approval from Engineer-in-Charge.

5.2 GRADE AND MINIMUM CEMENT CONTENT

5.2.1 Design Mix of Concrete grade specified in elsewhere in this document shall be used; the cement content shall be as per mix design conforming to IS: 10262. However, the minimum cement content shall be 400 Kg, per cubic metre of concrete. In case of piles subsequently exposed to free water or in case of piles where concreting is done under water or drilling mud using methods other than the tremie, 10 percent extra cement over that required for the design grade of concrete

at the specified slump shall be used subject to minimum quantities of cement specified above.

5.2.2 For the concrete, water and aggregates specifications laid down in IS: 456 shall be followed in general. Natural rounded shingle of appropriate size may also be used as coarse aggregate. It helps to give high slump with less water cement ratio.

5.3 SLUMP OF CONCRETE

The slump of concrete shall vary between 150 mm to 180 mm for concreting in water- free unlined boreholes. For concreting by tremie, a slump of 150 mm to 200 mm shall be used.

6.0 REINFORCEMENT

6.1 The minimum area of longitudinal reinforcements shall be 0.4 percent of the sectional area calculated on the basis of outside area of casing or the pile shaft where casing is not used, whichever is more. The minimum number of longitudinal reinforcement shall be six (6) and its minimum diameter shall be 12 mm. The stipulated minimum reinforcement shall be provided for the full length of pile. Adequate reinforcement shall be provided to take full uplift loads.

6.2 The longitudinal reinforcement shall project up to development length as per requirements laid in IS: 456 in terms of multiple of bar diameter above cut off level unless otherwise indicated.

6.3 The minimum diameter of the links or spirals bar shall be 8 mm and the spacing of the links or spiral shall not be less than 150 mm. The laterals shall be lied to the longitudinal reinforcement to maintain its shape and spacing.

6.4 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment these shall preferably be assembled before lowering into casing tube/pilebore by providing necessary laps as per IS: 456.

6.5 Laps shall be staggered as far as practicable and not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Centre to Centre).

6.6 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers cast specifically for the purpose.

6.7 Minimum clear cover to all main reinforcements in piles shall not be less than 50 mm unless otherwise specified.

7.0 PILE INSTALLATION

Installation of piles shall be carried out as per pile layout drawings, installation criteria and the direction of the Engineer-in-Charge.

7.1 EQUIPMENT AND ACCESSORIES

7.1.1 The equipment accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub-soil conditions, ground water conditions and the method of casting etc. These shall be of standard type and shall have the approval of the Engineer-in-Charge.

7.1.2 List of details of equipment and accessories proposed to be used for the job shall be submitted along with the bid.

7.1.3 The capacity of the rig shall be adequate so as to reach the specified founding level.

7.2 CONTROL OF POSITION AND ALIGNMENT

7.2.1 Piles shall be installed as accurately vertical as possible. The permissible limits for deviation with respect to position and alignment (inclination) shall conform to IS: 2911 (Part-1/Sec.-2), which is reproduced below for ready reference.

a. The maximum deviation of vertical piles shall not exceed 1.5 per cent in alignment.

b. Piles shall not deviate more than 75 mm or D/10 whichever is more from their designed position at cut off level.

In case of piles deviating beyond these limits, the piles shall be replaced or supplemented by one or more additional piles without any extra cost to the Owner.

7.3. BORING

7.3.1 Boring operations shall be done by rotary or percussion type drilling rigs using direct, reverse mud circulation (DMC or RMC) methods or grab method. In soft clays and loose sands, bailer method, if used, shall be used with caution to avoid the effect of suction. Boring operations by any of the above methods shall be done using drilling mud.

7.3.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used bentonite slurry shall be pumped through drill rods by means of high pressure pumps. The cutting tool shall have suitable ports for the bentonite slurry to flow out at high pressure. If on mobilization, the Contractor fails to make a proper bore for any reason, the Contractor has to switchover to other boring methods as approved by the Engineer-in-Charge at no extra cost to the Owner.

7.3.3 Working level shall be above the cut off level. After the initial boring of about 1.0 to 2.0 m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of concrete pile. The centre line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 1.0 m length. Additional length of casing may be used depending on the condition of strata, ground water level etc.

7.3.4 Use of drilling mud (bentonite suspension/slurry) for stabilizing the sides of the pile bore is necessary wherever is likely to collapse in the pile bore. Drilling mud to be used shall meet the following requirement.

a) Liquid limit of bentonite when tested in accordance with IS: 2720(Part-V) shall be more than 300 percent and less than 450 percent.

b) Sand content of the bentonite powder shall not be greater than 7 percent.

c) Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.034 and 1.10 gm/ml depending upon the pile dimensions and type of soil in which the pile is to be cast. However the density of bentonite suspension after mixing with deleterious materials in the pile bore may be up to 1.25 gm/ml.

d) The Marsh viscosity when tested by a Marsh cone shall be between 30 to 60 seconds.

e) The differential free swell shall be more than 540 percent.

f) The pH value of the bentonite suspension shall be between 9 and 11.5

7.3.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of slurry shall pass through setting tanks of adequate size to remove the sand and spoils from the slurry, before the slurry is re-circulated to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

7.3.6 The bentonite slurry shall be maintained at 1.5 m above the ground water level during boring operations and till the pile is concreted. When DMC and RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.

7.3.7 The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm. However, the pile bore shall be of the specified size.

7.3.8 Socketing shall be done as per Geo-technical Report/ pile design requirement point of view wherever required.

7.4. CHISELING

7.4.1 Chiseling may be restored to with the permission of the Engineer-in-Charge below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desire depth.

7.5 LENGTH OF PILE

The length of pile below cut off level shall be as per pile drawing.

7.6 CLEANING OF PILE BORE

7.6.1 After completion of the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge /bored material, debris of rock/boulder etc. Necessary checks shall be made for pile bore as described in the subsequent clauses to confirm the thorough cleaning of the pile bore.

7.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

7.6.3 Pile bore spoil along with used drilling mud shall be disposed off from site as directed by the Engineer-in-Charge.

7.7 ADJACENT STRUCTURES

7.7.1 When working near existing structures care shall be taken to avoid any damage to such structures.

7.8 CONCRETING

7.8.1 Concreting shall not be done until the Engineer-in-Charge is satisfied that the pile termination level is reached and the pile bore is cleaned properly and thoroughly.

7.8.2 The time interval between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs. the pilebore shall be abandoned. However, the Engineer may allow concreting provided the Contractor

extends the pile bore by 0.5 m beyond the proposed depth, and clean the pilebore. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

7.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

7.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

7.8.5 Concreting shall be done by tremie method. The operation of tremie concreting shall be governed by IS: 2911(Part-1/Sec.2). Drilling mud shall be maintained sufficiently above the ground water level.

7.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore posses density more than 1.25 T/Cu.m. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pilebore as mentioned in subsequent clause.

7.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilized as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

7.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.

7.8.9 The temporary guide casing shall be withdrawn cautiously after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.

7.9 CUT OFF LEVEL (COL)

7.9.1 Cut off level of piles shall be as indicated in drawings released for construction or as indicated by the Engineer-in-Charge.

7.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment in to pile cap.

7.9.3 Concrete shall be cast upto Ground level, to permit overflow of concrete for visual inspection.

7.9.4 In the circumstance where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Engineer-in-Charge.

7.10 SEQUENCE OF PILING

7.10.1 Each pile shall be identified with a reference number.

7.10.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

7.11 REJECTION AND REPLACEMENT OF DEFECTIVE PILES

7.11.1 The Engineer-in-Charge reserves the right to reject any pile which in his opinion is defective on account of load capacity structural integrity, position, alignment, concrete quality etc. Piles that are defective shall be pulled out or left in place as judged convenient by the Engineer-in-Charge, without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Engineer-in-Charge, at no extra cost to the Owner.

7.12 RECORDING OF PILING DATA

7.12.1 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data shall be as indicated in ANNEXURE- A of this document and the Pile Load Test Data shall also be recorded as per the details

indicated in Annexure- B of this document. On completion of each pile installation, pile record in triplicate shall be submitted to Engineer-in-Charge within two days of completion of concreting of the pile.

8.0 SAMPLING, TESTING, AND QUALITY ASSURANCE

8.1 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratories shall be provided by the contractor. The contractor shall carry out all sampling and testing in accordance with the relevant Indian Standards and this specification. Where no specific testing procedure is mentioned the test should be carried out as per the prevalent accepted engineering practice to the direction of Engineer-in-Charge. Test shall be done in presence of engineer of the engineer or his authorized representative. In case the Engineer requires additional tests, the contractor shall arrange to get these tests done and submit to the Engineer the test results in triplicate within three days after completion of any test.

8.2 RECORDS

The contractor shall maintain records of all inspection and testing, which shall be made available to the Engineer. The Engineer at his discretion may waive some of the stipulations for small and unimportant concreting operations and other works.

8.3 UNSUITABLE MATERIALS

Materials found unsuitable for acceptance shall be removed and replaced by the contractor. The work shall be redone as per specification requirements and to the satisfaction of the Engineer at no extra cost to the Owner.

8.4 QUALITY ASSURANCE PROGRAM

8.4.1 The Contractor shall submit and finalize a detailed Field Quality Assurance program within 30 days from the date of award of contract, according to the requirements of this specification. This shall include setting up of a testing laboratory, arrangement of testing apparatus/equipment, deployment of qualified/

experienced manpower, preparation of field quality plan, etc. On finalized field quality plan, the Owner shall identify, customer hold points, beyond which the work shall not proceed without written approval from the Engineer. The testing apparatus/equipment installed in the field laboratory shall be calibrated / corrected by the qualified persons as frequently as possible to give accurate testing results.

8.4.2 Frequency of sampling and testing, etc. and acceptance Criteria are given in Table- 1. The testing shall be done at field laboratory or any other laboratory approved by the Engineer-in-Charge. However, the testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications. The materials shall be tested to all the specified requirements as per relevant IS codes before acceptance at manufacturers premises or at independent Government laboratory. Tests indicated in the Table- 1 are for cross checking at site the conformity of the materials to some of the specifications.

8.5 TESTING OF CONCRETE

8.5.1 Concrete and other materials shall be tested for quality and strength and other properties as per relevant IS codes.

8.5.2 One sample consisting of six test cubes shall be made from the concrete used in each test pile, three to be tested after 7 days and three after 28 days.

8.5.3 For working piles, minimum one sample consisting of six test cubes shall be made from the concrete for the first ten piles, three to be tested after 7 days and three after 28 days. Thereafter minimum one sample consisting of there test cubes for every 25 piles shall be tested for the 28 day cube strength.

8.5.4 In preparation of test cubes/specimens vibrators shall not be used.

8.5.5 Concrete shall be tested for slump at every one hour interval.

8.5.6 Other materials like aggregates, reinforcement, etc., shall be tested as per relevant IS codes.

8.6 TESTING FOR POSITION AND ALIGNMENT

8.6.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.

8.6.2 Permissible limits for deviation shall be as specified elsewhere in this section of specification.

8.7. PROPERTIES OF DRILLING MUD

8.7.1 Properties of drilling mud shall be checked as per the requirements specified in clause no. 7.03.4 of this specification. Prior to use in piling work and there after minimum once in a week or as found necessary by the Engineer one sample consisting of 3 specimens shall be tested.

8.7.2 Density and sand content of the drilling mud shall be checked at least in each pile for first 10- piles before concreting. In case of satisfactory results the frequency of sampling shall not be less than one in 25 piles.

8.8 CHECK FOR PILE BORE

8.8.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Engineer-in-Charge to ensure that it is free from pile bore spoil/debris and any other loose material, before concreting shall be done only after the approval of the Engineer-in-Charge.

8.8.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimize the leakage while lifting the cone assembly to the ground

surface. The slurry collected in the sampler tube shall be tested for density and sand content.

9.0 LOAD TEST ON PILES

9.1 TYPE OF TESTS

9.1.1 The Contractor shall carry out two categories of load tests i.e. Initial Load and Routine Load Tests in accordance with IS: 2911 (Part-4).

9.1.2 Initial load test shall be conducted to assess the safe load carrying capacity of pile before start of installation of working piles. This shall include the following type of tests:

a) Cyclic compression load test to assess safe vertical load capacity.

b) Lateral load test to assess safe horizontal load capacity.

c) Tension load test to assess safe pull out load capacity.

9.1.3 The minimum number of Initial Load Test for each diameter of pile proposed shall be as under:

a) Vertical Compression : 2 No.

b) Lateral : 2 No.

c) Uplift /pullout : 1 No

9.1.4 Routine load tests of piles as per IS: 2911 (Part-4) shall be conducted to verify the load capacity of working piles. This shall include the following types:

a. Direct Compression load test for vertical load capacity.

b. Lateral load test for horizontal load capacity.

9.1.5 The minimum number of routine load test for each diameter and type shall be 1.5 percent of the total number of working piles. The number of tests may be increased up to 2 percent as decided by the Engineer -in-Charge in a particular case depending upon nature, type of structure and strata condition.

9.2 TEST PILE

9.2.1 The test piles for routine load test shall be identified by the Engineer-in-Charge.

9.2.2 A minimum time period of four weeks shall be allowed between the time of pile casting and testing Test pile head shall be prepared for testing purposes only one week after casting the pile.

9.2.3 The test piles shall be cut off at the proper level and provided with a proper cap so as to provide a plane bearing surface for the test plate and for proper arrangements for seating of the jack and dial gauges.

9.3 VERTICAL LOAD TEST

9.3.1 EQUIPMENT AND TEST SET UP

a) A steel plate of sufficient thickness not less than 50 mm shall be centred on the pile head to prevent it from crushing under applied load. The size of the plate shall neither be less than the pile size nor less than the area covered by the base of the hydraulic jack(s).

b) The datum bars shall be supported on immovable supports preferably of concrete pillars or steel sections placed sufficiently far away from the test pile. The distance shall not be less than 3 times the diameter of test pile and in no case less than 2 metres from the edge of test pile. These supports shall be placed at a sufficient depth below ground to be unaffected by ground movements.

9.3.2 LOADING SYSTEM

The test load on the pile shall be applied in one of the following ways as approved by the Engineer-in-Charge.

a) By means of hydraulic jack(s) which obtain reaction from kentledge heavier than the required test load. While using this method care shall be taken to ensure that the centre of gravity of kentledge heavier than the required test load. While using this method care shall be taken to ensure that the centre of gravity of kentledgte is

one the axis of the pile. The load applied by the jack(s) shall also be coaxial with the pile. The nearest edge of the crib supporting the kentledge stack shall not be closer than 1.5 metre to the edge of the test pile.

b) By means of hydraulic jack(s) which obtained reaction from anchor piles or/and suitable loading frame. While using this method all anchor piles shall be at a centre to centre distance of at least three times the test pile shaft diameter from the test pile and in no case less than 2 metres. Care shall be exercised to ensure that the datum bar supports are not affected by heaving up of the soil.

c) By means of hydraulic jack(s) which obtain reaction from suitable rock anchors. When this method is adopted, the anchor transferring the load to the ground shall not be closer than two times the test pile shaft diameter to the test pile and in no case less than 1.5 m.

d) By means of combination of kentledge, anchor pile, rock anchors.

9.3.3 MEASURING SYSTEM

Settlement of the pile shall be recorded by four dial gauges placed at diametrically opposite locations and suspended from the datum bar around the pile.

9.3.4 TEST PROCEDURE

The test shall be carried out by the Direct Loading Method in successive increments for routine load test and by the Cyclic Loading Method for initial load test as detailed below and as directed by the Engineer-in-Charge

a) DIRECT LOADING METHOD

The test shall be carried out as per the procedure outlined below:

i) The load shall be applied to the pile top in increments (steps) of about 20% of the rated capacity of the pile or as directed by Engineer. Each increment of load shall be applied as smoothly and expeditiously as possible. Settlement reading shall be taken before and immediately after the application of next increment and at 15, 30

minutes and thereafter at every half hour until application of the next load increment.

ii) Each stage of loading shall be maintained till the rate of movement of the pile top is not more than 0.2 mm/hr. or until two hours have elapsed whichever is earlier.

iii) The rate of movement of pile shall not be permitted to be extrapolated from period of test less than one hour.

iv) Loading on pile shall be continued till one of the following takes place:

v) In case of initial load test, applied load reaches three times the assumed safe load or the settlement of pile exceeds a value of 10 per cent of bulb diameter incase of under-reamed pile.

vi) In case of Routine load test, applied load reaches one and half time the safe load or the maximum settlement of test loading in position attains 12 mm.

vii) Where yielding of the soil does not occur, the full test load shall be maintained on the pile head for a minimum period of 24 hrs. after the last increment of load and settlement shall be recorded at 6 hours interval during this period.

viii) Unloading shall be carried out in the same steps as loading. A minimum period of 30 minutes shall be allowed to elapse between two successive stages of load decrement. The final rebound shall be recorded 6 hours after the entire test load has been removed.

b) CYCLIC LOADING TEST

The test shall be carried out to find out separately skin friction and point bearing capacity of single pile. However, this test is not applicable for under reamed piles. The test procedure shall be as given below:

i) In general this test shall be conducted on similar lines as mentioned in Direct Loading Method. In addition, alternate loading and unloading up to zero load shall be done in steps at each stage of loading. The load increment/decrement for each steps shall be 20% of the rated capacity. The readings of all the dial gauges shall

be recorded at the end of each step and the total and net settlement for each stage shall be calculated.

ii) For each stage, the loading of each steps shall be maintained for 15 minutes before reaching the maximum load. The maximum load for each stage shall be maintained for one hour. The full test load shall be maintained on the pile head for 24 hours.

iii) Each step of unloading shall be maintained for 15 minutes and the subsequent rebound in the pile shall be measured accurately.

iv) A period of 15 minutes shall be allowed to pass between the successive unloading and loading operations.

v) To find out separately skin friction and point bearing capacity of pile the procedure as given in Appendix- A of IS: 2911(Part-4) shall be followed.

9.3.5 ASSESSMENT OF SAFE LOAD

The safe vertical load on single pile from the load test shall be the least of following values:

a) 2/3 of the load at which the total settlement attains a value of 12 mm unless otherwise specified in tender documents.

b) 50% of the final load at which the total settlement equals 10 percent of the pile diameter in case of uniform diameter piles

9.4 HORIZONTAL LOAD TEST

9.4.1 EQUIPMENT AND TEST SET UP

a) The test plate shall be set in high strength grout to provide full bearing against the projected areas of the pile. The size of the test plate shall be adequate to accommodate the spherical bearing and transfer the load to the pile.

b) Sufficient clearance shall be allowed between the test pile and the datum bar for the anticipated lateral movement of the pile when datum bar (for fixing the dial gauge) is located on the opposite side to the point of load application.

9.4.2 LOADING SYSTEM

a) Loading shall be applied by a hydraulic jack of adequate capacity equipped with spherical bearing at the top of ram and bearing plate at the bottom side, abutting the pile horizontally and reacting against a suitable system.

b) The reaction may be provided by the wall of the excavated pit when the test is being conducted below ground level or by a neighboring pile, in which case thrust pieces shall be inserted on their end of the jack to make up the gap as approved by the Engineer.

c) Load shall be applied on the pile at or approximately at cut of level (COL).

9.4.3 MEASURING SYSTEM

a) The deflection shall be measured at a point diametrically opposite to the point of load application. In case such a measurements is not possible, the deflection shall be recorded using at least 2 dial gauges kept at a spacing of 30 cm. at a suitable height and the displacement interpolated at load point from similar triangles.

b) Deflection of the pile at the level of load application shall be measured by dial gauge fixed to datum bar. The datum bar shall rest on immoveable supports as described elsewhere in this specification.

9.4.4 TEST PROCEDURE

a) The test procedure shall be similar to that for vertical load test.

b) Loading on the pile shall be continued till one of the following takes place:

i. In case of Initial load test applied load reaches thrice the assumed safe lateral load capacity of deflection of pile at the loading point exceeds.

ii. In case of Routine load test, applied load reaches one and half times the assumed safe load capacity or a deflection at the loading point exceeds 5 mm

9.4.5 ASSESSMENT OF SAFE LOAD

a) The safe lateral load of single pile shall be the least of following:

i) 50 % of the load for which the total deflection is 12 mm.

ii) Load corresponding to 5 mm total deflection.

iii) Load corresponding to any other specified displacement as per performance requirement.

b) Pile groups shall be tested under conditions as per actual use in the structure as far as possible.

However, for routine test (i) above is not applicable.

NOTE: The deflection of pile is at the cut off level of the pile.

9.5 PULL OUT TEST

9.5.1 EQUIPMENTS AND TEST SET UP

Uplift force may be applied by means of hydraulic jack(s) using a suitable pullout set up as approved by the Engineer.

9.5.2 LOADING SYSTEM

a) Load shall be applied along the longitudinal axis of the pile using an approved reaction system. Uplift forces on the pile may be applied directly to the test pile or through a lever system.

b) The reaction may be provided by neighboring piles or blocks constructed for this purpose.

c) The reaction supports/blocks/piles shall be at least 2.5 times the test pile diameter.

9.5.3 MEASURING SYSTEM

a. Displacement of the pile shall be recorded using two dial gauges placed at diametrically opposite locations ad suspended from the datum bar around the pile. Datum bar shall be provided with immoveable supports as described elsewhere in this specification.

9.5.4 TEST PROCEDURE

a) The test procedure shall be similar to that for vertical load test.

b) The loading on pile shall be continued till one of the following takes place.

i. The loading on pile top equals three times the estimated safe load.

ii. The load- displacement curves shows a clear break (downward trend).

9.5.5 ASSESSMENT OF SAFE LOAD

a) The safe load of the pile shall be the least of the followings:

i. Two third of the load at which the total displacement is 12 mm.

ii. 50% of the load at which the load displacement curve shows a clear break (down work trend).

10.0 RECORDING OF DATA & PRESENTATION

10.1 The pile test data essentially concerns three variables, namely, load, displacement and time. These are to be recorded sequentially for the tests under consideration and shall be recorded in a suitable tabular form along with the information about the pile as per Annexure-A & B and Table-1 of this document.

10.2 The data may be suitably presented by curves drawn between the variables and safe loads shown on the graphs. Load displacement curve should be an assential part of presentation.

A N N E X U R E - A

P I L E D A T A

1. Reference No. Location(Co-ordinates) _____Area.
2. Sequence of Piling
3. Pile diameter & Type
4. Working Level (Platform level)
5. Cut Off Level (COL)
6. Actual Length Below COL
7. Pile Termination Level
8. Top Of Finished Concrete Level
9. Date and Time of Start and Completion of Boring
10. Depth of Ground Water Table in the Vicinity
11. Type Of Soil at pile tip
12. Method of Boring Operation
13. Details of Drilling mud as used:
    a. Freshly Supplied Mud, Liquid Limit, Sand Content, Density, Marsh Viscosity, Swelling Index, pH value.
    b. Contaminated Mud Density, Sand Content.

14. SPT (N) values in soil (from the nearest bore hole) UCS value in rock (from the nearest bore hole)

15. Chiseling, if any From..... M. To..... M.

16. Date and Time of Start and Completion of concreting.

17. Method of placing concrete.

18. Concrete Quantity:

    Actual

    Theoretical

19. Ref. Number of Test Cubes

20. Grade and Slump of concrete

21. Results of Test Cubes

22. Reinforcement Details:

Main Reinforcement	Stirrups: Type
No.:_____	No.:_____
Dia.:_____	Dia.:_____
Depth:_____	Depth:_____

23. Any other information regarding obstructions, delay and other interruption to the sequence of work

ANNEXURE - B

PILE LOAD TEST : VERTICAL / HORIZONTAL / UPLIFT

Type of Equipment and method of boring	Plan of Test arrangement showing position and distance of Kentiledge, Supports, tension or compression piles and reference frame to test pile etc.
Date of Cast	Commencement of Test
	Completion of Test
	Capacity of Jack
	Jack Constant Weight of Kentiledge
	Reaction pile details
Pile No.	
Type of Pile	
Diameter	
Capacity	
Type of Test Initial /routine	
Loading Method Direct / Cyclic	

Rebound	
Net(mm)	
Average Settlement	
Dial Gauge Reading	
Load MT	
Pressure Gauge	
Time	
Date	

Submission of Test Results

i , Time vs. Settlement.

ii , Load vs. Settlement Indicating the Safe Load.

TABLE-1: FREQUENCY OF SAMPLING AND TESTING

Sl.No.		Type of Material / Work	Nature of Test / Characteristics	Method of Test	No. of Samples & Frequency of Test	Acceptance Criteria
1		Pilebore size		Physical measurement`	Each Pile	drawing. Length as established by initial load test
	a.	Diameter				
	b.	Length				
2		Bentonite (Mud)				
		properties				
	a.	Basic properties of Bentonite before use.	viscosity, Specific gravity, Sand content, Swelling index, pH value	In Laboratory	Minimum one sample consisting of 3 specimen once in a week.	As per clause No. 7.03.4.
	b.	Contaminated mud from pile bore bottom before concreting	Density, Sand content	In Laboratory	piles before concreting. In case of satisfactory results, the frequency of sampling may be reduced to one in 25	be more than 1.25 Te/Cu.M. ii). Sand content shall not be more than 7%
3		Position and Alignment		Physical or any approved method.	Each Pile.	As per specification.
4		Cleaning of pilebore	As per Cl.No. 8.08.0	Each	Pilebore should be free from bored material	

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE-E: QUALITY ASSURANCE PLAN

QUALITY ASSURANCE PLAN

SL NO.	MATERIAL/ OPERATION	NAME OF TEST	FIELD/ LAB.	TEST PROCEDURE	FREQUENCY OF CHECKING	EXTENT OF CHECKING	REFERENCE DOCUMENT
1.	Earthwork in excavation	Lines, levels & depth	Field	Measurement	As per decision of site engr.	100%	Specn. & approved drg.
2.	**Concrete work**						Test will be carried out while establishing mix. design
	a) Coarse aggregate	i) % of soft or deleterious materials	Lab.	As per IS 2386 Part IX,1963	Once for each source/supply & shall be repeated in case source is changed	-do-	Specn.& IS 2386 (Pt.IX) & IS-383
		ii) Particle size distribution	Lab/ Field	As per IS 2386 (Pt.I)	-do-	-do-	IS 383, Specn.
		iii) Specific Gravity	Lab	IS:2386 Part III, IS:456, IS:383	Once in 12 weeks or change of source whichever is earlier	-do-	IS:2386 Part III, IS:456, IS:383
	b) Fine aggregate	i) Silt content	Lab	Appendix -D of CPWD Specn.Vol.I	-do-	-do-	CPWD Specn.
		ii) Particle size distribution	Lab./Field	IS 383	-do-	-do-	Specn. & IS 383
	c) Cement	i) Physical properties	Lab	As per IS 269 & 4031	-do-	-do-	IS 269,1489,4031 & test certificate
		ii) Chemical properties	-do-	As per IS 4032	-do-	-do-	IS 4032 & test certificate
	d) Reinforcing bars						
	i) Deformed bars	Physical properties & dimensions	Field /Lab	As per IS 1139	-do-	-do-	IS 1139& test certificate
	ii) Cold twisted bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786& test certificate

	iii) Hard Drawn Steel Wire Fabric	-do-	-do-	As per IS 1566	-do-	-do-	IS 1566& test certificate
	iv) TMT bars	-do-	-do-	As per IS 1786	-do-	-do-	IS 1786& test certificate
	v) Placement, laps, hooks, spacers etc.	Physical	Field	As per IS 456	ALL	-do-	IS 456 & approved drawings
	e) Water	Chemical test	-do-	As per IS 3025-64	Single Test	-do-	IS 3025-1964
	f) Tests for concrete	i) Slump test	Field	As per IS 1199	For each batch of concreting	-do-	CPWD Specn. & IS 1199
		ii) Cube test at 7/28 days	Field/Lab.	As per IS 516	No. of cubes to be decided as per given in IS 456/ Specn.	-do-	IS 456,IS 516
	g) Shuttering / Formwork Checking of levels, dimensions, unevenness, joints, cleanliness, oiling etc.	Physical	Field	Measurement	All	-do-	As per drawing, CPWD specifications & instruction of E.I.C
3.	**Brick Work/Hollow Concrete Block/ Cement Concrete Block work**						
	a) Brick/ Hollow Concrete Block / CC Block work	i) Physical properties & crushing strength	Field/Lab.	As specified in Specn & IS 1077	Once for each source	100%	Specn. / IS 1077
	b) Mortar	Uniformity in mix	Field	As specified in IS 2250	As & when required	-do-	IS 2250
4.	**Steel works using tubular, angles, plates, channels etc.**						
	i) Structural steel & plates	Dimension, manufacturers, Specn. test certilficates	Lab.	IS:226 & 2062	Once for each source/supply	100%	IS Codes & test certificates
	ii) Welding electrodes	-do-	-do-	IS:814 & 815	-do-	-do-	-do-
	iii) Welding	Quality of weld, weld	Field	Visual	As per discretion of site	-do-	IS: 823

		reinforcement, contour etc.			engr.		
	iv) Painting on steel works (synthetic enamel paint over 3 coats red oxide coat zinc primer)	Cleaning off rust dirt, grease etc. of coats.	-do-	IS:123 1962	-do-	-do-	IS Code, Relevant Specn.
5.	Providing & laying water proofing on roof	Thickness, slope etc.	-do-	As per Specn. & IS 2115	-do-	-do-	-do-
6.	**Flooring**						
	i) Cement concrete floor	Physical	Field	As per IS 1443	All	-do-	IS 1443
	i) Glazed tiles	Physical	Field	As per IS 13630	All	-do-	IS 13630 & Manufacturer's certificate
7	Pre-coated G.I sheet roofing laying & fixing.	Physical	-do-	As per IS 277 & 513	Once for each source/supply	-do-	IS code, spec. & Manufacturer's certificate
8.	Gypsum board false ceiling/ Prima board Armstrong false ceiling	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
9.	**Doors/windows/ventilators**						
	i) Glazing	Physical	-do-	IS 1081 & 2835	All	-do-	IS code, specn. & Manufacturer's certificate
	ii) Flush door shutters	Physical	-do-	IS 2095 & 2542	All	-do-	IS code, specn. & Manufacturer's certificate
	iii) Aluminium	Physical	-do-	IS 1948 & 1949	All	-do-	IS code, specn. & Manufacturer's

							certificate
	iv) Steel	Physical	-do-	IS 1038	All	-do-	IS code, specn. & Manufacturer's certificate
10.	Plastering	Physical	-do-	As per specn.	All	-do-	Specn.
11.	White washing, snowmen, distemper	Physical	-do-	IS 712, 428 & 5410	All	-do-	IS code & specn.
12.	**Toiletries & sanitary fixtures**						
	IWC, EWC, Urinals, washbasins, G.I pipes & fittings, C.I pipes & stoneware pipes etc.	Physical	-do-	IS 771, 775, 774, 1239, 2065, 781, 1729, 1726,,651,4127 etc.	All	-do-	IS code, specn. & Manufacturer's certificate

Note: Parameters/guidelines fixed for the quality control in accordance with the contract document, IS Codes/Technical Specification etc. are just the synopsis of the whole constructional activities in a bid to visualise the total involvement at a glance. Mere compliance of the QAP does not relieve the contractor from overall responsibility to render best quality of work in conformity with all the relevant documents and the best engineering practices. In order to minimise the size of QAP, only salient/important features have been taken into account and other small/minor involvement will be dealt with individually as per the provision of contract.

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DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE- G

LAYOUT / LAND DEVELOPMENT / TOPOGRAPHICAL SURVEY DRAWING

PART II: TECHNICAL

SECTION – 12

DESIGN PHILOSOPHY

FOR

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ANNEXURE- H

SOIL / GEO-TECHNICAL INVESTIGATION REPORT

SI. NO. P-II/16

CONSTRUCTION/ERECTION, PRE-COMMISSIONING, COMMISSIONING AND START-UP

FOR

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

P1	13.01.2021	Issued for Draft Tender	AK	JKY	GC
REV	REV ATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

Sl. No.	DESCRIPTION	
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2	General Scope of Works and Services Pre-commissioning	
3	Basic Plan for Temporary Services	
4	Mechanical completion	
5	Commissioning	
6	Start up	

LIST OF ANNEXURES

ANNEXURE NUMBER	DESCRIPTION	NUMBER OF SHEETS
ANNEXURE-7-1	LSTK Contractor's Work Definition	
ANNEXURE-7-2	Detail Technical Scope	
ANNEXURE-7-3	Quality Control Procedures and Inspection Requirement	
ANNEXURE-7-4	Schedule Progress Evaluation and Progress Reporting	
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ANNEXURE-7-8	Deployment Schedule of Construction Equipment	
ANNEXURE-7-9	Details Of Equipment Proposed to be used for Tendered Work	

1 General scope of Work and services - Construction/Erection

LSTK CONTRACTOR shall be responsible for construction and erection of the Plant/ Unit including but not limited to the following:

1.1 Construction and erection of Plant/Unit and perform all other activities required to be performed for implementation of the WORK.

1.2 Provide and supply in due course all construction Equipment and Materials, tools, and temporary facilities necessary for implementation of the WORK.

1.3 Establish and operate adequate material control system in site for receipt, unloading, inspection, maintenance, handling, storage and utilization to ensure all Equipment and Materials are preserved and available as necessary for completion of the Plant/Unit.

1.4 Provide and supply all staff, tradesmen and labours for implementation of the WORK.

1.5 Establishment of overall construction policy and procedures for the Plant/Unit.

1.6 Provision of overall management and control of construction phase of the Plant/Unit.

1.7 Ensuring that all parts of the Plant/Unit are constructed and tested strictly in accordance with the specifications and applicable codes and standards asked for in the project documents.

1.8 Ensuring that construction is accomplished in accordance with the schedules.

1.9 Provide transportation of all Equipment and Materials to be provided and supplied by LSTK CONTRACTOR under the CONTRACT either from inside or outside to Site.

1.10 Construct, operate and maintain all temporary facilities required for its personnel involved in the WORK.

1.11 Provide transportation in the area of the Site and between Site and temporary facilities for all its personnel involved in the implementation of the WORK, including field labour, administrative staff, etc.

1.12 Recruit field and organize, manage and supervise its Sub Contractors and field labour for the WORK.

1.13 Provide liaison with OWNER, Sub Contractors, Licensors and Vendors to ensure that the Plant/Unit is constructed in accordance with the respective standard and specifications, set forth in the CONTRACT.

1.14 Establish with OWNER adequate procedures, control and reporting systems to provide close control of the progress of the WORK.

1.15 Provision of labour and facilities for loading, unloading and transportation of the Equipment within the site area.

1.16 Performance and/or provision of all other works and/or services required for performance of the WORK.

1.17 Execution of the whole civil, structural and building works of the Plant/Unit and/or utilities and off-site facilities.

1.18 Prefabrication of piping spools in a shop on the Site.

1.19 Erection and installation of EQUIPMENT and auxiliary facilities associated with the Plant/Unit.

1.20 Erection and field fabrication of structural steelwork, cladding ladders, handrails, stairs and platform of the Plant/Unit and/or utilities and off-site facilities.

1.21 Installation of pipe work including field fabrication at site.

1.22 Installation and testing of all instrumentation network and equipment of the Plant/Unit.

1.23 Installation and testing of electrical system and equipment of the Plant/Unit.

1.24 Installation of rubber lining, refractory brick lining & C-Brick lining, FRP/PVC/HDPE lining, as required for the Plant/Unit.

1.25 Painting of steelworks, piping, Equipment and building of the Plant/Unit.

1.26 Maintenance of construction equipment, vehicles and tackles of the Plant/Unit, during construction and erection period.

1.27 Pre-commissioning, Commissioning and Start-up of the Plant/Unit.

1.28 Carrying out Mechanical Completion.

1.29 Perform all material identification as per application codes and standards.

1.30 Provide winterization during construction.

1.31 Provide drawings and documents as required.

1.32 Supply to OWNER complete test records within three (3) days after completion of actual testing.

1.33 Installation and testing of all underground piping, if any.

2.0 General scope of WORK and Services- Pre-commissioning

LSTK CONTRACTOR shall be responsible for the pre-commissioning phase of the Plant.

LSTK CONTRACTOR shall provide at SITE an adequate number of qualified pre-commissioning engineers to direct and control pre-commissioning activities.

LSTK CONTRACTOR shall also ensure that all special tools and test equipment required for pre-commissioning are available at its own cost.

LSTK CONTRACTOR shall provide adequate construction labour, construction tools and equipment for pre-commissioning.

Pre-commissioning which shall be performed by LSTK CONTRACTOR shall include, but not limited to the following:

2.1 Cleaning, flushing, draining blowing out, steaming out, drying and purging of Equipment and their linings and piping systems, including the installation and removal of temporary blinds, strainers, screens etc., and the replacement of all permanent items removed while the WORK is in progress.

2.2 Chemical cleaning wherever required, including but not limited to compressor suction piping and lube and seal oil piping, heaters, supply of chemical and disposal of wastes.

2.3. Chemical cleaning of feed water systems, and steam systems. Supply of chemical and disposal of wastes.

2.4 Chemical cleaning of any other parts, which have corroded to an extent, which, will detrimentally affect Plant/Unit performance or run length for such reasons as increased fouling due to rust. Supply of chemical and disposal of wastes.

2.5 Checking, Testing, calibration simulation test and adjustment of instruments, equipment and systems including control valves and safety devices, and installation and checking of orifices plates and other sensor devices in so far as this can be done before actual operation of the item concerns of complete system and loops.

2.6 Function test and checking out of electrical systems including substations, transformers, cables and switchgear, checking of all interlocks and setting of all relays. This shall include drying out operations, filtering of oil if required.

2.7 For motor driven equipment, amperage checking of motors and removal of temporary safety screens.

2.8 Cleaning of screens and filters replacement and adjustment of packing and seals and tightening of flanges.

2.9 Introduction of fuels.

2.10 Introduction of lubricants and oil flushing for machinery.

2.11 Introduction of chemical into and initial operation of treatment plant.

2.12 Boiling out, bringing up to pressure and performing all required code tests on steam generation facilities and associated instrumentation.

2.13 Drying out of stacks and all refractory lined equipment.

2.14 For all piping systems, installation and removal of temporary blinds as required, circulation and commissioning of systems including process systems, services, effluent and drainage, utilities distribution, relief and blow down and interconnecting lines.

2.15 Test running of all other rotating equipment for 24 hours wherever possible.

2.16 Adjustment of all piping expansion and support devices.

2.17 Air-drying of Plant/Unit, which is required to be water-free.

2.18 Testing (including running, tightness and vacuum) of systems, as necessary to ensure that the sections and components of Plant/Unit are ready for operation.

2.19 All such further works which LSTK CONTRACTOR judges to be necessary or in the reasonable opinion of OWNER is necessary to bring the Plant/Unit to a state of readiness for the introduction of feedstock into Process Plant/Unit for processing requirements and for safe commencement of operation.

3.0 Basic Plan for Temporary Services

Temporary Construction Facilities

The LSTK shall arrange following facilities at his own cost for Construction/Erection purpose. Demolition and cleaning of temporary facilities developed for construction purpose shall also be under LSTK Contractor's scope.

1. 1 No. 440 V Feeder at Existing Substation shall be made available. Tapping of Construction Power (on chargeable basis- as per existing practice: 1.5% of contract value of civil work) from this feeder (including supply & erection of all required materials like structural supports for cable tray, cable trays, power cables, control cables, protection & metering, cable termination etc. as well as underground cabling work) and further distribution shall be in LSTK Contractor's scope. Actual Power requirement to be confirmed by bidder.
2. Construction Water (on chargeable basis- as per client's existing rate) shall be made available

3. Construction sheds
4. Construction offices
5. Temporary Communication facilities
6. Office furniture
7. Labour colony during construction.

3.1 Sewage & Refuse Disposal

All temporary building like site office, canteen etc. shall be provided with individual septic tanks and soak pits for treatment and disposal of sanitary sewers. Construction site shall be provided with a network of temporary drain for disposal of rain water.

4.0 Mechanical Completion

Mechanical Completion means the time when all construction, erection & installation work per finally approved P&ID after HAZOP study and pre-commissioning related to the Plant is completed in accordance with the Project drawings and specifications, and all mechanical and pressure tests, including but not limited to hydro-testing, non-operating adjustments, cold alignment checks, final cleanup, hot bolting, refractory drying, field calibration of safety valves, calibration of all instruments, instrument loop checking and testing, monitoring / control / safety systems checking and testing, and all pre-commissioning activities have been completed, all incoming & outgoing services and utilities have been connected to each unit of the PLANT, interconnections of process lines and interconnection are completed and the Plant/Unit is ready in every respect for commissioning and for the first introduction of feed materials.

When OWNER is satisfied that Mechanical Completion of the plant has been achieved, OWNER shall issue certificate of Mechanical Completion to Contractor in accordance with the CONTRACT for Owner's Approval.

In order to meet this, LSTK CONTRACTOR shall perform all necessary mechanical works, tests and checks.

5.0 COMMISSIONING

5.1 **Schedule for Commissioning**

LSTK CONTRACTOR shall prepare a schedule for commissioning, start-up, and performance testing and initial operation in conjunction with OWNER. This shall be issued at least three months before commissioning of the first facility.

This schedule shall include all activities as detailed herein and any other special activities, which require to be performed during commissioning.

5.2 **Commissioning**

LSTK CONTRACTOR shall be responsible to perform commissioning of the Plants and to provide necessary facilities during commissioning of the Plant including the Performance Tests. LSTK CONTRACTOR shall provide commissioning engineers and supporting staff and adequate commissioning labour. LSTK Contractor shall associate OWNER's engineers and operating staff with the commissioning work.

6.0 START UP

LSTK CONTRACTOR shall be responsible to perform start-up of the Plant/Unit. LSTK CONTRACTOR shall provide necessary facilities and for Start Up of the PLANT.

NOTE:

Detail COTRACTOR'S scope of work in relation with the construction / erection, and pre-commissioning, commissioning and start-up from the point of scope of execution as well as performing way are described in detail in the following Sub-Annexes of Section-7.0.

Sub-Annexures:

Annex 7 - 1: LSTK Contractor's Work Definition

Annex 7 - 2: Detail Technical Scope

Annex 7 - 3: Quality Control Procedures and Inspection Requirement

Annex 7 - 4: Schedule Progress Evaluation and Progress Reporting

Annex 7 - 5 : General Notes

ANNEXURE-7-1

LSTK CONTRACTOR'S WORK DEFINITION

LSTK CONTRACTOR shall perform/provide the following activities but not limited to:

1. LSTK CONTRACTOR scope of work shall broadly consist of construction / erection, refurbishing, pre-commissioning, commissioning and Start Up of the Plant under the management of commissioning team it includes but not limited to civil works, fabrication & erection of structural steelwork, field assembly, mechanical erection and / or assembly and installation of all equipment and machinery, piping, electrical systems and network, instrumentation, insulation, painting, etc., except in so far as "Contract" otherwise provides, the provision of all temporary facilities, staff, tradesmen, labour, tools, tackle, construction equipment and materials, insurance, consumables and everything whether of temporary or permanent nature necessary and required in and for the work, so far as the necessity for providing the same is specified or reasonably inferred in or from the contract.

2. Perform all civil and building works as per Annex7 - 2A, titled civil and building works.

3. Perform all structural steel works as per Annex 7 - 2B, titled structural steelwork.

4. Perform all piping fabrication and erection works as per Annex7 - 2C, titled piping fabrication and erection work.

5. Perform all equipment erection works as per Annex 7 - 2D, titled equipment erection work.

6. Perform all electrical works as per Annex7 - 2E, titled electrical work.

7. Perform all instrumentation works as per Annex 7 - 2F, titled instrumentation works.

8. Perform all insulation works as per Annex 7 - 2G, titled insulation works.

9. Perform all painting works as per Annex 7 - 2H, titled painting Specification/work**.**

   Supply the materials in order to execute WORK as per CONTRACT.

10. LSTK CONTRACTOR shall be responsible for providing services and materials for construction of all temporary facilities, which are essential for successful completion of construction and erection.

    The LSTK CONTRACTOR shall establish, operate and maintain all temporary facilities, such as, but not limits to:

a) Labour camp/officers camps

b) Fabrication shops/yard

c) Workshop for maintenance of construction/testing equipment.

d) Field drawing office

e) Temporary warehouses, including open storage yards.

f) Construction offices (including facilities for photocopying, drawing reproduction, etc.)

g) First aid along with ambulance

h) Lab facilities, including NDT, for testing calibration, etc.

i) All temporary or approach roads for carrying out the WORK including temporary approach roads for access to LSTK CONTRACTOR'S site office/workshop/camp, etc. ground preparation for heavy lifts including approaches to cranes for heavy lifts. OWNER does not take any responsibility for making temporary roads.

j) Canteen & catering facilities for all LSTK CONTRACTOR'S work force.

k) All drainage around the facilities created for his WORK, and sewage disposal arrangements for labour camps/officers camps, site offices, etc.

l) Necessary transport for movement of its personnel, construction Equipment and Materials, consumables, etc.

n) Watering of roads through water tankers for dust suppression.

o) All temporary lighting for working during night.

p)All temporary hutments, sanitary & potable water and domestic sewerage requirements of LSTK Contractor's work force.

11. Supply to OWNER complete survey report within three (3) working days after completion of any survey.

12. All excess soil shall be disposed of by LSTK CONTRACTOR outside the premises in a location designated by OWNER representative.

13. Perform all nondestructive, hydrostatic and pre commissioning testing required.

14. Supply to OWNER complete test records within three (3) days after completion of actual testing.
15. Perform all welding including radiography required.
16. Provide drawings and documents as required.
17. Provide mobilization and demobilization, temporary material and temporary facilities and utilities required executing work.
18. Provide winterization during construction.
19. Provide scheduling, planning and reporting as per CONTRACT.
20. Keep complete administration and control of work, specified in CONTRACT.
21. Provide maintenance on all construction and permanent plant material as required during the CONTRACT period.
22. Perform all material identifications as per CONTRACT.
23. Perform all transportations as required.
24. Perform quality assurance, control and supply quality control documentation.
25. Perform all pre-commissioning activities as defined in the CONTRACT.
26. Provide and supply all procedures for execution of the work in accordance with drawings specifications, and applicable codes and standards.
27. Perform all other works and activities and supply all other materials which are required for completeness of the Work either mentioned in the CONTRACT or they are necessary for completeness of the work, in compliance with highest available standards and good quality.

ANNEXURE- 7 - 2

DETAIL TECHNICAL SCOPE

See accompanying by discipline

Annexure-7 - 2A	Civil and Building work
Annexure-7 - 2B	Structural steel work
Annexure-7 - 2C	Pipe prefabrication and Erection
Annexure-7 - 2D	Equipment erection
Annexure-7 - 2E	Electrical work
Annexure-7 - 2F	Instrumentation work
Annexure-7 - 2G	Insulation work
Annexure-7- 2H	Painting work (For detail refer **TS-2001**)

ANNEXURE- 7 - 2A

CIVIL AND BUILDING WORK

1.0 **SURVEYING**

1.1 Base line and base elevation will be furnished to LSTK CONTRACTOR. LSTK CONTRACTOR will furnish all surveys from this base line and elevation.

1.2 OWNER shall have the authority at anytime to determine, in accordance with the drawings or written directives, the correctness on completeness of the lines in use by LSTK CONTRACTOR.

1.3 Any erroneous WORK shall be corrected to OWNER'S satisfaction at LSTK CONTRACTOR'S expense.

2.0 **SITE**

Finish grading elevation to be as shown on drawing.
LSTK CONTRACTOR'S access to the WORK areas shall be via existing roads.
Any other roads required by LSTK CONTRACTOR are to be developed by LSTK CONTRACTOR.

3.0 **EXCAVATION AND BACKFILL**

3.1 **Excavation**

- Provide all excavation by machine or by hand according to the specifications.

- Excavation is to be executed by LSTK CONTRACTOR in a manner that will provide adequate space for performance, inspection and timely completion of the WORK. Supply dewatering as required. The method of dewatering shall be subject to Approval by OWNER.

- Temporary water drainage routing requires prior Approval by OWNER.

3.2 **Backfill**

All backfills shall be according to the specifications.

All excavations shall be kept dry and workable prior to and during backfiring and compacting.

Material that LSTK CONTRACTOR excavates in the course of WORK and which can be used for backfill, must be approved by OWNER prior to use. All other backfill material as required in this scope of work, drawings and specifications, shall be supplied by LSTK CONTRACTOR.

Back filling shall be to ground level as shown on drawing. The placing of backfill may only start after approval by OWNER.

LSTK CONTRACTOR will inform OWNER to arrange for the required proctor tests. Tests shall be done by OWNER on his account.

4.0 PILES AND CONCRETE FOUNDATIONS

4.1 Install Piles and major and minor concrete foundations in accordance with the specification and drawings.

4.2 Blinding to Underside Foundation Work

Prior to placing a blinding layer of concrete, LSTK CONTRACTOR shall supply, place, compact and prepare the surface of excavated area. After this LSTK CONTRACTOR shall supply a blinding layer of concrete. Blinding layer to be in accordance with specifications and / or drawings.

4.3 Reinforcement of Concrete

Cut and bend to bar bending schedules, all type of reinforcing bars.

Store and protect all reinforcing bars against corrosion and any other deleterious effects prior to placing.

Installation of reinforcement including installation of spacers, supports, tying, wire in accordance with the specifications and drawings.

4.4 Anchor Bolts

Install all anchor bolts, in accordance with the specifications and drawings.

The following WORK is included but not limited to LSTK CONTRACTOR'S scope for installation of anchor bolts:

- Deliver of all templates.
- Store and protect against corrosion and any other deleterious effects.
- Place anchor bolts accurately in formwork or by templates, if required, or in pockets.
- Clean and grease anchor bolts threads after Concrete pour and protect bolts after greasing with plastic covers.

4.5 Inserted and Embedded Item

Install all concrete inserts and embedded items, including but not limited to the following items in accordance with the specifications and to the detail drawings to be furnished by LSTK

CONTRACTOR.

- Cement - In sockets.
- Cinch anchors.
- Steel sleeves, various size angle.
- Channel shapes with anchors. Curb angles and steel plates.
- Anchor rails.
- Pipe sleeves of heavy duty PVC pipe.

The WORK shall include but not limited to:

Store and protect against corrosion and damage place accurately in Formwork or by templates, if required, or by temporary bars for proper positioning.

4.6 The following WORK is included but not limited to LSTK CONTRACTOR'S scope for installation of major and minor foundations:

- All excavation, including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, chosen by LSTK CONTRACTOR and approved by OWNER. The supply, installation and maintenance of a complete concrete batch plant, including concrete testing laboratory. Installation of selected backfill material, if required. Supply and delivery and installation of all formwork, assembly and disassembly of all reusable formwork, inclusive if any and all required supporting, bracing, pockets, cutouts, recesses, etc.

- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.

- Installation of all anchor bolts (including fabrication of templates), to the requirements and supply of items as defined in 4.4 above.

- Installation of embedded and inserted items, to the requirements and supply of items as defined in 4.5 above.

- Installation of construction and expansion joints where required.

- Mixing, delivery and pouring of concrete in accordance with specifications. Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.

- All temporary storage of formwork at SITE shall be of an orderly nature. In case storage does not comply with the above-mentioned rule, OWNER shall have the right to remove formwork from SITE within forty eight (48) hours after first warning and back charge LSTK CONTRACTOR for all related costs. OWNER shall not be held responsible for any of LSTK CONTRACTOR'S losses.

- The finishing of concrete, where required to a finish in compliance with the specifications.

A copy of all-concrete mix truck delivery slips if applicable.

Concrete composition analysis of the concrete batch plant.

All scaffolding required.

All required dewatering to keep the excavations / backfill dry for the WORK.

5.0 CONCRETE STRUCTURES AND ELEVATED SLABS

Install concrete structures, in accordance with the specifications and drawings.

6.0 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of concrete elevated slabs:

See 4.6; however with -following exceptions: No-excavation, no backfill and- no dewater

7.0 YARD PAVING AND FINAL SURFACING

7.1 Excavation

Setting out and grading by machine and/or by hand for yard paving to the shape and depth in accordance with the specifications and drawings.

Disposal of all excavated material and neatly stock piling to a location chosen by LSTK CONTRACTOR and approved by OWNER.

7.2 Concrete Yard Paving

- Mix and install concrete for heavy duty paving areas, in accordance with the specifications and drawings.

- Mix and install concrete for light and medium duty paving areas in accordance with the specifications and drawings.

- The following work is included but not limited to LSTK CONTRACTORS scope for installation of concrete yard paving: See 4.6 above

- Surface preparation, including the supply and placing of waterproof building paper or similar waterproof material, well lapped at joints, laid on top of the well compacted sand layer and before pouring concrete.

- Reinforcement for heavy duty paving at top and bottom face and for light duty paving at top face only, with square mesh fabric reinforcement including protection against corrosion, the cutting, the bending and placement.

- Mixing and pouring of concrete in accordance with specifications, sufficient vibrating. Stopping clear from bases, plinths and piers and forming around surface and lay to give levels and falls.

- Installation of construction / expansion joints.

7.3 **Unpaved Areas**

Install gravel, tiles or crushed stone on leveled unpaved areas, all in accordance with the specifications and drawings.

7.4 **Concrete Tiles for Walkways**

Install well compacted sub-base layer and install the tiles on the sub-base all in accordance with specifications and drawings.

8.0 **CONCRETE PIPE SLEEPERS**

Fabricate and install reinforced concrete sleepers for pipe, complete with foundations in accordance with the specifications and drawings.

9.0 **MANHOLES AND CATCH BASINS, TRENCHES**

9.1 Fabricate and install pre-cast or formed and poured in situ concrete manholes and catch basins and trenches in accordance with the specifications and drawings.

9.2 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of manholes and catch basins. All excavation including sheet piling of required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location, designated by LSTK CONTRACTOR and approved by OWNER.

For Poured in Site

- Delivery and installation of all formwork, inclusive if any and all required supporting, bracings, pockets, cutouts recesses etc.
- Bending and installation of concrete reinforcement bars to the requirements and supply of items as defined in 4.3 above.

- Fabrication and installation of embedded and inserted items, if any, to the requirements and supply of items as defined in 4.5 above.

- Mixing and pouring of concrete in accordance with specifications.

- Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.

- All required dewatering to keep the excavations / backfill dry for installation work.

- Install cast - iron manhole frames and solid cover and fabricate and install steelwork catch basin grating and frames in accordance with specifications.

10.0 **COLLECTION BASINS, PITS, SUMPS, RETAINING WALLS AND CULVERTS**

10.1 Fabricate and install concrete collecting basins in accordance with the specifications and drawings.

10.2 Fabricate and install concrete sumps and pits in accordance with the specifications and drawings.

10.3 Fabricate and install concrete walls around tanks and other retaining walls in accordance with the specifications and drawings.

10.4 Fabricate and install concrete pipe and bridge culverts including head walls in accordance with the specifications and drawings.

11.0 **DITCHES AND TRENCHES**

11.1 Fabricate and install earthen and concrete ditches and trenches including connection pipes and boxes in accordance with the specifications and drawings.

12.0 **STEEL SLIDING PLATES AND PTFE SLIDING PLATES**

12.1 **Steel Sliding Plates**

- Fabricate and install steel sliding plates in accordance with specifications and drawings.
- The following work is included, but not limited to LSTK CONTRACTOR'S scope for fabrication and installation of steel sliding plates
- Pick up materials, storage and protection against corrosion and any other deleterious effects.
- Fabricate, place in pockets, level and grout, protect against possible damage and corrosion.

12.2 **PTFE Sliding Plates**

- Install sliding plates, in accordance with the specification and drawings.

The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of sliding plates pick up materials, transport, store and protect

- Place in pockets, level and grout, protect against possible damage.

13.0 **GROUTING**

13.1 Mix and install grouting in accordance with the specifications and drawings.

13.2 LSTK CONTRACTOR shall grout under all structural steel columns and under all

equipments, as specified.

13.3 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of grouting:

- Prepare top surface of base and /or plinth, pockets, sleeves etc., prior to placing grout.
- Mix and install grout mortar in accordance with specifications.
- Grout mortar shall be used between steel base plate and concrete foundations.
- Mix and install non-shrink grout between reciprocating rotary equipment base frame including the filling of the equipment steel frame, if required, and concrete foundation in accordance with manufacturer specifications and project specifications.

13.4 Grouting of equipment shall proceed only when equipment setting has been accepted by OWNER.

14.0 **ASPHALT PAVING**

14.1 Mix and install asphalt paving over base courses installed by LSTK CONTRACTOR, in accordance with the specifications and drawings.

- Roads/ Driveways/ Parking areas/ Sidewalks/ Tank pads

14.2 The following work is included but not limited CONTRACOR'S scope for installation of asphalt paving to.

- Installation of all materials necessary to make a complete installation.
- Installation of sub-grade, sub-base and base courses all properly compacted.
- Delivery and installation of all formwork, inclusive if any and all required supporting, bracing, pockets, cutouts, recesses, etc.
- Installation of expansion joints where required and/or construction joints
- Stripping of formwork and removal of all surplus material to LSTK CONTRACTOR'S yard or locations designated by OWNER.
- Mixing, delivery, installation, spreading and compaction of asphalt paving mixture in accordance with specifications.
- Any and all measures for proper asphalt paving installation and curing.

15.0 ROAD REPAIR AND MAINTENANCE

15.1 Supply and deliver necessary materials, equipments and labour to repair and maintain all plant roads, as necessary.

- Repair work shall be in accordance with the specifications.

- LSTK CONTRACTOR shall be responsible for repair of roads, all on the indication of OWNER due to the damage to the roads, caused by LSTK CONTRACTOR'S activities and construction operations, or due to faulty construction by LSTK CONTRACTOR. LSTK CONTRACTOR is not entitled for compensation for such repair work.

16.0 REPAIR OF DYKES, SLOPES AND DITCHES

16.1 Supply and deliver necessary materials, equipment and labour to effect repairs on dykes, slopes and ditches as necessary.

- Repair WORK shall be in accordance with the specifications.

- LSTK CONTRACTOR shall be responsible for repair of dykes, slopes and ditches all on the indication of OWNER'S representative, due to damage to the dykes, slopes and ditches caused by LSTK CONTRACTOR'S activities and construction operations, or due to faulty construction by LSTK CONTRACTOR.

- LSTK CONTRACTOR is not entitled for compensation for such repair work.

17.0 UNDERGROUND SEWERS AND PIPING SYSTEMS

17.1 Install the underground piping systems, in accordance with the specifications and drawings.

17.2 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of underground piping systems.

- Excavation including sheet piling, if required, backfill, compacting and the transportation of surplus material, neatly stockpiled at a location designated by LSTK CONTRACTOR and approved by OWNER.
- Installation of sand backfill if required

- Receiving unload, inspect and transport LSTK CONTRACTOR'S supplied materials and store and protect.

- Installation of piping materials necessary for a complete installation.

- The installation of above ground fire hydrants, fire monitors and standpipe as well as the underground firewater system.

- The fabrication and installation of supports and thrust blocks for the piping as required.

- Surface preparations and installation of coating and wrapping of the underground piping, if required as per Technical specification Mentioned in **Annexure- 7 - 2C**

- Installation of glass fiber reinforced epoxy piping in accordance with manufacturers instructions as well as the specifications.

- Hydrostatic pressure testing of the underground piping systems including test apparatus, test piping, test blinds, bolts and gaskets in accordance with the specifications.

17.3 **Hydro Testing of Sewers and Underground Lines**

- Tests all sewers and underground piping systems as per test instructions. Testing is to be witnessed and approved by OWNER. A test schedule by test system shall be prepared by LSTK CONTRACTOR. Testing and completion shall be in accordance with project system priorities.

- Piping systems shall be tested with suitable water.

- Develop test system procedures and follow priorities established by OWNER. LSTK CONTRACTOR shall prepare detailed schedules based on this data for submittal to OWNER for his approval.

- The water for testing purposes is to be provided by LSTK CONTRACTOR.

- Inexpensive temporary gaskets shall be used in place of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test, the permanent gasket shall be installed when the blinds are removed.

- After hydro testing, LSTK CONTRACTOR shall perform the following activities:

- Flushing
- Remove temporary blinds
- Install permanent gaskets.
- Flange connection bolts tightened.
- Coat and wrap welds.
- Holiday testing and coating repairs.
- Backfill and compaction.

18.0 **CIVIL PART FOR UNDERGROUND ELECTRICAL GROUNDING SYSTEM**

18.1 Excavation of the routing for the direct buried cables, for the road crossing and for the branch conduit and sleeves in accordance with layout and detail drawings.

18.2 Transport of the excavated soil, neatly stockpiled to location chosen by LSTK CONTRACTOR and approved by OWNER.

18.3 Installation of all protection conduits and installation materials in accordance with the specification, and design and detail drawings.

18.4 Transport of excavated soil and backfill including compacting of the round up to finished plant level.

19.0 **CIVIL PART FOR UNDERGROUND CABLE TRENCHES (AND CABLE) CIVIL PART**

19.1 Excavation of the routing for the concrete cable trenches for the direct buried cables, for the crossings and for the branch conduit and pipe sleeves by machine or by hand as dictated by local conditions.

19.2 Transport the excavated soil, properly stockpiled to a location off chosen by LSTK CONTRACTOR and approved by OWNER.

19.3 Installation of the concrete cable trenches in accordance with the specification and the design and detail drawings.

19.4 For scope of installation of concrete cable trenches see item 11.

19.5 Installation of the road culverts, protection sleeves and cable ducts at road crossing in accordance with layout and detail drawings. For scope of installation see item 10

19.6 Transport of the excavated soil and backfill of the surrounding area of the concrete trenches up to finished plant level.

19.7 Transport of the excavated soil and backfill of road crossing up to road including the supply and installation of the repair of the paving and / or asphalt road covering.

19.8 Transport and backfill of the trenches with a layer of clean sand, free from stones equalized up to the bottom level of the first (bottom) cable layer.

19.9 Transport and backfill of the layer of clean sand between cable. Layers and above top cable layer.

19.10 Transport of excavated soil and backfill including compacting of the ground up to the layer of

concrete tiles or trench covers.

19.11 Installation of the cable protection covers and/or trench covers and /or cable routing colored marking tape.

19.12 Transport of the excavated soil and backfill including compacting of the ground above the layer of concrete tiles up to finished plant level.

19.13 Installation of the cable route designated, trench markers.

20.0 **STORAGE TANK PADS AND DYKES**

20.1 Install tank pads as specified and as quantified on the specifications and drawings.

20.2 Install tank dykes and ramps as specified and as quantified on the specifications and drawings.

20.3 Install impervious clay layer inside the dyked tankage areas in accordance with specifications and drawings.

21.0 **PERMANENT PLANT FENCING**

21.1 Install permanent plant fencing, including personnel gates and truck gates as located, specified and quantified in the specifications and drawings.

22.0 **SCAFFOLDING**

22.1 Supply and erect all scaffolding for WORK.

22.2 Scaffolding shall be supplied, erected and maintained in strict accordance with local and governmental regulations as well as OWNER'S safety requirements. If there are conflicts, the more stringent shall prevail.

LSTK CONTRACTOR shall dismantle all its scaffolding at the completion of its WORK.

23.0 **TESTING**

23.1 All necessary tests in order to control the quality of the field works shall be done and all such test certificates should be kept in record, such as but not limited to

- Soil compaction tests.
- Concrete testing
- Asphalt testing
- Reinforcing bars testing

23.2 If any test fails LSTK CONTRACTOR shall replace those items, which do not meet the requirements.

All costs for replacements shall be borne by LSTK CONTRACTOR.

24.0 **WELDING PROCEDURES SPECIFICATIONS AND WELDING PROCEDURE QUALIFICATION RECORDS**

24.1 Provide within two months before starting the construction execution, its welding procedures (for A.G, U.G piping and any structural steel) for comment and approval. Approval of welding procedures by OWNER is required before the start of welding.

24.2 Prior to start of filed welding LSTK CONTRACTOR shall submit one (1) copy of all welders' qualification paper and applicable welding procedures approved and stamped by regulating authorities to OWNER.

25.0 **DRAWINGS AND DOCUMENTS**

25.1 LSTK CONTRACTOR will carry out all construction activities directly from the AFC construction drawings and specifications.

25.2 LSTK CONTRACTOR shall submit reports of each test or inspection within three (3) days after actual test or inspection. Failure to comply with the above rule may result in OWNER arranging for additional tests or inspections. Costs of which will be back charged to LSTK CONTRACTOR.

25.3 LSTK CONTRACTOR shall submit material certificates and quality records of the materials, as specified in previous sections and the applicable engineering specifications and standards.

25.4 LSTK CONTRACTOR shall also furnish a concrete installation record within two (2) weeks after completion of the WORK indicating, date of installation and quantity of concrete of each foundations, floor slab, elevated slab, frames, columns, etc.

This concrete installation record shall also show a reference with the concrete compression test certificates of the respective concrete pours and the concrete delivery slip numbers.

Failure to comply with the above time may result in the preparation of the documents by OWNER in which case all related costs will be back charged to LSTK CONTRACTOR.

26.0 **MISCELLANEOUS**

26.1 LSTK CONTRACTOR shall be fully responsible for the correct and accurate setting out of all elevations, positions, dimensions, alignments, profiles. etc, of all parts of the WORK and for the provision of all necessary instruments, appliances and labour in connection therewith The checking of any such matter by OWNER shall not relieve LSTK CONTRACTOR of its responsibility for the correctness thereof.

26.2 If during the construction or maintenance of WORK, any error is discovered in WORK, LSTK

CONTRACTOR shall at its own cost rectify such error to the satisfaction of OWNER. LSTK CONTRACTOR shall in such case take all necessary actions such as overtime, etc. in order not to endanger the agreed upon time schedule.

26.3 All dimensions shown on the plans and drawings are given in the SI system, unless otherwise stated.

26.4 All costs for setting out the earthwork and for assisting OWNER in checking the various points, lines, levels, profiles, etc. shall be deemed to be included in the price.

26.5 LSTK CONTRACTOR shall under no circumstances extend its operations outside the limits of the area appropriated for WORK. LSTK CONTRACTOR will ensure that its operations shall not interfere in any way with properties of others.

26.6 No excavation work shall be started before the exact positions of the WORK have been marked by means of stakes controlled and approved by OWNER.

26.7 OWNER shall notify LSTK CONTRACTOR of all known existing underground pipes, cables, drains, manholes, etc, in current use, together with the approximate locations and hazards involved and LSTK CONTRACTOR shall ensure that they will not be broken or damaged in any way by the execution of WORK. Hand labour shall be used for excavation within a horizontal distance of 1.5 meters from existing utilities.

26.8 Any damage as referred to above shall be reported by LSTK CONTRACTOR. LSTK CONTRACTOR shall repair the damage.

26.9 The discovery of any unregistered pipes, drains, cables, etc., shall be promptly reported to and deals with as directed by OWNER. Excavation, as required to determine the exact location of existing underground pipes, drains, cables etc. shall be considered as a part of WORK.

26.10 LSTK CONTRACTOR shall take precautions i.e. mats, lining with timber, etc. not to cause damage to permanent plant roads curbing and sidewalks with its construction equipment.

26.11 LSTK CONTRACTOR shall provide and be responsible for the construction of all temporary dewatering. Drainage, sheet piling, timbering etc. to ensure the stability of slopes, trenches, embankments, etc. during excavation work and that all areas are adequately drained to the satisfaction of OWNER.

26.12 LSTK CONTRACTOR is responsible for all soil slides that may occur during the execution of the WORK and for any detrimental effect of the same. LSTK CONTRACTOR shall as directed by OWNER either correct or repair the damage to the satisfaction of OWNER at its own expense or pay for the cost of repair by others of all damage caused to the WORK or

adjacent property. No additional payments shall be made to LSTK CONTRACTOR to compensate the financial consequences of soil slides.

26.13 Collapse, cave-in, or movement of excavations, trenches, or the like shall be the responsibility of LSTK CONTRACTOR. LSTK CONTRACTOR acknowledges this responsibility and instructions of the OWNER.

26.14 Trenches, excavations, and the like shall be maintained in strict accordance with the requirements of the applicable national and local regulations.

26.15 LSTK CONTRACTOR shall be held entirely responsible for any effect or damage, which the execution of any of the earthwork may have upon, or which may be caused to any portion of WORK or any of the surrounding property.

26.16 Excavation will proceed until all unsuitable material is removed.

26.17 LSTK CONTRACTOR is responsible for the excavation required to installing bottom of footings at elevations as shown on drawings. The removal of a poor soil below the intended bottom of excavation is included in the CONTRACT. Any unnecessary over excavation will be in LSTK CONTRACTOR'S account.

26.18 Backfill shall be to the elevation shown on the approved drawings or as directed in writing by OWNER.

26.19 Special care must be taken in compaction operations over underground pipelines.

26.20 LSTK CONTRACTOR shall furnish all field engineering, surveying, layout, and checking to properly install all foundations to meet all requirements of the drawings and specifications, on completion of each foundation LSTK CONTRACTOR shall mark all foundations with a clear center line, locating both North, South, East and West and a bench elevation mark. LSTK CONTRACTOR shall stencil or by other means, paint equipment and column designation and coordinates, to all foundations installed by LSTK CONTRACTOR. All markings shall be located above high point of paving. These markings shall be preserved for use by others.

26.21 LSTK CONTRACTOR shall design concrete mix specification and furnish by means of reports from OWNER'S laboratory, proof that the materials and mixes for concrete conform to the specifications and codes prior to pouring the first concrete on SITE. LSTK CONTRACTOR shall furnish all field labour to make concrete tests and fill cubes quality of concrete aggregates and mix design will be checked by OWNER'S laboratory regularly.

26.22 All aboveground concrete for supports for steel structures must be smooth finished, and exposed edges of concrete to have a chamfer.

The top of the foundations shall be poured so as to ensure true surfaces and designated slopes in all cases. LSTK CONTRACTOR is to avoid damage or movement of already

installed reinforcement and/or other structures, formwork, etc., when pouring concrete.

26.23 All concrete pours for a given element must be monolithic, except where noted on the drawing or approved by OWNER.

25.24 If pouring cannot be finished within normal working hours, necessary actions shall be taken, sufficiently in advance for requesting permits for overtime. All pouring must be continued until the element is complete. OWNER shall be informed at least twenty-four (24) hours in advance.

26.25 Damaged formwork must be repaired in such a way as not to mark the concrete finish. All formwork must be braced adequately and be of a rigid construction. Gravel nests, surfaces crack, honeycombs, etc., and shall be repaired to the satisfaction of OWNER.

26.26 LSTK CONTRACTOR shall use immersion-vibrating equipment but it needs to be of a type approved by OWNER prior and also during use. Vibration of formwork and fresh concrete WORK is not allowed. OWNER will have the right to require replacement of inadequate during all phases of the WORK. A must condition shall be maintained after pouring as set forth in specifications. The WORK involved in this is to be included in the pricing.

26.27 OWNER reserve the rights to reject any WORK already poured which is not in accordance with drawing and specifications and of adequate quality.

Serious inclusions appearing in concrete shall be reason for the rejection of WORK and LSTK CONTRACTOR requested to repair or replace at his own expense.

26.28 All costs involved in demolition, removal and replacement of rejected WORKS shall be the responsibility of LSTK CONTRACTOR all materials, equipment or auxiliaries not accepted by OWNER shall be removed immediately from the OWNER'S property.

26.29 Ready - mixed concrete shall be delivered without segregation. The concrete batch plant has to be approved by OWNER. Small quantities of concrete may be made at SITE after approval of OWNER.

26.30 The pouring of any reinforced concrete may only start after having obtained Approval of OWNER.

26.31 LSTK CONTRACTOR shall provide, during the period of this CONTRACT, temporary drainage ditches in WORK so that water will not be pended and so that all areas are adequately drained to the satisfaction of OWNER.

26.32 LSTK CONTRACTOR shall provide, during the period of this WORK, systems for the dewatering of all its WORK areas as required to properly execute the WORK. All dewatering methods shall be subject to the approval of OWNER.

26.33 All excavated boulders will be removed from SITE by LSTK CONTRACTOR.

26.34 Manholes are to be marked with M.H. Number.

26.35 Underground service lines have to be marked at their installation limits to aboveground piping, indicating line size, and service and line number.

26.36 Prefabricated concrete -items are to - be marked with date of fabrication, size, Length, identification code and installation north arrow.

27.0 **BUILDINGS**

27.1 LSTK CONTRACTOR shall do the construction of the buildings, including all activities and installations as specified, in drawing and specifications including the fabrication of all items that are not standard hardware components.

28.0 Quality of all civil and building materials shall be approved by OWNER before usage in the PLANT.

ANNEXURE- 7-2B

STRUCTURAL STEELWORK

1. Delivery of all materials and fabricated structural steel to SITE, including all required transport, storage, intermediate storage, etc., including loading and unloading of materials.

2. LSTK CONTRACTOR will carry out all construction from the AFC construction / erection drawings and specifications.

3. LSTK CONTRACTOR shall be held entirely responsible for any effect or damage, which the erection of the structural steel may have upon, or which may be caused to any portion of WORK or any of the surrounding property.

4. **Erect Structural Steel-Structure Frames**

   This item covers all activities required to erect prefabricated structural steel framing for single and multilevel structures.

   It includes, but is not limited to, the following :

   - Provision of all tools, equipment and consumables used in the course of the work.
   - Shimming of foundations and joints.
   - Erecting.
   - Cutting, drilling, welding and bolting to achieve fitment.
   - Rectification required, if any.
   - Final levelling, aligning and bolting (including torquing).
   - Grouting of components and areas supplied unpainted or requiring finish coats, as per specifications.
   - Touch up painting of damaged areas.
   - Also included in this item are all clips plates, stiffeners, gussets, and connection material supplied loose for field installation.

5. **Fabricate and Erect Structural Steel-Structure**

This item covers all activities required to fabricate and erect structural steel framing for single and multilevel structures, from raw steel, if any, sections, plates, rounds, etc. It including, but is not limited to the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Shimming of foundations and joints.
- Measuring, cutting, bending, bolting and / or welding.
- Erecting.
- Cutting, drilling, welding and bolting to achieve fitment.
- Final levelling, aligning, bolting and /or welding (including torquing)
- Grouting of support piers.
- Painting as per specifications.

6. **Fabricate and Erect Ladder and Safety Cages**

This item covers all activities required to fabricate, assemble and erect ladders and safety cages in steel structures, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Measuring, cutting, bending, bolting and / or welding.
- Assembly and erecting including cutting, drilling, bolting, welding to achieve fitment.
- Cutting, drilling, welding and bolting to achieve fitment.
- Final Bolting and / or welding in position.
- Fabrication and installation of safety barrier rail and gate.
- Installation of raw bolts and forming of concrete pads, or connecting to a lower platform.
- Painting as per specifications.

7. **Fabricate and Erect Platform and Walkways**

This item covers all operations required to fabricate erect platforms and walkways on vessels, towers, structures, etc or on the ground from raw steel (unpainted) sections, plates, rounds, etc.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Measuring, cutting, bending, bolting and / or welding.
- Erecting including any, cutting, drilling, welding for fitment.

- Final levelling, bolting and / or welding.
- Installing anchor bolts and grouting.
- Painting as per specifications.

Not including is the installation of flooring or the erection of handrail.

8. **Fabricate and Erect Welded Handrail**

This item covers all operations required to fabricate and erect double rail handrail and tope plate of all welded construction, from raw steel (unpainted) sections, plates rounds, etc.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Preparation of detailed fabrication drawings and getting them approved from Owner.
- Fabrication including cutting, bending, welding, etc.
- Erecting of posts, top and middle rails toe plate including any cutting, trimming for figment and welding.
- Grinding smooth of all cut edges and welds.
- Painting as per specifications.

9. **Fabricate and Erect Galvanized Tubular Handrails**

This item covers all operations required to fabricate and erect double rail tubular galvanized hand railing including all standards, fittings, bends, etc., from raw steel (unpainted) sections, plates, tubes, etc.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Fabrication including cutting, trimming edge stripping to required size & shape.
- Erecting into position.
- Bolting and/or welding.
- Trimming to suit platform structure and providing openings for pipe or cable, etc.
- Making good edges, and touch up painting including cold galvanizing of cut or welded parts.
- Painting of unpainted steel sections

10. **Fabricate and Install Floor Grating**

This item covers all activities required to fabricate and install galvanized floor grating from large sheets ready for cutting, trimming, etc., to platform shapes.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Fabrication including cutting, trimming, edge stripping to required size & shape.
- Erecting into position.
- Bolting and/or welding.
- Trimming to suit platform structure and providing openings for pipe or cable, etc.
- Making good edges, and touch up painting including cold galvanizing of cut or welded parts.

11. **Fabricate and Install Chequer Plate Flooring**

This item covers all activities required to fabricate and erect chequer plate flooring, from sheets.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Fabrication including cutting, trimming edge stripping to required size & shape.
- Erecting into position.
- Bolting and/or welding.
- Cutting to suit platform structure and providing opening for pipe or cable, <etc.

12. **Erect Davits**

This item covers all activities required to erect fabricated davits on exchangers, vessels or in structures.

It includes, but is not limited to, the following :

- Delivery of davits and all other materials.
- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting up painting of damaged areas.

13. **Roof and Wall Sheeting**

This item covers all activities required to erect by bolting of roof and wall sheeting.
It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Cutting and fitting of sheeting including all shrilling, trimming and notching to facilitate openings.

- All flashing of ridges, corners gables, door jambs, etc.

14. **Down pipes and Gutters**

This item covers all activities required to install metal downpipes and gutters.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting including fitting, trimming supporting and jointing.

15. **Roof or Ridge Ventilator**

This items covers all activities required for the erection of roof or ridge ventilators on a steel clouded building.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting on roof including any trimming or figment.

16. **Install Gantry Crane Rails**

This item covers all activities required to install rails.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting jointing levelling, aligning, and bolting or welding in passion.

17. **Install Gantry/Overhead Travelling Crane**

This item covers all activities required to erect and complete the installation of overhead cranes.

It includes, but is not limited to, the following :

- Provision of all tools, equipment and consumables used in the course of the work.
- Erecting into rails.
- Installing all controls, both mechanical and electrical.
- Testing and running of crane.

18. **Install Travelling Trolleys**

This item covers all activities required for the installation of beam mounted travelling trolley.

It includes, but is not limited to, the following :

- provision of all tools, equipment and consumables used in the course of the work.
- Erecting into position.
- All levelling and shimming of trolley beam as required.
- Marking of all beams and trolley with safe Working Load.
- All testing and running as required.

19. **Inspection and Testing**

- Inspection of steel structure shall be in accordance with the codes and standards.

- LSTK CONTRACTOR shall provide NDE services acceptable to OWNER. NDE inspection shall be carried out in accordance with standards, codes and specifications .

- LSTK CONTRACTOR shall be responsible for the repair of faulty welds and for all required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography on LSTK CONTRACTOR'S account can be done as per code.

ANNEXURE- 7 – 2C

PIPE PREFABRICATION AND ERECTION

1.0 PIPING

1.1 Magnitude of Piping

LSTK CONTRACTOR shall prefabricate, install and test all piping as shown on the plan drawings and isometrics.

2.0 PIPING FABRICATION AND ERECTION

2.1 Piping systems and pipe supports shall be designed, fabricated, inspected, and tested in accordance with rules, codes, specifications and drawings.

2.2 Miscellaneous piping materials for vents, drains, instrument connections, etc. on equipment shall be installed using P & ID'S and equipment drawings.

2.3 The fabrication and erection of piping includes field welds. It is LSTK CONTRACTOR'S responsibility to choose the number and location of field welds to ensure efficient transportation and handling during erection. Furthermore LSTK CONTRACTOR shall locate the field welds in such a way that final adjustment for fit-up purposes will be possible.

For alloy piping that has to be stress relieved after welding the number of filed welds shall be kept to a bare minimum. LSTK CONTRACTOR shall thoroughly evaluate the need for each field weld in alloy piping he deems necessary.

2.4 LSTK CONTRACTOR will furnish OWNER with a marked up set of isometrics identifying all spool pieces, and weld numbers. All piping spools shall be clearly identified, per isometric by means of stainless steel tags affixed with wire.

2.5 LSTK CONTRACTOR shall erect all prefabricated and straight run piping as required by the drawings and specifications.

The erection and installation of the piping shall include but not be limited to the following

- Control valves.
- Safety valves
- Rapture disks.
- Level instrument and gauges.
- External level displacers.
- Special fittings.
- Breaching of vents, drains, instrument connections, etc.

- Rota meters.
- Orifice flanges.
- Orifice plates.
- In - line instruments.
- Steam tracing.
- Steam traps.
- Extension stems. Valve operators.
- Bellows, expansion joints and similar specialty items.
- Thermowells (flanged, screwed and weld Ins.).
- Sample coolers.
- Instrument connections (up to and including the first block valve).
- Spring hangers and spring supports.
- Installation of miscellaneous piping and instrumentation supplied by equipment vendor.
- Temporary piping for drying, flushing and hydrostatic testing if necessary.
- Connection of piping to equipment.
- Connection of aboveground piping to underground piping.
- Pipe supports.

This shall include any necessary work to the piping to correct equipment misalignment.

2.6 Fastening of floor supports on concrete will be done with expansion type foundation bolts, if no anchor bolts are provided.

2.7 LSTK CONTRACTOR is responsible for the installation of steam tracing of piping, valves fittings and instruments where required, in accordance with the specifications and drawings. In general steam and condensate headers will be indicated on the piping plans. Lines to the traced will be indicated on P& ID'S and lines lists. Details of steam and condensate headers will be shown on separate drawings. Identification of steam tracers shall be by aluminum tag noting circuit number. Each end of system should be tagged.

A method of identification and tagging of the other various systems shall be established, subject to approval by OWNER and is for account of LSTK CONTRACTOR.

2.8 LSTK CONTRACTOR is responsible for the fabrication and erection of pipe supports, hangers, anchors and guides, as required by the drawings and specifications.

Spring pots and spring hangers, which shall be provided by LSTK CONTRACTOR as will be assembled, installed, adjusted and unlocked by LSTK CONTRACTOR after hydrostatic testing of the line. The required angle iron, will be decided in the field and supplied by LSTK CONTRACTOR.

2.9 LSTK CONTRACTOR shall install and remove all temporary strainers required for WORK defined herein. The removal of these items will be directed by OWNER. OWNER may decide to leave temporary strainers in during commissioning.

2.10 LSTK CONTRACTOR shall be responsible for the fabrication, installation and dismantling of temporary spool pieces and blinds required for control valves, safety valves and in - line instruments during testing and cleaning. Requirements for these shall be minimized. Requirements for these will be prescribed by OWNER.

In general, in-line instruments, safety valves and control valves may be installed for fit-up purposes if available to avoid the use of temporary spool pieces. They shall be removed for flushing and testing and reinstalled as directed by OWNER. In the case of safety valves these must be installed for fit - up, taken down for calibration by LSTK CONTRACTOR, and reinstalled before mechanical completion. All open flanges and valves shall be blinded or plugged off.

2.11 LSTK CONTRACTOR is responsible for the installation and testing of all piping and steam, electrical tracing and all materials including all items necessary to completely close the systems in strict accordance with the established test system procedures and priorities as directed by OWNER.

2.12 **Wrapping & Coating**:- Surface preparations and installation of Wrapping & Coating of the underground piping with Cold tape (Materials for line coating and wrapping shall be of Tape coating system (Polyethylene backed tape with butyl rubber based adhesive system), if required

2.12.1 Protective coating shall consist of a coating system employing Primer, Inner Wrap and Outer Wrap.

2.12.2 The coating system shall be mechanically applied by an approved type of wrapping machine utilizing constant tension brakes except at tie-in welds, repair patches and at other locations where mechanical application is not practicable..

2.12.3 Coating and wrapping materials shall be handled, transported, stored and applied strictly in accordance with the manufacturer's instruction.

2.12.4 Wrapping Coating material is Cold tape type from **Polyken/Denso/Atla** shall be used.

2.13 **Flushing and Cleaning Of Piping Systems**

i) Sections fabricated in LSTK CONTRACTOR'S workshop shall be fitted with plastic end caps to seal pipe ends, and jointing surfaces shall be suitably protected.

These caps shall not be removed until sections are in the course of erection after delivery at SITE and then shall be removed for refuse.

ii) During fabrication and erection the sections shall be inspected or internal cleanliness.

iii) The water which will be used for testing and flushing of the piping system shall be recollected per instruction given by OWNER.

v) Piping systems shall be flushed with suitable water as supplied by LSTK Contractor unless designated for nitrogen or air testing or otherwise specified by licensor. OWNER'S approval is required before start of flushing.

v) LSTK CONTRACTOR shall supply all equipment, pumps, gauges, etc. required for flushing and testing of the piping systems.

vi) For hydro testing and flushing the piping LSTK CONTRACTOR shall weld and caps and install drain plugs, remove end caps after successful hydro test.

3.0 **HYDRO TESTING**

3.1 Inspection and hydro testing of the piping systems shall be in accordance with the drawings and specifications and in strict witness by OWNER representatives.

3.2 Atmospheric pressure systems shall be:

- Visually inspected that all joints are properly made.
- Filled with water for a 24 hours leakage test under atmospheric conditions.

If any leakage occurs in the system during testing, repairs must be made without extra costs to OWNER.

3.3 LSTK CONTRACTOR shall test all piping systems as per the project test diagrams. Testing is to be witnessed and approved by OWNER and where applicable by the appointed (independent inspection authority) filed inspector. A test schedule by test system shall be prepared by LSTK CONTRACTOR and shall be submitted to OWNER for Approval.

3.4 Testing and completion shall be in accordance with project system priorities.

3.5 All equipment, pumps, gauges, pressure recorders temporary piping and fittings, test gaskets and bolting, required for testing of the piping systems and part of LSTK CONTRACTOR'S supply. Before testing LSTK CONTRACTOR shall calibrate its testing equipment.

3.6 LSTK CONTRACTOR shall supply and install blind flanges when required to enable testing of the lines.

3.7 Inexpensive temporary gaskets supplied by LSTK CONTRACTOR, shall be used instead of permanent gaskets where test blinds are located for hydrostatic testing. On successful completion of a test the permanent gasket shall be installed when the blinds are removed.

3.8 Piping systems shall be tested with suitable water. Extreme care shall be taken that suitable water is used for stainless steel systems. For stainless steel the water must be approved by

OWNER and shall have a content of chlorides ≤ 50 mg/L

3.9 The water for testing purposes will be furnished by LSTK CONTRACTOR.

3.10 LSTK CONTRACTOR is to perform the testing in a sequence so as to allow sufficient time for insulation and/or painting to complete within the time frame of the project schedule.

3.11 A formal system of documentation will be developed by LSTK CONTRACTOR and approved by OWNER for use by LSTK CONTRACTOR to certify this testing phase of the piping erection. This system will also include a section for supplying OWNER'S "But list" comments.

3.12 Erected piping shall be hydrostatically tested in test systems, but not through equipment, control valves etc. except where piping is welded to equipment.

3.13 LSTK CONTRACTOR remains responsible for ensuring that no item of equipment, or instrument, is damaged by the test pressure or the test fluid. Suitability of test fluid to be Approved prior to testing by the OWNER.

3.14 It is emphasized that the installation of temporary strainers prior to testing shall be part of WORK. OWNER shall be contacted concerning installation of temporary strainers.

3.15 When lines are pressure tested, valves at the end of the lines must be covered with a test blank for safety reasons. A record, preferably on the test diagrams, shall be kept by LSTK CONTRACTOR indicating which sections have been completed.

Note : Testing against closed valves in not allowed (spades to be used)

3.16 All material damaged during tests shall be replaced on LSTK CONTRACTOR'S account. All joints broken after testing for installation of strainers, orifice flanges, safety valves, etc. must be remade tightly; labour is for LSTK CONTRACTOR'S account.

3.17 After testing the piping systems, they shall be completely flushed and drained. OWNER will approve when a line is considered flushed and drained by LSTK CONTRACTOR.

3.18 When each section or circuit has been pressure tested and passed, a certificate prepared by LSTK CONTRACTOR on LSTK CONTRACTOR'S furnished forms showing details must be signed by LSTK CONTRACTOR and OWNER, when the test has been completed and the system drained, test blanks must be removed by LSTK CONTRACTOR.

3.19 The following activities by LSTK CONTRACTOR are included for the reinstatement of piping after hydro testing:

- LSTK CONTRACTOR installed temporary testing blinds to be pulled.
- Temporary spool pieces taken out.

- Gaskets renewed, temporary replaced with permanent.

- Flange connection bolts tightened.

- Post hydro punch list items corrected.

- Temporary strainers installed.

- Chemical cleaning performed.

- Supports and hangers checked if in final position.

- Rotating equipment cold alignment checked.

- Reinstallation of control and safety valves and in - line instruments which LSTK CONTRACTOR has removed for hydro-testing.

3.20 Nondestructive testing of welds and systems is to be performed in accordance with standards, codes and specifications prior to perform any hydro-test.

3.21 Wrapping Coating material for Under Ground piping is Cold tape type of Polyken or equivalent cold Tape to be used.

4.0 PIPING MATERIAL IDENTIFICATION AND PAINTING

4.1 All piping materials are supplied by LSTK CONTRACTOR and shall be properly stamped and color-coded to ensure that the correct materials are used as required by the drawings, specifications, codes and regulations.

4.2 All materials will be adequately marked as to its specifications. Should LSTK CONTRACTOR be required to cut same or otherwise render piece(s) to have no marking, LSTK CONTRACTOR'S transfer or replacement of proper identification marking to the pieces involved, must be done according to approved stamping method and to be counter stamped by LSTK CONTRACTOR. Paint alone is unacceptable.

4.3 The governing principle shall be that in the installed piping systems, all components can be identified and their origin and complete specifications can be determined. The method for identification and stamping or tagging of the various components of the system shall be worked out in coordination with OWNER and only be implemented after approval.

LSTK CONTRACTOR shall be held responsible for this requirement as a minimum, and any other requirements of local codes and regulations as to identification and documentation of materials.

4.4 Surface preparation and paint application of piping system by LSTK CONTRACTOR, shall be

per paint specification.

4.5 LSTK CONTRACTOR shall assure that no welds are covered by prime coats prior to acceptance of hydro test.

4.6 LSTK CONTRACTOR must ensure that all stamping such as code stamps, registration spool identification, charge numbers etc. shall be visible after paintwork.

5.0 **WELDING**

5.1 All welding shall be carried out according to codes and specifications.

5.2 Welder's qualification

5.2.1 All welders including those with valid qualifications will be required to submit a test conducted by OWNER prior to start of welding.

Welders that have a certificate which is still valid for the type of material and in accordance with ASME IX will not be tested by OWNER.

5.2.2 A current list of qualified welders must be maintained by LSTK CONTRACTOR and a copy furnished to OWNER each time a revision is made.

5.3 Welders' identification stamps shall be provided by LSTK CONTRACTOR. Each weld shall be clearly stamped with welders identification. All welding including tack welding shall be carried out by qualified welders. Unstamped welds shall be-removed and replaced at LSTK CONTRACTOR'S expense.

5.4 Job SITE fabrication shall be carried out under cover where possible.

5.5 Weld spatter shall be knocked off around all welds leaving a smooth clean surface.

5.6 Where openings for branches are cut in run of pipe, all material, which may drop inside the pipe, shall be completely removed before the branch line is welded in place.

6.7 The interior welds of orifice flanges shall be ground smooth.

5.8 **Electrodes, Rods, Wires and Fluxes**

Electrodes shall be stored in the makers' airtight containers until required for use. Electrode heaters shall be used on Job SITE, for low hydrogen types of electrodes.

Electrodes and filler wires to be used at site in this job shall be procured from the approved vendors only. Electrodes and filter wires shall be **D&H, Advani Orlikon or ESAB, Mailam and Bohler group make only.**

5.9 **Open Air Welding**

Where welding in the open air is unavoidable, WORK must be discontinued where the quality of the weld may be impaired by weather conditions. Including but not limited to airborne moisture, sand or high winds. After rain the metal surfaces shall be dried. For metal temperature below 5 ^{0}C joints to be preheated.

5.10 **Welding Procedure Qualification**

LSTK CONTRACTOR shall supply welding procedure specifications and qualification in accordance with the rules as set by OWNER.

5.11 Fees for inspection required for welding procedure and welders qualifications, supply of equipment required for the qualification test of welders and welding procedures are for account of LSTK CONTRACTOR.

5.12 **Inspection and Testing**

5.12.1 Inspection of welds shall be in accordance with the instructions of OWNER and/or the requirements of codes and standards.

5.12.2 LSTK CONTRACTOR shall be responsible for the repair of faulty welds and for all the required extra radiography and inspection of the faulty welding work. In case of a faulty weld, 100% radiography, on LSTK CONTRACTOR'S account, shall be done on the weld performed as per code.

OWNER shall have absolute discretion in the selection of the welds, which are to be radio graphed.

5.12.3 LSTK CONTRACTOR shall provide NDE service, acceptable to OWNER.

NDT inspection shall be carried out in accordance with codes for all lines as indicated in the piping specification.

6.0 **STRESS RELIEVING**

6.1 LSTK CONTRACTOR shall provide stress-relieving service acceptable to OWNER. Spool pieces shall be stress relived in an approved furnace equipped with thermostatic control and temperature recorder. Field welds to be stress relieved with electric resistance heaters. Temperature cycles to be monitored with portable temperature recorder.

6.2 Stress relieved welds shall be hardness tested by approved procedure and must meet criteria spelled out in specifications.

7.0 TRANSPORTATION

The following various categories of transportation of pipe, pipe fittings and prefabricated pipe spools will be performed by LSTK CONTRACTOR. All categories include loading and unloading materials. Categories will consist of but not limited to:

- From LSTK CONTRACTOR'S warehouse to LSTK CONTRACTOR'S pipe prefab shop.
- From LSTK CONTRACTOR'S pipe prefab shop to LSTK CONTRACTOR'S painting shop.
- From LSTK CONTRACTOR'S pipe prefab or painting shop to LSTK CONTRACTOR'S storage area or working area located on site or any other location on SITE.
- All transportation required performing nondestructive testing of prefabricated pipe spools.

8.0 LIFTING, LIFTING EQUIPMENT AND GEAR

8.1 Rigging and hoisting shall be executed as per construction specification and local requirements and safety rules, as manufacturer's instructions. If there are stringent one shall prevail.

8.2 Testing And Certification

All LSTK CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and/or inspected before being used on SITE, and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on SITE for inspection on request by OWNER or other authorities.

8.3 Operation

8.3.1 LSTK CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.3.2 LSTK CONTRACTOR shall take express steps to ensure that all personnel employed by LSTK CONTRACTOR are competent and experienced for their assigned tacks.

9.0 DRAWINGS AND DOCUMENTS

LSTK CONTRACTOR shall fill in checklists as required by OWNER.

10.0 MISCELLANEOUS

10.1 LSTK CONTRACTOR shall furnish all field engineering surveying layout, and checking to properly install all above ground piping to meet all requirements of the drawings and specification. OWNER is authorized to reject any WORK already installed, which is not in

accordance with drawing and specifications and of adequate quality.

10.2 All costs involved in demolition, removal and replacement of rejected works shall be the responsibility of LSTK CONTRACTOR. All materials equipment or auxiliaries not accepted by OWNER shall be removed immediately from SITE.

10.3 Underground service lines are marked at their installation limits to above ground piping, indicating line size, service and line number.

10.4 During storage, fabrication and erection, care must be taken to ensure that sand, scrap materials, welding rods, items of clothing and other foreign bodies are not allowed to enter piping.

10.5 All connections which are left open by LSTK CONTRACTOR shall be well protected, so that no sand, dirt or any foreign object come into the system.

10.6 In certain instances special bolting torques might be required on critical connections. LSTK CONTRACTOR will arrange WORK in accordance with these requirements.

10.7 Flanged piping connections to vessels or equipment shall be aligned and shall be properly fitted before bolting up. Piping may be heated to bring it into alignment only when approved by OWNER. Extreme care should be exercised to avoid damage. Heating, welding and flame cutting on equipment will not be permitted.

10.8 No cold springing or pre- stressing of piping will be allowed other than indicated on piping drawings, isometrics and manufacturer's instructions (e.g. for expansion joints).

10.9 Flange faces shall be clean and free from foreign matter before assembly. Damaged flange faces may be dressed with a medium cut file only if the damage does not require new facing. This shall be decided by OWNER.

10.10 During erection care shall be taken to remove all dirt, seals, sand and foreign matters from inside the pipe.

10.11 Since LSTK CONTRACTOR is responsible for both the prefabrication and the erection of all the piping, it is LSTK CONTRACTOR'S sole responsibility to ensure that all piping to be installed fits properly prior to lifting. LSTK CONTRACTOR is to check all equipment and underground piping to be piped to, for proper location and orientation. OWNER will not entertain any claims for extra work for :

i. Taking piping down for rework after it is lifted

ii. Re-lifting piping after it is reworked.

10.12 Final hookup of piping to equipment such as pumps and compressors shall be done together with the final alignment of this equipment and shall include checking of dimensions. Piping must fill these flanges without inducing any strain on equipment.

10.13 In all cases, all designated support and hangers should be in unlocked / cold position before final alignment. LSTK CONTRACTOR will be expected to expedite this critical phase of construction.

10.14 Certain small vessels will be considered to be piping items and shall be fabricated as such by LSTK CONTRACTOR.

ANNEXEURE- 7 -2D

EQUIPMENT ERECTION

1.0 **SURVEYING**

1.1 Baseline and base elevation will be furnished to the LSTK CONTRACTOR. LSTK CONTRACTOR will furnish all surveying from this baseline and elevation.

1.2 OWNER shall have the authority at any time to determine in accordance with the drawings or written directives, the correctness or completeness of the lines in use by LSTK CONTRACTOR.

1.3 Any erroneous WORK shall be corrected to OWNER'S satisfaction at LSTK CONTRACTOR'S expense.

2.0 **RIGGING STUDIES AND PLANS**

2.1 LSTK CONTRACTOR shall supply rigging studies and plans as specified.

3.0 **EQUIPMENT HANDLING**

3.1 The handling of all equipment shall include, but not limited to the following activities by LSTK CONTRACTOR:

3.1.1 Submittal to OWNER of detailed rigging studies and plans for lifting, transporting and setting of equipment 4 weeks in advance of work for OWNER to review and approval. Complicated lifts shall be started in the morning and completed the same day.

The transportation plans are to include as a minimum:

Type of equipment to be used to transport each piece.

The planned route of the movement.

The estimated duration of the movement.

The obstructions to the route to be temporarily removed.

3.1.2 Receive, inspect, store, protect and perform preventative maintenance on all equipment in accordance with the specifications and drawings and/or equipment manufacturer's instructions.

3.1.3 Prepare foundations, pipe sleeves, paving, concrete structures and steel structures for

setting equipment.

3.1.4 Transport form warehouse or point of unloading and install equipment on foundations, paving or structures.

3.1.5 Plumb level and align equipment with coordinates in accordance with the specifications and drawings.

3.1.5.1 **GENERAL**

All of the equipment must be plumbed, leveled and aligned with the coordinates specified on the drawings both in plan and elevation and to the tolerances called out in the specifications, specific manufacturer's instructions or recommended manufacture's practices.

- LSTK CONTRACTOR will be required to verify field conditions and will be responsible for final alignment of mechanical items for this project. LSTK CONTRACTOR will check the anchor bolt locations against the equipment. Any deviation must be reported to OWNER in writing.

- LSTK CONTRACTOR will be required to supply and install shims required for all equipment erection. All cinch anchors required for equipment and supports will be supplied and erected by LSTK CONTRACTOR.

  Prior to the placement of the equipment on a foundation, the surfaces of the foundation shall be cleaned of oil, grease, excess concrete and foreign matters by LSTK CONTRACTOR.

- Prior to setting the equipment on the foundations, the underside of the equipment base plate or supports will be cleaned free of oil, grease and other loose materials by LSTK CONTRACTOR.

- Anchor bolts shall be checked for damage to the thread and the threaded part shall be properly greased.

- Damaged anchor bolts must be replaced by LSTK CONTRACTOR and brought to the attention of OWNER.

- The openings between the anchor bolts and sleeves have to be cleaned of foreign materials to full depth of the opening by LSTK CONTRACTOR.

- All steel wear plates and guide keys shall be coated by CONTRACT with proper lubrication, prior to setting the equipment.

- Equipment shall be set true to line. at correct elevation and in proper orientation as shown and noted on the drawings.

- Maximum allowable setting tolerances shall be in accordance with manufacturer's requirements or with the specifications, whichever is more stringent.

- All equipment, unless otherwise specified, shall be leveled with shims at each anchor bolt (shim on both sides of each anchor bolt) and at intermediate points as required to prevent distortion of the equipment. Shims shall have square cut edges (not trimmed or sheared) and shall be of various thicknesses to minimize the number of shims required. Shims shall be supplied by LSTK CONTRACTOR.

- The equipment shall be set, leveled, aligned and inspected with precision tools (steel straight edge, graduated machinist levels, dial indicators, theodolites, water level instruments, turbine levels, etc.). Setting, leveling and alignment shall be according to manufacturer's recommended tolerances and specifications.

- There may be a number of items not installed by the manufacturer, i.e. seals, packing, lubricators, gauges, miscellaneous piping and tubing, thermometers, etc. that will come separately packed from the equipment itself that must be identified, stored, preferably inside in accordance with project criteria, and finally installed. LSTK CONTRACTOR is responsible for these activities.

- LSTK CONTRACTOR shall remove all temporary shipping supports or erection materials.

- LSTK CONTRACTOR shall do surface preparation for, and apply coating and wrapping on buried vessels before installation.

  Equipment supported on legs or on saddles shall be set to the tolerances specified in specifications of the required elevation measured on the flange of the largest diameter pipe-connecting nozzle.

- For equipment with sliding type supports, LSTK CONTRACTOR will remove dirt, grease or other foreign matter and will coat with graphite grease supplied by LSTK CONTRACTOR on the support.

- The anchor bolt nuts will be placed so as not to restrict the longitudinal movement of the sliding end.

- Vessels, drums, etc. shall be aligned, where applicable and leveled per shown or drawing.

- Shims shall be placed approximately evenly spaced under the support ring of vessels, drums, tanks.

- Towers with two or more pieces shall be assembled and welded at site by LSTK CONTRACTOR.

- LSTK CONTRACTOR is responsible to check and inspect at these equipments in the vendor's shop.

- All costs are included in the lump sum price.

3.1.5.2 **Rotating Equipment**

- Rotating equipment will be installed in accordance with manufacturer's instructions.

Align drivers with all rotating equipment.

- LSTK CONTRACTOR shall install all ancillary equipment such as, but not limited to, drivers, guards, harness piping and all other interconnecting piping, casing drains, base plate drains and all necessary supports.

- The measurements for the positioning and leveling of mechanical equipment will be made on the suction flange.

- LSTK CONTRACTOR to install permanent packing, seals lubricating oils, greases and circulated oil systems.

- Services of manufacturer's technical representative by LSTK CONTRACTOR shall be used to the fullest extent.

- Rotating equipment base plates will be supported for positioning and leveling on shims located as follows.

- For bases with four (4) anchor bolts. one set of shims will be placed adjacent to each anchor bolt.

- For bases with six (6) or more anchor bolts, two (2) sets of shims will be placed adjacent to each anchor bolt, one on each side of the anchor bolt.

- In addition shims shall also be placed directly under those parts of the base plate carrying the greatest weight and shall be placed closely enough to give uniform support.

- When the base plate is level in all directions as indicated by an accurate instrument on the machined pads, the anchor bolt nuts shall be brought down evenly, but not too firmly. The unit is now ready for grouting. After the grout has adequately set, pull the anchor bolt nuts down tight and recheck the base for levelness.

- Release for grouting of base plates must be approved by OWNER.

- After completion of the electric installation to the motor, the direction of rotation of the

motor will be determined. Prior to checking the direction of rotation, the coupling between the motor and the equipment will be disconnected for the test run of motor by LSTK CONTRACTOR.

- Rough aligning of the centrifugal units and their respective drivers shall take place after the equipment has been put on the foundation.

- Coupling alignment

- Dial indicators shall be used and where possible optical alignment equipment.

  Peripheral alignment shall be checked by using one dial reading peripheral differences between coupling halves as they are rotated together.

  Face alignment shall be checked using two dials reading face-to-face differences between coupling halves.

- Tolerances shall be in accordance with manufacturer's instructions with and without pipe work connected.

- Manufacturer's representative shall check that the final alignment of equipment is satisfactory before any running takes place. For small equipment. Where it is agreed by OWNER that the services of a manufacturer's representative are not required, manufacturer's written instructions shall be followed.

- The final checks will be supervised by LSTK CONTRACTOR and the results recorded by LSTK CONTRACTOR and signed by OWNER and LSTK CONTRACTOR.

  Final alignment shall be carried out in two stages.

- After piping is complete with all bolts removed from the flange connections.

- Final alignment with piping assemblies 100% complete and all flanges bolted up to ensure that no unforeseen vertical or horizontal pipe loading is imposed on the unit.

- The final aligning supervised by OWNER to make sure that the detailed instructions furnished by the equipment suppliers are carried out to the full satisfaction.

  LSTK CONTRACTOR to supply qualified personnel in the final alignment activities.

- Prior to putting pumps, etc. into operation, loose equipment such as guards and gauges shall be installed by LSTK CONTRACTOR.

3.1.6 Mount the drivers to the rotating equipment in case of turbines and any large motors that are shipped separately.

3.1.6.1 In case electric motors have to be installed in the field, this shall be done after leveling of base plate, but prior to grouting.
Chrome / nickel shim martial, supplied by LSTK CONTRACTOR shall be used for alignment of drivers and pumps and shall be installed under the entire footing of the driver.

3.1.6.2 Equipment and drivers shall be doweled to bed plate if required by manufacturer's instructions.

3.1.7 Assembly whenever required for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces , compressors ,Turbo generators etc. units as part of the scope of WORK of installation by LSTK CONTRACTOR.

3.1.7.1 Compressor seal oil and lube oil systems and control panels are included in LSTK CONTRACTOR'S installation of compressors.

3.1.7.2 When equipment is delivered in two or more sections for site welding the weld preparation must match accurately on mating sections before assembling.

3.1.7.3 LSTK CONTRACTOR shall assemble and erect items, whether skid mounted or supplied in individual components as specified in the requisition or indicated on drawings in order to make a completed unit.

3.1.7.4 Installation, assembly and alignment of the various components shall be done by LSTK CONTRACTOR.

3.1.7.5 Installation of air - cooled exchangers includes the erection of structural steel on the pipe rack, which will support the tube bundles must be done by LSTK CONTRACTOR.

3.1.7.6 Walkways, platforms, stairs, ladders shall be installed for the items / package unit like Auxiliary Boilers, Waste Heat Boilers, Air - cooled exchangers, furnaces, compressors, Turbo generators etc. by LSTK CONTRACTOR.

3.1.7.7 Drying out systems, refractory and linings is included in LSTK CONTRACTOR scope of work.

3.1.8 Install ladders, platforms, davits, pipe supports and pipe guides in accordance with drawings and specifications.

3.1.9 Open man ways. Inspect. clean and close man ways of all tanks, towers. vessels and other equipment as directed by specification or manufacturer.

3.1.10 Install all trays and vessel internals and support for same shipped loose. in accordance with drawings, specifications and manufacturer's recommended installation instruction.

3.1.11 Under the supervision of OWNER and respective manufacturer’s representative LSTK

CONTRACTOR shall load the first loading of chemicals.

a) There will be certain items of equipment such as filters and package equipment that come with cartridges filled with -desiccants, resins, etc. Their items will be installed by LSTK CONTRACTOR if they are shipped separately from the equipment.

b) Installations include the pick-up of these chemicals from the place of storage and transportation to point of installation.

3.1.12 Under the supervision of OWNER, LSTK CONTRACTOR install the first loading of catalysts. Installations include the pick-up of these catalysts from the place of storage and transportation to point of installation.

3.1.13 Touch - up of painting on new equipment after erection.

3.2 LSTK CONTRACTOR shall install grout under all equipment as required.

3.3 Grouting will be as per the specification per the equipment manufacturer's recommendation, whichever is more stringent.

3.4 The following work is included but not limited to LSTK CONTRACTOR'S scope for installation of grouting:

3.4.1 Prepare top surface of base and/or plinth, pockets, sleeves etc., prior to placing grout.

3.4.2 Install grout mortar consisting of one part Portland cement and one part of clean sand and sufficient clean water for workability.

This grout mortar shall be used between steel base plate and concrete foundations.

3.4.3 Wherever non-shrinkage grout is specified on the drawings, the same shall be supplied by LSTK CONTRACTOR and installed in accordance with manufacturer's instructing.

3.5 Install non-shrink grout between reciprocating / rotary equipment base frame including the filling of the equipment steel frame if required, and concrete foundation in accordance with manufacturer specifications and project specifications. Type of non-shrink grout to be approved by OWNER. After grouting, shims used in leveling equipment will not be removed except where removal is specifically required by manufacturer's instructions.

3.6 Unless indicated otherwise on drawings vessels supported on skirts and support rings will be grouted using a stiff mix under the support ring so as to obtain full bearing, Grout will be placed within the area of the skirt the high point of ground at the vertical axis of the tower (or vessel), sloping downward to the support ring with four (4) weep holes under the support ring sufficiently large to ensure drainage.

4.0 MATERIAL HANDLING SYSTEM

4.1 ERECTION & COMMISSIONING

4.1.1 The complete material handling system including its all equipment shall erected at site and commissioned in accordance with the best engineering practice.

4.1.2 Packing, forwarding, transportation, unloading and storage at site, safety and protection of various components at site, insurance etc. shall be the responsibility of the LSTK Contractor / supplier.

4.1.3 All men, material and tools required shall be arranged by the LSTK Contractor at his own cost. The LSTK Contractor shall also arrange for the safe handling, storage, protection and security of his good at site.

4.1.4 The purchaser shall be responsible for supplying his part of material only as covered by the clause pertaining to the work to be excluded from LSTK Contractor's scope of supply.

4.1.5 After erection at site, the belt conveyors and related equipment shall be tested for satisfactory operation for mechanical completion and full-load performance run. The LSTK Contractor shall carry out performance test as per mutually agreed procedure. The details of the procedure shall be submitted by the LSTK Contractor for purchaser's approval.

4.2 MECHANICAL COMPLETION

4.2.1 Mechanical completion shall be considered as achieved when the system is mechanically complete along with the pre-commissioning activities and is ready for feeding. This shall include but not limited to the following :

1. The installation as per FINAL PROPOSAL is complete in all respects in accordance with the drawings, specifications including any approved changes thereto and in accordance with all applicable codes and laws.
2. The machinery, conveyors and all drives are aligned and run or cycled under no-load conditions.
3. The electrical system is installed and tested in accordance with applicable codes and specifications. All wiring is checked for correct hook-up. Motor rotation is checked and power system protective devices are set.
4. Painting is completed to the extent that the incomplete work does not prevent plant start-up and commissioning.
5. Successful completion of no-load test of all the equipment and the complete system.

6. Temporary construction facilities are removed to the extent necessary to permit the plant start-up and commissioning.

4.2.2 The OWNER shall inspect and certify that the LSTK Contractor executed the job in accordance with drawings and specifications.

4.2.3 When the complete belt conveyors and related equipment have been fully erected at site, LSTK CONTRACTOR shall request OWNER for his agreement to start the No-load Test Run. Owner shall, within 72 hours of receipt of such request, issue his agreement or advise LSTK Contractor in writing of any deficiencies noticed in the equipment.

4.2.4 Omissions / rectifications of minor items, if any, not affecting commissioning shall not withhold MECHANICAL COMPLETION as long as the LSTK Contractor agrees to supply / rectify the same within the specified period. The decision of the OWNER is final in this regard.

4.3 COMMISSIONING AND GUARANTEE TEST

4.3.1 After issue of Mechanical completion certificates by Owner, LSTK CONTRACTOR & OWNER shall mutually decide the date of commissioning of the equipment. From the date of commissioning, the equipment shall be gradually brought up to full load or any other load at the discretion of OWNER, and thereafter the equipment shall be run for a minimum period of 5 days. OWNER shall have the right to reduce this period where deemed necessary because of OWNER's difficulties. During this period of 5 days of operation or the reduced period, the system shall run at an average of 90% of rated capacity. If the LSTK CONTRACTOR is not able to bring the load to 90% of the rated capacity as mentioned above within 2 (two) months, OWNER shall, without prejudice to any of his rights under the contract, has the right to take over the equipment and to proceed with modifications / rectifications / additions as he considers necessary at LSTK CONTRACTOR's cost and risk to achieve this sustained load run.

5.0 PREPARE EQUIPMENT FOR OPERATION

5.1 Immediately prior to turnover, LSTK CONTRACTOR will make all the equipment ready for operation. This includes, but is not limited to such activities as:

5.1.1 Removal of preservatives and rust preventatives.

5.1.2 Installation of seals or removal of steel covers.

5.1.3 Removal of moisture absorbing materials.

5.1.4 Draining of oil reservoirs and the flushing and filling of the initial charge.

5.1.5 If required by OWNER for the final inspection the opening and closing of man ways of vessels and tanks.

5.1.6 Assisting equipment manufacturer's representatives by final checkout of equipment.

5.1.7 Remove all temporary supports, bracing, or other foreign objects that were installed in vessels rotating equipment or other equipment to prevent damage during shipping, storage, transport and erection.

5.1.8 Conduct all flushing, blowing and chemical cleaning required by the specifications.

5.1.9 Check and run in all rotating equipment, i.e. compressors, pumps.

6.0 Scaffolding Sufficient amount of scaffolding required for good performance of the WORK shall be supplied by LSTK CONTRACTOR.

7.0 DRAWINGS AND DOCUMENTS

7.1 **LSTK CONTRACTOR will carry out all construction and any required procurement activities directly from the AFC construction drawings and specifications and forming part of the CONTRACT. No additional design work or development e.g. completion of drawings will be required from LSTK CONTRACTOR.**

However, the plan type drawings called out to be supplied by LSTK CONTRACTOR in previous subsections of this section are included in LSTK CONTRACTOR'S scope of WORK.

7.2 All of LSTK CONTRACTOR'S drawings, calculations, documents, test reports, and test certificates are to be submitted to OWNER for approval in 6-fold. After receiving approval LSTK CONTRACTOR to submit for final approval all of the above and one (1) soft copy in CF format. LSTK CONTRACTOR drawings receiving "Approved as Noted" stamp may be worked on provided all notes are incorporated. It is understood that OWNER'S approval shall not receive in no way LSTK CONTRACTOR from any of his obligations and further more shall not relieve LSTK CONTRACTOR from his obligations to timely complete the WORK according to approved project schedule by OWNER.

7.3 LSTK CONTRACTOR'S drawings shall be clearly marked with titles, equipment numbers or other item identification.

7.4 Approval of drawings and calculations by OWNER in no way absolves LSTK CONTRACTOR from its responsibility for the accuracy or for the design, construction and timely performance of the WORK.

7.5 LSTK CONTRACTOR shall promptly submit reports of each and every. test or inspection.

7.6 LSTK CONTRACTOR shall submit quality records of the materials, as specified in previous sections and the applicable engineering specifications.

7.7 LSTK CONTRACTOR shall furnish an equipment installation record indicating date of installation and tag number of each piece of equipment.

7.8 LSTK CONTRACTOR shall furnish an equipment maintenance record indicating date and type or maintenance of each piece of equipment during the LSTK CONTRACTOR period.

7.9 LSTK CONTRACTOR shall fill out checklists as required by OWNER.

8.0 **LIFTING, LIFTING EQUIPMENT AND GEAR**

8.1 Rigging and hoisting shall be executed in accordance with construction specification local and governmental requirements and safety manuals, as well as specific equipment manufacturer's instructions. If there are conflicts. the more stringent shall prevail.

8.2 LSTK CONTRACTOR shall only perform the lifts and movements in accordance with approved LSTK CONTRACTOR submitted rigging studies and plans.

8.3 Preferably, equipment will be lifted in accordance with manufacturer's instructions, if include, using lifting trunnions, lifting lugs if provided, or by slings attached to or around the equipment, with adequate protective measures to prevent damage to equipment. No temporary lifting lugs shall be used without the written approval of OWNER.

8.4 No nozzles or other appurtenances not intended for lifting shall be used for attachment of slings.

8.5 Equipment shall be handled with sufficient care to prevent damage. Slings shall have adequate protection to prevent marring the surface of equipment. Where necessary, sling spreaders shall be used to prevent crushing or other damage to the equipment.

8.6 **Testing And Certification**

All LSTK CONTRACTOR furnished cranes, lifting appliances and lifting gear must be properly tested, examined and /or inspected before being used on site and at the intervals specified in the applicable regulations. Copies of the relevant certificates must always be available on site for inspection on request by OWNER or proper authorities.

8.7 **Operation**

8.7.1 LSTK CONTRACTOR shall not permit a lifting appliance to be operated otherwise than by a person trained and competent to do so.

8.7.2 LSTK CONTRACTOR shall take express steps to ensure that all personnel employed by LSTK CONTRACTOR are competent and experienced for their assigned tasks.

9.0 **WELDING**

Welding of or on equipment shall only be permitted with the approval or OWNER.

10.0 **EQUIPMENT PAINTING & INSULATION TOUCH**

Rotating and special equipment to be erected by LSTK CONTRACTOR will be delivered to SITE finished painted. LSTK CONTRACTOR is responsible to apply remedial *I* touch up painting for any damages to paint, or protective coatings on equipment handled by it in connection. With any aspect of this operations such as unloading. transport, handling and **erection as per Annexure mention in ITB Section.**

ANNEXURE- 7 - 2E

ELECTRICAL WORK

1.0 **SCOPE: ELECTRICAL WORK COVERS**

1.1 Installation and erection of the following equipment (items) consists of the preparation for installation, connection, testing and pre-commissioning etc. as per specifications and as per drawings.

1.2 Provision of all tools, equipment and consumables used in the course of the work.

1.3 The installation of the following systems (items) shall consist of the connection, testing and pre-commissioning etc., so that the systems are ready for use as per specifications and as per drawings.

1.4 Transport, store and protect supplied materials to the construction location.

2.0 **ELECTRICAL ITEMS**

2.1 Generators / Motors

2.2 Control panels

2.3 Transformer

Note: Installation of all accessories, tanks, levelling and fixing in place are also considered.

2.4 **Switch Gears**

Note: Bolting together sections where supplied separately and installation of panels, levelling and fixing in place are also considered.

2.5 **Bus Ducting**

Note: Jointing and securing the associated switch boards / transformers are also considered.

2.6 Battery charger, battery sets and UPS unit.

2.7 Cables in trench / conduit / tray / Rack.

Note: Following items are also necessary.

a) Measuring and cutting of cable and protection of cut ends.
b) Identification of cables
c) Fixing of cable to tray / rack

2.8 Cable Glands

2.9 Cable terminations

2.10 Earthing cable in trench / conduit / tape on tray / Rack
2.11 Earth cable tape terminations

2.12 Lightening protection

2.13 Lighting/ fittings / supports

2.14 Earth Rod PRT and cover

2.15 Cable tiles

2.16 Trench marker posts

2.17 Air craft warning

2.18 Underground electrical grounding system

Note: All bellow items are also considered:

a) Pulling of grounding cable in trenches, through culverts, protection sleeves and cable ducts as per grounding cable supplier installation instruction, project specifications and layout and detail drawings.

b) Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.

c) Install, including the provision of the required tools, the required through branch and end connections.

d) Installation of all grounding electrodes including inspection pits as per specification and the layout and detail drawings.

e) Return of the cable drums to the storage area including a clear make up of cable lengthleft on the reels of drums that are not empty.

f) Measure cable resistance for grounding continuity and grounding resistance of ground rods, record data and submit the rest result reports to OWNER prior to commissioning of the installation.

g) Check cables are in proper trenches and ground rods at their location.

h) Perform all test; witnessed by OWNER'S REPRESENTATIVES of the founding installation including the provision of all OWNER approved testing equipment and measuring devices.

2.19 Miscellaneous Electrical equipment

2.20 Earth resistance testing including earth resistance rods for grounding, continuity of grounding, installation resistance testing for electrical cables and HL-POT testing for electrical cables.

3.0 TESTING AND COMMISSIONING

Testing and commissioning consist of the complete testing prior to commissioning, including provision of required testing apparatus and testing documents as requested and as specified in the testing specifications.

- All test results shall be recorded on the test form and submitted to OWNER. Each test record shall include. date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identifications of equipment, ground electrode or circuit tested.

- Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LSTK CONTRACTOR. LSTK CONTRACTOR will notify all necessary interested parties including manufacturer's representatives.

  High potential tests shall not be repeated without authorization by OWNER.

4.0 DRAWINGS AND DOCUMENTS

4.1 LSTK CONTRACTOR will carry out all construction and any required erection activities directly from the AFC construction drawings and specifications.

4.2 LSTK CONTRACTOR shall promptly submit reports of each and every test or inspection.

4.3 For more details LSTK CONTRACTOR shall follow **Electrical design philosophy elsewhere mentioned in ITB.**

ANNEXURE- 7 – 2F

INSTRUMENTATION WORK

1.0 **GENERAL**

1.1 Instrumentation symbols and identification of functions shall be based on the current edition of ISA S5.1.

1.2 Specifications for instruments and items of control equipment are shown on data sheets to be issued as they become available.

1.3 All materials and connections for control valves, relief valves, level controllers and similar equipment shall comply with applicable requirements for valves and fittings as noted in the piping specification.

1.4 LSTK CONTRACTOR shall install all shim plates, fixing material such as but not limited to anchors, red heads, etc.

1.5 LSTK CONTRACTOR shall install all instrument equipment tag plates.

2.0 **FIELD INSTRUMENT INSPECTION AND CALIBRATION AND INSTALLATION**

2.1.1 This item covers all activities and supply of all materials to import calibration of instruments. It includes, but is not limited to, the following :

2.1.1 Provision of all tools, equipment and consumables used in the course of the work.

- Calibration of instruments and provision of all necessary test equipment gauges, materials and ancillary items. All necessary testing instruments to be used must be certified by Govt. recognized testing laboratories.

- Check orifice plates and control valves.

- Protection of instruments to maintain cleanliness at all times.

- Mark instrument to indicate status of calibration.

- Return instruments, after calibration and checking to lay-down areas and / or stores including all packaging.

- Pressure and leak test including the provision of all necessary test equipment gauges materials and ancillary items.

Note : The calibration of all instruments within the packages is also the responsibility of LSTK Contractor.

2.1.2 LSTK CONTRACTOR shall install all instruments as listed in the instrument index and further per the relevant installation specifications, documents and drawings.

2.1.3 Field instrument installation includes, but is not limited to:

Mounting of instruments and related equipment, supports protection boxes, manifolds, junction boxes, nameplates, etc.
Installation of measuring elements (probes, sensors, detectors, etc) including their auxiliaries as required (thermo wells, supports, valves, etc.) unless done by others

Installation of on-line instruments (by piping)

The following is a typical list of on-line instruments :

- Safety blow down valves.
- Control valves (all types)
- Motor - operated valves.
- Safety shut - down valves (including solenoid valves).
- Safety / relief valves.
- Pressure / vacuum relief valves.
- Self - regulating valves.
- Level gauges.
- Level displacer chambers.
- Orifice assemblies.
- Orifice plates.
- Ventures.
- Turbine meters, annubars, magnetic flow meter.
- Positive displacement meters.

- Variable area meters (rotameters)

- Stilling Wells.
- Thermo wells and etc.

- Installation of process connections, impulse lines and capillaries.

- Installation of purge and flushing supply tubing, filter blocks and rotameters.

- Installation of air supply lines.

- Supply and installation of instrument nameplates for field instruments.

2.2 Cable, Supports and Fixing Wire pins, Conduit

LSTK CONTRACTOR shall use for cable installation for indoor and outdoor use the materials such as tubing, cable trays, etc. as called in the specifications.

2.2.1 Cable tray. ladder rack and tubing systems shall be installed to ensure electrical continuity throughout the run and such that water cannot collect or remain in any part of the system.

2.2.2 Pulling of the cables into the trenches, through culverts, protection sleeves and cable ducts as per cable supplier installation instructions and layout drawings, cable lists, trench sections and reel schedules.

2.2.3 Installation of the cable separation tiles, if specified.

2.2.4 Coil up and clearly designate the final destination of the cable ends, especially if cables have to be continued their routing underground or overhead via cable tray or otherwise to their final destination at a later date.

2.2.5 Installation of the sealing shrouds to avoid water ingress after cable cutting.

2.2.6 Installation of the cable markers stamped with cable number by LSTK CONTRACTOR as per cable list.

2.2.7 Installation of cable splicing if required.

2.2.8 Return of the cable drums to the storage area including clear markup of the cable length left on the reels of cable drums that are not empty.

2.2.9 Check if cables are spaced as specified.

2.2.10 Measure cable resistance and cable insulation, record data and submit the test result reports

prior to commissioning of installation.

2.2.11 Check whether all cables are installed in the proper trenches.

2.2.12 Perform all tests, witnessed by OWNER of the underground cable installation including the provision of the OWNER'S approved testing equipment and measuring devices.

2.2.13 Record of actual installed cable lengths and location of cable splices.

2.2.14 Where cables required to be installed through or across the edges of tray or other metal work the edge of the lips shall be smoothed. painted and lined with a protective sleeving to avoid cable damage.

2.2.15 Supporting steelwork shall be fabricated and installed by LSTK CONTRACTOR. The material shall be primed in accordance with the painting specification by LSTK CONTRACTOR.

2.2.16 Storage and handling of cable before and during installation shall be carried out with due regard to manufacturer's recommendations. Cable drums shall be rotated only in the direction indicated by drum markings, and open ends of cables are to be effectively sealed immediately after cutting to prevent the ingress of moisture.

2.2.17 At all times, the utmost care shall be exercised to avoid damaging the protective sheathing to cable or of causing excessive bending or twisting which may result in damage to core insulation, sheaths armor and so on.

2.2.18 The bending radius of a cable either during or after installation shall not be less than manufacturer's recommended minimum.

2.2.19 Cables shall be run in continuous unbroken lengths and joints shall not be permitted unless specifically called for in the cable drum-cutting schedule.

2.2.20 Cables installed above ground shall be routed to avoid high-risk areas, e.g. high fire risk areas, and those areas where accidental leakage or spillage may occur and cause damage to cables and supports.

2.2.21 During installation, the ends of cables shall temporarily be protected using compound, tape, heat shrink seals or similar approved methods to avoid damage or entry or moisture until they are permanently terminated.

2.2.22 Pre-cast concrete members should not be drilled for any reason. Fixing shall always be by means of clamping brackets in the most efficient way and in consolation with OWNER.

2.2.23 Under no circumstances shall welding be carried out to any process plant equipment, vessels, pipelines, or structures or to any protected surface unless specifically indicated on the drawings and documentation and then in strict accordance with a procedure subject to

Approval of OWNER.

2.2.24 Fixings to the above shall normally be made where brackets and so on, have already been provided or when agreed by the use of purpose built clamps.

2.2.25 On trays horizontal cable runs shall be fastened every 1200 mm, vertical cable runs every 600 mm.

2.2.26 **Grouping**

The cables employed to convey electricity shall be grouped according to the signal kinds. The main group kinds are but not limited to the followings

a) Intrinsically safe signals.
b) Signal cables not intrinsically safe.
c) Instruments power supply cables.
d) Coaxial cables or telephone cables used as serial data buses.

2.2.27 All cable trays, ladders, tubing and supports and fixing material for indoor and outdoor use shall be installed by LSTK CONTRACTOR.

2.2.28 All cables shall always be installed and connected in such a way that no forces can act on terminals. Further, all instrument and power supply cables inside and outside buildings shall be installed in accordance with both cable lists and drawings by LSTK CONTRACTOR.

Carbon steel coated cable stub ups shall be installed by LSTK CONTRACTOR for all cables from sand trenches to 500 mm above ground, in accordance with electrical connection detail drawings.

2.2.29 **Conduit system**

Single pair cables shall be used to connect field mounted instruments to local junction boxes. Single cables shall be armoured type laid in galvanized carbon steel / aluminium pipes with open ends or on closed cable trays. In order not to damage the cable, a plastic annular cap shall cover the pipe end.

Multipair cables shall be used to connect above said local junction boxes to the control room. Multipair cables shall be armoured type and shall run over head in closed cable trays / ladders supported on the pipe racks.

2.2.30 **Wire Pins**

All stranded cable conductors shall be fitted with crimped taper pins, amp (or equivalent) and all screens with lugs. Installation of all amp wire pins and screen lugs by LSTK CONTRACTOR.

Further, in general, all standby conductors shall be wired to terminals.

2.2.31 **Cable Marking**

All instrument cables, conductors and the instrument screen/earth wires shall be tagged on both sides in accordance with the instrument connection list for local and central control room signals by LSTK CONTRACTOR.

2.2.32 **Cable Entry Sealing**

- **General**

  After installation of all cables and on direction of OWNER, LSTK CONTRACTOR shall seal off all cable entries and passages.

- **Outside walls**

  All cable entries in outside walls and below grade level shall be watertight sealed. Method of sealing shall be supplied by LSTK CONTRACTOR.

- **Separation walls**

  All cable entries in separation walls of buildings shall be sealed with a fire resistant sealing as described hereafter.

- **Control Room Floors**

  All cable and cabinet entries in floors shall be sealed with polyurethane foam.

- **Fire - resistant sealing**

  All fire resistant sealing shall be class H-30.
  Small openings in walls shall be sealed with CSD –F (or equal) in luminescent foam.

  Large openings in walls and between computer floor and cable basement shall be sealed by inserting CSD-F (or equal) in luminescent plates under between and above the cables. The remaining openings shall be sealed with CSD-F (or equal) in luminescent foam.

2.3 **Alarm Systems**

2.3.1 LSTK CONTRACTOR shall install the fire alarm including sensors, cabling, local panels, mimic panels and host system. In accordance with:

- Project engineering specification and codes and standards.

- Cabling between panel and detectors, alarms, switches etc. as described above.

- Installation of all junction / terminal boxes, cable terminations and connections, supporting brackets for cabling as described above.

2.3.2 All work related to the fire and gas system, including overall test / loop check as per specifications and drawings, among which the installation, placing and connection of all cables of the fire and gas panel located in the control building and panel in the firehouse shall be done by LSTK CONTRACTOR.

2.4 **Analyzers Installation**

LSTK CONTRACTOR shall install all analyzers and sampling conditioning systems in the analyzer house as well as in the field consisting of, but not limited to:

- Installation of all vents and drains from analyzers.

- Installation of calibration gas bottles as well as regulators and connecting tubing, as required.

3.0 **LOCAL PANELS**

LSTK CONTRACTOR shall install local panels, consisting of, but not limited to:

a) Mounting, aligning and fixing to the foundation or steelwork. Uncoil, install and terminate underground cable ends. Install and terminate all aboveground cable to / from panels.

b) Install and connect air supply and air signal piping and tubing to 'from panels.

c) Install cabling and connect alarm horns.

d) Identification / tagging of all equipment, terminals, cables and tubing which is not installed by panel vendor. Tag plates to be installed by LSTK CONTRACTOR.

e) Installation of brackets / supports for cable, etc. and installation material as required to complete the installation.

4.0 **TERMINATION OF CONTROL CABLES FROM THE LV SWITCH ROOM**

The control cables running from the switch room shall be installed and connected in the marshaling cabinet by LSTK CONTRACTOR.

5.0 **CONTROL BUILDING INSTRUMENT INSTALLATION**

5.1 LSTK CONTRACTOR shall install all control building instrumentation in accordance with the relevant installation specifications and drawings.

6.0 **CABINETS AND CONSOLES**

6.1.1 LSTK CONTRACTOR shall install align and anchor all equipment cabinets and consoles in accordance with design drawings and seller's installation instructions.

6.1.2 The false floor shall be completely installed by LSTK CONTRACTOR.

All panels, cabinets, tables, boxes, computers etc. located on the instrument equipment layout shall be place and installed by LSTK CONTRACTOR.

6.1.3 Where cable passage is required according to installation drawings, LSTK CONTRACTOR to indicate locations of holes and passages.

6.1.4 FCS/ESD/PLC cabinets and data base unit:

These groups / cabinets shall be installed in place and bolted together by LSTK CONTRACTOR.

Internal wiring / cabling and / or connections between these groups of cabinets shall be done by LSTK CONTRACTOR in accordance with the instructions of the system vendor's representative.

6.1.5 **FCS Consoles**

The consoles shall be installed in place and bolted together by LSTK CONTRACTOR, including installation of special table with peripherals.

Internal wiring and cabling and/or connections between consoles shall be done by LSTK CONTRACTOR in accordance with the instructions of the system vendor's representative who will be present during these operations.

6.1.6 Communication racks with the same work description as specified elsewhere in Tender documents.

6.1.7 Main processor cabinets (data base units) with the same work description as as specified elsewhere in Tender documents.

6.1.8 **Marshaling Cabinets**

Cabinets shall be installed in place and bolted together by LSTK CONTRACTOR.

Cross wiring between these assembled sections shall be done by LSTK CONTRACTOR.

6.1.9 **Fire Panel Cabinets.**

6.2 **Handling and installation. Termination and Connection of Cabling**

Cables entering instrument room are installed under false floor. These cable shall be handled, cut to length, stripped and after installation of the cabinets be terminated and connected by LSTK CONTRACTOR.

LSTK CONTRACTOR shall leave slack in the cables and provide markings.

6.3 **Installation of System Cables**

LSTK CONTRACTOR shall install, plug in and support all system cables. Cable supporting rail in cabinets is installed by cabinet / console vendors, but in any case LSTK CONTRACTOR is responsible.

- System cable shall be installed by LSTK CONTRACTOR under false floor in auxiliary room. System cables are covered by instrument cable list.

6.4 **Conduits Cable Tray / Trucking. Support Frames and Brackets**

All cable trays, cable trucking, supports / brackets, etc. if required , shall be installed by LSTK CONTRACTOR. For cable tray installation see respective part.

6.5 **Auxiliary Cable Installation and Termination.**

LSTK CONTRACTOR shall install, terminate, support and connect all auxiliary cables.

Auxiliary cables are all cables covered by instrument cable list and instrument cable layout for control room.

LSTK CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation.

6.6 **Communication Cables**

LSTK CONTRACTOR shall install and support communication cables. The connection of the cables in the consoles and cabinets shall be done by LSTK CONTRACTOR, under direct supervision of system vendor. LSTK CONTRACTOR shall open / remove and close parts of the false floor as required for cable installation. Communication cables are listed on instrument cable layout for control room and the system cable list.

6.7 **Power Supply Cabling**

LSTK CONTRACTOR shall install. terminate and connect all power supply cables between power distribution boards and cabinets, consoles, printers and other instrument equipment when listed on the power supply list

6.8 **Earthing System**

LSTK CONTRACTOR shall install and connect the insulated earthing cabling *I* wiring from the earth buses to the cabinets, consoles and all other instrument equipment.

All cabinets and consoles shall be fitted with earthing bus bars and earthing connection bolts by the vendors and under supervision of LSTK CONTRACTOR.

LSTK CONTRACTOR shall install utility, shield and dedicated earth (clean earth) cabling and connections including tags at both ends.

LSTK CONTRACTOR shall check and test earthing system in accordance with relevant documents.

7.0 **LIFTING**

7.1 Major instrument equipment shall be rigged from points designated or suitable to accept rigging. When available, LSTK CONTRACTOR shall utilize lugs on equipment.

7.2 When establishing hoisting loads, riggings plans and crane capacities, LSTK CONTRACTOR shall adhere to the requirements and instructions as defined in the specifications and as instructed by OWNER.

8.0 **TESTING AND PRECOMMISSIONING (FUNCTION TEST)**

8.1 Testing and pre-commissioning consist of the complete testing and pre-commissioning prior to commissioning, including provision of required testing apparatus and testing documents, comprising, but not limited to:

8.1.1 Check for completion and conformance to specifications.

8.1.2 Check the accessibility of all instruments and components for field adjustments, routine maintenance and removal for overhaul, and relocate as necessary.

8.1.3 Perform pressure test on all air sub headers as required by the line specifications.

8.1.4 Clean all instrument air sub headers, transmission tubing and control tubing by blowing with dry, filtered air prior to connection of instrument components

8.1.5 Leak test pneumatic transmission and control tubing, using an approved method acceptable to OWNER

8.1.6 Perform hydrostatic or, where appropriate, pneumatic pressure tests on all instrument process piping, as required by the respective line specifications. Drain and below free of water, as necessary after test.

8.1.7 Check continuity and identification of transmission and control systems for each instrument to ensure proper hookup. Perform megger and continuity tests for instrument electrical wiring. Check correct source of power, polarity and earthing (take into account intrinsically safe technology of this procedure).

8.1.8 Check the bore of the orifice plates and flow direction during and after installation.

8.1.9 Check (on/off valve and) control valves for direction of flow and proper operation, e.g. travel, action with air failure, etc.

8.1.10 Calibrate all instruments (including the instruments in the fire and gas system) and synchronize transmitter and receiver readings for each instrument loop. Check the orifice plates and flow nozzles. Set air pressure regulators.

8.1.11 Install pressure and temperature gauges after line flushing.

8.2 Check fuses, perform voltage checks and energize all electrically powered instruments, alarm and shutdown system, etc. Maintain power supply.

8.3 Set pneumatic and electronic type switches and local control by simulation of input signals.

8.4 Check thermocouples and resistance thermometer circuits from element to measuring instrument by simulation.

8.5 Check and adjust calibration of all other field and panel mounted instruments.

8.6 Complete loop functional test of all instruments, including the instruments in all package units and in the fire and gas system. Functionally test complete control loops alarm and shutdown systems and partial process sequence, etc., to verify capability to measure, operate and stroke final control elements in the direction and manner required by the process application.
All test results shall be recorded and submitted to OWNER. Each test record shall include date of test, ambient temperature, climatic conditions, instruments used with serial numbers, names of test personnel and witnesses, identification of equipment, ground electrode or circuit tested.

Testing shall be scheduled at least 24 hours in advance and OWNER is to be notified by LSTK CONTRACTOR. LSTK CONTRACTOR shall advise OWNER prior to testing, of make, type and accuracy of test equipment used for above-mentioned items. All required test certificates should be of a recent date not exceeding 6 months.

9.0 **PAINTING**

Surface preparation and application of all required paint layers shall be executed in accordance with paint specifications and related standards.

10.0 **WELDING**

LSTK CONTRACTOR shall perform welding in accordance with the normal accepted industrial standards.

11.0 **MECHANICAL COMPLETION**

LSTK CONTRACTOR shall advise OWNER in writing when erection is completed.

Mechanical completion date shall be the date when the activities have been accomplished by LSTK CONTRACTOR as dictated by the construction schedule, which shall be submitted by LSTK CONTRACTOR and approved by OWNER on due time.

12.0 **QUALITY ASSURANCE, QUALITY CONTROL, INSPECTION, CALIBRATION TEST AND MATERIAL CERTIFICATES**

12.1 LSTK CONTRACTOR shall perform quality control, inspect, calibrate required testing, pre-commissioning and supply certificates.

12.2 LSTK CONTRACTOR shall submit reports of each and every test or inspection within three (3) days after actual test or inspection is made.

12.3 Calibration and Testing.

12.3.1 Calibration and testing to be executed by LSTK CONTRACTOR in accordance with respective specifications.

Local instruments such as transmitters, converters, receivers and so on, will be preset by bench testing by LSTK CONTRACTOR in accordance with the specifications before installation on the process, so that no new settings will be necessary for loop acceptance tests.

12.3.2 LSTK CONTRACTOR shall inspect all materials up on receipt for damage and completeness. In case of damage incomplete material, LSTK CONTRACTOR shall modify and immediately inform OWNER.

12.3.3 LSTK CONTRACTOR shall carry out all tests included in this paragraph shall fill out the installation checklists and shall submit all required test certificates and documentation as required.

12.3.4 All tools and test gear necessary to carry out described tests shall be provided by LSTK CONTRACTOR.

12.3.5 Inspection and testing shall be phased with construction and installation in such a manner as to involve the minimum necessary concentration of effort and manpower and the minimum loss of time in reaching the pre-commissioning stage.

12.3.6 All inspection and testing shall be witnessed and approved by OWNER / authorized representative.

12.3.7 LSTK CONTRACTOR shall be responsible for the complete loop continuity check of the field and control room installation, including the parts of the package units, which have been connected by others.

12.3.8 OWNER reserves the rights whenever distinguished package Plant(s)/Unit(s) vendor's representative to be present at site LSTK CONTRACTOR shall be responsible to arrange this WORK.

12.3.9 LSTK CONTRACTOR shall be responsible for the loop continuity checks from the marshaling cabinets or direct connected cabinet cables in the control room (termination point of underground multi core cable). The loop continuity checks shall be performed on a complete loop, including all parts of the loop as indicated on the instrument loop diagrams (ILD'S).

12.3.10 The communication equipment between field and control room building and/ or other buildings shall be the responsibility of LSTK CONTRACTOR.

12.3.11 Only complete loops shall be accepted, signed by OWNER after all calibration / function checks have been demonstrated successfully completed and recorded.

12.3.12 For all package units and systems supplied by LSTK CONTRACTOR, installed or partly installed and connected by LSTK CONTRACTOR.

LSTK CONTRACTOR shall perform a normal wiring and loop check of signals and supplies to and from these systems.

The following systems apply:

- Analyzer system
- Bentley Nevada system
- Flow metering system
- Fire, smoke and gas detection system
- Tank gauging
- FCS / ESD / PIC system, etc.

For more details LSTK CONTRACTOR shall follow **Electrical design philosophy elsewhere mentioned in ITB.**

13.0 **Miscellaneous**

LSTK CONTRACTOR shall remove all waste and debris from the SITE.

ANNEXURE- 7 - 2G

INSULATION WORK

1.0 **GENERAL**

1.1 **SCOPE**

This standard covers the requirement for supply and application of materials for thermal insulation of equipment, piping and other items.

1.2 **REFERENCE STANDARDS**

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations applicable to the country. The main codes, standards and statutory regulations considered as minimum requirements are as follows:- (Latest revision of these shall be followed)

IS 14164	Code of Practice for Industrial Application and finishing of thermal insulation material at temperature -80^{0}C and up to 750^{0}C.
IS 737	Wrought aluminimum and aluminium alloys, sheet, strip
IS 1254	Specification for corrugated aluminum sheet
IS 1322	Bitumen felts for waterproofing and damp proofing
IS 3069	Glossary of terms, symbols and units relating to thermal insulation materials.
IS 8183	Specifications for bonded mineral wool.
IS 9743	Thermal insulation finishing cements
IS 12436	Specification for Preformed Rigid Poly-urethane (PUF) and Poly-isocyanurate (PIR) Foams for Thermal Insulation
IS 13205	Code of practice for the application of polyurethane insulation by the in-situ pouring method.
ASTM C921	Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
ASTM C1029	Specification for Spray-Applied Rigid Cellular Polyurethane Thermal Insulation
ASTM C1696-16	Standard Guide for Industrial Thermal Insulation Systems
ASTM C411	Standard Test Method for Hot-Surface Performance of High - Temperature Thermal Insulation

ASTM C450	Practice for Fabrication of Thermal Insulating Fitting Covers for NPS Piping, and Vessel Lagging
ASTM C871	Test Methods for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions
ASTM C1338	Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.
ASTM C1055	Guide for Heated System Surface Conditions that Produce Contact Burn Injuries
ASTM C1139	Specification for Fibrous Glass Thermal Insulation and Sound Absorbing Blanket and Board
ASTM D1622	Test Method for Apparent Density of Rigid Cellular Plastics
ASTM C680	Standard Practice for Heat Loss or Gain and Surface Temp.

1.3 **Deviations**:

Should unforeseen difficulties arise to comply with requirements of this standard.

Alternative material and application techniques superior to the requirements of this standard be submitted with complete details for approval of owner.

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

1. Statutory regulations.
2. Job specifications.
3. Engineering design basis.
4. Standard specification.

1.4 **LIMITATIONS**

Temperature Limits.

This standard deals with insulation applied externally on piping equipments etc. as per the table below:-

Maximum Operating Temperature	**Type of Insulation**
60^0C to 750^0C for C.S., A.S. & S.S.	HOT
- 180^0C to 20^0C	COLD

1.5 **THICKNESS DESIGN BASIS**

Thickness calculation method as per procedure given in ASTM C-680

1. **Hot Insulation**

Design Ambient Temperature	: 35ºC
Design Surface Temperature	: 45^0C
Permissible Heat Loss	: 100 kcal./m2 hr.
Permissible Wind Velocity Outside	: 1 m/sec
Permissible Wind Velocity Inside	: 0.25 m/sec

2. **Cold Insulation**

Design Ambient Temperature	: 35ºC
Design Surface Temperature	: 2 ºC below ambient/ 0.5 Deg C above the Dew Point
Permissible Heat Gain	: 10-12 kcal/m2 hr
Relative Humidity	: 85%
Permissible Wind Velocity Outside	: 1 m/sec.
Permissible Wind Velocity Inside	: 0.25 m/sec.

1.6 GENERAL REQUIREMENTS

1.6.1 Information to be supplied

- Material of construction / dimension of equipments / pipes required to be insulated.
- Temperature
- Location of equipment (Indoor/Outdoor/Elevn.)
- Requirement of removable box type insulation if any
- Special requirements if any regarding type of insulation material and other properties.
- These information shall be supplied in form of insulation schedule.
- Design calculations, drawings and insulation material schedule.
- Material Test certificate's.
- Insulation works execution schedule.
- Detailed procedure for all types of execution works.
- Bill of Quantities, Initial material take-off, final material take off and material requisition.
- QA/QC plan.

1.6.2 STORAGE OF MATERIAL

Insulation material shall at no time be stacked directly on the ground; instead it will be stored at a level higher than ground level. It should not only be covered by tarpaulin but other effective protections against weather are also to be provided. The contractor shall provide a properly covered storage to the satisfaction of engineer-in-charge (Refer IS: 10556).

1.6.3 HYDROSTATIC TEST FOR PIPES

Before taking up insulation job on piping or vessels it shall be ensured that hydrostatic test of the concerned equipment / piping is completed. Where it is felt necessary to take up the insulation job before such testing are performed all welded and mechanical joints shall be left un-insulated for a length of at least 150mm on either side of the joint.

1.6.4 PROTECTION OF INCOMPLETE JOBS

Any part of insulation job which is not provided with final weather proofing will be adequately protected by means of tarpaulins and other aids. After the day's work similar protection

should be provided for the partially completed jobs to be continued the next day to avoid any absorption of rain / moisture during the night.

2.0 INSULATION SUPPORTS (CLEATS) TO BE PROVIDED BY EQUIPMENT SUPPLIER

Suitable supports (cleats) in the form of rings, lugs, studs or pins shall be provided on equipment by equipment supplier, however should any additional supports or anchorage be felt necessary for insulation works, the same shall be also considered in LTSK's scope, including all allied work necessary for the same. These will be installed by the contractor free of any extra cost. Owner shall be informed about the same in advance, so also design/drawings shall be updated accordingly.

3.0 MATERIAL REQUIREMENTS

3.1 INSULATION MATERIALS

3.1.1 General

Whenever reference to any Standard is made it is presumed that the latest revision as on date should be considered unless otherwise specified.

3.1.2 Specification and other requirements

Specification and other requirements will be as per below mentioned table:-

Hot Insulation:

For operating temperature Upto 400 deg.C,	Rockwool Mattress of density 120 kg/m3 conforming to IS:8183.
For operating temperature 401-450 deg.C,	Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.
For operating temperature 451-500 deg.C,	1st layer insulation shall be 25mm Ceramic Fibre Blanket of density 128 kg/m3 conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.
For operating temperature 501-550 deg.C	1st layer insulation shall be 50mm Ceramic Fibre Blanket of density 128 kg/m3 conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.
For operating temperature 551-600 deg.C,	1st layer insulation shall be 75mm Ceramic Fibre Blanket of density 128 kg/m3 conforming to IS :15402 and balance layers with Rockwool Mattress of density 150 kg/m3 conforming to IS:8183.

Bands/Wires for securing insulation shall be of ASTM 8209 Alloy 3003 H16 or 18-737 designation 31000 (old NS3) condition H3 or 18/8 Stainless steel.

For securing cladding on insulation on piping, aluminium band 12mm (min) X 24 SWG thick shall be used. For securing cladding on insulation on equipment, aluminium band 20mm wide X 24 SWG shall be used.

Other insulating materials may be used provided they have the same or better properties and durability aspects.

Insulation thickness of insulating materials shall be based on design calculation of thermal conductivity, insulation class, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

For Valves, Turbines & Compressors Insulation

Prefabricated factory made Ceramic Fibre pad to be used made out of Ceramic Fibre Blanket of density 128 kg/m3 encased in high temperature resistant cloth. The minimum thickness of the pad shall be –

1. 0 Deg.C to 300 Deg.C = 25mm
2. 301 Deg.C to 400 Deg.C = 50mm
3. 401 Deg.C to 500 Deg.C = 75mm

Removable insulation for flanges and valves, like tailor made jackets or pre formed insulation boxes, shall be suitable for quick removal and reinstallation. All tailor made jackets shall fit the actual valve/flange/equipment and secure adequate overlap to incoming insulated pipes.

Technical data sheet of the Ceramic Fibre Pad is as below:

A.	Purpose/Application This Engineering specification is for Fabric jacketed supercera ceramic Fibre insulated flexible reusable covers/pad for application on pipes: pipe fittings, valves, flanges etc vessels & equipments, tubes etc in hot services.				
01	Dimension (mm)	As per drawing/sketch provided by OEM.			
02	Thickness (mm)	25-100			
1.	Specification of Protective jacketed material				
i	Vest Cover	Liner Fibre Glass Fabric			
ii	External Top Cover Fabric (for cold face)	Polymer Coated Fibre Glass fabric Temp. resistance 300 Deg. C, oil & water resistant			
iii	External Bottom Cover fabric (for hot face)	High silica cloth for Temp Resistance up to 900 Deg C			
2.	Specification of insulation Material	Ceramic Fibre Blanket (As per IS 15402)			
i	Classification Temperature	1260 degree Celsius			
ii	Thickness	25 – 100mm			
iii	Bulk Density	128kg/m3			
iv	Shot content on 70 mesh (%)	<30			
v	Tensile strength (KPa)	>40			
vi	Mean Fibre Dia (Micron)	2-4			
vii	Linear Shrinkage (%) At 1200 Deg. C for 24 Hrs	3.5			
viii	Thermal Conductivity (W/mK) Max.	1000C	2000C	3000C	5000C
		0.046	0.072	0.078	0.150
ix	Chemical composition	SiO2%		49-58	
		Al2O3%		41-48	

		ZrO2%	0-7
		FeO3%	<0.1
3	Hardware & Non Metal fastening		
i)	Buckle/Draw Stings	Stainless steel (min SS 316), High Temp Braided Chord of fibre glass	
ii)	Stic Pins	Stainless Steel (min SS 316), Pins to prevent the insulation from movement inside the cover	
iii)	Stitching	Double sewn with Teflon coated Fibre glass wrapped stainless thread. The sewing thread shall not resolve or decompose in typical chemical plant environment.	
iv)	Belting	High Temp Fabric same as used in hot face cover	
4	Other Properties		
i	Fire Resistance (As per BS 476 Part-4)	Non-Combustible	
ii	Chemical Stability/Resistance of Corrosion/water	Good	
iv	Shock Resistance	Excellent	

Rockwool Insulation shall be of water Repellent Grade and tested as per BS: 2972 for Water Absorption. Maximum water absorption is 0.5 kg/m2 in 48 hours duration.

Precautions must be implemented in the design and fabrication of the insulation jackets to avoid the insulation material from sagging causing reduction of the insulation properties of the jackets.

Cold Insulation:

Insulation material and specifications for cold insulation for operating temperatures up to (-) 180°C and dual temperature (cold/hot) service where, upper temperature limit is 125˚C shall be as given below for all sizes of piping/equipment:

- **Polyurethane Foam**

Preformed pipe section's and radial lags (for higher diameter pipe) of polyurethane foam of self-extinguishing type shall be in accordance with ASTM C591 TYPE-II Grade 2.The physical requirement of bulk density, chloride content, thermal conductivity and PH value of the material shall be as follows:

Temp. Limit Bulk density: Upto (-)180°C & 120°C (max) 35.0 to 39.9kg/m3
Chloride content : 20 ppm (max)
Thermal conductivity : 0.221 mw/cm˚C at mean temp. 10 deg C
PH Value : Neutral.
Closed cell content : 95% (min)

High density polyurethane foam block of bulk density more than 300 Kg/m3 shall be used for supports.

- **Polyurethane Foam Cast-in-Situ**

Cast-in-Situ Polyurethane Foam of density 42±2 kg/m3 conforming to IS: 13205 shall be used. High density polyurethane foam block of bulk density more than 300 Kg/m3 shall be used for supports.

Temp. Limit : Up to (-) 45°C and 120°C (max.)

- **Polyisocynaurate**

Temp. Limit : Up to (-) 180˚C and 125˚C (max.)

Other insulating materials may be used provided they have the same or better properties and durability aspects.

Insulation material specification/ thickness/application mentioned in this document are the minimum requirements. Insulation specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, relevant IS/ ASTM codes etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters. LSTK shall submit detailed material specifications, durability parameters assured, test certificates and application procedure to OWNER/ PMC approval.

3.2 AUXILIARY MATERIALS FOR CLADDING

a) **Aluminium Cladding**

- **Horizontal Vessels**

Aluminium sheet as per IS-737 (designation 31000, condition H3 for flat sheet & 31500/51300, H4 for corrugated sheets)) shall be used for cladding. Insulation on overall piping, vessel and equipment, cladding will be coated on the side in contact with insulation with 3 mil thick polysurlyn film.

Specifications for aluminium Cladding material shall be as follows:

Material	Reference Code / Standard	Thickness	Application
Aluminium sheet with applied moisture barrier of 3 mil thick Polysurlyn coating	IS : 737 / ASTM C-653	22 SWG (0.71mm)	For all piping, tanks, vessels, heat exchanger, flanges, valves, equipments etc. upto 24” outside dia
		20 SWG (0.91mm)	For piping, tanks, vessels, heat exchanger, flanges, valves etc. above 24” outside dia
Removable cover for flanges, valves etc. shall be made out of minimum 18 SWG thickness Aluminium Sheets.			

- Vertical Vessels

Cladding material for vessels with insulation O.D. 900 mm and less shall be same as for pipes. For vessels above 900 mm insulation O.D. 22 SWG corrugated aluminium sheet as per IS-1254 or ribbed aluminium sheet 32 mm x 5 mm deep corrugations may be used.

Aluminium Foil to protect stainless surfaces in Temperature below 0 deg c shall be 0.1 mm (42 SWG) thick per ASTM 8209 alloy 3003 H16 or IS-737 designation 31000 (0IdNS3) condition H3. For securing aluminium foil on stainless steel surface 24 SWG thick x 20mm wide aluminium bands shall be used.

b) **Screws**
Screws used with aluminium sheeting shall be of self tapping type, A No.8x12mm long cadmium plated / SS of high quality at intervals of 150mm.

c) **S-Clips**.
Aluminium, 20x1.5mm or 25mm wide stainless steel banding bent to form a shape of "S" provide a minimum lap of 50mm.

d) **Bands for securing cladding**.
Aluminium of dimensions 12mm width x 0.56 mm thick (24 SWG) for pipes. Stainless Steel bands Type 304, 0.4mm thick x 13mm wide for large dia pipes (above 24") and cylindrical equipment up to outside dia 900mm, 0.5mm thick x 19mm wide for cylindrical equipment above 900mm outside dia meter.

e) **Quick release clips for removable covers**.
Suitable quick release clips will be made as shown in fig. 7 from 20Cm width x 20 SWG aluminium sheet and some fig.7 from 20mm width x 20 SWG aluminium sheet and some suitable rectangular ring.

f) Sealant for cladding joints with Foster 95-44 /TIKI F9544.

g) The vapour barrier mastic shall be Foster 60-38/39 /TIKI M6038/39

h) Adhesive for cold insulation shall be Foster 81-33 /TIKI P8133

i) Vapour Stops at pipe support location shall be Foster 90-66 /TIKI F9066

j) **Rivets**: Aluminium 'POP' blind eye type / Stainless Steel 9.5mm long x 5mm dia meter.

k) Filler material shall be PUF dust or mineral wool mixed with specified adhesive shall be placed lightly so as to fill irregular voids and sealant shall be Foster Foam Seal Sealer 30-45. Glass cloth to be used for vapour barrier reinforcement shall be open weave 10 mesh having glass fibre thickness of 5 mils.

Galvanised steel sheets/ Annealed galvanised steel sheets/ Galvanised colour coated sheet are strictly **PROHIBITED** for use in cladding works. Other cladding materials (except G.I.) may be used provided they have the same or better properties and durability aspects, after prior approval from Owner/PMC.

Cladding material / auxiliary material specification/ thickness/ application mentioned in this document are the minimum requirements. Cladding material/ auxiliary material specification/ thickness/ application shall be based on design calculation of thermal conductivity, insulation class, corrosion aspects, durability, relevant IS/ ASTM codes, etc. Same shall be submitted to the Owner with necessary design calculations, drawings, test certificates and durability parameters.

LSTK shall submit material specifications, durability parameters assured, test certificates and application procedure to OWNER/PMC approval.

4.0 INSPECTION.

4.1 General

All insulation material shall be subject to inspection by owner before application. In case of doubt, Owner's representative will have the liberty to get the material tested by the contractor at any approved test laboratory. Any material not meeting specified requirement will be rejected and the rejected material shall have to be replaced by the contractor with material of specified type and quality. Insulation found to be improperly installed shall be removed and reinstalled properly by the contractor.

Contractor shall maintain detailed log of various insulation works and same shall be updated on daily basis. QA/QC checks of work done and materials shall be also registered in the daily logs. Owner will have the liberty to check the logs.

4.2 Inspection

Inspection of materials and / or installation by owner shall not relieve the contractor of his responsibility to ensure that finished insulation conform to specified requirements and is free from defects, contractor shall correct any defects due to poor workmanship. Contractor shall maintain test certificates and other relevant data from manufacturer.

4.3 Test for thickness

Test for thickness shall be carried out after application. Thickness at any point shall not be less than 2mm than the indicated designed thickness and excess thickness up to 115% of the designed thickness is permissible. .

4.4 Testing for bulk density

Testing of bulk density of the insulating materials shall be carried out before the application of insulation. This should be within ± 15% of the specified value. Test location shall be selected by owner and its repair shall be done by contractor.

5.0 APPLICATION

5.1 General

Insulation thickness shall be as per design calculations as specified in the drawings/ insulation schedule/ specification/isometric drawings prepared for equipments/piping.

Contractor shall submit detailed calculations and procedure for different insulation works based on relevant IS / ASTM codes.

5.2 **No. of Layers**

When insulation thickness exceeds 75 mm, the insulation shall be applied in multi-layers with all joints staggered. Each layer will be separately secured with metallic bands/wires.

No. of layers shall be as follows:

Insulation Thickness	**No. of Layers (Min.)**
Up to 75mm	1 Layer
76 to 150 mm	2 Layers
151 and above	3 Layers or more.

5.3 **GENERAL REQUIREMENTS**

5.3.1 **Surface preparation**

- Surface to be insulated shall be cleaned of all dirt. Oil loose scale etc. by wire brushing. Insulation works shall commence only after necessary clearance from QA/QC for painting works as per painting specification. All insulation shall be applied at ambient temperature and both the metal surface and insulation material shall be dry prior to application of insulation.

- The surface for cold insulation shall be then coated with a bitumen emulsion or a mastic coating.

- If the vessel is made of stainless steel, it shall be wire-brushed. with stainless steel wire brush**.**

5.3.2 **Expansion / contraction joint**

Depending on the type of insulation used the operating temperatures and nature of the material it may be necessary to provide expansion/contraction joints on vessels or pipes to prevent the insulation from rupturing/buckling when the surface expands/contracts. Joints are to be designed as per relevant IS / ASTM codes.

5.3.3 **Filling of Voids**

All voids, irregularities and joints shall be packed with loose insulation material/insulation cement trowelled smooth whichever is applicable.

6.0 **MEASUREMENT OF INSULATION WORK.**

6.1 Measurement of insulation works shall be as per IS: 14164.

7.0 **GUARANTEE**

- There shall be a surface temperature recording as mentioned in the Design Parameter to be performed with the help of Thermography Camera, post the line/ equipment is charged in operating conditions. The same shall be in LSTK's scope and LSTK shall give a detailed report of the same.

-The guarantee test shall be carried out when plant is fully operative.

-The surface temperature, reading shall be taken at six points per pipe line and at each point it shall be taken on all four sides in top, bottom, left side and right side.

-The above reading shall be taken at 2 hours intervals and shall be taken for 18 hours starting from 11 a.m. in the morning.

- Simultaneously ambient temperature shall be taken as per IS: 14164

- A graph shall be plotted between ambient and surface temperature reading

- From this graph the surface temperature against ambient temperature shall be found out

- The ambient and surface temperature shall be measured by the instrument provided by the contractor. The instrument shall be calibrated to the satisfaction of owner/consultant.

- The contractor is required to guarantee the surface temperature of 60ºC (max.) for equipments and piping in case of Hot Insulation. For cold insulation of equipments and piping, the difference between skin temperature and ambient temperature shall not exceed 2 ºC.

- Ambient temperature and surface temperature shall be measured by duly calibrated instruments provided by CONTRACTOR.

- The CONTRACTOR shall undertake immediate replacement of insulation material damaged in transit, storage or application, at no additional cost to Owner.

- LSTK shall produce required number of copies of test certificates as per relevant IS/ASTM Standard. LSTK shall certify/ensure that Test to be done are from NABL approved laboratory, approved by Owner.

- All materials are new and unused and are as per specifications called for in this standard.

- The operating thermal conductivity shall be as specified

- The workmanship shall be in accordance with good practice.

- Other terms & conditions of the guarantee clause shall be as per NIT / purchase order / Commercial documents of ITB.

ANNEXURE- 7 - 2H

PAINTING SPECIFICATION

1.0 GENERAL

1.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of mechanical equipment, structural steelwork, plate work, tankage, guards, pipe work, handrails and associated metal surfaces, which will be exposed to atmospheric for the Project**.**

1.2 Definitions

C.S	-	Carbon steel and low chrome (1-$^1/_4$ Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304,316, 321, 347,
Non-ferrous		- copper, aluminium and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DFT	-	Dry Film thickness, the thickness of the dried or curved paint or coating film.

1.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

1.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and Material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

1.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

Specification number
Colour reference number
Method of application
Batch number
Date of Manufacture
Shelf life expiry date
Manufacturer's name or recognised trade mark.

2.0 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

2.1 Indian Standards:

IS-5: 1994	Colors for ready mixed paints and enamels.
IS-2379: 1990	Color codes for identification of pipe lines.
IS-2629: 1985	Recommended practice for hot-dip galvanizing on iron and steel.
IS-2633: 1986	Methods for testing uniformity of coating of zinc-coated articles.
IS-8629: 1977	Code of practice for protection of iron and steel structures from atmospheric corrosion.
IS:110	Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers
IS:101	Methods of test for ready mixed paints & enamels.

2.2 Other Standards:

2.2.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988
(Surface preparations standards for Painting Steel Surface).
This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

2.2.1 DIN: 53151 Standards for Adhesion test.

2.3 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

a) Instructions for storage to avoid exposure as well as extremes of temperature.

b) Surface preparation prior to painting.

c) Mixing and thinning.

d) Application of paints and the recommended limit on time intervals between coats.

3.0 SURFACE PREPARATION

3.1 Metal Surface Preparation

3.1.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

3.1.2 Pre-cleaning

Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating

3.1.3 Surface Decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired.

Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces.

Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m2 of surface area to be painted.
Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm2;

Soluble iron salts, less than 7 microgram / cm2; and

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

3.1.4 Abrasive Blasting

All C.S. materials shall be abrasive blast cleaned in accordance with Codes (Ref. Clause 2.0). To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any chloride or Iron / Steel contamination).When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3^{o} C above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.

Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/Cm^2 using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

3.1.5 Alternate Methods of Surface Preparation

When open air blasting is not permitted on site, or when space limitations or surface configurations preclude blasting, the alternate cleaning methods listed below may be used with prior approval. Alternate cleaning methods shall consider the degree of surface cleanliness and roughness profile required by the specified coating system.

- Vacuum or suction head abrasive blast-cleaning,

- Wet jet abrasive blast-cleaning,
- Compressed-air wet abrasive blast cleaning,
- Pressurized liquid blast-cleaning,
- Power tool cleaning,
- Hand or power tool cleaning,

Hand and/or power tool cleaning shall only be used for spot repair where abrasive blasting is not permitted or is impractical, and on items which could be damaged by abrasive blasting. Power tool cleaning shall not be carried out with tools which polish the surface, e.g. power wire brushes.

The surfaces of equipments and prefabricated piping etc. which are received at site Primerised or with finish paints, depending upon their conditions, shall be touched up and painted at site. For these surfaces sand blasting is not envisaged and these surfaces shall be prepared using power brushes, buffing or scraping, so as to achieve a surface finish to St-3 as per SIS-05-5900 . After wash-up the area to be touched up shall be jointly marked, measured and recorded for payment purposes. The type of system & nos. of coat (primer and/or finish paint) to be applied after touch up, which shall be decided by OWNER/CONSULTANT in writing before taking up the job.

When paint is to be applied on damaged painted surfaces of equipments all loose and flaking paint work should be removed to a firm feathered edge. Rusted spots should be cleaned by one of the methods specified in the clauses 4.4.1 & 4.4.2 above. In case the previous paint work is not compatible to the specified one the entire coating must be removed.

It shall be ensured that sand blasted surface/machine cleaned surface is not contaminated with oil and grease. Water shall also not be allowed to come in contact with sand blasted surface.

4.0 APPLICATION

4.1 General

The final specification of paint systems to be used to suit the exposure conditions of equipment and steelwork, shall be as specified on the scope of work, equipment data sheets or the drawings.

All coatings shall be in accordance with Indian / International Standards, the coating manufacturer's product data sheets and application instructions and the requirements contained in this specification.

4.1.1 General Requirements for Shop Application

All work areas which facilitates shop paint application shall be surface prepared for painting and have the paint system applied before installation.
Equipments assembled at site shall only receive primer coat in the shop and finish coatings will be applied at site.
In all cases, where surfaces will be inaccessible after shop assembly, they shall be prepared and have the paint system applied before assembly is carried out. Drying times between successive coats shall be at least those recommended by the manufacturer.

All known field weld areas shall be given the specified abrasive blast surface preparation but left uncoated for a distance of 50mm from the weld line. Such areas shall be given the appropriate touch-up treatment after installation.

The manufacturer's directions for preparation and application of coatings shall be followed to ensure that the durability of the coating system is not impaired.

The Contractor shall submit the full details of the proposed surface preparation and paint systems prior to the commencement of any surface preparation.

4.1.2 General Requirements for Site Application

Paint shall be stored only in accordance with the manufacturer's instructions.

All materials used for the specific system being applied shall be products supplied by one manufacturer and details of such product shall be submitted for approval before commencement of work.

The contents of cans shall be thoroughly stirred before being poured into paint pots and shall be thinned only in the specified proportions in accordance with the manufacturer's instructions.

Finish coats may be applied by spraying except where any over spray is likely to affect finished surfaces or where spraying constitutes a health hazard to workmen in the other areas. Brush and roller application will require multiple coats to achieve the specified dry film thickness.

Brush application may be used only with the approval of the company.

Roller application shall only be used on relatively large surface areas (i.e. > 50m2) and only if spraying is not an option.

The Contractor shall complete the application of any one type of paint or each coat thereof, before beginning the next coat on that section.

In cases nominated as critical, the application of each coat shall be approved before application of the next coat can proceed, in accordance with ‘hold’ points nominated in the Inspection and Test Plans (ITPs)

All fittings within any given area are to be painted with the same system as the area unless otherwise specified.

Where 2 coat of finish paint are indicated they shall be applied in two different shades to ensure that two coat are applied.

Paint shall not be applied in rain, snow, fog or mist or when the relative humidity is such as to cause condensation on metal surface.

The CONTRACTOR must ensure the availability of a specialist from the paint manufacturer, at SITE during pendency of CONTRACT within his quoted rates to ensure the quality of painting & procedure. Addition of drying agents, pigments or other substances is not allowed unless specifically prescribed or approved by paint manufacturer's specialist.

Name plates/tags attached to the equipments/machineries shall not be painted or removed during painting job. Failing to comply with above, the CONTRACTOR may be required to replace name plates/tags at his cost.

4.1.3 Qualifications and Materials

All surface preparation, coatings application and inspection, shall be carried out by personnel experienced in that particular field. Contractors shall submit the names of subcontractors to be employed for the specific work together with the brand names of coating materials for approval prior to commencement of application.

4.1.4 Handling and Transport

All pipe work, steelwork and equipment that have been finish coated shall be handled with care to preserve the coating in the best practical condition.

Painted materials shall not be handled until the coating has completely cured and dried hard Supports in contact with coated steel during transport and storage shall be covered with a soft material to prevent damage to the coating. Appropriate materials shall be used during transportation between coated steelwork and holding down chains to prevent damage to the coating.

4.2 Application of Coatings

4.2.1 General

The application method and type of equipment to be used shall be suitable for the paint specified and the surface being painted.

Paints and thinners shall be brought to the point of usage in unopened original containers bearing the manufacturer's brand name and colour designation and ready-mixed unless otherwise specified. Two-pack systems shall be mixed at the site of application to the paint manufacturer's recommendations. The mixed amount prepared shall be no more than the amount that can be applied during the stated pot life.

Paint shall be applied so that an even film of uniform thickness, tint and consistency covers the entire surface and is free of pin holes, runs, sags or excessive brush marks. Film finish shall be equal to that of first class brushwork.
Unless it is practical to do so colour shades for primer, intermediate coat and finish coat must be different to identify each coat without any ambiguity

Paint ingredients shall be kept properly mixed during paint application.

Equipment shall be kept clean to ensure dirt, dried paint and other foreign materials are not deposited in the paint film. Any cleaning solvents left in the equipment shall be completely removed before painting.
To ensure the required film thickness is achieved on angles, welds, sharp external edges, nuts and bolts, a coat shall be applied to such items/locations immediately prior to the application of each coating to the whole area.

Care shall be taken to ensure paint application into all joints and crevices.

The contact surfaces between steelwork to be fastened by means of friction grip bolting shall be abrasive blast cleaned and prime coated only, prior to erection.

4.2.2 Atmospheric conditions

Surface preparation and coating shall not be carried out in inclement weather and shall be carried out such that the surface being coated is free of moisture, wind-borne or blast cleaning dust.

Coatings shall not be applied if:

- The relative humidity exceeds 85%.
- The ambient temperature is less than 5^0C (depending on local condition)
- The metal temperature is less than 3^0C above the dew point.
- There is likely hood of an unfavourable change in weather conditions within two hours after painting.

As a general rule, sufficient ventilation, dehumidification and heating capacity to cope with local climatic conditions must be secured before any coating – related work is started.

In any case, humidity, ambient and surface temperature conditions at the time of paint application, and curing and drying time before application of the next coat, shall be in accordance with the paint manufacturer's recommendations. These conditions shall be recorded in the Inspection Test Record (ITR) by the Contractor and be available for review.

4.2.3 Conventional or Airless Spray

Spray equipment shall be equipped with accurate pressure regulators and gauges. Spray gun nozzles and needles shall be those recommended by the paint manufacturer.

Air from the spray gun shall be clean and dry with no traces of oil or moisture.

Coatings shall be wet on contacting the painted surface. Areas of dry spray shall be removed and the correct system re-applied.

4.2.4 Brush Application

The method of "laying-off" shall be suited to the paint specified and shall ensure minimum brush marking.

4.2.5 Roller Application

A uniform method of application shall be adopted when painting large areas. The rolling direction shall minimise paint joint build up. Edges and areas subject to possible roller damage shall be brush-painted prior to rolling.

4.2.6 Thickness of Coatings

The maximum thickness DFT in any one application shall not exceed that specified in Technical specifications/ recommended by the paint manufacturer.

Wet film thickness gauges shall be used to make frequent checks on the applied wet film.
The Contractor shall maintain at the site of painting operations, a dry film thickness tester of an approved type with a valid current calibration.

Coating thickness checks in accordance with reference code shall be performed, and the Contractor shall undertake remedial action if the measured thickness is less than specified.

Build up of each material to required thickness shall be made prior to the application of the subsequent coat; final film build shall be the minimum specified.

4.2.7 Multiple Coat Applications (Except Wet-On-Wet)

Before successive paint coats are applied, intermediate coats shall be inspected for surface contamination. The presence of any grease or oil, shall be removed by a suitable solvent, and any salt and dirt adhering to the surface shall be removed by scrubbing with a solution of non-toxic detergent (except those prescribed by the manufacturer as “wet-on-wet"). Removal of contaminants shall only be performed after an intermediate coat has had sufficient time to cure.

The surface shall then be pressure hosed or dusted down by brush to disturb and remove deposits not apparent on visual inspection.

Coatings shall be applied only under the following conditions:

- The surface has been cleaned and is dry;
- The manufacturer's stated minimum time for re-coat has elapsed;
- The manufacturer's stated maximum time for re-coat has not elapsed. If the maximum time has elapsed then pre-treatment shall be in accordance with the paint manufacturer's recommendations; and

  Damaged areas in preceding coat have been made good in accordance with this Specification.

When multiple coat of finish paint are indicated, they shall be applied in different shades to ensure that multiple coats have been applied.

4.2.8 Protective Coatings for Fasteners

Black and galvanised erection bolts/nuts and galvanised holding down bolts/nuts shall be prepared and painted in accordance with Section 4.4 of this Specification.

Black high tensile bolts/nuts shall be painted after erection to the same paint system specification as the surrounding structural steel.

4.3 Hot Dip Galvanising

All galvanising shall be carried out by the hot dipping process and conform to the requirements of IS-2629:1985 and uniformity of coating shall confirm to IS 2633:1986.

All welding slag shall be removed by chipping, wire brushing, flame cleaning or abrasive blast cleaning where necessary prior to galvanising

For temporary identification, either water-soluble marking paints or detachable metal labels shall be used. For permanent identification, figures/labels shall be heavily punched or embossed by the fabricator.

For galvanised items after pickling, the work shall be inspected and any defects that render the work unsuitable for galvanising shall be repaired. After such repairs, the work shall again be cleaned by pickling.

The coating mass of zinc shall be as specified on equipment data sheets and the Drawings. Galvanised coatings shall be tested by the methods described in referred code.

After galvanising all material shall be cooled to air temperature in such a manner that no embrittlement occurs.

Galvanised coatings shall be smooth, uniform, adherent and free from stains, surface imperfections and inclusions.

All gratings and fixtures including nuts, bolts and washers that are required to be galvanised, shall be hot dipped galvanised and all nut threads shall be re-tapped after galvanising and a lubricant applied on Cold working of galvanised steelwork shall be avoided.

4.4 Damaged or Inaccessible Surfaces

4.4.1 Damaged Paint Surface

Repair of damaged painted surfaces, as well as painting of galvanised and black bolts, and galvanised holding down bolts after erection shall comply with this Clause. The treatment shall be:

- Pre-clean the damaged or unpainted areas in accordance with Section 4.2.1 of this Specification;
  - Disc or hand sand to clean bright metal;
- Inorganic zinc primers subject to mechanical damage or weld etc shall be power tool cleaned
- Feather backs by sandpapering or whip blasting the original coatings surrounding the damaged area over a 50mm distance. A rough surface shall be obtained on epoxy coatings;
  - Clean surface to remove all dust;
- Conduct surface contaminant test in accordance with Section 4.2.2 of this document; and

  Build up a new paint system over the affected area with paints equal to those originally used and having the same dry film thickness for each coat. As an exception, damaged inorganic zinc primers shall be repaired with epoxy organic zinc rich paint and shall be applied within four hours of blast cleaning.

The new coatings shall overlap the original coating over the 50mm prepared distance and shall be colour matched to the specified colour of the original coating.

4.4.2 Damaged Galvanised Surfaces

Damaged areas caused by oxy-cutting, welding or physical impact shall be treated as follows:

- Prepare the surface by removing any weld slag followed by vigorous power wire brushing of the coating surrounding the damaged area over a 50mm distance;
  - Clean surface to remove all dust; and
- Apply two coats of organic zinc-rich primer to a minimum DFT of 100 microns.

The area to be reinstated shall be colour matched to the surrounding finish colour with 40 microns of aluminium paint to the manufacturer's **written instructions.**

4.4.3 Inaccessible Surfaces

Surfaces that will be inaccessible after erection of other elements of the structure, shall be fully painted prior to the installation of the obstructing item.

4.5 Surfaces Not To Be Coated

The following surfaces shall not be blasted or coated unless specifically directed:

Machined surfaces, bearings, seals, grease fittings, adjusting screws and name plates, and identification tags.

- Valve stems;
- Raised faces on pipe and equipment flanges;
- Electrical cabling;
- Instrumentation, gauges and sight glasses;
- Titanium, stainless steel and non-metallic surfaces; and

  Field weld margins, 50mm either side of weld, on tankage and piping, prior welding.

The rear face of piping flanges shall be shop prime coated only. Flange holes for fasteners shall be fully coated.

4.6 Wash-Up

All surface of equipments/prefabricated piping etc. Primerised / painted at Vendor shop and received at site if required shall be washed up as follow:

a) Washing with clean water (Pressure 7 Kg/cm2) using suitable nozzles. During washing, broomcorn brushes shall be used to remove foreign matter.

b) Solvent washing, if required , to remove traces of wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates of oil, grease etc. Wash up as per above procedure of all surfaces of equipment, piping, structure etc. completely painted at contractor's shop shall be included in the quoted rates.

4.7 Touch-Up Painting

Prior to the application of any coat, all damage to the previous coat(s) shall be touched-up. Damage to finished work shall be thoroughly cleaned and re-coated.

Surface preparation shall be done as per clause no. 3.0.....

Items supplied with the manufacturer's standard coating system shall be touched-up with the same generic coating system or recoated.

4.8 Paint Storage

The following must be ensured:

a) All paints and painting material shall be stored only in such rooms assigned for the purpose. All necessary precaution shall be taken to prevent fire. The Storage building shall preferably be separate from adjacent buildings. A sign-board bearing the Words "PAINT STORAGE- NO NAKED LIGHT" shall be clearly displayed outside. The building shall be properly ventilated and shall be adequately protected with fire fighting equipment.

b) Storage shall be far away from heated surface open flames, sparks & well protected from sun rays.

c) Ambient temperature at which paints are stored shall be intimated to paint manufacturer & their advice sought regarding precautions to be taken if any, regarding flammability, explosiveness & toxicity.

d) Maximum allowed storage time for various paint materials shall be clearly indicated on individual containers. Materials which have passed expiry date shall not be used.

e) Paints in non-original containers and/or in containers without seals, shall not be used.

5.0 COATING SYSTEM SELECTION

Coating Systems for Structures Piping and Equipment

The following Table 1 shall be used as a general guide for the selection of a paint system suitable for a particular plant area application. Paint systems specified on equipment data sheets and the Drawings shall take precedence over the general paint system area applications listed in Table 1.

TABLE - 1

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
01	Structural Steel work with operating temp. Up to 90^{O} C (Steel structures, Piping support, uninsulated CS piping, flanges, valves, stairways, walkways etc. except grating).	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High durability	Total dry film thickness of paint system: 320 microns as per C5 – High durability
02	Uninsulated CS piping, flanges, valves with operating temp. From Above 90^{O}	Blast cleaning to near white metal grade Sa-2½, of Swedish	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1	P1 : 75 microns F3 : 2 x 25 microns	Total dry film thickness of paint system: 125 microns.	

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	C to 200^{O} C.	Standards SIS-05-5900 (Latest)	F3 : Two coats of single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.	for each coat Total - 125 microns.		
03	Uninsulated CS piping, flanges, valves with operating temp. Over 200^{O} C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
04	Insulated CS piping flanges, valves with operating temp up to 90^{O} C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : One coat of high temperature epoxy phenolic	F8 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	
05	Insulated CS piping, flanges, valves with operating temp. From 90^{O} C to 200^{O} C.	Blast cleaning to near white metal grade Sa-2½, of Swedish Standards SIS-05-5900	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system:250 microns	
06	Insulated CS piping, flanges, valves with operating temp. Over 200^{O} C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.	F9 : 2 x 150 microns	Total dry film thickness of paint system: 300 microns.	
07	Uninsulated CS equipment with operating temp. Up to 90^{O} C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
			pack aliphatic acrylic polyurethane		
08	Uninsulated CS equipment with operating temp. From 91^{O} C to 200^{o}C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.
09	Uninsulated CS equipment with operating temp. Over 200^{o}C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
10	Insulated CS equipment with operating temp. Up to 90^{O} C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system:250 microns
11	Insulated CS equipment with operating temp. From 91^{O} C to 200^{o}C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system:250 microns
12	Insulated CS equipment with operating temp. Over 200^{o}C, to be treated at Manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F9 : Two coats of Inorganic Co-polymer based coating With an Inert Multipolymer Matrix.	F9 : 2 x 150 microns	Total dry film thickness of paint system: 300 microns.

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
13	Surface of structural steel for furnaces, external surface of furnaces, external surface of flue duct, metal stacks and similar with operating temp. Up to 200°C. (With exclusion of stair ways, walk ways etc.).	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleo resinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	
14	For external surfaces of flue ducts, metal stacks, and similar with operating temp. Above 200°C.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
15	For surfaces of air cooler heads not galvanized with operating temperature up to 90^0 C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
		NOTE: All surfaces shall be galvanized at manufacturer's shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
16	For surfaces of air cooler heads not galvanized	Blast cleaning to near white metal grade 2	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer	P1 : 75 microns	Total dry film thickness of paint system: 125 microns.	

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	with operating temperature up to 91^0 C TO 200^OC, treated at manufacturer's shop.	½, of Swedish Standards SIS-05-5900 (Latest).	meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	F3 : 2 x 25 microns for each coat		
		NOTE: All surfaces shall be galvanized at manufacturer's shop with exception of the end header of air cooled heat exchangers that shall be treated as described above at Manufacturer's shop. In case the same surfaces shall not be treated at shop, they shall be treated at site according to environmental and operating conditions.				
18	STORAGE TANKS					
a)	Acid / Alkali CS Storage Tank (External Surface including all stair ways)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
b)	CS Storage Tanks, Excluding indicated in Sl. No. (a)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F1 : One coat of two pack Polyamide Cured Epoxy. F5 : Two-pack aliphatic Isocyanate cured acrylic finish paint	P1 : 60 microns F1 : 120 - 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
19	Cold Insulated Carbon Steel and low alloy Steel (1-$^1/_4$ Cr through 9 Cr) Piping and	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900	F7 : Two coats of Tar Free Epoxy paint suitably pigmented	F7 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.	

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks	
	Equipment. (Upto 60 Deg. C)	(Latest).				
20	Cold Insulated high alloy Steel piping and Equipment (Upto 200 Deg. C)	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system:250 microns	
21	DELETED					
22	Surface (CS) with Equipment with temp. Indicating paint from 220°C to 240°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F6 : Temperature indicating paint	P1 : 75 microns F6 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.	
23	PACKAGE:					
a)	Surface(CS) with operating temperature upto 90°C treated at Manufacturer's shop	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P2 : ONE coat of two pack zinc rich epoxy Primer meeting SSPC Paint 20 level 1 F1 : One coat of two packs. Polyamide Cured Epoxy. F5 : One coat of two pack aliphatic acrylic polyurethane	P2 : 60 microns F1 : 120 – 200 microns F5 : 60 microns	Total dry film thickness of paint system: 240 microns as per C4 – High Durability	Total dry film thickness of paint system: 320 microns as per C5 – High Durability
b)	Surfaces (CS) with operating temperature upto 91^0 C TO 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F3 : Two coats of single pack special Oleouresinous based heat resistant ready mixed Aluminium Paint.	P1 : 75 microns F3 : 2 x 25 microns for each coat	Total dry film thickness of paint system: 125 microns.	

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
c)	Surface (CS) with operating temp. Over 200°C, treated at manufacturer's shop.	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	P1 : One coat of Ethyl Silicate zinc rich with solvent Primer meeting SSPC Paint 20 level 1 F4 : Two coats of Heat Resisting Silicon Aluminium Paint.	P1 : 75 microns F4 : 2 x 25 microns for each coat Total - 50 microns.	Total dry film thickness of paint system: 125 microns.
d)	Package in Carbon Steel and low Alloy Steel (1-1/4 Cr through 9 Cr) with cold insulated surface treated at manufacturer's shop (Upto 60 Deg. C)	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented	F7 : 2 x 125 microns	Total dry film thickness of paint system: 250 microns.
e)	Package in Cold Insulated high alloy Steel. (Upto 200 Deg. C)	Lightly Blast cleaned as per Sa 1.0 Swedish Standards SIS-05-5900 (Latest).	F8 : Two coats of high temperature epoxy phenolic (novolac)	F8 : 2 x 125 microns	Total dry film thickness of paint system:250 microns
f)	DELETED				
24	For internal surface of shell, roof of CS tanks, with operating temp. Upto 110°C	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F2 : Two coats of two pack amine adduct cured Phenolic (Novolac) epoxy (immersion grade)	F2 : 2 x 150 microns for each coat	Total dry film thickness of paint system: 300 microns.
25	For underside (soil side) of the tank bottom (CS) below only of the fixed tanks, bottom & shell shall be treated as follows:	Blast cleaning to near white metal grade 2 ½, of Swedish Standards SIS-05-5900 (Latest).	F7 : Two coats of Tar Free Epoxy paint suitably pigmented OR F8 : Two coats of high temperature epoxy phenolic (novolac)	F7 : 2 x 200 microns OR F8 : 2 x 150 microns	Total dry film thickness of paint system: 400 microns. OR Total dry film thickness of paint system: 300 microns.

Ref No.	Application	Surface Preparation	Generic Coating System	Minimum DFT	Remarks
26	CS Equipment and associated piping subject to cyclic, intermittent or regeneration operating condition (e.g. Molecular Sieve Driers) subjected to very severe corrosion with wide operating temperature range.	Blast cleaning to near white metal grade 3, of Swedish Standards SIS-05-5900 (Latest).	Primer: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal Finish Coat: One coat of Thermal spray Aluminium paint and sealed with a Silicon Aluminium seal.	Primer: 125 microns Finish: 125 microns	Total dry film thickness of paint system 250 microns.

NOTES:

Primers

ZINC ETHYL SILICATE PRIMER – P1

The zinc ethyl silicate consists of two packs. One pack contains the ethyl silicate binder with suitable solvents. The other pack contains zinc dust (NOT Paste). Zinc dust shall be ASTM D 520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

Volume solids	**:**	Min.64% ±2
DFT Range	**:**	50 – 75 microns
Theoretical Spreading Rate	**:**	12.8 – 8.53 sqm/litre
Colour	:	Grey
Application	:	Spray (airless/air)
Drying time (dry to handle)	:	< 45 mins. @ 30 Deg. C and 65% RH
Curing	:	<16 hrs @ 30 Deg. C and 65% RH
% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)	:	**(SSPC SP 20 Level 1) >85% by wt.**
Specific Gravity	:	**2.5 Kg/Litre min.**
Storage life	:	6 months under sealed conditions

Zinc silicate Material curing shall be checked using ASTM D 4752, minimum Acceptable value is 4.

ZINC RICH EPOXY PRIMER – P2

The zinc rich epoxy consists of two packs. One pack contains the epoxy binder with suitable solvents. The other pack contains zinc dust as per ASTM D520 Type II. They have to be mixed in suitable proportions before application as recommended by manufacturer.

Volume solids	**:**	65% min. ±2
DFT	**:**	50 – 100 microns
Theoretical Spreading Rate	**:**	13 – 6.5 sqm/litre
Colour	:	Grey
Application	:	Airless spray/air spray/brush
Drying time (dry to handle)	:	<10 min. @ 30 Deg C
Hared Dry	:	< 1.5 hrs @ 30 Deg C
% of total metallic zinc in dry film (As per the ASTM D520 – Spherical size)	:	**(SSPC SP 20 Level 2) 81% by wt. min.**
Specific Gravity	:	**2.3 Kg/Litre min.**
Storage life	:	12 months under sealed conditions

Finish Paints

HIGH BUILD EPOXY FINISH – F1

This finish paint is fast drying, high build, Two-pack polyamide cured epoxy resin

Volume solids	**:**	85% min. ±2
DFT Range	**:**	100 – 200 microns
Theoretical Spreading Rate	**:**	7.6 – 3.8 sqm/litre
Colour	**:**	As per Manufacturer List
Binder	**:**	Polyamide cured epoxy resin, Lead & Chrome Free
Application	**:**	Brush or spray
Drying time	**:**	< 2 hrs @ 30 Deg C
Over coating time	**:**	< 2 hrs @ 30 Deg C
Storage life	**:**	24 months under sealed conditions

HIGH BUILD EPOXY FINISH (Immersion Grade) – F2

This finish paint is high build, Two-pack phenolic (novolac) epoxy

Volume solids	**:**	68% min. ±2
DFT Range	**:**	100 – 150 microns
Theoretical Spreading Rate	**:**	6.8 – 4.5 sqm/litre
Colour	**:**	As per Manufacturer List
Binder	**:**	Amine adduct cured epoxy resin
Application	**:**	Brush or spray
Drying time	**:**	< 1.5 hrs @ 30 Deg C
Over coating time	**:**	< 6.5 hrs @ 30 Deg C
Storage life	**:**	24 months under sealed conditions

HEAT RESISTANT ALUMINIUM FINISH PAINT : F3

It is a single pack system based on oleo resinous general purpose aluminium paint with good heat resistance upto 250 Deg. C. and light reflection.

Volume solids	:	25% min. ±2
DFT Range	:	25 microns
Theoretical Spreading Rate	:	10 sqm/litre
Main pigment	:	Aluminium (ASTM 962), Lead & Chrome Free
Colour	:	Metallic Aluminium
Pigment Volume Concentration	:	15 – 20%
Application	:	Brush or spray
Drying time	:	Surface dry <1hr. @ 30 Deg. C
		Hard dry < 3 hrs. @ 30 Deg. C
Storage life	:	24 months under sealed conditions

HEAT RESISTANT SILICON ALUMINIUM FINISH PAINT : F4

It is a single pack system based on ambient curing silicone aluminium pigmented polysiloxane paint with maximum heat resistance of upto 600 Deg. C.

Volume solids	:	25% min. ±2
DFT Range	:	25 microns
Theoretical Spreading Rate	:	10 sqm/litre
Main pigment	:	Aluminium (ASTM 962), Lead & Chrome Free
Colour	:	Metallic Aluminium
Pigment Volume Concentration	:	15 – 20%
Application	:	Brush or spray
Drying time	:	Surface dry < 1hr. at 30 Deg. C
		Hard dry < 3 hrs. at 30 Deg. C
Storage life	:	12 months under sealed conditions

TWO PACK ALIPHATIC ACRYLIC POLYURETHANE FINISH PAINT – F5

It Consists of Acrylic Resin in Part A. Part B consists of an aliphatic poly-isocyanate with appropriate solvents and additives.

Volume solids	:	51% min. ±2
DFT range	:	50 – 100 microns
Theoretical Spreading Rate	:	10.2 – 5.1 sqm/litre
Main pigment	:	Suitable pigments to get the desired colour, **Lead & Chrome Free**
Colour	:	Metallic Aluminium
Binder	:	Shall not contain any binder other than acrylic resin; should not contain any **alkyd / acrylate alkyds / esters.**
Application	:	Brush or spray
Drying time	:	Surface dry < 1hr. @ 30 Deg. C
		Hard dry < 8 hrs. @ 30 Deg. C
ISO 11507/ASTM G 154, QUV A - Accelerated weathering	:	**Gloss retention: approx. 80 % and colour change approx. DE 1.2 after 3000 hours exposure**
Storage life	:	24 months under sealed conditions

TEMPERATURE INDICATING PAINT : F6

It is a single pack temperature indicating system based on silicone binder. Pigments change colour by heating. The colour change of the coating is permanent. At approximately 200°C, the colour changes from green to blue, above 310°C, the colour changes from blue to greyish white. Maximum service temperature is 400°C.

Volume solids	:	40% min.
DFT	:	25 microns
Theoretical Spreading Rate	:	16 sqm/litre
Main pigment	:	As per shade requirement, Lead & Chrome free
Colour	:	As per manufacturer

Binder	:	Based in silicone Resins
Application	:	Brush or spray
Drying time	:	Surface dry < 1hr. @ 30 Deg. C
		Hard dry < 4 hrs. @ 30 Deg. C
Storage life	:	12 months under sealed conditions

TAR FREE EPOXY – F7 (Coal Tar is Banned Globally being Carcenogic)

A high build two component abrasion resistant, pure epoxy with anti-corrosive properties meant for excellent performance.

Volume solids	:	Minimum 72%
DFT Range	:	150 – 200
Theoretical Spreading Rate	:	4.8 – 3.6 sqm/litre
Application	:	By brush or airless spray
Drying time	:	Touch Dry within 4 hrs. @ 30 Deg C
		Hard dry < 9 hours @ 30 Deg. C
Storage life	:	12 months under sealed conditions

EPOXY PHENOLIC (NOVOLAC) – F8

Two Pack epoxy-phenolic (novolac) cured with amine adduct used as an External coating for the protection of insulated (CUI) equipment.

Volume solids	:	68% min.
DFT Range	:	100 – 150 microns
Theoretical Spreading Rate	:	6.8 – 4.5 sqm/litre
Binder	:	Epoxy phenolic (novolac)
Dry Temp. Service	:	Min. -196 to max. 205 Deg. C.
Application	:	Airless Spray / Brush Touch up
Drying Time	:	Surface dry < 1.5hr. @ 30 Deg. C
		Hard dry < 6 hours @ 30 Deg. C
Storage life	:	12 months under sealed conditions

INORGANIC CO-POLYMER COATING – F9

MIO pigmented single component inorganic copolymer coating which cures to form an in polymer matrix able to resist temperatures up to 650°C/1202°F and thermal shock/cycling dry or dry/wet service.

Volume solids	:	74% min.
DFT Range	:	150 microns
Theoretical Spreading Rate	:	5 sqm/litre
Binder	:	Inorganic copolymer coating
Dry Temp. Service	:	Min. -196 to max. 650 Deg. C.
Application	:	Airless Spray / Brush Touch up
Drying Time	:	Surface dry < 0.5hr. @ 30 Deg. C

		Hard dry < 1.5 hours @ 30 Deg. C
Storage life	:	12 months under sealed conditions

6.0 MACHINERY, ELECTRICAL AND INSTRUMENT EQUIPMENT:

6.1 Machinery

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std. However, suitable for operating condition and the environmental condition where the machinery will operate. Where necessary machinery shall be restored at site by Contractor with suitable finish.

6.2 Electrical and Instrument Equipment

Steel surfaces shall be treated with complete paint system at Manufacturer's shop. The paint system shall be according to Manufacturer's Std., however suitable for operating condition and the environmental condition where the electrical and instrument equipment will operate. Where necessary Electrical and Instrument Equipment shall be restored at site by Contractor with suitable finish.

7.0 COLOURS:

These shall be as required by specification and in particular for:

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Piping with temperature less than 90°C	GREY	7035	
- Piping, hot surface, flue gas ducts and stacks with temperature above 90°C	SMOOTH	ALUMINIUM	"
- Cooling Water Piping	SEA GREEN		"
- Fire fighting Piping	Red	3002	"
- Structures upto 2 MT	BLACK	9005	"
- Structures above 2 MT	GREY	7010	"
- Stair cases – ladders	BLACK	9005	"
- Walkwais	GREY	7010	"
- Handrails assemblies	YELLOW	1004	"
- Equipment	GREY	7035	"
- Hot equipment	SMOOTH	ALUMINIUM	"
- Fire fighting equipment	RED	3002	"
- Valves in general	GREY	7035	"
- Hot valves	SMOOTH	ALUMINIUM	"

Description	Colour	Ra1	Correspond. Asian Paint colors to be defined – See Note-2
- Safety and Fire fighting valves	RED	3002	"
- Valves handwheels	BLACK	9005	
- Electric Rotary Machines	SKY BLUE	5012	
- Electric Static Machines	GREY	7035	
- Machinery (compressors & pumps) with operating temperature less than 90°C	GREY	7035	"
- Machinery (compressors & pumps) with operating temperature above 90°C	SMOOTH	ALUMINIUM	"
FURNACES			
- Cassing and connected steel works	SMOOTH	ALUMINIUM	"
- Steel work not connected to casing	SMOOTH	ALUMINIUM	"
AIR COOLER			
- High Temperature Surfaces (Temp. > 90°C)	SMOOTH	ALUMINIUM	
- Low Temperature surface (Temp. ≤ 90°C)	GREY	7035	"
- Flare ≤ 90°C	GREY	7035	"
- Flare ≥ 90°C)	SMOOTH	ALUMINIUM	"
TANKS			
- Shell of fixed roof	WHITE	9010	"
- Roof of fixed roof tank	WHITE	9010	

NOTE-1: The colours shall be according to IS2379:1990/International STD. RAL or BS, proposed by Contractor or Manufacturer

8.0 PARTICULAR DESCRIPTION

The abrasive Grit Blasting shall be used for surface preparation. **Sand blasting is prohibited due to environmental regulations.**

Primerized surface shall be faultless and shall not have mud-cracking, dripping over thickness and dry sprays.

Blast cleaning and painting shall not be carried out on wet surfaces.
Blast cleaning shall not be done when surfaces temperatures are less than 3°C above dew point, or temperature is below 5°C.

No acid washes or other cleaning solutions or solvents shall be used on metal surfaces after they have been blasted.

The surface preparation of all steel surfaces to be coated shall be free of all mill scale, rust corrosion product, oxides, paint, oil or other foreign matter

Only dry abrasive blasting procedures will be allowed. The compressed air supply used for blasting shall be free of detrimental amounts of water and oil. Adequate separator and traps shall be provided and these shall be kept emptied of water and oil. Any blast cleaning set up without functioning moisture separators shall be removed from blast cleaning areas.
All welded areas and appurtenances shall be given special attention for removal of welding flux in crevices. Welding splatter, slivers, laminations and underlying mill scale exposed during sand blasting shall be removed or repaired.

The blast-cleaned or power brushing surfaces shall be coated with primer within four hours of surface preparation.

No primer or intermediate or finishing coating shall be applied without prior notification to the Company.

The application of the products shall be carried out in strict compliance with the paint manufacturer's recommendation.

The Contractor shall provide suitable protection for all adjacent plants or equipment from airbone during spraying and sand blasting.

9.0 INSPECTION AND TESTING

The inspection and testing requirements outlined in this section shall be performed for shop and site applied coating systems.

Preference shall be given to manufacturers and applicators that are quality certified to ISO 9001: 2000.

Documentation of coating material manufacturers and applicators shall include daily inspection reports, equipment reports, and shall clearly identify and trace materials supply and testing performed on coated items and areas.

Inspection and Test Plans (ITPs), and quality control procedures used for application of coating systems shall form part of the Method Statement and shall be submitted for approval by the Principal prior to commencement of work.

The applicator shall appoint a certified inspector of coatings for inspection and testing of coating systems.

Tests of coated areas and items shall form part of the ITPs.

- Surface Preparation in accordance to Swedish Standard SIS-05-5900 (Latest).
- Blast cleaning profile shall be checked using a suitable profile meter – Acceptable profile shall be 40 - 60 microns.
- Check of time of top coating and drying in accordance with the direction of the paint manufacturer.
- Check of dry film thickness by suitable non-destructive Instrument such as "MIKROTEST", "DIAMETER" or equivalent.

- Before any coating work is preformed on the site, the contractor shall ensure that any works applied by others is acceptable.

  Any defect that are discovered, are to be notified in writing to the owner before proceeding with the contract work. To ensure the good execution of painting work following test shall be performed:

  - Surface Preparation
  - Surface contaminant tests
  - Surface profile tests
  - Coating thickness tests
  - Tests for cure of coatings
  - Adhesion tests
  - Continuity testing
  - Iron contamination
  - Chloride contamination
  - Dust Contamination

  All Inspection and Test Records (ITRs) shall be submitted with the Manufacturer's Data Report (MDR) at the conclusion of the job.

  Defective coated areas shall be suitably marked for rectification work to be performed in compliance with this specification.

  Access shall be granted for inspection of all paint work, and witnessing of test work. This shall not however relieve the Contractor of their own QA/QC responsibilities.

10.0 ADHESION TEST RESULTS

For all type of primer the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D3359. The acceptable Rate Adhesion Test Results shall be for sandblasted and primerized surfaces shall be minimum 3A (or Higher)

For primer plus finishing coat(s) the Contractor shall guarantee the Classification of Adhesion Test Results as per ASTM D 3359. The acceptable Rate Adhesion Test Results shall be for blast cleaned and painted surfaces shall be minimum 3A (or higher).

After test, the surface must be repaired according to the system applied.

11.0 SUBMISSION OF DATA

Contractor shall submit in phase of bid the original technical data sheet and system for all material supplied by him to apply for the permanent works and test report for the paint in compliance to IS101.This material shall be subject to Owner's approval.
The test certificates of zinc silicate shall provide the specific gravity of mixed paint.

12.0 LETTER AND NUMBER INSCRIPTION

Inscriptions letters, as herebelow indicated, shall be made on equipments, piping, storage tanks, machinery etc.

12.1 Geometric forms and dimensions

Letters and numbers dimensions shall be orientatively fixed according to following:

(A – Dimension of side of unitary elements of grid)

a) Storage Tanks A – 60 mm
b) Equipments and piping with O.D. above 600 mm A– 40 mm and
c) Equipments and pipings with O.D. from 300 to 600 mm and for machinery of great dimensions A – 20 mm
d) Equipments and pipings with O.D. less than 300 mm and for machinery with small dimensions A – 10 mm

12.2 Inscription's Colours

Inscriptions shall be Black ENI 901 (RAL 9005) on light base

Inscriptions shall be White ENI 101 (RAL 9010) on dark base

12.3 Spaces and Interspaces

Spaces between words and assemblage of numbers shall have dimensions equal to 2A

Interspaces between letters or numbers shall have dimensions equal to A.

13.0 Colour Band for piping ;-

As a rule minimum width of colour band shall confirm to the following Table:-

Nominal pipe Size	Width L (mm)
3" & below	25
4" NB-6" NB	50
8" NB-12"NB	75
14" OD & above	100

14.0 LIST OF MANUFACTURERS :

1. M/s Berger Paints
2. M/s Jensons & Nickolson
3. M/s Jotun Paints
4. M/s Asian Paints
5. M/s Grauer & Weil (India) Limited
6. M/s Shalimar paints
7. M/s Garware Paints
8. M/s Goodlass Nerolac Paints Ltd
9. M/s.HEMPEL Paints
10. M/s International Paints (Akzo Nobel Brand)
11. M/s Carboline (India) Pvt. Ltd.
12. M/s Mohan Paints

15.0 The contractor shall obtain prior approval from Engineer-In-Charge for the brands of paint material proposed to be used. The contractor shall submit the following details of paint material either at the time of bidding or soon after award of work for approval of paints.

a. Technical data sheet
b. Material safety data sheet
c. Finger printing of paint products as per ISO 20340

16.0 Owner reserves the right to take random samples and get it tested through reputed labs. In case the supplied paint material do not meet the specified performance requirements then suitable action shall be taken against the paint supplier. The decision of Engineer-In Charge shall be final and binding on the Contractor in such cases

17.0 WARRANTY:

Contractor along with Paint Manufacturer jointly shall develop the paint schemes following the system specification.

They shall jointly provide a performance guarantee for a period 5 years as stipulated below,

After 1 years – Corrosion in 3% of total painted area accepted

After 2 years – Corrosion in 6% of total painted area accepted

After 3 years – Corrosion in 9% of total painted area accepted

After 4 years – Corrosion in 12% of total painted area accepted

After 5 years – Corrosion in 15% of total painted area accepted

where spontaneous visible corrosion has broken down the paint film to a degree exceeding “Ri 3” (as defined in ISO 4628/3-2003).

ANNEXURE- 7 - 3

QUALITY CONTROL PROCEDURE AND INSPECTION REQUIREMENTS

1.0 LSTK CONTRACTOR'S QUALITY CONTROL

1.1 LSTK CONTRACTOR shall provide a quality control program manual include specific WORK methods and inspections, which assure quality.

This quality control program manual must be submitted to OWNER for Approval before starting the construction activities.

All installation WORK must be in strict accordance with this approved manual.

1.2 The quality control program shall include as a minimum the following:

- Methods use to control drawings; specifications and CONTRACT correspondence to assure that only the latest revisions are being used in the field.
- Inspection personal name, organization.
- Inspection methods and documentation of inspection (or tests) for shop fabrication, if required, and installation.
- Material control procedures from SITE receiving point, through "over, short and damage inspection" through storage and through installation.
- Positive material identification Procedures for:
- Electrical cable pulling and testing.
- Asphalt placement inspection.
- Handling and storage methods to prevent damage.
- Inspection and testing procedures and reports for civil, structural, piping, electrical, instrument, equipment and all installation WORK.
- Repair.
- Scrap and reject.
- Grouting.
- Welding.
- Welder qualification.
- Receiving all permanent plant material & equipment.
- Rigging.
- Welder's tests.
- Nondestructive examinations to be used.
- Positive material identification. etc.
- Identification of LSTK CONTRACTORS and ensuring their compliance with the manual and WORK required.
- Material certification verification methods.
- Calibration procedures for measurements and test equipment.
- Marking and identification of components in process and complete assemblies.

2.0 Shop fabrication and field installation inspection OWNER'S REPRESENTATIVE to ensure specifications. in the following areas will be performed by full adherence to Receiving and inspection.

- Calibration of test inspection equipment.
- Preventive maintenance and storage protection.
- Internal cleanliness.
- Proper material use and control.
- Nondestructive testing and its results.
- Workmanship.

3.0 OWNER'S REPRESENTATIVE or others as authorized by OWNER are to be permitted access to LSTK CONTRACTOR'S work areas for the purpose of inspection of material, equipment, documentation and other areas as required in LSTK CONTRACTOR'S quality assurance *I* quality control program.

4.0 No concrete will be placed by LSTK CONTRACTOR without an OWNER "Pour Release Form'.

5.0 OWNER'S construction inspections will not relieve. LSTK CONTRACTOR of inspection or other responsibilities.

6.0 For piping all welders test pieces shall be supplied by LSTK CONTRACTOR and fully prepared for welding by LSTK CONTRACTOR.

7.0 LSTK CONTRACTOR shall evidence its familiarity and experience with the execution of the installation of WORK to the requirements of the applicable codes and shall perform its WORK in accordance to these requirements and to instructions issued by OWNER'S REPRESENTATIVE in this regard.

8.0 **CHECK ON QUALITY OF WORK**

8.1 OWNER'S REPRESENTATIVE'S inspector shall have free access to the place where the WORK is performed at all times, in order to check the quality of WORK

8.2 If during inspection *I* check reveals unsatisfactory WORK, LSTK CONTRACTOR shall immediately at LSTK CONTRACTOR'S expense. take such corrective measures as deemed required.

9.0 **CONTROL SYSTEMS**

LSTK CONTRACTOR shall initiate and maintain the following control systems

9.1 **Backfilling**

- Compaction tests.

9.2 **Concrete**

- Design mix and approval record(s).
- Batch plant inspection record.
- Slump test record.
- Compressive test record.
- Pour release record.
- Grouting release record.
- Placement inspection records.
- Concrete curing records.

9.3 **Asphalt**

- Design mix and approval records.
- Batch plan inspection records. Placement inspection records.

9.4 **Piping**
- Weld x-ray file.
- Pipe and fitting certificate file.
- Isometric weld control sheet. Hydrostatic test records.

9.5 **Grounding**

Earth resistance test records.

9.6 **Electrical Cable and Instrument cable**
- Insulation resistance test records.
- Continuity test records.

9.7 **Material certification files**

9.8 **Equipment**
- Weld x-ray file.
- Material certificate files.
- Equipment installation records.
- Equipment maintenance record.
- Hydrostatic test records.
- Grouting release records.
- Alignment records.
- Vibration records.

10. **Requirements for Certification of Materials**

10.1 Mill certification of materials will be required based on the material type, the use and the codes and requirements.

10.2 LSTK CONTRACTOR shall provide:

Type A certification of compliance, for all but not limited to the following materials which LSTK CONTRACTOR is responsible to supply:
- Imported backfill materials.
- Ready mix concrete.
- Asphalt paving materials
- Prefab concrete items, including pre-cast manholes, catch basins, pits, sumps and sleepers.
- Paving stones and tiles.
- Inserted and embedded items, other than rebar, wire mesh and anchor bolts.
- Masonry blocks.
- Steel sliding plates.
- Special grouting materials, i.e. non-shrink type.
- Grouting materials, including grounding loop and branch wire which they are LSTK CONTRACTOR'S supply.

Type "B “certificate, for all but not limited to the following materials, which LSTK CONTRACTOR is responsible to supply:

- Materials to be considered structural or structural grade.
- Reinforcing grade.
- Wires mesh reinforcement fabric.
- Anchor bolts.

10.3 **Definition of Type of Certificates**

Type A (certificate of Compliance):

This is a certificate of compliance, issued by the manufacturing or processing works and signed by the quality department or persons to carry the responsibility for quality and conformity, stating that the materials) supplied correspond (5) with what was agreed in the purchase order.

Type B (mill Certificate) :
This is a certificate on which the manufacturer's head of quality department confirms that the product supplied corresponds with what has been agreed in the purchase order. Certification shall be on the basis of tests carried out on the material of the product itself, as per purchase order specification. The testing and certification are to be carried out by a testing center which is independent of the production section of the manufacturing works and which has the code-approved facilities.
Independence of such testing center should be warranted by LSTK CONTRACTOR.

10.4 LSTK CONTRACTOR will maintain a systematic filing system of all certificates and reports for all tests and inspections carried out by it under the applicable specifications, standards and codes of practice quoted therein.

LSTK CONTRACTOR may use its own format for records but this must be submitted to OWNER'S REPRESENTATIVE for his approval prior to use.

LSTK CONTRACTOR can expect to be audited on a continuous basis. Originals of all documents to be sent to OWNER'S REPRESENTATIVE.

ANNEXURE- 7 – 4

SCHEDULE, PROGRESS EVALUATION AND PROGRESS REPORTING

1.0 **GENERAL**

1.1 WORK shall start and be completed in the field as indicated on the approved project construction schedule.

LSTK CONTRACTOR shall follow the sequence of construction in executing the WORK as shown in the schedule or as modified by OWNER.

The detailed scheduling of WORK will be supplied by the LSTK CONTRACTOR. WORK shall be conducted in such a manner that other construction activities are not affected.

Once detailed schedule, established and approved by OWNER, LSTK CONTRACTOR commits itself to follow the schedule in detail.

2.0 **DETAILED & SCHEDULE**

2.1 Detailed construction schedule must cover all construction work, from lowest level up to highest level.

2.2 Activities shown by means of a bar chart must include as a minimum the activities listed in 4.

3.0 **PROGRESS REPORTING**

LSTK CONTRACTOR shall issue a reporting procedure and a representative sample of all progress reports.

Following schedules and reports must be issued by LSTK CONTRACTOR to OWNER:

Construction schedule. (preliminary and detailed)
Monthly status report.
Weekly progress report.
Monthly construction guide schedule.
Daily manpower reports.

All except detailed construction schedule based on approved project construction schedule.

4.0 **CONSTRUCTION SCHEDULE**

Within **Two** months after Effective Date, LSTK CONTRACTOR will issue separate graphical "S" curves for the following work activities of total CONTRACT.

Installation of :

- Concrete foundations, pits. manholes. catch basins, trenches and concrete structures.
- Prefabricated concrete items
- Concrete paving and elevated slabs
- Other paving and final surfacing
- Grouting.
- Final road paving.
- Underground piping.
- Underground cable trenches and cables.
- Building erection.
- Structural steel erection.
- Engineering and design of small bore carbon steel piping systems.
- Prefabrication of piping.
- Electrical installation.
- Instrument installation.
- Equipment assembly and elect
- Erection of piping.
- Flushing and cleaning
- Hydro-testing
- Painting
- Insulation.

5.0 INTRODUCTION

The introduction to the monthly status report shall include LSTK CONTRACTOR'S comments on the overall construction schedule with a status update line as attachment, and shall consist of the following items:

- Goals achieved last month.
- Goals for next month.
- Reason for delay, if any. Reason for deviation of original schedule.
- Average manpower by craft, including management and indirect staff.
- LSTK CONTRACTOR'S comments to general situation.

6.0 CONSTRUCTION ACTIVITIES STATUS

This section consists of scheduled versus actual progress curves.

The progress curves are to be commented upon by LSTK CONTRACTOR.

The basis for reporting shall be the construction schedule:

The monthly status shall be reported as a percentage of the total WORK per type of WORK.

7.0 MANPOWER AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LSTK CONTRACTOR shall submit its manpower availability requirements for the next month. This section consists also of the scheduled versus the actual manpower curves.

These manpower curves are accompanied by LSTK CONTRACTOR'S comments hereon.

8.0 MAIN CONSTRUCTION EQUIPMENT AVAILABILITY / REQUIREMENTS FOR THE MONTH COMING

LSTK CONTRACTOR shall submit its main construction equipment availability / requirements for the next month. This section consists also of the scheduled versus actual construction equipment requirement curves. These by LSTK CONTRACTOR'S comments hereon.

9.0 WEEKLY PROGRESS REPORT

Progress reporting will be done on a weekly basis by the actually completed work based on details of work such as quantities or piece of equipment as a percentage of the total anticipated work per work activities as defined in item 4.

9.1 Progress will only be reported on the basis of completed activities as per the percentage breakdown of the major steps as follows:

Progress Measurement Parameters

Actual physical progress in the field shall be measured based upon standard percentage of completion of progress stages, that, they are to be prepared by LSTK CONTRACTOR and Approved by OWNER to calculate actual physical progress of the WORK, the exact weight value of each activity from lowest level up to highest level in each category of the WORK shall be specified by LSTK CONTRACTOR and supplied to OWNER.

After OWNER'S Approval this weight value can be used for calculation of actual progress of the WORK

10.0 WEEKLY PROGRESS MEETING

10.1 Weekly Work List

In the weekly progress review meeting LSTK CONTRACTOR shall forecast the WORK it plans to perform during the week by means of a weekly WORK list including its manpower resource allocation as per the activities listed in 4 and 6.

This weekly program shall be in accordance with the construction guide schedules.

10.2 Work Front

LSTK CONTRACTOR shall submit monthly and weekly a total recapitulation Of the total work front available with estimated manpower requirements, materials and equipment which shall

be supplied by LSTK CONTRACTOR.

11.0 MONTHLY CONSTRUCTION GUIDE SCHEDULE

Based on approved overall construction schedule, LSTK CONTRACTOR must issue a monthly construction guide schedule covering a two (2) months period, for each individual activity.

Progress updating of construction guide schedules must be weekly and presented in the weekly progress review meeting at site.

The updated issue will show for each individual activity:

- Percent complete.
- Weight factor complete.

12.0 DAILY MANPOWER REPORTS

LSTK CONTRACTOR shall be furnished daily manpower report as per agreed format.

ANNEXURE- 7 – 5

EXECUTION PLAN

1.0 BIDDER ORGANISATION

1.1 Company Organisation

Bid shall include a description of the organization, its management structure and organization chart of Bidder's company with particular reference to the means whereby the execution of this project will be related to the overall company organization.

The Bidder shall also furnish the name(s) of their partners, associated/ subsidiary companies & their activities, and whether any such associated/ subsidiary company will be involved in the execution of WORK, and if so, their scope thereof.

1.2 Project Organization

Bidder shall give charts of organization, which he intends to use in the execution of the work. Such charts must show lines of authority and communication of senior personals who will be assigned to this work in Bidder's home - office and other offices where WORK shall be performed (if any) and the lines connecting such Project Organization to the Bidder's internal overall organization including partners (if any). The chart shall be supported by a narrative, which shall explain how the proposed organisation will operate and in particular will provide

The name of the location of the office(s) in which the Basic and Detail Engineering Design Packages of the plant shall be carried out.

If any parts of the Basic and Detail Engineering Design Packages are to be carried out in more than one office, then details of the distribution of the jobs between offices and coordination procedure shall also be presented.

A description of the facilities offered to the OWNER'S resident engineers.

2.0 Estimated project and Engineering man-hours

Bidder shall give an estimate of the engineering man-hours and its break down for all activities

3.0 Methods and procedures

Bidder shall summarise the methods and procedures that BIDDER intends to implement during the performance of the WORK. It shall include the proposed procedures such as Engineering, Procurement, construction strategy, WORK Progress Measurement, Pre-commissioning, Commissioning and Performance Test Run of the PLANT, and Training.

BIDDER shall also furnish proposed procedures for the Project management, communication and method and frequency of reporting the progress of the WORK.

The final form for reports, which will be subject to OWNER's Approval, shall include as a minimum the following :

a) Planning and Scheduling

b) Work Progress

c) Safety and Security

NOTES:

a) Sample reporting forms and other key standard forms shall be included.

b) Bidder shall state the extent to which he will be using computerized drafting, etc.

4.0 Job descriptions and personnel resumes

Bidder shall include job descriptions and personnel resumes of his staff nominated to the key positions, including (where applicable) at least the followings, or Bidder's equivalent:

Project director
Process engineering co-ordinator
Construction manager
Process engineer
Project engineering co-ordinator
Senior pre-commissioning engineer
Senior commissioning engineer
Training co-ordinator and instructor.
Construction Engineering Coordinator
Construction Quality Control Engineer
Construction Project Control Engineer
Welding Specialists
Heavy Lift Rigging Specialist
Senior Specialist Engineers
Senior Planning Engineers
Materials Coordinators
Senior Construction Engineers
Senior Pre-commissioning Engineers
Warehousing Officer
Material Planning Engineers

Resumes shall give at least the name, age, nationality, education, professional exception/deviation and previous experience of each assigned personnel. Additionally, one alternative shall be offered for each position. **Bidder shall ensure that personnel to be deployed meet the minimum criteria specified in Annexure-7-6**

Bidder shall confirm that these key personnel will be made available to WORK on the Project as required by the schedule on full time basis.

Bidder shall furnish Summary of its Deployment Schedule Personnel as per **Annexure-7-7.**

Bidder understands that the said proposal represents the minimum deployment and the Bidder acknowledges that the said deployment may have to be augmented with additional number and/or categories, if required, if directed by Engineer-in-Charge in order to complete the work within the completion schedule and quoted lump sum price.

5.0 Construction equipment and machinery

The BIDDER shall furnish details of construction equipment & machinery, testing equipment, tools/tackles, etc., which will be made available by the Bidder at the Site. Bidder shall furnish Summary of such details as per **Annexure-7-8, Annexure-7-9.**

Such list shall, in no way limit the CONTRACTOR's responsibility to arrange & provide any additional construction equipment, tools, tackle, etc., which might be required to execute and complete the WORK as per contractual schedule.

BIDDER shall furnish the procedures and his tools for erection of the Heavy Lift Equipments including tall columns):

6.0 Heavy lifts

BIDDER shall furnish his proposed, site transportation, lifting, along with preliminary rigging schemes and erection procedure for the heavy lifts. Such plans / schemes shall be furnished along with detailed write -up on heavy cranes proposed to be deployed by CONTRACTOR, duly supported by relevant technical literature.

7.0 BIDDER experience & exception/deviation to perform the work

The BIDDER should have experience in the construction of similar Plants. The BIDDER should have successfully executed and completed construction of at least one similar Plant with his own project management and with complete responsibility of construction / erection and pre-commissioning.

The BIDDER shall furnish, as a part of his Tender Documents establishing the BIDDER'S experience and exception/deviation to perform the CONTRACT. Such documentary evidence shall also establish to OWNER's satisfaction that the BIDDER has the necessary financial, technical, project management capabilities and the requisite resources to execute the Work.

Such documentary evidence shall also be furnished for BIDDER'S proposed Subcontractors, if any. The Bidder shall furnish, in a tabular from, a list of jobs of similar type and magnitude executed by them in the past. BIDDER shall also furnish details of their experience in erection of heavy lifts. The Bidder shall furnish documentary evidence, establishing to OWNER satisfaction, that such jobs have been timely and successfully executed by them. The BIDDER shall also furnish the details of their present major commitments.

8.0 QA/QC Program

Bidder shall furnish a summary description of their proposed QA/QC program.

Bidder shall furnish any other technical information / details as per the requirements of ITB.

9.0 Technical assistance

The extent of the Technical Services and Assistance to be rendered by CONTRACTOR for, commissioning and performance test run, etc., is to be proposed

10.0 Training

Bidder shall furnish the following details regarding the Training of OWNER'S personnel:

a) Bidder's organisation set up for Training program.

b) Training facilities available with the Bidder to train the OWNER'S personnel in

- Theory of process, operation, maintenance and manufacturing of products
- Field (on the job) training in process, operation, maintenance and manufacturing of products, to train the personnel on the job.

- Test procedure and other matters.

c) The courses and their duration, number of attendees in each course and location where such courses will be held that the Bidder would recommend OWNER to consider.

d) Bidder's experience of training the personnel for units similar to the subject PLANT.

11.0 Estimate of the number of personnel required for the safe and satisfactory operation of the Plant.

For and on behalf of .....

Stamp & Signature : .....

Name : .....

Designation : .....

Date : .....

ANNEXURE-7-6

Minimum Qualification & Exp. of Key Supervisory Construction Personnel

SL. NO.	CATEGORY	QUALIFICATION & EXPERIENCE
1	RESIDENT CONSTRUCTION MANAGER / RESIDENT ENGINEER / SITE-IN-CHARGE	Degree in Engg. With minimum 20 years relevant experience in construction should successfully constructed & commissioned at least one process unit in hydrocarbon / fertilizer sector.
2	LEAD DISCIPLINE ENGINEER	Degree in relevant Engg. discipline with minimum 15 years experience in Construction or Diploma in relevant Engg. Discipline with minimum 20 years experience in Construction.
3	LEAD WELDING / NDT ENGINEER	Degree in Mechanical Engg./Metallurgy with minimum 15 years experience in Welding / NDT (Non-Destructive Testing) plus Level-II in RT (Radiographic Testing) or diploma in Mechanical Engg. / Metallurgy with minimum 20 years experience in Welding / NDT plus Level–II in RT.
4	LEAD QA/QC ENGINEER	Degree in Engg. With 15 years Construction Experience of which 5 years should be as QA Manager.
5	LEAD PLANNING ENGINEER	Degree in Engg. With 15 years experience in Planning & Scheduling.
6	LEAD SAFETY OFFICER	Degree / Diploma in Engg. And Diploma in Industrial Safety with min. 10 years relevant experience in Construction Safety.
7	WAREHOUSE-IN-CHARGE / MATERIALS MANAGER	Graduate in Science or Diploma in Engg. / Materials Management with 15 years experience in Warehousing / Stores Management of similar nature.
8	DISCIPLINE SURVEYORS	Degree in relevant Engineering Discipline with minimum 3 years experience in Construction or diploma in relevant Engineering Discipline with minimum 6 years experience in Construction.
9	QUANTITY SURVEYORS	Degree in relevant Engineering Discipline with minimum 3 years experience or diploma in relevant Engineering Discipline with minimum 6 years experience in quantity estimation, field measurement, rate analysis etc. in construction field.

For and on behalf of .....

Stamp & Signature : .....

Name : .....

Designation : .....

Date : .....

ANNEXURE-7-7

Deployment Schedule of Supervisory Personnel

SL. NO.	DESCRITPION	DEPLOYMENT SCHDULE																												
		1	2	3	4	5	6	7	8	9	10	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	35	36	37	TOTAL
1	**PROJECT MANAGEMENT**																													
1.1	PROJECT MANAGER																													
1.2	PLANNING MANAGER																													
1.3	PLANNING ENGINEERS																													
2	**RESIDUAL DESIGN AND DETAILED ENGINEERING**																													
2.1	PROJECT ENGINEERING MANAGER																													
2.2	ENGINEERING COORDINATOR																													
2.3	ENGG. PERSONNEL FOR VARIOUS DISCIPLINE																													
2.3.1	CIVIL STRUCTURAL																													
(i)	ENGINEERS																													
2.3.2	PRESSURE VESSELS																													
2.3.3	MECHANICAL EQPT/ ROTARY EQPT.																													
2.3.4	PIPING																													
(i)	ENGINEERS																													
2.3.	ELECTRICAL																													

5																													
(i)	ENGINEERS																												
2.3.6	INSTRUMENTA-TION																												
(i)	ENGINEERS																												
2.3.7	MISCELL-ANEOUS																												
3	**PROCUREMENT**																												
3.1	PURCHASE																												
3.1.1	PURCHASE MANAGER																												
3.1.2	PURCHASE COORDINATOR																												
3.1.3	PURCHASE OFFICER																												
3.2	INSPECTION																												
3.2.1	INSPECTION MANAGER																												
3.2.2	INSPECTORS																												
3.3	EXPEDITING																												
3.3.1	EXPEDITING COORDINATOR																												
3.3.2	EXPEDITORS																												
3.4	CUSTOM CLEARANCE, IMPORT LICENCE, TRANSPORTA -TION PERSONNEL																												
4	**SITE CONSTRUCTION**																												
4.1	PROJECT MANAGER																												
4.2	CONSTRUC-TION MANAGER																												

4.3	CIVIL STRUCTURAL																											
4.3.I	LEAD ENGINEER																											
4.3.2	SITE ENGINEER																											
4.3.3	SUPERVISORS																											
4.4	MECHANICAL WORKS																											
4.4.1	LEAD ENGINEER																											
4.4.2	SITE ENGINEER																											
4.4.3	SUPERVISORS																											
4.5	PIPING WORK																											
4.5.1	LEAD ENGINEER																											
4.5.2	SITE ENGINEER																											
4.5.3	SUPERVISORS																											
4.6	ELECTRICAL WORK																											
4.6.1	LEAD ENGINEER																											
4.6.2	SITE ENGINEER																											
4.6.3	SUPERVISORS																											
4.7	INSTRUMENTA-TION WORK																											
4.7.1	LEAD ENGINEER																											
4.7.2	SITE ENGINEER																											
4.7.	SUPERVISORS																											

3																												
4.8	QUALITY ASSURANCE/ QUALITY CONTROL																											
4.8.1	QC/QA MANAGER																											
4.8.2	INSPECTOR (CIVIL)																											
4.8.3	INSPECTOR (PIPING)																											
4.8.4	INSPECTOR (MECH EQPT)																											
4.9	SAFETY ENGINEER																											
4.10	SITE ENGINEERING WORKS																											
4.10.1	ENGINEERS																											
4.10.2	SUPERVISORS																											
4.11	COMPUTER ENGINEER																											
4.12	ADMINISTRA – TION MANAGER																											
4.13	MISCELLAN-EOUS																											
4.14	WAREHOUSE PERSONNEL																											
4.15	MATERIAL MANAGER																											
4.16	COMMISSION-ING																											
i)	COMMISSION-ING COORDINATOR																											
ii)	COMM ENGINEER (SHIFT- IN-CHARGE)																											

iii)	CONTROL ROOM COORDINATOR																											
iv)	FIELD SUPERVISOR																											
v)	TECHNICIAN																											

For and on behalf of ……

Stamp & Signature : ……

Name : ……

Designation : ……

Date : ……

ANNEXURE-7-8

Deployment Schedule of Construction Equipment

SL. NO.	DESCRIPTION	CAPA-CITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	..	33	34	35	36	37	TOTAL
1	CRANES																							
1.1	1200 MT																							
1.2	700 MT																							
1.1	500 MT																							
1.2	300 MT																							
1.3	150 MT																							
1.4	75 MT																							
1.5	50 MT																							
1.6	20 MT																							
1.7	15 MT																							
1.8	10 MT																							
1.9	5 MT																							
2	DIESEL GENERATORS																							
2.1	500 KVA																							
2.2	300 KVA/250KV																							
2.3	150 KVA/125KV																							
3	COMPRESSORS																							
3.1	600 CFT																							
3.2	350 CFT																							
4	WELDING M/CS																							
4.1	DIESEL WELDING M/C																							
4.2	DIESEL GENERATOR																							

SL. NO.	DESCRIPTION	CAPA-CITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	..	33	34	35	36	37	TOTAL
4.3	WELDING TRANS FORMERS/RE C-TIFIERS																							
4.4	TIG WELDING M/CS																							
5	GRIT BLASTING M/CS																							
6	SPRAY PAINTING M/CS																							
7	STRESS RELIEVING M/CS																							
8	RADIO-GRAPHY M/CS																							
9	TEST PUMP																							
10	WATER PUMP																							
11	TRANSPORTA-TION EQPT																							
11.1	TRACTOR -TRAILOR																							
11.2	TRUCKS																							
11.3	BUS																							
12	JACKS																							
12.1	MECHANICAL																							
12.2	HYDRAULIC																							
13	CIVIL																							
13.1	EXCAVATORS																							
13.2	DUMPERS																							
13.3	BATCHING PLANT																							

SL. NO.	DESCRIPTION	CAPA-CITY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	..	33	34	35	36	37	TOTAL
13.4	CONCRETE PUMP CAR																							
13.5	TRANSIT MIXER																							
13.6	MIXER																							
13.7	VIBRATORS																							
13.8	COMPACTORS																							
13.9	THEODOLITES																							
14.0	OTHERS																							
14.1	INSULATION TESTING EQUIPMENT																							
14.2	SECONDARY INJECTION TESTING KIT																							
14.3	METERS, TOOLS & TACKLES ETC.																							
14.4	CALIBRATION EQUIPMENT																							
14.5	OTHER TOOLS & TACKLES																							
14.6	MULTI METERS CALIBERAT-ORS ETC.																							
14.7	INDUCTION PIPE BENDING PLANTS																							
14.8	METALOGRAPHY																							
14.9	SPECTRO-METERS																							

For and on behalf of :

……

Stamp & Signature : ……

Name : ……

Designation : ……

Date : ……

ANNEXURE-7-9

Details Of Equipment Proposed to be used for Tendered Work

I / We, shall use the following MAJOR equipments owned by the tenderer for the work, if awarded to me /us :

Sl. No.	Description	Quantity. (Numbers)	Make	Capacity	Owner	Approximate date when it will be deployed at site	Period of retention at site

For and on behalf of ……

Stamp & Signature : ……

Name : ……

Designation : ……

Date : ……

DRAWINGS AND DOCUMENTS

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY

PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

1	16.02.2021	16.02.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
0	21.01.2021	21.01.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
P	25.11.2020	25.11.2020	PRELIMINARY	AK/PT/HK	RKS	RKS/MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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Section Number	Description	Sheet Number
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2.0	Category of Documents	5
3.0	Procedure	7
4.0	List of Drawings & Documents	7

1.0 DRAWINGS & DOCUMENTS

This chapter details out various drawings and documents to be generated at various stages during the course of execution of the Project by the LSTK Contractor for different project activities. Categorization of the documents/ drawings for review/ information/ records of PMC and the review/ approval requirements of the Owner/ PMC along with routing of the documents/ drawings will be conveyed separately as a philosophy.

The efficient handling of drawings and documents to be prepared by the LSTK Contractor under the contract is the key to the timely completion of the plants. The LSTK Contractor undertakes to ensure that all drawings and documents to be submitted by him to the Owner/ PMC shall be of professional quality and conforming to the contractual requirements. The LSTK Contractor also undertakes to institute a formal drawing control system which will be documented and submitted to the Owner/PMC for review or approval.

Compliance of this chapter on drawings and documents is mandatory and is non-negotiable.

The drawings / documents are to be generated by the LSTK Contractor at various stages of the project covering different activities. The drawings / documents generated will be in the category of Approval/ Review/ Information. The list of drawings and documents required is enclosed; however, the categorisation for the drawings/ documents will be informed separately. However, this will in no way relieve the LSTK Contractor of responsibility to conform to drawings, standards, specification, codes and contractual requirements / obligations.

The LSTK Contractor shall prepare the drawing numbering procedure and submit to Owner/ PMC for approval. Each Drawing submitted by the LSTK Contractor shall be clearly marked with the name of the Owner, PMC with revision number & date. It should contain the minimum following details:

a. Size of Drawing.

b. Discipline of Engineering for which the drawing is issued.

c. Discipline wise segregation of numbering sequence for example:
   100 Series for Process. 200 Series for Mechanical etc.

LSTK Contractor to note that the number corresponds to Ammonia and Urea plants and shall be prefixed to all related documents/deliverables which shall be indicated to successful bidder.

For Details of the Drawing and Documents submission and tools to be used for generating these documents, LSTK contractor is requested to refer Part- B of Section -9 of the NIT.

All other documents like presentations etc. and other data shall be in MS Office; the required operating system for Data Exchange shall be at least Windows.

All documents before forwarding to Owner/PMC will have to be vetted in detail by the LSTK Contractor/duly approved engineering sub-contractor appointed by the LSTK Contractor. Document received without vetting will be returned.

The review by the PMC/Owner shall not be construed by the LSTK Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications and drawings.

Each drawing submitted by the LSTK Contractor shall be clearly marked with the name of the Owner, Unit Designation, Specifications, Title, Specification number and the name of the Project with Revision number and date. If standards, catalogue pages are to be submitted, the applicable items shall be indicated therein. All titles, noting, markings and writings on the drawings shall be in English.

All the dimensions should be in metric units. Upon receiving comments on Drawings & Documents by the LSTK Contractor, the subsequent submission should give compliance report, separately on each of the comments, document-wise. Comments given by PMC/Owner to be discussed and finalised within agreed schedule.

The schedule of submission of the Drawings & Documents shall be in accordance with project plans only. The detailed list under different category, document-wise, shall be prepared by the LSTK Contractor for approval of Owner/PMC. This activity is to be completed within one month of Fax of Intent.

Sequence of submission of drawing is essential for proper review of documents and timely completion of the project is to be adhered. In case sequence is not maintained, the documents submitted will not be reviewed by Owner/ PMC and responsibility of timely execution of plant shall be to the LSTK Contractor's account.

2.0 CATEGORY OF DOCUMENTS

Category	Description	Action by Owner/ PMC
1	Records/ Information	LSTK Contractor can continue to progress with the work. This drawings or documents will be retained with Owner/PMC for information only. Owner/ PMC reserves the right to advise the LSTK Contractor of any comments (deviations from the contract) at any time and the LSTK contractor is liable to respond to satisfy that the work being done is in accordance with the contract; deviations, if any will be bidder's risk and cost.
2	Review	Owner/PMC will review and advise the LSTK Contractor of any Comments on Contractor's Drawings / documents within specified schedule (ie 2 weeks), from date of receipt in PMC office of LSTK Contractor's drawings/documents. The review period is defined as date of receipt of documents by PMC, to date of issue of comments by PMC. This review period shall be valid only if submission of drawings is done by LSTK Contractor in accordance with approved drawings / documents schedule as indicated in ITB. In case of any non-conformity to the above by LSTK Contractor due to which the period of review extends beyond 2 weeks by the PMC, schedule delay, if any will have to be absorbed by the Contractor.

The documents falling under Review category will be returned with comments within specified time schedules subject to fulfilling other conditions enumerated. The information category document will be retained for information only but however Owner/PMC reserves the right to comment at any stage of the Project, but not later than two weeks of receipt.

Where clearance of Owner/ PMC is required for ordering of equipment materials, enquiry documents and one technically selected offer is to be submitted for review. The unpriced copies of purchase orders detailing both technical and commercial aspects for all items shall be submitted to PMC/ Owner within 15 days of issue of the same.

Each purchase order forwarded should contain complete technical documents. It is obligatory for the LSTK Contractor to obtain acceptance on all the technical documents and accepted copy only to be forwarded to Owner / PMC. Any inaccuracies /omissions/inconsistencies noticed and brought to the notice of the LSTK Contractor at any stage of the project will be rectified/ replaced by LSTK Contractor without any cost & time implication to the Owner/ PMC.

Detailed manufacturing schedules of fabricated/ manufactured items shall be submitted within one month of ordering, Status report for all the items in detail, will be submitted once in a month.

Documents to Boiler Regulation authorities shall be submitted and getting the documents reviewed by PMC/Owner. To any other agencies, documents shall be submitted under intimation to PMC/Owner.

As built drawings and documents will be generated within one month of completion of activities on respective items of work.

As Built Drawings:

LSTK Contractor will furnish reproducible and electronic files of all the drawings under their scope to Owner / PMC, certified as “As-Built Issue” by Third Party Inspection Agency (TPIA) for Vendor Items coming under Third Party Inspection / LSTK Contractor for all other drawings.

Upon completion of identifiable units or components of the fabrication, construction and installation phase of the project the Contractor will complete all the related plans to the "as built' stage including all Vendor drawings and furnish Owner/PMC with the following:

a. One complete set of all original tracings copies.

b. One complete set of reduced size (A3-297x420 mm) copies of all drawings.

c. One set of CD for all documents/drawings/data

d. All the as built drawings duly certified should be scanned and converted into electronic files made on magnetic/discs/optical long storage.

e. All other project documents such as operating and maintenance manuals, manufacturers' Catalogues etc. shall also be scanned on magnetic/optical discs for safe storage and retrievals by the Owner when needed.

f. 10 complete sets of full size prints of the drawings and 4 sets of reduced size prints.

g. 10 complete bound sets of Manufacturer's specifications including design calculations.

h. 10 complete sets in hard binders of the Manufacturers data book including certified prints and data

for all items including test reports. Data Books shall be complete with index as tag numbers associated with Manufacturer's data shown. Equipment data shall include as a minimum requirement the principal and description of operation, drawings and dimensions, spare parts lists and un-priced purchase orders and bill of material.

i. 10 bound copies each of the Spare Parts data books and the Lubricants inventory Schedule.

j. 10 complete sets of field records shall be signed by both the Contractor's and Owner's Representative at the site.

k. Original approvals and related drawings and documents from the statutory authority.

l. Copies of correspondence with the statutory authorities.

3.0 PROCEDURE

The procedure for compilation of final as-built documents / drawings shall be informed later. However the Procedure for routing the final / as built documents/ drawings to PMC / Owner shall be informed during the execution stage.

4.0 LIST OF DRAWINGS & DOCUMENTS

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
A.	**PROCESS**				
1.0	Basis of Design	Y	Y		Y
2.0	Process Description	Y	Y		Y
3.0	Process Flow Diagram	Y	Y		Y

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
B.	**STATIC EQUIPMENTS**				
	1) STORAGE TANK				
1.0	OUTLINE SKETCHES SHOWING THICKNESS OF MAIN PARTS, DETAILS OF INTERNAL INCLUDING WEIGHT (ERECTION & OPERATING) AND ANCHORAGE DETAILS ETC.	Y	-	-	-
2.0	GENERAL ARRANGEMENT DRAWINGS INDICATING DESIGN DATA , FABRICATED EQUIPMENT WEIGHT, GENERAL NOTES, NOZZLE SCHEDULE, DETAILS OF SHELL, SUPPORTING ARRANGEMENT , MAIN WELD SEAMS ,NOZZLE ORIENTATION PLAN ETC.	N	Y	-	Y
3.0	BOTTOM AND ANNULAR RING LAYOUT & WELD DETAIL	N	Y		Y
4.0	DETAIL OF SUMP FOR DRAIN NOZZLES	N		Y	Y
5.0	SHELL PLATE LAYOUT (SHOWING LOCATION OF NOZZLES AND MANHOLE)	N		Y	Y
6.0	MECHANICAL DESIGN CALCULATIONS COMPLYING WITH THE SPECIFICATIONS AND CODES.	N	Y	-	Y
7.0	DETAIL OF WIND GIRDER	N	Y	-	Y
8.0	STAIRWAYS, INTERMEDIATE & TOP PLATEFORM	N	-	Y	Y
9.0	ROOF PLATE LAYOUT & WELD DETAIL	N	Y	-	Y
10.0	DETAIL OF NOZZLES ON SHELL & ROOF	N	-	Y	Y
11.0	DETAILS OF INTERNALS LIKE GUIDE ROLLERS, ROOF STOPPERS, STILL WELLS, DIP PIPE, HEATING COIL e.t.c	N	-	Y	Y
12.0	MATERIALS TEST CERTIFICATES DULY STAMPED BY INSPECTING AUTHORITY (**)	N	-	-	Y
13.0	QAP & INSPECTION AND TEST PLAN (**)	N	Y	-	Y
14.0	WELDING PRCEDURE AND QUALIFICATION TEST REPORTS (**)	N	-	Y	Y
15.0	DESTRUCTIVE AND NON DESTRUCTIVE PROCEDURE & TEST REPORTS (**)	N	-	Y	Y
16.0	HEAT TREATMENT PROCEDURE AND TIME TEMPRATURE CHARTS (**)	N	-	Y	Y
17.0	RADIOGRAPHIC EXAMINATION REPORTS & FILMS (**	N	-	-	Y
18.0	ALL FINAL AS- BUILT SHOP DRGS. & DESIGN CALCULATIONS DULY CERTIFIED BY THIRD PARTY INSPECTING AUTHORITY (**)	N	-	Y	Y
19.0	COMPLETION CERTIFICATES (INCLUDING INSPECTION CERTIFICATE, HYDROSTATIC TEST CERTIFICATE , LOCAL CODE REQUIREMENTS)	N	-	-	Y
20.0	FINAL CIVIL LOAD DATA INCLUDING DETAILS OF FOUNDATION/ANCHOR BOLTS	N	-	Y	Y
21.0	LIST OF SPARE PARTS AND DETAILS	N	Y	-	Y
	2) VESSEL & COLUMN				

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
1.0	OUTLINE SKETCHES SHOWING THICKNESS OF MAIN PARTS,MOC, DETAILS OF INTERNAL INCLUDING DEMISTER,WEIGHT (ERECTION & OPERATING) AND ANCHORAGE DETAILS	Y	-	-	-
2.0	GENERAL ARRANGEMENT DRAWINGS INDICATING DESIGN DATA , FABRICATED EQUIPMENT WEIGHT, GENERAL NOTES, NOZZLE SCHEDULE, DETAILS OF SHELL, HEADS SUPPORTING ARRANGEMENT , MAIN WELD SEAMS ,NOZZLE ORIENTATION PLAN ETC	N	Y	-	Y
3.0	DETAIL OF NOZZLES, MANHOLES,ACCESSORIES ETC.	N	-	Y	Y
4.0	DETAIL OF INTERNALS SUCH AS TRAY,TRAY SUPPORT RING, BOLTING BARS ETC.	N	-	Y	Y
5.0	DETAIL OF DEMISTER	N	Y	-	Y
6.0	MECHANICAL DESIGN CALCULATIONS COMPLYING WITH THE SPECIFICATIONS AND CODES.	N	Y	-	Y
7.0	DETAIL OF PACKING SUPPORT,DEMISTER SUPPORT, GRATING & GRATING SUPPORT	N	Y	-	Y
8.0	DETAIL OF INTERNAL DISTRIBUTOR	N	Y	-	Y
9.0	DETAIL OF EXTERNAL CLIPS SUCH AS LADDER, PLATEFORM,PIPE SUPPORT	N	-	Y	Y
10.0	DETAIL OF INSULATION ,FIREPROOFING	N	-	Y	Y
11.0	DETAIL OF PIPE DAVIT	N	-	Y	Y
12.0	DETAIL OF LIFTING LUG, TAILING LUG & TRUNION ETC. INCLUDING DESIGN CALCULATION	N	-	Y	Y
13.0	SHELL DEVELOPMENT DRAWINGS INCORPORATING ALL ATTACHEMENTS AMD WELD SEAMS	N	-	Y	Y
14.0	ALL FINAL AS- BUILT SHOP DRGS. & DESIGN CALCULATIONS DULY CERTIFIED BY THIRD PARTY INSPECTING AUTHORITY (**)	N	-	Y	Y
15.0	DATA FOLDER AS PER SPECIFICATION	N	-	Y	Y
16.0	MATERIALS TEST CERTIFICATES DULY STAMPED BY INSPECTING AUTHORITY (**)	N	-	-	Y
17.0	QAP & INSPECTION AND TEST PLAN (**)	N	Y	-	Y
18.0	WELDING PRCEDURE AND QUALIFICATION TEST REPORTS (**)	N	-	Y	Y
19.0	DESTRUCTIVE AND NON DESTRUCTIVE PROCEDURE & TEST REPORTS (**)	N	-	-	Y
20.0	HEAT TREATMENT PROCEDURE AND TIME TEMPRATURE CHARTS (**)	N	-	Y	Y
21.0	RADIOGRAPHIC EXAMINATION REPORTS & FILMS(**)	N	-	-	Y
22.0	COMPLETION CERTIFICATES (INCLUDING INSPECTION CERTIFICATE, HYDROSTATIC TEST CERTIFICATE , LOCAL CODE REQUIREMENTS)	N	-	-	Y

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
23.0	PACKING AND FORWARDING INSTRUCTION (**)	N	-	-	Y
24.0	TRANSPORTATION DRAWING SHOWING OVERALL DIMENSION, C.G. WEIGHT AND HANDLING INSTRUCTIONS DULY APPROVED BY APPROPRIATE AUTHORITY	N	-	Y	Y
25.0	FINAL CIVIL LOAD DATA INCLUDING DETAILS OF FOUNDATION/ANCHOR BOLTS	N	-	Y	Y
26.0	LIST OF SPARE PARTS AND DETAILS	N	Y	-	Y

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
	3) HEAT EXCHANGERS				
1.0	OUTLINE SKETCHES SHOWING THICKNESS OF MAIN PARTS, MOC, WEIGHT (ERECTION & OPERATING) ETC.	Y	-	-	-
2.0	GENERAL ARRANGEMENT DRAWINGS INDICATING DESIGN DATA , FABRICATED EQUIPMENT WEIGHT, GENERAL NOTES, NOZZLE SCHEDULE, DETAILS OF SHELL, HEADS SUPPORTING ARRANGEMENT , MAIN WELD SEAMS ,NOZZLE ORIENTATION PLAN ETC.	N	Y	-	Y
3.0	DETAILS OF TUBE SHEET & TUBE LAYOUT.	N	Y	-	Y
4.0	DETAILS OF NOZZLES AND EXCHANGER SUPPORT	N	-	Y	Y
5.0	DETAILS OF GASKETS	N	Y	-	Y
6.0	LIST OF SPARE PARTS AND DETAILS	N	-	Y	Y
7.0	FINAL CIVIL LOAD DATA INCLUDING DETAILS OF FOUNDATION/ANCHOR BOLTS	N	-	Y	Y
6.0	MECHANICAL DESIGN CALCULATIONS COMPLYING WITH THE SPECIFICATIONS AND CODES.	N	Y	-	Y
8.0	WELDING PRCEDURE AND QUALIFICATION TEST REPORTS (**)	N	-	Y	Y
9.0	TRANSPORTATION DRAWING SHOWING OVERALL DIMENSION, C.G. WEIGHT AND HANDLING INSTRUCTIONS DULY APPROVED BY APPROPRIATE AUTHORITY	N	-	Y	Y
10.0	DESTRUCTIVE AND NON DESTRUCTIVE PROCEDURE & TEST REPORTS (**)	N	-	Y	Y
11.0	PROCEDURE FOR REPAIR OF DAMAGED TUBES (**)	N	-	Y	Y
12.0	QAP & INSPECTION AND TEST PLAN (**)	N	Y	-	Y
13.0	RECORDS OF NDT TESTS E.G. RADIOGRAPHY, ULTRASONIC TESTING(UT), MAGNETIC PARTICAL / PENETRANT TESTING (MP/PT), HARDNESS ETC. (**)	N	-	-	Y
14.0	MATERIALS TEST CERTIFICATES DULY STAMPED BY INSPECTING AUTHORITY (**)	N	-	Y	Y
15.0	PWHT CHARTS (**)	N	-	Y	Y
16.0	TEST ON PRODUCTION TEST COUPONS (**)	N	-	-	Y
17.0	HYDRAULIC/PNEUMATIC TEST REPORTS (**)		-	-	Y
18.0	MOCK-UP TEST FOR TUBE TO TUBESHEET JOINT(**)		-	-	Y
19.0	ALL FINAL AS- BUILT SHOP DRGS. & DESIGN CALCULATIONS DULY CERTIFIED BY THIRD PARTY INSPECTING AUTHORITY (**)	N	-	-	Y
20.0	RADIOGRAPHIC EXAMINATION REPORTS & FILMS (**)	N	-	-	Y

S. No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
21.0	MECHANICAL GUARANTEE CERTIFICATE (**)	N	-	-	Y
22.0	INSPECTOR'S FINAL CERTIFICATE (**)				y
23.0	PACKING AND FORWARDING INSTRUCTION (**)	N	-	-	Y

Notes :

1. Final documentations shall be supplied in hard copies as well as soft copes in CD Formats. Applicable. software are MS Office 2000, Word, Access, and Excel.
2. Document marked as (**) are to be approved by authorized Third Party Inspection Agency and Statutory Authorities as applicable.
3. Final documentation shall be supplied in hard copies (6 prints) and soft (two CDs/DVDs) in addition to Submission through email.
4. All drawing & documents shall be submitted in A2/A3 or A4 paper size .Documents in higher paper size Shall be submitted in exceptional circumstances or as indicated in MR/Tender.
5. Bill of material (showing part no. MOC, Size, quantity, weight of each part) shall form part of the respective drawing.

S.No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
C	**Pumps**				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart)	N	Y	-	Y
3.0	Certified dimensional outline drawing	Y	Y	-	Y
4.0	Cross sectional drawing and bill of material	N	Y	-	Y
5.0	Shaft seal drawing and bill of material	N	Y	-	Y
6.0	Shaft coupling assembly drawing and bill of materials including allowable misalignment clearances, shaft bores & key ways dimensions with tolerances and the style of coupling guard	N	Y	-	Y
7.0	Primary & auxiliary sealing schematic and bill of materials including seal fluid, fluid flows, pressure pipe and valve sizes, instrumentation, orifice sizes, and piping arrangement drawings	N	Y	-	Y
8.0	Cooling or heating schematic and bill of materials including cooling & heating media, fluid flows, pressure, pipe and valve sizes, instrumentation, orifice sizes and piping arrangement drawings	N	Y	-	Y
9.0	Lube oil schematic and bill of materials	N	Y	-	Y
10.0	Lube oil system arrangement drawing including sizes, rating and location of all customer connections	N	Y	-	Y
11.0	Lube oil component drawings data	N	Y	-	Y
12.0	Electrical and instrumentation	N	Y	-	Y

S.No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
	schematics, wiring diagrams and bill of materials				
13.0	Electrical and instrumentation arrangement drawing and list of components	N	Y	-	Y
14.0	Performance curves	N	Y	-	Y
15.0	Pump specification sheet with complete details in Performa enclosed with enquiry / order	N	Y	-	Y
16.0	Certified foundation assembly drawing of pump with driver & all accessories mounted on base plate with load diagram for foundation design (In case of motor being procured by purchaser, motor frame details will be supplied to vendor within 4 weeks.)	N	Y	-	Y
17.0	Engineering flow diagram showing: - Lubrication & sealing lines - Flushing / washing lines - Cooling / steam lines	N	Y	-	Y
18.0	Reference list for pumps supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning	Y	-	-	Y
19.0	Lube oil schedule	N	-	-	Y
20.0	Automatic recirculation valve assembly drawing, sectional drawing with bill of material	N	Y	-	Y
21.0	Quality Assurance Plan.	N	Y	-	-
22.0	Material test certificates and Inspection & performance test report along with dispatch clearance certificates from inspector	N	-	-	Y

S.No	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved/ As-built
23.0	Instruction manuals describing installation, operation and maintenance procedures	N	-	-	Y
24.0	Spare parts recommendations and price list	Y	-	-	Y
25.0	Parts catalogue complete with reference drawing nos. and sketches etc.	N	-	-	Y

D.	COMPRESSORS				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart)	N	Y	-	Y
3.0	Specification sheet complete filled in PDIL proforma enclosed with enquiry/order.	N	Y	-	Y
4.0	Equipment layout with main overall dimensions including those required for foundations and piping design for compressor and auxiliaries. (This layout shall include the driven equipment and its auxiliaries).	Y	Y	-	Y
5.0	Performance curves for Centrifugal compressor :				
	i) For turbine driven compressor, Discharge pressure, Brake horse power, Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115 % of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt. of the gas and at 80, 90, 100 and 105 % speed for each stage and for overall compressor	N	Y	-	Y
	ii) For constant speed motor driven compressors Discharge pressure , Brake horse power , Polytropic head and Efficiency Vs Inlet capacity (from surge point to 115 % of rated capacity) of the compressor at specified inlet pressure, temp. and mol. wt of the gas for each stage and for overall compressor	N	Y	-	Y
	iii) Torque Vs Speed curve for the compressors.	N	-	Y	Y

6.0	Performance Curve	N	Y	-	Y
7.0	i) Calculation of the lateral critical speeds of the compressors. ii) Calculation of the torsional critical speeds. Analytical report for torsional vibration of whole set. iii) Thrust loading curves for each casing / barrel for various operating conditions. iv) Response curve of deflection Vs RPM for varying amount of imbalance. v) Torsional critical response curve	N	-	Y	Y
8.0	Overall dimensional drawing with all main dimensions, size and location of piping connections for compressors and its auxiliaries.	N	Y	-	Y
9.0	Cross sectional drgs. Of the compressor showing details of construction including sealing details, bearing etc. With part no., description and material of construction.	N	Y	-	Y
10.0	Coupling drawings	N	-	Y	Y

11.0	Seal assembly drawings & Bill of material	N	-	Y	Y
12.0	Lube oil Pumps a) Specification sheet b) Performance curve c) Cross Sectional drawing	 N N N	 Y Y		 Y Y Y
13.0	Certified foundation scope drawing of the compressor with driver and all accessories resting on the foundation and control panel. In the event of motor not in the scope of supply of vendor the motor frame dimensions shall be supplied by the purchaser later). Direction and magnitude of all unbalanced forces, couples and centre of gravity along with direction of rotation shall also be mentioned	N	Y	-	Y
14.0	a) Engineering flow diagram indicating all instruments, valves, etc. marked with battery limit of supply of : - Process Gas lines - Cooling Water lines - Lubricating Oil lines - Condensate drain and vent lines The above drawings shall identify all components by size, pressure rating and material b) Material balance for gas, lube & seal oil.	Y	Y	-	Y
15.0	Piping layout plan and elevation drawings for gas, cooling water and utility lines, lube and seal oil lines etc.	N	Y	-	Y
16.0	Driver : Selection details a) Speed - torque diagram b) GD2 of the rotating masses of the compressor referred to the motor speed	N	-	Y	Y
17.0	a) Piping isometrics for gas pipes DN>20, piping manifold and all oil lines. b) Flexibility analysis for gas lines.	N	-	-	Y

18.0	Piping support location drgs. With forces, moments and movements for gas pipes and with weights for all lines.	N	Y	-	Y
19.0	Certified allowable forces, moments, movements, stresses for compressor nozzles.	N	Y	-	Y
20.0	Bill of Material for Piping and supports.	N	Y	-	Y
21.0	Bill of Material for insulation for Pipings.	N	Y	-	Y
22.0	Bill of quantity for Painting for piping, equipments and auxiliaries.	N	Y	-	Y
23.0	Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and Pressure vessels.	N	Y	-	Y
24.0	Inspection and Test Procedure.	N	-	-	Y
25.0	Quality Assurance Plan.	N	Y	-	-
26.0	Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority, certificates for compressors, heat exchangers, pressure vessels, pipings, valves, instruments and other auxiliaries.	N	-	-	Y
27.0	Lubrication schedule	N	-	-	Y
28.0	Instruction manual for erection, installation, operation and maintenance of compressor and its accessories (important clearances to be maintained should be clearly specified.).	N	-	-	Y
29.0	Recommended list of spares for two years trouble free operation	Y	-	-	-
30.0	List of special tools	Y	-	Y	Y
31.0	Installation list of similar machines shall also include the following : a) Client, location and year of	N	-	-	-

	installation b) Drive c) Model No. and type of compressor d) Duty condition of the compressor e) Speed and KW rating				
E.	**TURBINE**				
1.0	List of drawings / documents including drawing number, revision number, description and approval status	N	Y	-	Y
2.0	Detailed manufacturing programme (Time bar chart)	N	Y	-	Y
3.0	Specification sheet with complete details in proforma enclosed with enquiry/order	N	Y	-	Y
4.0	Equipment layout with main overall dimensions including those required for foundations and piping design for Turbine and auxiliaries.	Y	Y	-	Y

5.0	Performance curves for steam turbine : a) steam consumption versus KW (for various extraction rate in case of extraction turbine) b) overall efficiency vs. load curve c) steam consumption correction curves d) curve showing variation of exhaust temperature with inlet flow (i.e. under various loads) : - for change in live steam pressure - for change in live steam temperature - for change in speed from governor set point speed to max. continuous speed - for change in cooling water inlet temperature from 25°C to 35°C	N	Y	Y	Y
6.0	Thrust loading curves of each casing / barrel for various operating conditions	N	-	Y	Y
7.0	Overall dimensional drawing with all main dimensions, size and location of piping connections for turbine and its auxiliaries.	N	Y	-	Y
8.0	Cross sectional drawings of the turbine showing details of construction including governor, inlet trip and control valves sealing details, bearing details etc. With part no., description and material of construction.	N	Y	-	Y
9.0	Description of governing system	N	-	Y	Y
10.0	Blading plan for turbine	N	-	Y	Y
11.0	Coupling drawings	N	-	Y	Y
12.0	a) Engineering Flow diagram indicating all the Instruments with limit of supply of steam and	N	Y	-	Y

	condensate lines, lube and control oil lines, Flushing and washing line and cooling water lines. b) Material balance for steam condensate, lube & control oil.				

13.0	Certified civil scope drawings for foundation of steam turbine and all auxiliaries.	N	Y	-	Y
14.0	Piping layout plan, elevation and support drawings for steam and condensate lines, lube and control oil lines, gland sealing steam lines, flushing and washing lines.	N	Y	-	Y
15.0	a) Piping isometrics for steam pipes for DN>20, piping manifold and all oil lines b) Flexibility analysis for steam lines	N	Y	-	Y
16.0	Piping support location drgs. With forces, moments and movements for steam and condensate pipes and with weights for all lines	N	Y	-	Y
17.0	Certified allowable forces, moments, movements, stresses for turbine nozzles.	N	-	Y	Y
18.0	Calculation of the lateral critical speeds of the turbines, Campbell diagram and Goodman diagram.	N	-	Y	Y
19.0	Bill of materials for piping and supports.	N	Y	-	Y
20.0	Bill of materials for insulation for piping.	N	Y	-	Y
21.0	Bill of quantity for painting for piping, equipments and auxiliaries.	N	Y	-	Y
22.0	Thermal calculation for heat exchangers, Mechanical calculation and fabrication drawings for heat exchangers and pressure vessels.	N	Y	-	Y
23.0	Instruction and Maintenance manual for erection & maintenance of turbine and its accessories (important clearances to be maintained should be clearly specified.).	N	-	-	Y
24.0	Cross sectional drawings of the Barring gear.	N	-	Y	Y
25.0	Lubrication schedule	N	-	-	Y

26.0	Inspection and Test Procedure.	N	-	-	Y
27.0	Quality Assurance Plan.	N	Y	-	Y
28.0	Inspection and test reports, material test certificates, radiographic reports duly approved by specified inspecting authority.	N	-	-	Y
29.0	Reference list for Turbines supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning.	Y	-	-	-
30.0	Spare parts recommendations and price list	Y	-	-	Y
31.0	Parts catalogue complete with reference drawing nos. and sketches etc.	N	-	-	Y

F.	FANS & BLOWERS				
1.0	Specification sheets completely filled in proforma.	N	Y	-	Y
2.0	Characteristic Curves - Performance curves, showing discharge pressure, capacity, and brake horse power at the inlet specified conditions (Pressure, capacity, temperature, molecular weight).	N	Y	-	Y
3.0	Spare parts list	Y	-	-	Y
4.0	Details of Lubrication and sealing system	N	-	-	Y
5.0	Data for selection of motor :	N	Y	-	Y
	a) Type				
	b) HP absorbed at duty point				
	c) RPM				
	d) Recommended HP				
	e) Max. starting torque as % NRT				
	f) GD^2 figure for rotating mass of the Fan / Blower				
	g) Speed vs. Torque for the Fan / Blower				
6.0	General Arrangement Drawing with all main dimensions, size and location of connections for ducting with all horizontal & vertical clearance necessary for installation and disassembly.	N	Y	-	Y
7.0	Cross sectional drawing of fan with parts list	N	Y	-	Y

8.0	Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).	N	-	-	Y
9.0	Q.A.P and Test procedure	N	Y	-	Y
10.0	Lubrication schedule	N	-	-	Y
11.0	Reference list indicating duty condition, location, year of installation, name of client etc.	Y	-	-	-
12.0	GA drawing with all details & dims. Including fan, drive, motor	Y	Y	-	Y
13.0	Description of capacity control with details	Y	-	-	Y

G	**AGITATORS**				
1.0	Specification sheets completely filled in PDIL proforma.	N	Y		Y
2.0	General Arrangement Drawing with all main dimensions, size and location of connections for installation and disassembly.	N	Y		Y
3.0	Spare parts list	Y	Y		Y
4.0	Details of Lubrication and sealing system	N	-	-	Y
5.0	Instruction manual for erection, installation operation and maintenance of fan and its accessories (Important clearances to be maintained should be clearly specified).	N	-	-	Y
6.0	Reference list indicating duty condition, location, year of installation, name of client etc.	Y	Y	-	Y
H	**EOT Crane**				
1	Data sheets – completely filled		Y		Y
2	Information to be supplied by manufacturer / Vendor		Y		Y
3	General arrangement Drg. showing various details & all principal dimensions of the assembled unit, horizontals and vertical clearances and approaches.		Y		Y
4	List of spare parts with individual part Nos. and prices.		Y		Y
5	Descriptive literature / catalogue		Y		Y
6	Detailed manufacturing programme Time-Bar Chart.		Y		Y
7	Individual structural drgs. For main girders and End-carriages.		Y		Y
8	Mechanical calculations (Brakes, Gear boxes, gears, pinions coupling, Bearing, Rope-drum, Wire-rope etc.		Y		Y
9	Civil load data drawing, Cross-sectional detailed drawings of sub-assemblies part nos., materials of construction and heat treatment details wherever applicable :		Y		Y

10	a) General Assembly Drg. Showing the complete mechanical details.		Y		Y
11	Crane rail & end stops fixing arrangement.		Y		Y
12	Material test certificates (including the originals) of load bearing parts e.g.		Y		Y
13	Crane rail & end stops fixing arrangement.		Y		Y
14	Material test certificates (including the originals) of load bearing parts e.g.		Y		Y
15	Test certificates of motors (including the originals)		Y		Y
16	Certificates of No load, load, over load defection Test duly witnessed by the Inspector		Y		Y
17	Operation & Maintenance Manual (including the lubrication schedule also.)		Y		Y
18	Drg. Showing the supporting arrangement of flexible cable with main bridge and trolley.		Y		Y
I	**HVAC System**				
1	List of drawings / documents including drawing number, revision number and Description & approval status.		Y		Y
2	Specification sheets - Completely filled in agreed proforma.		Y		Y
3	General Assembly drawings - with main overall dimensions including those required for accessories and auxiliaries and all horizontal & vertical clearances for dismantling, direction of rotation etc.		Y		Y
4	List of spares for 2 years normal maintenance in PDIL proforma.		Y		Y
5	Description of Lubrication and sealing system (if any).		Y		Y
6	Manufacturing schedule.		Y		Y
7	Cross-Sectional drawing of AC Plant and auxiliaries alongwith Bill of Materials.		Y		Y
8	Parts catalogue complete with reference drawing numbers & sketches etc.		Y		Y

9	Instruction manuals for erection, installation, operation and maintenance of AC Plant and accessories.		Y		Y
10	Material test certificates and Inspection & performance test report alongwith despatch clearance certificates from inspector.		Y		Y
11	Reference list for similar types of AC Plant supplied in past for similar duty conditions. Reference list shall contain complete address of user, user's purchase order number, brief specifications and date of commissioning along with operating conditions..		Y		Y
12	Lube oil schedule, if any.		Y		Y
13	Drivers specification and Drg.		Y		Y

Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved / As-built
J	**ELECTRICAL**				
1.0	Load List indicating rated and absorbed power of loads and duty type (Continuous / Standby / Intermittent) at different voltages including emergency loads.	Y	-	Y	Y
2.0	Load Data indicating normal, peak, starting and construction power requirement at various voltage levels.	Y	-	Y	Y
3.0	Single line distribution diagram (power, lighting, DC supply and UPS supply) including protection and metering details.	Y	Y	-	Y
4.0	Specification of all Electrical Equipment	Y	Y	-	Y
5.0	Filled in Specification Sheets and Technical Particulars of all equipment.	Y	Y	-	Y
6.0	General arrangement and foundation drawings of all equipment.	N	-	Y	Y
7.0	Equipment layout in Sub Station, MCC room, and plant area showing location of all electrical equipment.	N	Y	-	Y
8.0	Cable schedule.	N	-	Y	Y
9.0	Cable rack / trench / pipe layout.	N	-	Y	Y
10.0	Power Layout	N	-	Y	Y
11.0	Schematic diagram for all control panel & switch boards.	N	-	Y	Y

Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved / As-built
12.0	Feeder Details of all switch boards	N	Y	-	Y
13.0	Interconnection & Terminal connection diagram	N	-	Y	Y
14.0	List of controls, interlocks, indication & metering at various locations for all drives.	N	-	Y	Y
15.0	Characteristic curves for motor/ relays etc.	N	-	-	Y
16.0	Design calculations (for equipment sizing, earthing, lighting, cables, bus ducts etc.)	N	Y	-	Y
17.0	Earthing and lightning protection layout	N	-	Y	Y
18.0	Lighting layout	N	-	Y	Y
19.0	Catalogues for all bought out items	N	-	-	Y
20.0	Bill of Materials covering all electrical equipment and installation materials	N	-	-	Y
21.0	Installation operation and maintenance (Manual)	N	-	-	Y
22.0	Relay settings	N	-	Y	Y
23.0	Spare Parts list	Y	-	Y	Y
24.0	Test Certificates	N	**	-	Y
25.0	Guarantee Certificates	N	**	-	Y
26.0	Quality Assurance Plan & Formats	N	**	-	Y
27.0	Hazardous area Classification Drawing	Y	Y	-	Y

Sl. No.	Description	With Bid (Y/N)	For Review/ Approval	For Information	Final/ Approved / As-built
28.0	Erection Drawings & Details	N	Y	-	Y
29.0	Construction & Commissioning specification and procedure for all equipment.	N	-	Y	Y
30.0	Native files (in excel, AutoCAD, ETAP etc.) of Drgs., Docs., Calculations & Electrical System Study Reports.	N	Y	Y	Y

SECTION 18

SPARE PARTS

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY

PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD
1	16.02.2021	16.02.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
0	21.01.2021	21.01.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
P	25.11.2020	25.11.2020	PRELIMINARY	AK/PT/HK	RKS	RKS/MN

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SL. NO.	DESCRIPTION
1.0	Spare Parts For Commissioning
2.0	2 Years Operation & Maintenance Spares
3.0	Mandatory Spare Parts
3.1	Centrifugal / Rotary Compressor
3.2	Screw Compressor
3.3	Centrifugal Fan
3.4	Steam Turbine
3.5	Centrifugal Pump
3.6	Reciprocating Pump
3.7	Metering Pump
3.8	Agitator
3.9	EOT Cranes
3.10	Static Equipments
3.11	Electrical Items
3.12	Instrumentation Items
3.13	Piping
3.14	Fire Fighting
4.0	Vendor recommended spare parts

1.0 SPARES PARTS FOR COMMISSIONING:

1.1 LSTK Contractor shall supply free of cost all spares and consumables covering pre-commissioning, commissioning ,testing,PGTR and till handing over of the Steam Generation Plant .

1.2 Supply of Mandatory Spares/Insurance spares for Electrical/Mechanical/Instrumentations and other plant machinery shall be under LSTK Scope.

1.3 Supply of spares and consumables post handing over of the plant shall be under Owner's scope.

1.4 LSTK Contractor shall submit/provide recommended 2 years O&M spares (other than Mandatory spares) list with budgetary offers valid for 2 years from the date of submission of offer for TFL /Owners consideration.

2.0 2 YEARS OPERATION & MAINTENANCE SPARES:

Bidders will be requested to quote for their recommended two years' operation and maintenance spares with 2 years validity but the same will not be considered for price evaluation. These will be selected and ordered by RCF separately as and when required.

Notes:

1) Set means complete replacement of particular part in one machine/equipment/Fired heater etc.
2) Item wise price for 2 years operation & maintenance spares against each item shall be furnished.
3) Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"
4) Wherever "% qty." is specified, Bidder to quote in next higher rounded figure.
5) Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.
6) Any other spare parts required, but not specified, shall also be offered.

3.0 MANDATORY / INSURANCE SPARE PARTS

LSTK Contractor shall supply mandatory spare parts of the plant as detailed below.

a) Centrifugal / Axial / Rotary Compressor
b) Screw Compressor
c) Centrifugal Fan

d) Steam Turbine
e) Centrifugal Pump
f) Reciprocating Pump
g) Metering Pump
h) Agitator
i) EOT cranes
j) Static Equipments
k) Electrical items
l) Instrument items
m) Piping

3.1 Centrifugal Compressor (for air / HVAC services, if applicable)

The mandatory spares to be supplied for each working train /unit shall be as under .
No spares considered for standby unit.

S. No.	DESCRIPTION	QUANTITY
1.0	COMPRESSOR	
1.1	**Completely assembled dynamically balanced spare rotor including clearance check and mechanical run test**	**1 set**
1.2	**Complete spare coupling including distance piece and set of coupling bolts & nuts**	**1 set**
1.3	**Complete set of bearing (each type)**	**2 sets**
1.4	**Complete Set of Seals/ Mechanical seals for process media (each type)**	**2 set**
1.5	**Complete Set of oil seals**	**200%**
1.6	**Complete Set of 'O' rings, gaskets, sealing rings, Oil seals for compressor each type**	**200%**
2.0	GEAR BOX	

S. No.	DESCRIPTION	QUANTITY
2.1	**Complete set of bearing each type**	**2 sets**
2.2	**Set of spare wheels with shaft**	**1 set**
2.3	**Oil seals, gaskets**	**200%**
3.0	COOLERS (Inter cooler / after cooler spares)	
3.1	**Tubes for cooler**	**1 set of total tubes bundle**
3.2	**Gaskets/ end gaskets, O-rings for coolers & press. Vessels**	**200 %**
3.3	**Tube Plugs**	**5% of tube holes**
4.0	LUBE OIL SYSTEM	
4.1	**Complete set of Lube Oil Pumps with drive**	**1 set**
4.2	**Spares for lube oil pump :**	
	a) Set of bearings	**1 set**
	b) Set of seal	**200 %**
4.3	**Lube oil filter cartridges**	**4 sets**
4.4	**Set of Couplings**	**2 Set**
5.0	ACCESSORIES	**1 set**
5.1	**Spare permanent filters in gas/ air line**	**2 sets**
6.0	INSTRUMENTATION	
	As per Instrumentation specification enclosed with enquiry / order specification.	

3.2 Screw Compressor (for air / HVAC services, if applicable)

The mandatory spares to be supplied for each working train /unit shall be as under. No spares considered for standby unit

S. No.	DESCRIPTION	QUANTITY
1.0	COMPRESSOR	
1.1	**Completely assembled dynamically balanced spare rotor including clearance check and mechanical run test**	**1 set**
1.2	**Complete spare coupling including distance piece and set of coupling bolts & nuts**	**1 set**
1.3	**Complete Set of Bearings each type**	**2 set**
1.4	**Mechanical seal**	**1 set**
1.5	**Set of 'O' rings, gaskets, Oil seals sealing rings etc.for compressor**	**200 %**
2.0	OIL SYSTEM	
2.1	**Complete set of Lube Oil Pumps with drive as applicable**	**1 set**
2.2	**Spares for lube oil pump :**	
	a) Set of bearings	**1 set**
	b) Set of seal	**200 %**
2.3	**Lube oil filter cartridges**	**4 sets**
2.4	**Set of Couplings**	**2 Set**
3.0	GEAR BOX	
3.1	**Complete set of bearing each type**	**2 sets**
3.2	**Set of spare wheels with shaft**	**1 set**
3.3	**Oil seals, gaskets**	**200%**

S. No.	DESCRIPTION	QUANTITY
4.0	ACCESSORIES	
4.1	**Spare permanent filters in gas/ air line**	**2 sets**
5.0	INSTRUMENTATION	
	As per Instrumentation specification	

3.3 Centrifugal Fan (FD / ID Fan)

The mandatory spares to be supplied for each working train /unit shall be as under. No spares considered for standby unit

S. No.	DESCRIPTION	QUANTITY
1.0	**Completely dynamically balanced rotor assembly including impeller, wheel, key etc.**	**1 Set**
2.0	**Shaft sleeve**	**1 Set**
3.0	**Bearings**	**2 Set**
4.0	**Stuffing box packing rings sets (DE/ NDE)**	**200 %**
5.0	**Complete set of all Gasket & 'O' rings**	**200 %**
6.0	**Complete mechanical seal , if applicable**	**1 set**
8.0	**Coupling bushes**	**2 Set**
9.0	**Complete coupling with elements**	**1 Set.**
10.0	**All type of Fasteners**	**200%**

3.4 Steam Turbine

The mandatory spares to be supplied for each working train /unit shall be as under. No spares considered for standby unit

S. No.	DESCRIPTION	QUANTITY
1.0	Turbine	
1.1	**Completely assembled dynamically balanced rotor**	**1 set**
1.2	**Discharge assembly**	**1 set**
1.3	**Inlet nozzles**	**1 set**
1.3	**Complete set of Journal bearing with internals**	**1 set**
1.4	**Complete set of Journal bearing Pads**	**2 set**
1.5	**Complete set of Thrust bearing with internals**	**1 set**
1.6	**Complete set of Thrust bearing Pads**	**2 set**
1.8	**Shaft seal carbon labyrinth**	**2 sets**
1.9	**Labyrinth seal**	**2 sets**
1.10	**Complete coupling (turbine & gear box)**	**1 set**
1.11.1	**Coupling bolts, nuts& washer**	**200 %**
1.11.2	**Coupling shims**	**1 set**
1.11.3	**Rubber bush for coupling**	**1 set**
1.12	**Governor assembly**	**1 set**
1.13	**Control valve & servo spares**	**1 set**
1.14	**Emergency stop valve spare / pilot valve spare**	**1 set**
1.15	**Over speed trip spare**	**1 set**
1.16	**Thrust collar assembly**	**1 set**
1.20	**Complete set of all type Oil seals, o-rings & gaskets**	**200 %**
1.21	**All type of Fasteners**	**200%**
1.22	**Inner Casing**	**1 set**

S. No.	DESCRIPTION	QUANTITY
1.23	**Guide blade carriers**	**1 set**
2.0	Gear Box Spares	
2.1	**Pinion & gears**	**1 set**
2.2	**Bearings**	**1 set**
2.3	**Shaft seal**	**2 sets**
2.4	**'O' ring, gaskets , Oil seals**	**200 %**
3.0	Lube Oil System	
3.1	**Complete set of Lube Oil Pumps (MOP/AOP/EOP) including jacking oil pumps with their drives :**	**1 set**
3.5	**Mech. seal complete**	**1 set**
3.6	**Spare for mech. seal**	
3.6.1	**'O' ring , gaskets**	**200 %**
3.6.2	**Stationary ring & rotating ring**	**1 set**
3.7	**Complete coupling**	**2set**
3.7.1	**Coupling bolts, nuts & washer**	**200 %**
3.10	**Relief valve assembly**	**1 set**
3.11	**Plug & seat for relief valve**	**1 set**
3.12	**Spring & stem for PSV**	**1 set**
3.13.1	**Set of gaskets for each cooler**	**2 sets**
3.13.2	**Lube oil filter cartridges**	**3 sets**
3.13.3	**Relief valve**	**1 set**
3.13.4	**Safety valve plug seal**	**1 set**
3.13.5	**Spring & stem for safety valve**	**1 set**

3.5 Centrifugal Pump

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
1.	**Impeller**	**1 set**	**1 set**	**1 set**	**1 set**
2.	**Impeller locking nut**	**2 sets**	**2 sets**	**2 sets**	**2 sets**
3.	**Wear Rings**	**1 set**	**2 sets**	**3 sets**	**4 sets**
4.	**Shaft with keys**	**1 No.**	**1 No.**	**1 No.**	**1 No.**
5.	**Shaft Sleeve**	**1 set**	**2 sets**	**3 sets**	**4 sets**
6.	**Interstage sleeves**	**1 set**	**2 sets**	**3 sets**	**4 sets**
7.	**Interstage Bushes**	**1 set**	**2 sets**	**3 sets**	**4 sets**
8.	**Mech. Seal where applicable**	**1 no.**	**1 no.**	**2 nos.**	**2 nos.**
9.	**'O' Rings / Springs for Mech. Seal**	**2 set**	**2 sets**	**3 sets**	**4 sets**
10.	**Mechanical Seal Faces**	**1 set**	**2 sets**	**3 sets**	**4 sets**
11	**Constant level Oiler**	**2 sets**	**2 sets**	**2 sets**	**2 sets**
12	**Deflectors**	**2 sets**	**2 sets**	**3 sets**	**3 sets**
13	**Complete coupling**	**1 No.**	**1 No.**	**1 No.**	**1 No.**
14	**Flexible elements, Bushes, Pins for Coupling**	**1 set**	**1 set**	**2 sets**	**2 sets**
15	**All type of Bearings**	**1 set**	**2 sets**	**2 sets**	**2 sets**
16	**Gaskets & 'O' Rings**	**2 sets**	**3 sets**	**4 sets**	**6 sets**
17	**Labyrinths**	**2 sets**	**3 sets**	**4 sets**	**5 sets**
18	**Throat Bushing**	**1 No.**	**2 Nos.**	**3 Nos.**	**4 Nos.**

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
19	**Throttle Bushing**	**1 No.**	**2 Nos.**	**3 Nos.**	**4 Nos.**
20	**Oil Seals**	**2 sets**	**3 sets**	**4 sets**	**6 sets**
21	**Balancing drum & sleeves**	**1 set**	**1 set**	**2 sets**	**2 sets**
22	**Leak-off valve-gaskets, 'O' Rings and springs**	**2 sets**	**3 sets**	**4 sets**	**5 sets**
23	**Spares for gear box (bearings, gears and seals)**	**1 set**	**1 set**	**1 set**	**1 set**
24	**All type of Bearings and Oil filter elements for variable hydraulic Turbo coupling (if applicable).**	**1 set**	**2 sets**	**2 sets**	**2 sets**
25	**All type of Fasteners**	**200%**	**200%**	**200%**	**200%**

3.6 Reciprocating Pump

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
A	MAIN FRAME				
1.	**Main Bearings**	**1 set**	**1 set**	**1 set**	**1 set**
2.	**Big End Bearings**	**1 set**	**1 set**	**1 set**	**1 set**
3.	**Thrust Bearings**	**1 set**	**1 set**	**2 sets**	**2 sets**
4.	**Crosshead shoes**	**1 set**	**1 set**	**1 set**	**1 set**

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
5.	**Crosshead bushes**	**1 set**	**1 set**	**1 set**	**1 set**
6.	**Connecting rod bolts complete with nuts**	**4 Nos.**	**4 Nos.**	**6 Nos.**	**6 Nos.**
7.	**Crank shaft**	**1 No.**	**1 No.**	**1 No.**	**1 No.**
8.	**Lube oil pump (w/o motor)**	**1 No.**	**1 No.**	**1 No.**	**1 No.**
9.	**Spare parts for lube oil pump (set of gears, bushes, gaskets etc.)**	**1 set**	**1 set**	**2 sets**	**2 sets**
10.	**Cartridge for oil filter.**	**2 Nos.**	**2 Nos.**	**4 Nos.**	**4 Nos.**
11.	**Special gaskets, oil seals, 'O' rings, special bolts etc.**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
12	**Complete set of coupling with fasteners**	**1 set**	**1 set**	**1 set**	**1 set**
B	FLUID END				
1.	**Cylinders**	**1 No.**	**1 No.**	**2 Nos.**	**2 Nos.**
2.	**Plungers / piston & piston rod assembly, piston rings (if applicable)**	**1 set**	**1 set**	**1 set**	**1 set**
3.	**Stuffing box Packings**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
4.	**Plunger Packings**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
5.	**Suction valve & seat**	**1 set**	**2 sets**	**3 sets**	**4 sets**
6.	**Discharge valve & seat**	**1 set**	**2 sets**	**3 sets**	**4 sets**
7.	**Flushing pump (if applicable)**	**1 No.**	**1 No.**	**1 No.**	**1 No.**
8.	**Spares for flushing pump.**	**1 set**	**1 set**	**2 sets**	**2 sets**
	- Plunger **- Plunger Packings**				

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
	- Valves **- Gaskets**				
9.	**Special gaskets, springs, 'O' rings, and ring nuts for stuffing box packing, cylinder bolts.**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
C	GEAR REDUCER (IF APPLICABLE)				
1.	**Oil seals**	**2 set**	**1 set**	**2 sets**	**2 sets**
2.	**Lube oil pump**	**1 No.**	**1 No.**	**1 No.**	**1 No.**
3.	**Spare parts for lube oil pump-gears, bushes, gaskets etc**	**1 set**	**1 set**	**2 sets**	**2 sets**
D	LUBE OIL COOLERS (IF APPLICABLE)				
1.	**Complete Set of gaskets, o-rings if any**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
2.	**Set of tube bundles**	**100%**	**200%**	**300%**	**400%**

3.7 Metering Pump

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
A	POWER END				
1.	**Main Bearings**	**1 set**	**1 set**	**1 set**	**1 set**

S. No.	DESCRIPTION	QUANTITY			
		No. of Pumps working			
		1	2	3	4
2.	**Big End Bearings**	**1 set**	**1 set**	**1 set**	**1 set**
3.	**Crosshead shoes**	**1 set**	**1 set**	**1 set**	**1 set**
4.	**Crosshead bushes**	**1 set**	**1 set**	**1 set**	**1 set**
5.	**Connecting rod bolts complete with nuts**	**200%**	**200%**	**400%**	**400%**
6.	**Special gaskets, oil seals, 'O' rings , special bolts etc.**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
7.	**Complete set of coupling with fasteners**	**1 set**	**1 set**	**1 set**	**1 set**
B	FLUID END				
1.	**Cylinders**	**1 No.**	**1 No.**	**2 Nos.**	**2 Nos.**
2.	**Plungers**	**1 set**	**1 set**	**1 set**	**1 set**
3.	**Diaphragm**	**1 set**	**2 sets**	**3 sets**	**4 sets**
4.	**Stuffing box Packings**	**2 sets**	**2 sets**	**4 sets**	**4 sets**
5.	Suction valves & seats	**1 set**	**2 sets**	**3 sets**	**4 sets**
6.	Discharge valves & seats	**1 set**	**2 sets**	**3 sets**	**4 sets**
7.	All gaskets , springs , 'O' rings , ring nuts for stuffing box packing , cylinder bolts	**200%**	**200%**	**200%**	**200%**

3.8 Agitator :

Sl. No.	DESCRIPTION	Quantity
		No. of Agitator working

		1	2	3	4
1.	**Complete set of all Bearings**	**1 set**	**1 set**	**2 set**	**2 set**
2.	**Complete set of impeller blades of each type with set of fasteners.**	**1 set**	**1 set**	**2 set**	**2 set**
3.	**Complete set of High speed flexible coupling with bushes / elements.**	**1 set**	**1 set**	**1 set**	**1 set**
4.	**High speed Coupling bushes**	**3 sets**	**3 sets**	**4 Sets**	**4 Sets**
5.	**Complete set of Low speed flexible coupling with bushes / elements.**	**1 set**	**1 set**	**1 set**	**1 set**
6.	**Low speed Coupling bushes**	**3 sets**	**3 sets**	**4 Sets**	**4 Sets**
7.	**Complete set of all Oil seal for gear box**	**1 set**	**1 set**	**1 set**	**1 set**
8.	**Complete set of all Oil seal for bearing housing**	**4 set**	**4 set**	**6 set**	**6 set**
9.	**Complete set of Seal packing.**	**2 sets**	**2 sets**	**4 sets**	**4 sets**

3.9 EOT Cranes :

Sl. No.	DESCRIPTION	QUANTITY
1.	**Wire rope for main hoist**	**1 set**
2.	**Wire rope for Auxiliary hoist**	**1 set**
3.	**Rope guide for main Hoist**	**1 set**
4.	**Rope guide for Auxiliary Hoist**	**1 set**
5.	Brake linings of each type	**2 sets**
6.	Gear sets	**2 sets**

7.	All type of Bearings	**2 sets**
8.	**All type of Seal, Gaskets , O-rings**	**2 sets**

3.10 STATIC EQUIPMENT:

Sl.No	Spare Items	Quantities
1.0	**Pressure Vessel**	
1.1	Gaskets for each nozzle with blind flange	200 %
1.2	Gaskets for girth flange.	200 %
1.3	Bolting for each nozzle with blind/girth flange	10 % (Minimum 2 numbers) for each nozzles/girth flange
1.4	Bolting for internal flange	10 % (Minimum 2 numbers)
1.5	Gasket for internal flange	200 %
1.6	Spare for internals Clamps Washer Stud & bolt	 2 % excess, min. 5 piece 20 % excess, min. 3 piece 10%(Minimum 2 numbers)
1.7	Sight/light glass assembly complete with bolting and gasket	300% of each installed glass
1.8	Filter Cartridge/Elements	200%
2.0	**Tanks**	
2.1	Gaskets for each nozzle with blind flange	200 %
2.2	Gaskets for girth flange.	200 %
2.2	Bolting for each nozzle with blind/Girth flange	10 % (Minimum 2 numbers) for each nozzles/Girth flange
3.0	**Heat Exchangers – Shell & Tube type**	
3.1	Bolting for each nozzle with blind/Girth flange	10 % (Minimum 2 numbers) for each nozzles/Girth flange
3.2	Gaskets for each nozzle with blind flange	200 %
3.3	Gaskets for girth flange.	200%
3.4	Tube Plug	5 % of tube holes
4.0	**Plate type Exchanger**	
4.1	Plate gasket	**10 %**
4.2	Flow plate	**10 %**
4.3	Nozzle gasket	**200 %**

4.4	Glue (1 kg pot)	**1**
4.5	Special spanner tool	**1 for each size/ type**

3.11 Electrical Items:

Sl. No.	Item	Quantity
1.0	**DG Set**	
A.	**Ring of various types &sizes**	**2 Sets**
B.	**Bearing of various types &sizes**	**2 Sets**
C.	**Gaskets of various types &sizes**	**2 Sets**
D.	**Lube oil filter, air filters etc.**	**2 sets each**
E.	**Solenoids of various types &sizes**	**2 Nos.**
F.	**Electrical actuator of various types &sizes**	**2 Nos.**
G.	**Circuit breaker arcing & fixed contact assembly**	**3 Nos.**
H.	**Excitations system diodes**	**2 Sets**
I.	**Fuses of all ratings**	**3 Nos.**
J.	**Any other spare part not covered but required**	**2 Nos.**
K.	**AVR Protection relays**	**2 Nos.**
L.	**Instrumentation items like pressure/temp switches, gauges etc.**	**2 Nos. each**
2.0	**HV & LV Switchgear (including Distribution Boards) of each type and rating per substation**	
1.1	**Spares for HV & LV circuit breakers (of each rating)**	
A.	**Complete CB (ready to use) along with fixed &**	**1 for each rating**

Sl. No.	Item	Quantity
	draw out contacts	
B.	Main contact sets/Jaw contact complete	2 sets for each rating
C.	Fixed Arcing contact Assembly	2 sets for each rating
D.	Moving Arcing contact Assembly	2 sets for each rating
E.	Trip coils	3 sets for each rating
F.	Closing coils	3 sets for each rating
G.	Spring charging motors	2 sets for each rating
H.	Arc chute Assembly	1 for each rating
I.	Vacuum Bottle (of each type)	2 nos.
J.	O ring / Gasket	2 sets
K.	Limit switches complete	2 sets
L.	Auxiliary Contactors (of each type)	2 nos.
1.2	Contactors	
A.	Power contactors (of each type)	2 Nos.
B.	Auxiliary contactors (of each type)	4 Nos.
C.	Coils for contactors (of each type/voltage)	4 Nos.
1.3	Fuse Switch Units (of each type)	2 Nos.
1.4	Thermal Overload Relay (of each type)	2 Nos.
1.5	Push Button (of each type)	3 Nos.
1.6	Instrument Transformers	
A.	Current Transformer (of each rating)	3 Nos.
B.	Voltage Transformer (of each rating)	3 Nos.

Sl. No.	Item	Quantity
1.7	Control Transformers (of each rating)	2 Nos.
1.8	Meters	
A.	Ammeter, Voltmeter (of each range)	2 Nos.
B.	Multifunction Meters (of each type)	2 Nos.
1.9	Fuses (of each type)	
A.	Fuse Link	2 Nos.
B.	Fuse Assembly	2 Nos.
1.10	Indicating Lamps Assembly Complete	10 Nos. each colour & voltage
1.11	Control Switches	
A.	Ammeter Selector Switch	2 Nos.
B.	Voltmeter Selector Switch	2 Nos.
C.	Trip-Neutral-Close Control Switch	2 Nos.
D.	Local-Remote Selector Switch	2 Nos.
1.12	MCB's of each rating	3 Nos.
1.13	Protective Relays	
A.	Microprocessor based relay of each type	1 No.
B.	Electromechanical Relays of each type (Lockout relay, Trip Circuit supervision and any other electromechanical relay used)	2 Nos.
C.	Auxiliary Contact multiplication relay	10 Nos.
D.	Timers - each type/range/voltage	3 Nos.

Sl. No.	Item	Quantity
1.14	**Miscellaneous**	
A.	**Alarm bell**	2 Nos.
B.	**Alarm Buzzer**	**2 Nos.**
3.0	Power & Distribution Transformer (of each type & rating) per substation	
A.	Bushing with accessories for High voltage grade	2 Sets
B.	Bushing with accessories for Low voltage grade	2 Sets
C.	Dial Type Thermometer	2 Nos.
D.	Oil Level Gauge	**2 Nos.**
E.	Explosion vent Diaphragm / Pressure Release Device	**2 Nos.**
F.	Complete set of Silica Gel Breather	**2 Nos.**
G.	Complete set of Gaskets	2 Sets
H.	Buchholz Relay	2 Nos.
I.	Miscellaneous spares (control switches, fuses lamps) for Marshalling Box	2 Sets
J.	Transformer mounted CTs	2 Sets
4.0	Auxiliary Service Transformer (of each type & rating) per substation	
A.	Bushing with accessories for all voltage grades	2 Sets
B.	Complete set of Gaskets	2 Sets
C.	Oil Level Gauge (for oil cooled transformer only)	**2 Nos.**
D.	Complete set of Silica Gel Breather (for oil cooled transformer only)	**2 Nos.**
E.	Gland packing / O-ring for every valve (for	**2 Nos.**

Sl. No.	Item	Quantity
	oil cooled transformer only)	
5.0	**Bus ducts (of each type & rating) per substation**	
A.	Bus support insulator	4 set
B.	Flexible connector (for Switchgear end connection)	1 set
C.	Flexible connector (for Transformer end connection)	1 set
D.	Gasket	2 Sets
6.0	**HV Motor (of each type & rating)**	
A.	Bearings (Driving end) with bearing housing (complete)	1 set
B.	Bearings (Non driving end) with bearing housing (complete)	1 set
C.	Cooling fan	1 No.
D.	Space heater	2 Nos.
E.	Terminal box	1 No.
F.	Dial Type thermometer	2 sets
G.	Grease nipple & Plug	2 Nos.
7.0	**LV Motor (of each type & rating)**	
A.	Bearings (Driving end)	1 set
B.	Bearings (Non driving end)	1 set
C.	Cooling fan	1 No.
D.	Space heater	2 Nos.
E.	Terminal box	1 No.
F.	Grease nipple & Plug	2 Nos.
G.	Cooling fan cover	1 No.

Sl. No.	Item	Quantity
8.0	Battery (of each type & rating) per substation	
A.	**Vent plugs**	**6 Nos.**
B.	**Inter cell connectors**	**6 Nos.**
C.	**Set of nuts, bolts and washers**	**12 Nos.**
9.0	Battery Charger (of each type & rating) per substation	
A.	**Controller card of each type**	**2 Nos.**
B.	**Power Devices of each type**	**2 Nos.**
C.	**Fuses of each type and rating**	**2 Nos.**
D.	**Batteries**	**5% (rounded off to next higher digit)**
10.0	**Lighting Fixtures (of each type & rating)**	
A.	Lighting fixtures (along with control gear)	10% of the total no. of fixtures (rounded off to next higher digit with minimum 5 Nos. of each type).
B.	Lamp holder of each type	5 Nos. of each rating & type
C.	Terminal block of each type	**5 Nos.**
D.	Heat resistance toughened glass cover of each type	**5 Nos.**
11.0	**Local Control Station (of each type & rating)**	
A.	Ammeters of different ranges	**20% (rounded off to next higher digit)**
B.	Terminal block	**20% (rounded off to next higher digit)**
C.	Indicating Lamps of different type	**20% (rounded off to next higher digit)**

Sl. No.	Item	Quantity
12.0	**Variable Frequency Drives (of each type & rating)**	
A.	Controller Card of each type	1 No.
B.	**Power Devices of each type**	**2 Nos.**
C.	Fuses of each types & rating	2 sets
13.0	**Capacitor Bank (of each type & rating) per substation**	
A.	Capacitor of each rating	3 Nos.
B.	Fuses (if used) of each rating	5 Nos.
C.	Contactor of each rating	2 Nos.
D.	PF controller card/unit of each type	2 Nos.
14.0	**Cathodic Protection System**	
A.	Anode of each type & rating	2 Nos.
B.	Transformer/rectifier unit (complete) of each type & rating	1 No.
C.	Half cells	5 Nos.
15.0	UPS (of each type & rating) per substation	
A.	**Fuses of each type**	**30% (rounded off to next higher digit)**
B.	**Control Cards of each type**	**2 Nos.**
C.	**Batteries**	**5% (rounded off to next higher digit)**
D.	**Ventilation Fan**	**2 Nos.**
16.0	**Neutral Grounding System (of each type & rating) per substation**	
A.	**Support insulators**	**4 Nos.**

Sl. No.	Item	Quantity
B.	Bushing insulators	2 Nos.
C.	Interposing insulators	2 Nos.
D.	Resistor Element	20% (rounded off to next higher digit)

Note:

7) The above spares do not include commissioning spares and shall be purely warehouse spares.
8) Set means complete replacement of particular part in one machine.
9) **Item wise unit price against each item shall be furnished.**
10) **Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"**

3.12 Instrumentation Items:

1) **Set means complete replacement of particular part in one machine.**
2) **Wherever "Each Type" is specified, it means "of the Type/make/model/size/rating and exactly replaceable"**
3) **Wherever "% qty." is specified, Bidder to quote in next higher rounded figure**
4) **Out of % age spares and minimum qty specified against each item - higher of the two shall be supplied.**
5) **Any other instruments which are not covered and is applicable for AN melt plant.spares quantity shall be minimum 10% or 1 number each type.This type of instruments list shall be shared to owner/PMC prior to placement of order**

Sl. No.	DESCRIPTION	QUANTITY

1.0	Field instruments	
	Pressure Gauges, Differential Pressure Gauge, Draft Gauges, Field Indicators, RTD/T/C with Thermowells, welded thermowell, Skin Thermocuple Sets, Speed Probes with Cables and Fixing Screws and Bolts, Vibration Probes, with Cables (including extension cable) and Fixing Screws and Bolts, Speed Transmitter with Cables and Fixing Screws and Bolts, Proximeters of diff. model and Fixing Screws and Bolts, Gas Sensors with Cables and Fixing Screws and Bolts	**10% of each type of instruments, subject to minimum 2 nos. of each type**
	Pressure Switches, DP Switches, Purge Rotameters	**10% of each type of instruments, subject to minimum 2 nos of each type**
	Special thermocouples/multipoint thermocouples,	**10% of each length subject to minimum 1 number of each type.**
	Transmitters for Flow, Pressure, Temperature, Level, Diff. Pressure application, Remote Seal Transmitter, Transmitter for LEL/GAS Detector System including Sensors .	**10% of each type of instruments, subject to minimum 2 nos of each type**
	Mass flow meter & Mag Flow meter	**A) Power fuses 6 nos per set** **B) Sensor assembly-10% min 1 no** **C) 10% or minimum one number complete electronic head unit**
	Vortex Flow Meter	**A) One sensing probe ,one set of gasket and Packing for each type and Size** **B) 10% or minimum one number complete electronic head unit**
	Ultrasonic Flow meter	**A) 1 pair probe for each instrument**

		B) 1 number electronic card of each type **C) 2 numbers fuses of all Types.**
	Variable Area Flow meter (Rota meters)	**10% or minimum one no. float & set of Packing for each type, size, rating and material**
	Glass tube Rotameters	**20% or min 2 Nos of glass tubes of each size/rating /make.**
	Averaging Pitot Tube	**Set of Gasket, O-ring, Packing for Retract Mechanism and one no. Needle Valve with each Pitot Tube.**
	Flame scanners and optical pyrometer **a) Electronics** **b) Detectors / sensors or spares with limited life**	**a)10% subject to minimum 1 No. of each type.** **b)As required for 1 year operation or 1 set minimum**
2.0	**Displacer type Level Transmitters**	**A) 10% of each type of instruments head with Torque Tube Assembly and Transmitter, subject to minimum 2 nos of each type. 1 No of float of each type.** **B) 10% Electronic cards and Display module – Minimum 1 no. of each type**
2.1a	**Ultrasonic / Guided Wave Radar Type – Level Instrument**	**A) 10% complete Instrument – Minimum 1 No. of each Type / Range / Material** **B) 10% Electronic – module / Cards /Display module – Minimum 1 no. of each type**

2.2	**Level gauge- Transparent / Reflex Type**	**20% subject to minimum 10 numbers of glass along with pair of Gaskets and glands sets for I/V valves of each type, size (Cushion & Wet Gaskets), whichever is higher.**
2.2.1	**Level Gauge- Magnetic Type**	**10% subject to minimum 1 set of Float, Magnet/ball follower-ring gaskets of each type.**
3.0	Control Valve, Shut Down, On-Off, Butterfly, Ball Valves, Gate Valves, Angle Valves, PCV, MOV Spares	
3.1	**Soft part / actuator spares, including actuator diaphragm, actuator seal kit and spring sets, for each type of actuator**	**10% of each type of instruments, subject to minimum 1 no. of each type**
3.2	**Trim Set**	**Trim set consisting of seat ring / seal ring, plug with stem, cage (wherever applicable), packing material for each make, type , size, presssure rating valve to be provided as spare**
3.3	**Complete Actuator with Hand Wheel assembly**	**one complete Actuator for each type and size**
3.4	**Complete Spare Control Valve for Antisurge Control Valve**	**One No. of each type.**
3.5	**Gland packing, O rings, Packing and Bonnet gasket, seat gasket**	**100 % for each valve. i.e. one set for each tag.**
3.6	**Greases and grease guns**	**5 sets of each type of grease and 1 grease gun of each type**
3.7	**Solenoid valves**	**10% of each type of instruments, subject to minimum 2 nos of each type**

3.8	**Proximity switches including enclosure**	**10% of each type of instruments, including enclosure- subject to minimum 2 nos of each type**
3.9	**SMART Positioners**	**10% of each type of instruments, subject to minimum 2 nos of each type**
3.11	**Other accessories: Quick Exhaust relay, Volume Boosters, Air Filter regulators, position Transmitters, change over relay, NRV, Pilot valves.**	**10% of each type of instruments, subject to minimum 3 nos of each type**
		b) Gaskets for valve and connections per unit (if such gaskets, are special and supplied by PRDS/De-Super heater vendor
3.12	**For PCV Repair kit consisting of (orifice, plug, spring, gasket, diaphragm, spring, O-ring for each valve.**	**20% or minimum 1 no. in each type**
3.13	**HHT loaded with latest HART software**	**1 no. minimum**
4.0	DCS, ESD, F&G PLC, Analyser PLC, Any other Control and PLC system.	
4.1	**CPU**	**10% or minimum 1 no. each type.**
4.1a	**Communication cards, Processor cards (Controller) ,FTA cards**	**2 nos of each type of cards.**
4.2	**System Pre-fab cables,** **I/O Card cables, communication bus cables.**	**10% or min. 5 sets of each type with all connectors, plugs,**
4.3	**Racks, Backplane units**	**2 Nos each type**
4.4	**Local Panel, Hardwire console & annunciator** **All items like Push buttons, indicators, hand switches lamps, relays selector switches, IS**	**10% or minimum 2 no. each type.**

	type indicators / Annunciators, holders etc. mounted in the local panel	
4.5	**HDD unit**	**2 set of each type (normal as well as Raid-5) with all connectors, plugs.**
4.6	**Various Keyboards (including operator keyboard) /mouse**	**2 nos. of keyboard each type and 5 Nos. of mouse.**
4.7	**Relays**	**5% of each type of relays, including relevant terminal modules/sockets minimum 5 nos of each type**
4.8	**Pushbuttons, Lamps, Selector switches**	**10% of each type , including relevant terminal modules/accessories as a complete set**
4.10	**All type of system/PDB/Marshalling cabinet /console filters**	**100%**
4.11	**All type of system/PDB/Marshalling cabinet/console fan**	**2 Nos of each type including relevant terminal modules/pre-fab system cables.**
4.12	**All type of system/PDB/Marshalling cabinet/console Tube light**	**2 Nos of each type.**
4.13	**All type of various PDBs Voltmeters**	**2 Nos of each type.**
4.14	**I/O Cards**	**20% of each type of card, including relevant terminal modules/pre-fab system cables, etc., subject to minimum of 5 nos. each**
4.15	**Various System Battery, Terminators**	**1 no. of each type**
4.16	**All system Fuses and various glass fuses**	**100% for imported fuses**
4.17	**All PDB fuses, like HRC, GSA Fuses**	**100% of total qty. of each type**

4.18	MCBs	5 Nos. of each type
4.19	Terminal Blocks	Spare Terminal Blocks along with DIN rail – 100 nos each type
4.20a	Cables for wiring inside Marshalling Racks of DCS of relevant size	100 mtr of each color and size
4.20b	Cables for wiring inside Marshalling Racks of ESD of relevant size	100 mtr of each color and size
4.21	24 V DC Bulk Power Supply modules	Min. 2 nos of each type
4.22	System DC Power supply for DCS	Min. 2 nos of each type
4.23	System DC Power supply for ESD	Min. 2 nos of each type
4.23 a	Diode-o ring modules	10% or minimum 1 no. each type.
4.24	Safety barriers, active isolators, signal convertors, trip amplifiers, signal multipliers	10% of each type of instruments, subject to minimum 5 nos of each type
4.25	Hubs, Bus units, Switches, Routers	20% or Min 1 nos of each type
4.26	OPC / Modbus interface Cards	1 No each along with connectors / cables
4.27	DCS operator and engineering subsystem	
	Communication card Operator Station communication bus	1 No.
	Communication card for Engineering Station communication bus	1 No.
	Motherboard for Operator Workstation	1 No. of each type or 10% whichever is higher
	Motherboard for Engineering Workstation	1 No. . of each type or 10% whichever is higher
	SMPS	2 Nos. . of each type or 10%

		whichever is higher
4.28	**PLC operator and engineering subsystem**	
	Communication card for PLC programming Station communication bus	**1 No.**
	Communication card for PLC SOE Station communication bus	**1 No.**
	Communication card for PLC Operating Station communication bus	**1 No.**
5.0	Bentley Nevada 3500 Series Vibration Monitoring System Spares	
5.1	**Central Rack cards : Power supply card, Vibration/Thrust Monitoring card, Axial displacement card, Speed monitor card, Key phasor module, Relay module, Display Unit., transducers and transmitters**	**20% of each type of cards, subject to minimum 2 nos of each type**
5.2	**Vibration probes with leads, axial displacement probes with leads, Bearing thermo elements, speed probes with leads, I/H converter, E/H Convertor, trip solenoid valves, transducers, barriers for vibration probes.**	**10% or minimum 1 no. of each type.**
6.0	Consumables for DCS	
6.1	**Printer papers A3, A4 size**	**A3- 10 Rims, A4- 50 Rims**
6.2	**Laser Cartridges (Black and Color)**	**For 6 month usage, min. 2 sets for each printer**
6.3	**DATs of HP/ 3-M**	**25 nos. each**
6.4	**CDs of HP/Samsung**	**200 with individual casing**
6.5	**DVDs of HP/Samsung**	**200 with individual casing**
7.0	GC Spares	
a	**Set of Filters**	**1 set**

b	**Detector Assembly**	**1 set**
c	**PCB assembly Power Supply**	**2 nos.**
d	**PCB assembly Digital temp control**	**2 nos each type**
e	**Pressure Regulator**	**1 no**
f	**Thermocouple Assembly**	**1 no**
g	**Sol Valve**	**1 no**
h	**Backplane Assembly**	**1 no**
i	**PCB Assembly**	**1 no**
j	**Ignitor Assembly**	**1 no**
k	**Pressure Sensor**	**1 no**
l	**Filament Kit**	**2 nos**
m	**Set of Fuses**	**1 no**
n	**Set of Fittings**	**1 no**
o	**Pressure Gauge**	**1 no**
p	**Temperature gauge**	**1 no**
q	**Sample flow meter**	**1 no**
r	**Bypass flow meter**	**1 no**
8.0	Gas Analyzer Spares applicable for all Gas Analyzers / MassSpectrometer	
a	**Sample Flow Meter**	**1 no**
b	**By pass Flow meter**	**1 no**
c	**Solenoid Valve**	**1 no**
d	**Communication board**	**1 no of each type**
e	**Display Unit**	**1 no each type**

f	**CPU Board**	**1 no each type**
g	**Sensor Electronic**	**1 no each type**
h	**Modulation Unit**	**1 no each type**
i	**Sample Cell**	**1 no**
j	**Sensor**	**1 no each type**
k	**O Ring**	**3 sets**
l	**Thermal fusses**	**2 sets**
m	**Heating cartridge**	**1 set**
n	**Thermal trip**	**2 set**
o	**Analogue module**	**1 set each type**
p	**Filter membrane (pack of 25)**	**1 set**
q	**Fuse**	**1 set each type**
9.0	pH / Conductivity Analyzer	**1 Complete Analyzer complete with sensor, cables, transmitters etc of each type**
10.0	Silica Analyzer Spares	
a	**Sensor board**	**1 no.**
b	**Sensor and Detector**	**1 no each type**
c	**Rotameter**	**1 no.**
d	**Pressure Control Valve**	**1 no.**
e	**Fuses**	**5. sets.**
f	**Electronic card**	**1 no. each type**
g	**Other Aux. Cards**	**1 each**
h	**Probe**	**1 no. each type**
i	**Filters, O-rings, Gaskets**	**2 sets**

j	**Consumable Kit**	**2 sets**
11.0	Sample Conditioning system applicable for all analyzers / Mass spectrometer	
a	**Complete sample kit for sample pumps inclusive of 'O' rings, Seal ring, Diaphragm**	**1 set**
b	**Solenoid valve for, more than one stream application**	**1 no**
c	**Flow switch**	**1 no**
d	**Vaporization system if required, which includes vaporizer, thermostat, electrical tracing cable and heater**	**1 set**
e	**Cooling system if required, which includes one cooler, flow conditioning system**	**1 set**
f	**Sample handling system fitting, valves, pressure gauges, regulators, solenoid valves, flow meters / flow switches and other components, etc**	**10% or minimum 1 no. of each type**
g	**Consumables like filters, membranes, reagents, cal. Gas, carriers**	**For 1 year of continuous operation**
12.0	Ferruling machine	**1 no along with printer ribbon and sleeves size of 5.0 mm2 and 3.5 mm2 100 meter each**
	Other Items	
13.0	Snubber, Syphon, Gauge Saver	**10% (subject to minimum of 2) of each item used, whichever is higher**
14.0	Loop powered indicators	**10% (subject to minimum of 2) of Loop powered indicators used, whichever is higher**
15.0	Panel mounted instruments	**10% or minimum one no.**

		whichever is higher
16.0	Tools	
16.1	**Technician's Tool Kit Set including screw drivers, slide wrench, O & D Spanners Kits**	**10 nos**
16.2	**Crimping Tool for RJ-45 Connector, Tapria**	**5 nos**
16.3	**Crimping Tool 0.5 to 4.0 mm2 wire, Tapria**	**5 nos**
16.4	**Crimping Tool BNC connector for Bentely Neveda**	**2 nos**
16.5	**Torque Wrench (Adjustable)**	**2 nos**
16.6	**Insulation Remover**	**5 nos**
16.6	**IC Puller**	**2 nos of each type**
16.8	**Logic probe**	**2 nos.**
16.9	**Screw driver kit (Taparia make)**	**5 set**
16.10	**Allen Key Set (1mm to 8 mm)**	**5 set**
16.11	**Lamp puller**	**3 nos.**
16.12	**Torches (LED) handheld**	**10 nos**
16.13	**Torches (Head Lamp)**	**10 nos**
16.14	**Battery charger alongwith 1 set of batteries**	**2 nos of each type**
17.0	**CCTV camera, camera station, lens with zoom, Pan & Tilt Unit, Receiver Unit, electronic unit, , power supply, etc.**	**10% or minimum one of each type of module.**
18.0	**EPABX Unit, Electronic Card each type**	**10% or minimum one of each type of module.**
19.0	**Gas Detector system** **a) Transmitter assembly (including field display)** **b) Sensors**	**10% subject to minimum 1 No. of each type.** **20% subject to minimum 2 No.**

		of each type
20.0	**Smoke Detectors , MCP, Sounders, Hooters**	**10% or minimum one of each type of module.**
21.0	**Pressure Relief Valves/Thermal Relief Valves/ Vaccum Relief Valves / Low Pressure Relief Valves / Pilot Operated Valves**	**10% of minimum one of each type & size for nozzle, disc insert, guide whichever is higher**
22.0	**Rupture Disc**	**2 spare disc for each Tag.**
23.0	**MOVs** **Main PCB of each type** **Local / Remote / off Selector Switch each type** **Open / close / stop Selector Switch each type**	 **1 Nos** **1 Nos** **1 Nos**
24.0	Installation Material	
24.1	**Instrument valves and**	**10% subject to minimum 1 no. of each type.**
24.1.1	**Valve manifolds**	**10% subject to minimum 3 no. of each type.**
24.2	**Tube fittings**	**10% subject to minimum 10 no. of each type.**
24.3	**Tubes**	**10% of the total length of each type**
24.4	**Cables**	**20% of the total length of each type**
24.5	**Junction boxes and cable glands**	**10% subject to minimum 1 no. of each type**

NOTE:

1. **'Set' means complete replacement of particular part in one machine.**
2. **The quotation should contain sectional drawing showing location & part no. (For exact identification) & material specification**
3. **Quantities shown are for each size and type of part.**
4. **The parts listed are the principal parts only. Other parts shall be considered for recommendation in quantities consistent with the above table.**
5. **All special tools and tackles required for maintenance for critical items shall be supplied along with equipment.**

3.0 VENDOR'S RECOMMENDED SPARE PARTS

Contractor shall submit list of recommended spare parts of specialised items not covered under Mandatory spares, along with itemised price. Owner will review and decide the recommended spares required for the project.

PART: TECHNICAL

SECTION –18.0

SPARE PARTS

PLANT: AMMONIA NITRATE (AN) MELT PLANT AT RCF, TROMBAY

1.0 SPARE PARTS FOR COMMISSIONING

LSTK Contractor shall supply free of cost (Include in the scope) spare parts and Consumables required during Pre-commissioning & Commissioning of the plants until the plant is handed over to the Owner after Performance Guarantee and final acceptance of the plant Test.

However, LSTK Contractor shall provide Pre-Commissioning and Commissioning Spare List along with their Bid.

2.0 SPARE PARTS FOR TWO YEARS OPERATION (MANDATORY):

Contractor shall supply spare parts as per list of spares for 2 years operation of the plant as detailed below.

a) Piping items
b) Fire Fighting System

2.1 Piping Items:

Sl. No.	Part Description	Size Range (NB)	Quantity Required (% of as built)	Remark
1	Pipes & Fittings	≤1.5”	5%	min. qty. 6 mtr. / 1 No.
2	Pipes & Fittings	≥ 2”	2%	min. qty. 6 mtr. /1 No.
3	Flanges	≤1.5”	5%	min. qty. 1 No.
4	Flanges	2” to 6”	5%	min. qty. 1 No.
5	Flanges	8” to 36”	2%	min. qty. 1 No.
6	Valves	≤1.5”	5%	min. qty. 1 No.
7	Valves	2” to 14”	5%	min. qty. 1 No.
8	Valves	≥16” with rating ≥900#		Note-5
9	Bolts, Nuts & Gaskets (For each size, rating, material)		10%	min. qty. 1 No.
10	Traps (For each size, rating, material)		2%	min. qty. 1 No.
11	Expansion Bellow (For each size, rating, material)		10%	min. qty. 1 No.
12	Strainer element (For each size, rating, material)		10%	min. qty. 1 No.
13	Complete Gear Box for gear operated Valves		5%	min. qty. 1 No.
14	Seal ring for the Pressure seal type valves		5%	min. qty. 10 Nos.
15	Hose assembly		50%	min. qty. 10 Nos.
16	Bolt torque wrenches (Manual)		1 set	min. qty. 1 set.
17	Bolt torque wrenches		1 set	min. qty. 1 set.

	(Hydraulic)			
18	Bolt tensioning for equipment		1 set	min. qty. 1 set.

NOTES:-

1. Percent of quantity required as mandatory spares is for each and every item/size/material consumed in as built.
2. No substitution in size, rating and material is allowed.
3. Pipe length in meter and other items in No. or Set shall be supplied.
4. Fractional part of quantity shall be converted into nearest upward whole part.
5. For rating ≥900# and sizes ≥16", minimum one qty. valve spare shall be supplied for each size, rating & material.

2.17 Fire Fighting

S. No.	Description	Quantity (% of total installation qty. or as specified)
1	Hose box, RRL hose with couplings, jet nozzle with branch pipe, hose reel with nozzle, hydrant valve, landing valve	5% per item.
2	Monitor per type & capacity	1 no.
3	Portable fire extinguisher per type & capacity (up to 10 kg)	1%
4	Wheel mounted fire extinguisher per type & capacity (greater than 10 kg)	1 no.

SECTION-19

VENDOR LIST

NEW AMMONIUM NITRATE MELT PLANT

PLANT: RCF TROMBAY

JOB NO: PC-185

PREPARED BY

PROJECTS & DEVELOPMENT INDIA LIMITED, NOIDA

1	16.02.2021	16.02.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
0	21.01.2021	21.01.2021	FOR ISSUE	AK/PT/HK	RKS	RKS/MN
P	25.11.2020	25.11.2020	PRELIMINARY	AK/PT/HK	RKS	RKS/MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

CONTENTS

SECTION NUMBER	DESCRIPTION
1.0	Static Equipments
2.0	Rotating Equipments
3.0	Electrical
4.0	Civil
5.0	Piping

1.0 Static Equipments

ITEM DESCRIPTION	PAGE NO
VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm2g	
VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm2g	
VESSELS IN CS/AS/SS PRESSURE ABOVE 60 Kg/cm2g	
TALL COLUMNS	
SMALL COLUMNS	
SHOP FABRICATED TANKS & NONCODED VESSELS	
STORAGE TANKS (Site Fabricated)	
METALLIC TOWER PACKINGS	
TRAYS, DISTRIBUTORS & INTERNALS	
DEMISTERS	
HEAT EXCHANGERS UPTO 30 Kg/cm2g	
HEAT EXCHANGERS 30 TO 60 Kg/cm2g	
PLATE TYPE HEAT EXCHANGERS	
FRP/PVC TANKS & VESSELS	
FRP/PVC LINING	
FILTERS & SEPARATORS	

VESSELS IN CS/AS/SS PRESSURE UPTO 10 Kg/cm2g		
1	AERO ENGINEERS	INDIA
2	AIRFRIGE INDUSTRIES	INDIA
3	ARTSON ENGINEERING LIMITED	INDIA
4	B H P V	INDIA
5	BHARAT HEAVY ELECTRICALS LTD.	INDIA
6	FABTECH PROJECTS & ENGINNERS LTD. (For CS Only)	INDIA
7	FLOWLINK INDUSTRIES PVT. LTD. (CS/SS Except Urea Service)	INDIA
8	FURNACE FABRICA (INDIA) LTD. (CS/SS)	INDIA
9	G R ENGINEERING PRIVATE LIMITED	INDIA
10	GANSONS LTD.	INDIA
11	GEMINI ENGI-FAB PVT. LTD. (Excluding AS Mati)	INDIA
12	GHANSHYAM STEEL WORKS LTD. (CS/SS)	INDIA
13	GMM PFAUDLER LIMITED	INDIA
14	GODREJ & BOYCE MFG. CO. LTD	INDIA
15	GRAND PRIX ENGINEERING PVT. LTD. (upto 4m D x 6m L x80mm Thk)	INDIA
16	GRASIM INDUSTRIES	INDIA
17	HEATEX INDIAN CORPORATION	INDIA
18	HINDUSTAN DORR-OLIVER LTD.	INDIA
19	ICEM ENGG. CO. LTD.	INDIA
20	INDIA TUBE MILLS & METAL INDUSTRIES LTD. (For CS/SS only)	INDIA
21	INDUS PROJECTS LTD (FORMERLY INDUS ENGG)	INDIA
22	ISHAN EQUIPMENTS PVT. LTD. (CS/SS only)	INDIA
23	KINETICS TECHNOLOGY INDIA LTD.	INDIA
24	LARSEN & TOUBRO LTD.	INDIA
25	LLOYDS STEEL INDUSTRIES LIMITD	INDIA
26	LOYAL EQUIPMENTS PVT. LTD. CS/SS and Non IBR only)	INDIA

27	MARS DESIGN PVT. LTD.	INDIA
28	MISTRY PRABHUDAS MANJI ENGG. PVT. LTD.	INDIA
29	MOD FABRICATORS	INDIA
30	MULTI-MAX ENGINEERING WORKS PVT. LTD. (CS and SS Material only)	INDIA
31	NAVA BHARAT FERRO ALLOYS LTD	INDIA
32	NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD. CS/SS Only)	INDIA
33	NIVITA ENGINEERING WORKS	INDIA
34	NOVATECH PROJECTS INDIA (P) LTD. (CS and SS material only)	INDIA
35	ORIENTAL MANUFACTURERS PRIVATE LIMITED (CS/SS only)	INDIA
36	PATELS AIRTEM (INDIA LIMITED	INDIA
37	PRECISION EQUIPMENTS (CHAANAI) PVT LTD	INDIA
38	PROJECT TECHNOLOGISTS PVT. LTD.	INDIA
39	R.D. ENGINEERS (INDIA) PVT. LTD.	INDIA
40	RAJ ENGG. CO.	INDIA
41	RELIANCE FABRICATIONS PVT. LTD.	INDIA
42	REYNOLDS CHEMEQUIP PRIVATE LIMITED (CS/SS)	INDIA
43	SHRENO LTD. (UNIT 2)	INDIA
44	TAS ENGINEERING CO. (P) LIMITED	INDIA
45	TATA CHEMICALS LTD	INDIA
46	THE ANUP ENGINEERING LIMITED	INDIA
47	ISGEC HEAVY ENGINEERING LIMITED	INDIA
48	TITANIUM EQUIPMENT AND ANODE MFG. CO. LTD.	INDIA
49	TRIVENI STRUCTURALS LTD.	INDIA
50	UNITOP ENGINEERS PVT. LTD. (Max. Shell Dia 4.65, Water vol. 140m3)	INDIA
51	HYOSUNG CORPORATION (CS/SS/LAS only)	KOREA
52	APPARATEBAU SCHWEISS TECHNIK GMBH	AUSTRIA
53	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA

54	OLMI SPA	ITALY
55	JAPAN STEEL WORKS LTD	JAPAN
56	DOOSAN MECATEC CO. LTD.	KOREA
57	HANJUNG DCM CO. LTD.	KOREA
58	HUNDAI HEAVY INDUSTRIES	KOREA
59	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD	KOREA
60	CHEM PROCESS SYETEM PVT. LTD. (CS/SS ONLY)	INDIA
61	COPERION IDEAL PVT. LTD.	INDIA
62	ESSAR HEAHY ENGINEERING SERVICES	INDIA
63	PHILS HEAVY ENGINEERIG PVT. LTD.	INDIA
64	PRAJ INDUSTRIES LIMITED	INDIA
65	SPETECH PLANT EQUIPMENT PVT. LTD. (CS ONLY)	INDIA
66	TECHNO PROCESS EQUIPMENT (I) LTD. (CS/AS/SS(AS only for P3 Material))	INDIA
67	UNIVERSAL HEAT EXCHANGER LIMITED (CS/SS/LTCS only)	INDIA
68	VIJAY TANKS & VESSELS LIMITED (CS/LAS AND SS ONLY)	INDIA
69	VIJAY TANKS & VESSELS LIMITED (KANDLA) (CS/ SS ONLY)	INDIA
70	CRYOSTAR TANKS & VESSEL PVT. LTD.(CS ONLY)	INDIA
71	BTL EPC LIMITED (CS ONLY)	INDIA
72	THE KCP LIMITED	INDIA
73	SUNGJIN GEOTECH CO. LTD. (CS and SS only)	KOREA
74	AERO ENGINEERS	INDIA
VESSELS IN CS/AS/SS PRESSURE 11 TO 60 Kg/cm2g		
1	ALTECH INFRASTRUCTURE (INDIA) PVT. LTD. (Upto 20 Kg/cm2(g)CS Material)	INDIA
2	ARIEN NEW DELHI PRIVATE LIMITED (CS/SS UP TO 11 to 30 kg/cm2(g))	INDIA
3	B H P V	INDIA
4	BHARAT HEAVY ELECTRICALS LTD.	INDIA
5	EXPO GAS CONTAINERS LTD. (Upto 30 Kg/sq cm (g) CS/SS Material.)	INDIA
6	FABTECH PROJECTS & ENGINNERS LTD. (For CS Only)	INDIA
7	FURNACE FABRICA (INDIA) LTD. (CS/SS UP TO 11 to 30 kg/cm2(g))	INDIA

8	G R ENGINEERING PRIVATE LIMITED	INDIA
9	GANSONS LTD.	INDIA
10	GHANSHYAM STEEL WORKS LTD (CS/SS)	INDIA
11	GODREJ & BOYCE MFG. CO. LTD	INDIA
12	GRAND PRIX ENGINEERING PVT. LTD.	INDIA
13	GRASIM INDUSTRIES (upto 30Kg/cm2g)	INDIA
14	HEATEX INDIAN CORPORATION	INDIA
15	HINDUSTAN DORR-OLIVER LTD. (CS/SS Only)	INDIA
16	INDIA TUBE MILLS & METAL INDUSTRIES LTD. (For CS/SS only upto 30 Kg/cm2g)	INDIA
17	INDUS PROJECTS LTD (FORMERLY INDUS ENGG)	INDIA
18	ISHAN EQUIPMENTS PVT. LTD. (CS/SS Upto 30 Kg/Cm2(g) only)	INDIA
19	KAVERI ENGG. INDUSTRIES LTD.,	INDIA
20	LARSEN & TOUBRO LTD	INDIA
21	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
22	LOYAL EQUIPMENTS PVT. LTD. (Upto 11-30 Kg/cm2, CS/SS and Non IBR only.)	INDIA
23	MULTI-MAX ENGINEERING WORKS PVT. LTD. (Up to 30 Kg/cm2g (CS and SS Materials only)	INDIA
24	NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD. (Upto 30 Kg/cm2g (CS/SS Only)	INDIA
25	ORIENTAL MANUFACTURERS PRIVATE LIMITED (CS/SS only)	INDIA
26	PATELS AIRTEMP (INDIA LIMITED (CS & SS only)	INDIA
27	PRECISION EQUIPMENTS (CHENNAI) PVT. LTD (upto 44 Kg/cm2g)	INDIA
28	RAJ ENGG. CO. (up to 30kg/cm 2 (g) CS/SS/AS (P3 & P4 only)	INDIA
29	THE ANUP ENGINEERING LIMITED	INDIA
30	BTL EPC LIMITED (up to 36 kg/cm2 (CS Only))	INDIA
31	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), DAHEJ (Except Urea Plant Critical Equipment)	INDIA
32	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR	INDIA
33	HYOSUNG CORPORATION (CS/SS/LAS only)	KOREA

34	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
35	BORSING GmbH	GERMANY
36	BELLELI S.P.A	ITALY
37	FBM HUDSON ITALIANA S.p.A	ITALY
38	GE POWER (NUOVO PIGNONE SPA)	ITALY
39	ROLLE S.P.A. (11 TO 60 kg/cm2 pr.)	ITALY
40	WALTER TOSTO SpA	ITALY
41	HITACHI ZOSEN	JAPAN
42	KOBE STEEL LIMITED	JAPAN
43	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
44	MITSUI ENGINEERING & SHIPBUILDING CO. LTD	JAPAN
45	DOOSAN MECATEC CO. LTD.	KOREA
46	HANJUNG DCM CO. LTD.	KOREA
47	HANTECH LIMITED	KOREA
48	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD	KOREA
49	MECANICA DE LA PENA S.A.	SPAIN
50	BEAIRD INDUSTERIES LOUISIANA	U.S.A
51	CHEM PROCESS SYSTEM PVT. LTD. (CS/SS upto 30 kg/cm^2g only)	INDIA
52	CICB-CHEMICON PVT. LTD. (upto 30 kg/cm^2 only (CS only))	INDIA
53	ESSAR HEAVY ENGINEERING SERVICES	INDIA
54	FAB-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED (CS/SS/LTCS)	INDIA
55	GMM PFAULER LIMITED (CS/SS only)	INDIA
56	INDCON PROJECTS & EQUIPMENT LIMITED (for CS/LTCS/SS only upto 30 kg/cm^2g)	INDIA
57	MEENAKSHI ASSOCIATED (P) LTD. (CS/LTCS/SS upto 30 kg/cm^2g)	INDIA
58	NUBERG ENGINEERING LIMITED (CS/SS upto 30 kg/cm^2g)	INDIA
59	PHILS HEAVY ENGINEERING PVT. LTD. (upto 30 kg/cm^2g)	INDIA
60	R.D. ENGINEERS (INDIA) PVT. LTD. (upto 30 kg/cm^2g)	INDIA

61	RELIANCE FABRICATIONS PVT. LTD. (CS/SS upto 30 kg/cm^2g)	INDIA
62	SPETECH PLANT EQUIPMENT PVT. LTD. (CS upto 30 kg/cm^2g)	INDIA
63	TECHNO PROCESS EQUIPMENTS (I) LTD. (CS/AS/SS upto 30 kg/cm^2g (AS only for P3 Material))	INDIA
64	NEWTON ENGINEERING AND CHEMICAL LTD.(upto 36 kg/cm^2g)	INDIA
65	UNIQUE CHEMOPLANT EQUIPMENTS (CS/SS only upto 30 kg/cm^2g)	INDIA
66	UNIVERSAL HEAT EXCHANGERS LIMITED (CS/SS/LTCS upto 30 kg/cm^2g)	INDIA
67	VIJYA TANKS & VESSELS LIMITED (CS/SS and LAS Upto 37 kg/cm^2g only)	INDIA
68	VIJYA TANKS & VESSELS LIMITED (KANDLA)(CS/SS upto 30 kg/cm^2g only)	INDIA
69	AERO ENGINEERS (CS only)	INDIA
70	AVADH INDUSTRIES (Upto 34 kg/cm2g), CS only	INDIA
71	GEMINI ENGI-FAB PVT. LTD. (Upto 40 Kg/cm2g)	INDIA
72	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS only)	INDIA
73	PRAJ INDUSTRIES LIMITED (CS/SS ONLY)	INDIA
74	TECHNOPROCESS EQUIPMENT INDIA PVT.LTD (NON IBR)	INDIA
75	THE KCP LIMITED	INDIA
76	ALPEC CO. LTD. (CS & AS only)	KOREA
77	SUNGJIN GEOTEC CO., LTD. (CS and SS only)	KOREA
VESSELS IN CS/AS/SS PRESSURE ABOVE 60Kg/cm2g		
1	B H P V	INDIA
2	BHARAT HEAVY ELECTRICALS LTD.	INDIA
3	G R ENGINEERING PRIVATE LIMITED	INDIA
4	GODREJ & BOYCE MFG CO. LTD.	INDIA
5	LARSAN & TOUBRO LTD.	INDIA
6	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), DAHEJ (Except Urea Plant Critical Equipment)	INDIA
7	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR (Except Urea Plant Critical Equipment)	INDIA
8	HYOSUNG CORPORATION (CS/SS/LAS only)	KOREA
9	BORSIG GmbH (upto 1500 Deg. C & upto 35000KPa)	GERMANY
10	FERROSTAAL AKTIENGES ELLSCHAFTG	GERMANY
11	KRUPP INDUSTRIES-TECHNIK	GERMANY
12	THYSSEN RHEINSTAHL TECHNIK GMBH	GERMANY
13	ACCIAI SPECIALI TERNI	ITALY
14	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP	ITALY

15	BELLELI S.P.A	ITALY
16	FBM HUDSON ITALIANA S.p.A	ITALY
17	GE POWER (NUOVO PIGNONE SPA)	ITALY
18	OLMI SPA	ITALY
19	WALTER TOSTO SpA	ITALY
20	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
21	KOBE STEEL LIMITED	JAPAN
22	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
23	SUMISHO MACHINERY TRADE CORPORATION	JAPAN
24	DOOSAN MECATEC CO. LTD.	KOREA
25	HANJUNG DCM CO. LTD.	KOREA
26	HUNDAI HEAVY INDUSTRIES	KOREA
27	KOREA HEAVE INDUSTRIES & CONSTN. CO. LTD	KOREA
28	ALPEC CO. LTD. (CS & SS ONLY)	KOREA
29	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
30	HINDUSTAN DORR-OLIVER LTD. (CS/SS/LAS/LTCS only)	INDIA
31	SUNGJIN GEOTEC CO. LTD. (CS and SS only)	KOREA
TALL COLUMNS		
1	B H P V	INDIA
2	EXPO GAS CONTAINERS LTD.	INDIA
3	G R ENGINEERING PRIVATE LIMITED	INDIA
4	GODREJ & BOYCE MFG CO. LTD.	INDIA
5	INDIA TUBE MILLS & METAL INDUSTRIES LTD.	INDIA
6	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS ONLY)	INDIA
7	LARSAN & TOUBRO LTD.	INDIA
8	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
9	R.D. ENGINEERS (INDIA) PVT. LTD	INDIA
10	RAJ ENGG. CO. (CS/SS only)	INDIA
11	THE ANUP ENGINEERING LIMITD	INDIA
12	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), DAHEJ (CS/SS/AS)	INDIA
13	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR (CS/SS/AS)	INDIA
14	HYOSUNG CORPORATION	KOREA
15	APPARATEBAU SCHEWEISSTECHNIK GMBH	AUSTRIA
16	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
17	BORSING GmbH	GERMANY
18	BELLELI S.P.A	ITALY
19	HITACHI ZOSEN	JAPAN
20	KOBE STEEL LIMITED	JAPAN
21	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
22	DOOSAN MECATEC CO. LTD.	KOREA
23	HANJUNG DCM CO. LTD.	KOREA
24	HUNDAI HEAVY INDUSTRIES	KOREA
25	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD.	KOREA
26	ALPEC CO. LTD.	KOREA
27	MECHNICA DE LA PENA S.A.	SPAIN
28	ESSAR HEAVY ENGINEERING SERVICES	INDIA
29	GMM PFAUDLER LIMITED	INDIA
30	HINDUSTAN DORR-OLIVER LTD.	INDIA
31	PHILS HEAVY ENGINEERING PVT. LTD.	INDIA

32	UNIVERSAL HEAT EXCHANGERS LIMITED	INDIA
33	VIJAY TANKS & VESSELS LIMITED	INDIA
34	VIJAY TANKS & VESSELS LIMITED (KANDLA)	INDIA
35	FABTECH PROJECTS & ENGINEERS LTD. (FOR CS ONLY)	INDIA
36	GEMINI ENGI-FAB PVT. LTD	INDIA
37	SUNGJIN GEOTEC CO. LTD. (CS and SS only)	KOREA
SMALL COLUMNS		
1	ARTSON ENGINEERING LIMITED	
2	B H P V	INDIA
3	G R ENGINEERING PRIVATE LIMITED	INDIA
4	GODREJ & BOYCE MFG CO. LTD.	INDIA
5	GRASIM INDUSTRIES	INDIA
6	INDIA TUBE MILLS & METAL INDUSTRIES LTD.	INDIA
7	KAVERI ENGG. INDUSTRIES LTD.	INDIA
8	LARSEN & TOUBRO LTD.	INDIA
9	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
10	NOVATECH PROJECTS INDIA (P) LTD. (CS & SS only)	INDIA
11	PATELS AIRTEMP (INDIA LIMITED (CS & SS)	INDIA
12	PRECISION EQUIPMENTS (CHENNAI) PVT. LTD	INDIA
13	R.D. ENGINEERINGS (INDIA) PVT. LTD.	INDIA
14	RAJ ENGG. CO. (CS/SS only)	INDIA
15	TATA CHEMICALS LTD.	INDIA
16	THE ANUP ENGINEERING LIMITED	INDIA
17	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), DAHEJ (CS/SS/AS)	INDIA
18	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR	INDIA
19	HYOSUNG CORPORATION	KOREA
20	APPARATEBAU SCHEWEISSTECHNIK GMBH	AUSTRIA
21	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
22	ATB ACCIAIERIA E TUBIFICIO DI BRESCIA SP	ITALY
23	BELLELI S.P.A	ITALY
24	GE POWER (NOUVO PIGNONE SPA)	ITALY
25	ROLLE S.P.A (Small Column)	ITALY
26	HITACHI ZOSEN	JAPAN
27	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
28	MITSUI & COMPANY LTD.	JAPAN
29	DOOSAN MECATEC CO. LTD.	KOREA
30	HANJUNG DCM CO. LTD.	KOREA
31	HUNDAI HEAVY INDUSTRIES	KOREA
32	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD.	KOREA
33	SEMBAWANG ENGG. (PTE) LTD.	SINGAPORE
34	MECANICA DE LA PENA S.A.	SPAIN
35	ESSAR HEAVY ENGINEERING SERVICES	INDIA
36	GMM PFAUDLER LIMITED	INDIA
37	HINDUSTAN DORR-OLIVER LIMITED	INDIA
38	NUBERG ENGINEERING LIMITED	INDIA
39	PHILS HEAVY ENGINEERING PVT. LTD.	INDIA
40	PRAJ INDUSTRIES LIMITED (Non IBR)	INDIA
41	TECHNO PROCESS EQUIPMENT (I) LTD.	INDIA

42	UNIQUE CHEMOPLANT EQUIPMENTS	INDIA
43	UNIVERSAL HEAT EXCHANGERS LIMITED	INDIA
44	VIJAY TANKS & VESSELS LIMITED	INDIA
45	VIJAY TANKS & VESSELS LIMITED (KANDLA)	INDIA
46	SUNGJIN GEOTEC CO. LTD. (CS and SS only)	KOREA
47	EXPO GAS CONTAINERS LTD.	INDIA
48	FABTECH PROJECTS & ENGINEERS LTD. (FOR CS ONLY)	INDIA
49	GEMINI ENGI-FAB PVT. LTD	INDIA
50	JINDAL STEEL & POWER LTD. (MACHINERY DIVISION) (CS ONLY)	INDIA
51	NEWTON ENGINEEIRNING & CHEMICALS LTD.	INDIA
52	ALPEC CO. LTD	KOREA
SHOP FABRICATED TANKS & NONCODED VESSELS		
1.	ALTECH INFRASTRUCTURE (INDIA) PVT. LTD.	INDIA
2.	ARTSON ENGINEERING LIMITD	INDIA
3.	BAKSHI CHEMPHARMA EQUIPMENTS PVT. LTD.	INDIA
4.	ESSAR HEAVY ENGINEERING SERVICES	INDIA
5.	FLOWLINK INDUSTRIES PVT. LTD. (CS/SS only)	INDIA
6.	G R ENGINEERING PRIVATE LIMITED	INDIA
7.	GANSONS LTD.	INDIA
8.	GAYATRI TANKS & VESSELS	INDIA
9.	GEMINI ENGI-FAB PVT. LTD.	INDIA
10.	GENERAL MECH & PROCESS EQUIPT. (P) LTD.	INDIA
11.	GODREJ & BOYCE MFG. CO. LTD.	INDIA
12.	GRANDPRIX ENGINEERING PVT. LTD	INDIA
13.	INDIA TUBE MILLS & METAL INDUSTRIES LTD.	INDIA
14.	INDUS ENGG. COMPANY	INDIA
15.	ISHAN EQUIPMENTS PVT. LTD. (CS/SS only)	INDIA
16.	KINETICS TECHNOLOGY INDIA LTD.	INDIA
17.	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITD (CS/SS only)	INDIA
18.	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
19.	MABEL ENGINEERS PVT. LTD.	INDIA
20.	MULTI-MAX ENGINEERING WORKS PVT. LTD.	INDIA

21.	NEWTON ENGG. & CHEMICALS LTD.	INDIA
22.	NIVITA ENGINEERING WORKS	INDIA
23.	NOVATECH PROJECT INDIA (P) LTD.	INDIA
24.	ORIENTAL MANUFACTURERS PRIVATE LIMITED (CS/SS only)	INDIA
25.	PRECISION EQUIPMENTS (CHENNAI) PVT. LTD.	INDIA
26.	PRECISION TANKS & VESSEL	INDIA
27.	PROJECT TECHNOLOGISTS PVT. LTD.	INDIA
28.	R.D. ENGINEERS (INDIA) PVT. LTD.	INDIA
29.	RAJ ENGG. CO.	INDIA
30.	RELIANCE FABRICATIONS PVT. LTD.	INDIA
31.	SHARP TANKS & STRUCTURALS PVT. LTD.	INDIA
32.	TAS ENGINEERING CO. (P) LIMITED	INDIA
33.	TATA CHEMICALS LTD.	INDIA
34.	UNITOP ENGINEERS PVT. LTD. (Max shell Dia 4.65m. Vol 140m3)	INDIA
35.	VIJAY TANKS & VESSELS LIMITED	INDIA
36.	VIP J INDUSTRIAL ENTERPRISES PVT. LTD.	INDIA
37.	RELIABLE FABRICATION & ENGINEERING INDUSTRIES	INDIA
38.	TITANIUM TANTALUM PRODUCTS LTD.	INDIA
39.	VIJAY TANKS & VESSELS LTD. (KANDLA)	INDIA
40.	OSWAL INFRASTRUCTURE LIMITED	INDIA
41.	BTL EPC LIMITED (CS Only)	INDIA
STORAGE TANKS (Site Fabricated)		
1.	ARTSON ENGINEERING LIMITD	INDIA
2.	BAKSHI CHEMPHARMA EQUIPMENTS PVT. LTD.	INDIA
3.	BRIDGE & ROOF CO.	INDIA
4.	EXPO GAS CONTAINERS LTD.	INDIA
5.	FACT EINGINEERING WORKS	INDIA

6.	GANSONS LTD.	INDIA
7.	GODREJ & BOYCE MFG. CO. LTD.	INDIA
8.	INDIA TUBE MILLS & METAL INDUSTRIES LTD.	INDIA
9.	INDUS PROJECTS LTD. (FORMERLY INDUS ENGG.)	INDIA
10.	LARSEN & TOUBRO LTD.	INDIA
11.	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
12.	MABEL ENGINEERS PRIVATE LIMITED	INDIA
13.	MARS DESIGN PVT. LTD.	INDIA
14.	NEWTON ENGG. & CHEMICALS LTD.	INDIA
15.	NOVATECH PROJECTS INDIA (P) LTD.	INDIA
16.	PRECISION TANKS & VESSELS	INDIA
17.	PROJECT TECHNOLOGISTS PVT. LTD.	INDIA
18.	RAJ ENGG. CO.	INDIA
19.	SHARP TANKS & STRUCTURALS PVT. LTD.	INDIA
20.	SPS ENGINEERING LIMITED	INDIA
21.	TAS ENGINEERING CO. (P) LIMITED	INDIA
22.	TATA CHEMICALS LTD.	INDIA
23.	VIJAY TANKS & VESSELS LIMITED	INDIA
24.	FABTECH PROJECTS & ENGINEERS LTD. (For CS only)	INDIA
25.	TECHNO PROCESS EQUIPMENTS (INDIA) PVT. LTD.	INDIA
26.	FABTECH WORKS AND CONSTRUCTION PVT. LTD.	NDIA
METALLIC TOWER PACKINGS		
1	HAVER STANDARD INDIA PVT. LTD	INDIA
2	HI-PACK MASS TRANSFER PRODUCTS, (ALL CAPACITY)	INDIA
3	KEVIN ENTERPRISES PVT. LTD.	INDIA
4	KOCH CHEMICAL TECHNOLOGY GROUP INDIA PVT. LTD.	INDIA
5	MASS TRANSFER PRODUCTS INDUSTRIES	INDIA
6	RASCHIG AG	GERMANY
7	KOCH GLITSCH ITALIA SRL	ITALY
8	SULZER CHEMTCH NEDERLAND B.V.	NETHERLAND
9	KOCH ENGG. CO. INC.	U.S.A
10	NORTON CHEMICAL PROCESS PRODUCTS CORPN.	U.S.A

TRAYS, DISTRIBUTORS & INTERNALS		
1	GODREJ & BOYCE MFG. CO. LTD.	INDIA
2	HAVER STANDARD INDIA PVT. LTD.	INDIA
3	KAMAL ENGINEERING CORPORATION	INDIA
4	KEVIN ENTERPRISES PVT. LTD.	INDIA
5	KOCH CHEMICAL TECHNOLOGY GROUP INDIA PVT. LTD.	INDIA
6	MASS TRANSFER PRODUCTS INDUSTRIES	INDIA
7	SULZER INDIA LTD.	INDIA
8	APPARATEBAU SCHWEISSTECHNIK GMBH	AUSTRIA
9	B.S.L. INDUSTRIES	FRANCE
10	RASCHING AG	GERMANY
11	GLITSH ITALIANA, SPA	ITALY
12	KOCH GLITSCH ITALIA SRL	ITALY
13	CHIYODA CORPORATION	JAPAN
14	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
15	SULZER CHEMTECH NEDERLAND B.V.	NETHERLAND
16	GEA SPIRO GILLS LTD.	U.K
17	NORTON CHEMICAL PROCESS PRODUCTS CORPN.	U.S.A
DEMISTERS		
1	EVERGREEN INDUSTRIES	INDIA
2	GRAND PRIX ENGINEERING PVT. LTD.	INDIA
3	HAVER STANDARD INDIA PVT. LTD. (Demister pads with grids)	INDIA
4	HEIN LEHMANN (I) LTD.	INDIA
5	MISTER – MESH WIRE PRODUCTS	INDIA
6	COSTACURTA VICO S.P.A	ITALY
7	GLITSH ITALIANA, SPA	ITALY
8	KNITMESH LTD.	U.K.
9	KEVIN ENTERPRISES PVT. LIMITED	INDIA
HEAT EXCHANGERS UPTO 30 Kg/cm2g		
1	ARTSON ENGINEERING LIMITED	INDIA
2	B H P V	INDIA
3	BHARAT VEAVY ELECTRICALS LTD.	INDIA
4	EXPO GAS CONTAINERS LTD.(Upto 30 Kg/sq (g) CS/SS Material.	INDIA
5	FABTECH PROJECTS & ENGINEERS LTD. (For CS Only)	INDIA
6	FLOWLINK INDUSTRIES PVT. LTD. (CS/SS Except Urea service)	INDIA
7	G R ENGINEERING PRIVATE LIMITED	INDIA
8	GANSONS LTD.	INDIA
9	GEMINI ENGI-FAB PVT. LTD.	INDIA
10	GHANSHYAM STEEL WORKS LTD. (CS/SS)	INDIA
11	GODREJ & BOYCE MFG. CO. LTD.	INDIA
12	GRASIM INDUSTRIES	INDIA
13	HEATEX INDIAN CORPORATION	INDIA
14	HINDUSTAN DORR-OLIVER LTD.	INDIA
15	INDIA TUBE MILLS & METAL INDUSTRIES LTD.	INDIA
16	INDUS PROJECTS LTD. (FORMERLY INDUS ENGG.)	INDIA
17	LARSEN & TOUBRO LIMITED	INDIA
18	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITED (CS/SS only Except Urea service)	INDIA
19	LLOYDS STEEL INDUSTRIES LIMITED	INDIA

20	MABEL ENGINEERS PVT. LTD.	INDIA
21	MANISH UDYOG HEAT EXCHANGERS PVT. LTD.	INDIA
22	MISTRY PRABHUDAS MANJI ENGG. PVT. LTD.	INDIA
23	MULTI-MAX ENGINEERING WORKS PVT. LTD. (CS and SS Materials only)	INDIA
24	PATELS AIRTEMP (INDIA LIMITED)	INDIA
25	PRECISION EQUIPMENTS (CHENNAI) PVT. LTD. (Tubesheet thk upto 150mm)	INDIA
26	R.D. ENGINEERS (INDIA) PVT. LTD.	INDIA
27	RADIANT HEAT EXCHANGER PVT. LTD. (CS/SS only)	INDIA
28	RAJ ENGG. CO.	INDIA
29	REYNOLDS CHEMQUIP PRIVATE LIMITED (CS/SS)	INDIA
30	TAS ENGINEERING CO. (P) LIMITED	INDIA
31	TATA CHEMICALS LTD	INDIA
32	TEMA INDIA LIMITED	INDIA
33	THE ANUP ENGINEERING LIMITED	INDIA
34	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR	INDIA
35	TITANIUM EQUIPMENT AND ANODE MFG. CO. LTD.	INDIA
36	APPARATEBAU SCHWEISSTECHNIK GMBH	AUSTRIA
37	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
38	D'HONDT S.A.	BELGIUM
39	BORSING GmbH	GERMANY
40	BELLELI S.P.A.	ITALY
41	FBM HUDSON ITALIANA S.p.A.	ITALY
42	GE POWER (NUOVO PIGNONE SPA)	ITALY
43	OLMI SPA	ITALY
44	WALTER TOSTO SpA	ITALY
45	HITACHI ZOSEN	JAPAN
46	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
47	KOBE STEEL LIMITED	JAPAN
48	MITSUI ENGINEERING & SHIPBUILDING CO. LTD	JAPAN
49	DOOSAN MECATEC CO. LTD.	KOREA
50	HANTECH LIMITED	KOREA
51	HYUNDAI CORPORATION	KOREA
52	KOREA HEAVY INDUSTRIES & CONSTN. CO. LTD.	KOREA
53	HANJUNG DCM CO. LTD	KOREA
54	MECANICA DE LA PENA S.A.	SPAIN
55	MANNING & LEWIS ENGINEERING CO.,	U.S.A
56	CHEM PROCESS SYSTEM PVT. LIMITED (CS/SS only)	INDIA
57	ESSAR HEAVY ENGINEERING SERVICES	INDIA
58	FAF-TECH WORKS & CONSTRUCTIONS PRIVATE LIMITED	INDIA
59	GMM PFAUDLER LIMITES	INDIA
60	NUBERG ENGINEERING LIMITED	INDIA
61	PHILS HEAVY ENGINEERING PVT. LIMITED. (for AS (P3 & P4) only)	INDIA
62	RELIANCE FABRICATIONS PVT. LTD. (CS/SS only)	INDIA
63	TECHNO PROCESS EQUIPMENTS (I) LTD.	INDIA
64	TEMA INDIA LIMITED (PANOLI, ANKLESHWAR-UNIT-III & UNIT-IV) (IN Non ASME Certification LIKE U, U2, R ETC. Category)	INDIA
65	TEMA INDIA LIMITED (SILVASSA, UNIT-II (In Non IBR Category))	INDIA
66	TITANIUM TANTALUM PRODUCTS LTD. (CS & SS Material)	INDIA
67	UNIQUE CHEMOPLANT EQUIPMENTS	INDIA

68	UNIVERSAL HEAT EXCHANGERS LIMITED (CS/SS/LTCS Only)	INDIA
69	SUNGJIN GEOTEC LTD. (CS and SS Only)	KOREA
HEAT EXCHANGERS 30 TO 60 kg/cm2G		
1	B H P V	INDIA
2	BHARAT VEAVY ELECTRICALS LTD.	INDIA
3	G R ENGINEERING PRIVATE LIMITED	INDIA
4	GODREJ & BOYCE MFG. CO. LTD.	INDIA
5	GRASIM INDUSTRIES	INDIA
6	HINDUSTAN DORR-OLIVER LTD. (CS/SS only)	INDIA
7	LARSEN & TOUBRO LIMITED	INDIA
8	LAXMI ENGINEERING INDUSTRIES (BHOPAL) PRIVATE LIMITED (CS/SS only)	INDIA
9	LLOYDS STEEL INDUSTRIES LIMITED	INDIA
10	PATELS AIRTEMP (INDIA LIMITED)	INDIA
11	PRECISION EQUIPMENTS (CHENNAI) PVT. LTD. (Tubesheet thk upto 150mm)	INDIA
12	TEMA INDIA LIMITED (ACHHAD UNIT-1)	INDIA
13	THE ANUP ENGINEERING LIMITED	INDIA
14	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), DHHEJ (Except Urea Plant Critical Equipment)	INDIA
15	THE INDIAN SUGAR & GENERAL ENGG. CORPN. (ISGEC), YAMUNA NGR	INDIA
16	APPARATEBAU SCHWEISSTECHNIK GMBH	AUSTRIA
17	SCHOELLER-BLECKMANN NITEC GMBH	AUSTRIA
18	BORSING GmbH	GERMANY
19	FBM HUDSON ITALIANA S.p.A.	ITALY
20	OFFICIENCE LUIGI RESTA S.P.A.	ITALY
21	ROLLE S.P.A. (30 to 60 kg/cm2 pr.)	ITALY
22	HITACHI ZOSEN	JAPAN
23	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
24	DOOSAN MECATEC CO. LTD.	KOREA
25	HANJUNG DCM CO. LTD.	KOREA
26	HANTECH LIMITED	KOREA
27	HUNDAI HEAVY INDUSTRIES	KOREA
28	MECANICA DE LA PENA S.A.	SPAIN
29	CICB-CHEMICON PVT. LTD. (CS Only)	INDIA
30	ESSAR HEAVY ENGINEERING SERVICES	INDIA
31	GMM PFAUDLER LIMITED	INDIA
32	INDCON PROJECTS & EQUIPMENT LIMITED (CS/SS Only)	INDIA
33	MEENAKSHI ASSOCIATES (P) LTD. (CS/SS Only)	INDIA
34	TECHNO PROCESS EQUIPMENTS (I) LTD.	INDIA
35	TEMA INDIA LIMITED (SILVASSA, UNIT-II (In Non IBR Category))	INDIA
36	SUNGJIN GEOTEC CO. LTD. (CS & SS Only)	KOREA
37	AERO ENGINEERS (UP TO 46 KG/CM2 g)(CS ONLY)	INDIA
38	EXPOGAS CONTAINERS LTD. (CS ONLY)	INDIA
39	FABTECH PROJECTS A& ENGINEERS LTD. (For CS Only)	INDIA
40	GEMINI ENGI-FAB PVT. LTD	INDIA
41	NEWTON ENGG. & CHEMICALS LTD. (UP TO 36 KG/CM2)	INDIA
42	ALPEC CO. LTD (CS & AS ONLY)	KOREA
PLATE TYPE HEAT EXCHANGERS		

1	ALFA LAVAL INDIA LIMITED	INDIA
2	APV (PRAJ)	INDIA
3	DOVER INDIA LTD (TRANTER PHE DIVN)	INDIA
4	KELVION NDIA PVT. LTD (FORMERLY GEA ECOFLEX INDIA PVT.) LIMITED	INDIA
5	LARSEN & TOUBRO LIMITED	INDIA
6	SHRACHI ENGINEERINF & INDUSTRIES LTD.	INDIA
7	URISAN HEAT EXCHANGERS PVT. LTD.	INDIA
8	LINDE AG	GERMANY
9	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
10	MECANICA DE LA PENA S.A.	SPAIN
11	MANNING & LEWIS ENGINEERING CO.,	U.S.A
12	TRANTER PHE, INC.	U.S.A
13	HRS PROCESS SYSTEM LIMITED	INDIA
14	TRANTER INDIA PVT. LTD.	INDIA
FRP / PVC TANKS & VESSELS		
1	GANDHI AND ASSOCIATES	INDIA
2	SONAL ENGG. PLASTIC FABRICATOR	INDIA
3	APPARATEBAU SCHWEISSTECHNIK GMBH (acid storage tanks upto 3.8 in dia.)	AUSTRIA
FRP / PVC LINING		
1.	GANDHI AND ASSOCIATES	INDIA
FILTERS & SEPARATORS		
1.	COPERION IDEAL PVT. LTD.	INDIA
2.	FIL SEP EQUIPMENTS PVT LTD	INDIA
3.	FILTRATION ENGINEERS PVT. LTD.	INDIA
4.	GANSONS LTD.	INDIA
5.	GRAND PRIX FAB (P) LTD. (CARTRIDGE FILTERS UPTO 1500#, 40” SIZE)	INDIA
6.	HAVER STANDARD INDIA PVT. LTD	INDIA
7.	MULTITEX FILTERATION ENGINEERS LTD	INDIA
8.	OTOKLIN PLANTS & EQUIPMENT LTD.	INDIA
9.	SUPERFLO FILTERS PVT. LTD.	INDIA
10.	ULTRA FILTER (INDIA) PVT. LTD	INDIA
11.	PEERLESS MFG. COMPANY	SINGAPORE
12.	WATSON PROCESS SYSTEM (FOR VANE TYPE SEPARATORS)	CANADA
13.	MURA CHEMICALS EQUIPMENT CO. LTD (FOR VANE TYPE SEPARATORS)	JAPAN
14.	RAUSCHERI VERFARENSTECNIK GMBH	GERMANY
15.	NORTHEAST CONTROLS EQUIPMENT CO. LTD (FOR VANE TYPE SEPARATORS)	U.S.A

Note: LSTK contractor shall evaluate and decide present financial, performance Credential and Shop loading conditions of the vendors.

Any addition to vendor list shall be reviewed and approved by Owner subject to submission of back-up credentials with proven & reliable record of performance for similar or comparable plant design capacity by LSTK contractor.

2.0 ROTATING EQUIPMENTS:

S.NO	VENDOR'S NAME	COUNTRY
PUMPS FOR HP BFW SERVICE (ABOVE 60 KG/CM2 DISCHARGE PRESSURE)		
1.	KSB PUMPS LTD	INDIA
2.	SULZER PUMPS INDIA LIMITED	INDIA
3.	KSB AG	GERMANY
4.	EBARA CORPORATION	JAPAN
5.	SHIN NIPPON MACHINERY CO. LTD	JAPAN
6.	FLOWSERVE (IDP)	U.K
PUMPS FOR CRITICAL PROCESS		
1.	KSB PUMPS LTD	INDIA
2.	ITT CORPORATION INDIA PVT. LTD.	INDIA
3.	PUMPEN FABRIK ERNST VOGEL	AUSTRIA
4.	KSB GUINARD	FRANCE
5.	KSB AG	GERMANY
6.	FLOWSERVE	ITALY
7.	GE POWER (NUOVO PIGNONE SPA)	ITALY
8.	WEIR GABBIONETA SRL(FORMERLY POMPE GABBIONETA SPA)	ITALY
9.	MITSUBISHI CORPORATION	JAPAN
10.	EBARA CORPORATION	JAPAN
11.	SHIN NIPPON MACHINERY CO. LTD	JAPAN
12.	TORISHIMA PUMP MFG. CO. LTD	JAPAN
13.	GOULD PUMPS INC	SINGAPORE
14.	SULZER PUMPS LTD.	SWITZER LAND

PUMPS FOR CHEMICALS/ ACID/ ALKALI/ BFW/ CONDENSATE USE		
1.	A.R WILFLEY INDIA PVT. LTD	INDIA
2.	AKAY INDUSTRIES PVT. LTD	INDIA
3.	ITT CORPORATION INDIA PVT. LTD.	INDIA
4.	KIRLOSKAR BROTHERS LTD.	INDIA
5.	KIRLOSKAR EBARA PUMPS LTD	INDIA
6.	KISHORE PUMPS PVT. LTD	INDIA
7.	KSB PUMPS LTD	INDIA
8.	MICROFINISH PUMPS PVT. LTD	INDIA
9.	SAM TURBO INDUSTRY PRIVATE LTD.	INDIA
10.	SULZER PUMPS INDIA LTD.	INDIA

11.	PUMPEN FABRIK ERNST VOGEL	AUSTRIA
12.	ENSIVAL S.A	BELGIUM
13.	GE POWER (NUOVO PIGNONE SPA)	ITALY
14.	WEIR GABBIONETA SRL(FORMERLY POMPE GABBIONETA SPA)	ITALY
15.	ARAI PUMP MFG. CO. LTD	JAPAN
16.	SANWA HYDROTECH CORPORATION	JAPAN
17.	GOULD PUMPS INC.	SINGAPORE
18.	FLOWSERVE (IDP)	U.K
19.	LABOUR PUMP CO. LTD	U.K
COOLING WATER PUMPS (HORIZONTAL)		
1.	A.R WILFLEY INDIA PVT. LTD	INDIA
2.	FLOWMORE LTD (FORMALLY FLOWMORE PVT. LTD.)	INDIA
3.	JYOTI LIMITED	INDIA
4.	KIRLOSKAR BROTHERS LTD.	INDIA
5.	MATHER & PLATT (INDIA) LTD. (A SUBSIDIARY OF WILO SE GERMAN)	INDIA
6.	SAM TURBO INDUSTRY PRIVATE LTD.	INDIA
7.	KSB AG	GERMANY
8.	MITSUBISHI HEAVY INDUSTRIES LTD	JAPAN
9.	SHIN NIPPON MACHINERY CO. LTD	JAPAN
10.	TORISHIMA PUMP MFG. CO. LTD	JAPAN
11.	FLOWSERVE (IDP)	U.K
COOLING WATER PUMPS (VERTICAL)		
1.	A.R WILFLEY INDIA PVT. LTD	INDIA
2.	FLOWMORE LTD (FORMALLY FLOWMORE PVT. LTD.)	INDIA
3.	JYOTI LIMITED	INDIA
4.	KIRLOSKAR BROTHERS LTD.	INDIA
5.	MATHER & PLATT (INDIA) LTD. (A SUBSIDIARY OF WILO SE GERMAN)	INDIA
6.	KSB AG	GERMANY
7.	MITSUBISHI HEAVY INDUSTRIES LTD	JAPAN
8.	SHIN NIPPON MACHINERY CO. LTD	JAPAN
9.	TORISHIMA PUMP MFG. CO. LTD	JAPAN
10.	FLOWSERVE (IDP)	U.K
PUMPS FOR SLURRY SERVICE		
1.	A.R WILFLEY INDIA PVT. LTD	INDIA
2.	AKAY INDUSTRIES PVT. LTD	INDIA
3.	FLOWMORE LTD. (FORMALLY FLOWMORE PVT. LTD.)	INDIA
4.	GREAVES LTD.	INDIA
5.	KISHORE PUMPS PVT LTD	INDIA
6.	KSB PUMPS LTD	INDIA
7.	MICROFINISH PUMPS PVT. LTD	INDIA
8.	SAM TURBO INDUSTRY PRIVATE LTD.	INDIA
9.	SU MOTORS PVT. LTD	INDIA
10.	SULZER PUMPS INDIA LTD.	INDIA
PUMPS FOR UTILITY SERVICES		
1.	AKAY INDUSTRIES PVT. LIMITED	INDIA
2.	FLOWMORE LTD. (FORMALLY FLOWMORE PVT. LTD.)	INDIA
3.	FLOWSERVE INDIA CONTROL LTD.	INDIA

4.	KIRLOSKAR BROTHERS LIMITED	INDIA
5.	KIRLOSKAR EBARA PUMPS LIMITED	INDIA
6.	KISHORE PUMPS LTD	INDIA
7.	MICROFINISH PUMPS PVT. LTD	INDIA
8.	SULZER PUMPS INDIA LTD.	INDIA
CENTRIFUGAL MONOBLOCK PUMP SET		
1.	CROMPTON GREAVES LTD	INDIA
2.	JYOTI LIMITED	INDIA
3.	KIRLOSKAR BROTHERS LTD.	INDIA
4.	MATHER & PLATT (INDIA) LTD.(A SUBSIDIARY OF WILO SE GERMAN)	INDIA
5.	PRECISION ENGINEERING INDUSTRIES (SMALL PUMPS UPTO 2 HP)	INDIA
6.	UJALA	INDIA
SUMP PUMPS		
1.	AKAY INDUSTRIES PVT. LTD	INDIA
2.	KISHORE PUMPS PVT. LTD	INDIA
3.	SAM TURBO INDUSTRY PVT LTD.	INDIA

PUMPS FOR CHEMICAL DOSING/ METERING		
1.	BRAN & LUEBBE INDIA	INDIA
2.	MATZ PUMPS PRIVATE LIMITED	INDIA
3.	MILTON ROY INDIA (P) LTD	INDIA
4.	POSITIVE METERING PUMPS (I) PVT. LTD.	INDIA
5.	SHAPO TOOLS	INDIA
6.	SWELORE ENGINEERING PVT. LTD	INDIA
7.	V.K PUMPS INDUSTRIES PVT. LTD	INDIA
8.	VARICON SYSTEMS (MOTOR DRIVEN/ PNEUMATIC)	INDIA
9.	DOSAPRO MILLTON ROY	FRANCE
10.	LEWA HERBERTOTT GMBH & CO	GERMANY
11.	PERONI POMPE SPA	ITALY
12.	NIGATA WORTHINGTON PUMPS	JAPAN
13.	NIKKISO CO. LTD.	JAPAN
14.	BRAN & LUEBBE LTD.	U.K
PUMPS FOR MISC. NON CRITICAL SERVICE (RECIPROCATING TYPE)		
1.	A.R WILFLEY INDIA PVT. LTD	INDIA
2.	KSB PUMPS LTD.	INDIA
3.	SULZER PUMPS INDIA LTD	INDIA
4.	V.K PUMPS INDUSTRIES PVT. LTD	INDIA
5.	UT PUMPS & SYSTEM PVT. LTD	INDIA
6.	LEWA HERBERTOTT GMBH & CO	GERMANY
7.	URACA PUMPENFABRIK GMBH & CO	GERMANY
8.	DOSAPRO MILLTON ROY	ITALY
9.	PERONI POMPE SPA (CAPACITY = 95 M3/HR, PRE = 306 KG/CM2)	ITALY

10.	NIGATA WORTHINGTON PUMPS	JAPAN
11.	NIKKISO CO. LTD.	JAPAN
12.	BRAN & LUEBBE LTD.	U.K
ROTARY PUMPS AND SCREW PUMPS		
1.	AIRAUTO INDUSTRIES	INDIA
2.	DELTA CORPORATION	INDIA
3.	ROTO PUMPS LTD	INDIA
4.	UT PUMPS AND SYSTEMS LTD	INDIA

CENTRIFUGAL COMPRESSOR FOR INSTRUMENT/ SERVICE AIR SERVICES		
1.	INGERSOLL RAND INDIA LTD.	INDIA
2.	ATLAS COPCO ENERGAS GMBH	GERMANY
3.	GHH BORSIG TURBOMASCHINEN AG	GERMANY
4.	LINDE AG WERKSGRUPPE	GERMANY
5.	MANNESMAN DEMAG AG	GERMANY
6.	SIEMENS AG PGI	GERMANY
7.	GE POWER (FORMERLY NUOVO PIGNONE SPA)	ITALY
8.	EBARA CORPORATION	JAPAN
9.	HITACHI LTD	JAPAN
10.	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
11.	KOBE STEEL LTD.	JAPAN
12.	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
13.	MITSUI ENGINEERING & SHIP BUILDING CO. LTD	JAPAN
14.	SULZER TURBO LIMITED	SWITZERLAND
15.	DRESSER-RAND CO.	SINGAPORE
16.	ELLIOT OVERSEAS CORPORATION	U.S.A
RECIPROCATING COMPRESSOR FOR INSTRUMENT/ SERVICE AIR SERVICES		
1.	ATLAS COPCO	INDIA
2.	INGERSOLL RAND INDIA LTD.	INDIA
3.	KIRLOSKAR PNEUMATIC CO. LTD	INDIA

SCREW COMPRESSOR FOR INSTRUMENT/ SERVICE AIR SERVICES		
1.	ATLAS COPCO KOMPRESSORTEKNIK AIS	DENMARK
2.	MAN TURBOMASCHINEN AG GHH BORSIG	GERMANY
3.	KOBE STEEL LTD.	JAPAN
4.	SULZER TURBO LIMITED	SWITZERLAND
5.	HOWDEN SIROCCO LIMITED	U.K
STEAM TURBINE UPTO 3 MW		
1.	ASEA BROWN BOVERI LIMITED	INDIA
2.	BHEL	INDIA
3.	TRIVENI ENGG. WORKS LIMITED	INDIA
4.	KIRLOSKAR EBARA PUMPS LIMITED (KEPL)	INDIA
5.	ABB TURBINEN NUMBERG GMBH	GERMANY
6.	ALSTOM POWER TURBINEN GMBH	GERMANY
7.	ALTHOM POWER	GERMANY
8.	GHH BORSIG TURBOMASCHINEN GMBH	GERMANY
9.	SIEMENS AKTIENGESELLSCHAFT	GERMANY
10.	TUTHILL NADROWSKI TURBINEN GMBH	GERMANY
11.	GE POWER (NUOVO PIGNONE SPA)	ITALY

12.	EBARA CORPORATION	JAPAN
13.	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
14.	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
15.	MITSUI ENGINEERING & SHIP BUILDING CO. LTD	JAPAN
16.	SHIN NIPPON MACHINERY CO. LTD	JAPAN
17.	DRESSER RAND CO.	U.S.A
18.	ELLIOT OVERSEAS CORPORATION	U.S.A
19.	TRANSMERICA DELAVAL INC.	U.S.A
20.	TUTHILL ENERGY SYSTEMS	U.S.A
STEAM TURBINE ABOVE 3 MW		
1.	BHEL	INDIA
2.	ABB TURBINEN NUMBERG GMBH	GERMANY
3.	ALSTOM POWER TURBINEN GMBH	GERMANY
4.	GHH BORSIG TURBOMASCHINEN GMBH	GERMANY
5.	SIEMENS AKTIENGESELLSCHAFT	GERMANY
6.	GE POWER (NUOVO PIGNONE SPA)	ITALY
7.	EBARA CORPORATION	JAPAN
8.	FUJI ELECTRIC SYSTEMS CO. LTD	JAPAN
9.	KAWASAKI HEAVY INDUSTRIES LTD.	JAPAN
10.	MITSUBISHI HEAVY INDUSTRIES LTD.	JAPAN
11.	MITSUI ENGINEERING & SHIP BUILDING CO. LTD	JAPAN
12.	ASEA BROWN BOVERI	SWEDEN
13.	DRESSER RAND CO.	U.S.A
14.	ELLIOT OVERSEAS CORPORATION	U.S.A
15.	TRANSMERICA DELAVAL INC.	U.S.A
16.	TUTHILL ENERGY SYSTEMS	U.S.A
FANS & BLOWERS		
1.	ABB FLAKT INDIA LTD.	INDIA
2.	AEROTO BOLDROCCHI INDIA PVT. LTD.	INDIA
3.	AEROVENT PROJECT PVT LTD	INDIA
4.	DRAFT INDIA PVT LTD	INDIA
5.	MAX FLOW FANS MANUFACTURING PVT LTD	INDIA
6.	SWAM PNEUMATICS	INDIA
7.	BHEL	INDIA
8.	TLT ENGINEERING INDIA PVT. LTD	INDIA
9.	ILLONOIS BLOWERS INC	U.S.A
AGITATORS/ MIXERS		
1.	GANSONS LTD.	INDIA
2.	HYTEC GRANT INSTRUMENTS	INDIA
3.	MARS DYE CHEM PVT. LTD	INDIA
4.	RATHI LIGHTNIN MIXERS PRIVATE LIMITED	INDIA
5.	REMI PROCESS PLANT & MACHINERY LTD.	INDIA
6.	SAFE MAX AGITATOR	INDIA
7.	STANDARD ENGINEERS	INDIA

FILTERS & SEPARATORS		
1.	COPERION IDEAL PVT. LTD.	INDIA
2.	FIL SEP EQUIPMENTS PVT LTD	INDIA
3.	FILTRATION ENGINEERS PVT. LTD.	INDIA
4.	GANSONS LTD.	INDIA
5.	GRAND PRIX FAB (P) LTD. (CARTRIDGE FILTERS UPTO 1500#, 40" SIZE)	INDIA
6.	HAVER STANDARD INDIA PVT. LTD	INDIA
7.	MULTITEX FILTERATION ENGINEERS LTD.	INDIA
8.	OTOKLIN PLANTS & EQUIPMENT LTD.	INDIA
9.	SUPERFLO FILTERS PVT. LTD.	INDIA
10.	ULTRA FILTER (INDIA) PVT. LTD	INDIA
11.	PEERLESS MFG. COMPANY	SINGAPORE
12.	WATSON PROCESS SYSTEM (FOR VANE TYPE SEPARATORS)	CANADA
13	MURA CHEMICALS EQUIPMENT CO. LTD (FOR VANE TYPE SEPARATORS)	JAPAN
14.	RAUSCHERI VERFARENSTECNIK GMBH	GERMANY
15	NORTHEAST CONTROLS EQUIPMENT CO. LTD (FOR VANE TYPE SEPARATORS)	U.S.A
PROCESS EJECTORS		
1.	WIEGAND INDIA PVT. LTD	INDIA
2.	NEW FIELD INDUSTRIAL EQUIPMENT PVT. LTD.	INDIA
3.	GEA JET PUMPS GMBH	GERMANY
4.	KORTING HANNOVER AG	GERMANY
5.	GRAHAM CORP.	U.S.A
6.	KETEMA INC. SCHUTTE & KOERTING DIVISION	U.S.A
GEAR BOX		
1.	LUFKIN- FRANCE S.A	FRANCE
2.	FLENDER GRAFFENSTADEN	FRANCE
3.	VOITH TURBO BHS - GETRIEBE GMBH	GERMANY
4.	RENK AKTIENGESELLSCHAFT	GERMANY
5.	THE TIMKEN COMPANY	USA
COUPLINGS (for BFW Pumps)		
1.	EUROFLEX TRANSMISSIONS	INDIA
2.	BIBBY TURBOFLEX	UK
3.	EAGLE INDUSTRIES CO.LTD (EKK)	JAPAN
4.	VOITH TURBO	GERMANY
5.	KOP-FLEX	USA
COUPLINGS (miscellaneous non critical equipment)		
1.	ELECON ENGG. CO. LTD	INDIA
2.	FENNER INDIA LTD.	INDIA

3.	HI-CLIFF	INDIA
4.	RATHI TRANSPOWER PVT. LTD	INDIA
5.	RATHI TURBOFLEX PVT. LTD	INDIA
ARC VALVES		
1.	HOLTER REGELARMETUREN GMBH & CO. KG (HORA)	GERMANY
2.	SCHROEDAHL	GERMANY
3.	SCHROEDER	GERMANY
4.	YARWAY CORPORATION (FORMERLY TYCO ENGINEERING & CONSTRUCTION PVT. LTD)	GERMANY
AIR CONDITIONING SYSTEM		
	MAKE OF CHILLER UNIT / AC PACKAGE :	
1	YORK	INDIA
2	TRANE	INDIA
3	CARRIER	INDIA
4	BLUE STAR	INDIA
5	VOLTAS	INDIA
AIR CONDITIONING SYSTEM (EPC VENDORS)		
1	BLUE STAR	INDIA
2	VOLTAS LTD.	INDIA
3	ADVANCE VENTILATION PVT LTD	INDIA
4	VERTIV ENERGY PRIVATE LIMITED	INDIA
5	S K SYSTEMS PVT LTD	INDIA

3.0 ELECTRICAL:

ITEM	NAME OF THE VENDOR	COUNTRY
DIESEL GENERATOR SET		
1.	BATLIBOI & CO. LTD.	INDIA
2.	BHASKAR POWER PROJECTS LTD.	INDIA
3.	BHEL (ELECTRICAL MACHINES DIVN.)	INDIA
4.	CATERPILLAR	INDIA
5.	CUMMINS INDIA LIMITED	INDIA
6.	GARDEN REACH SHIPBUILDERS & ENGINEERS LTD.	INDIA
7.	GREAVES COTTON & CO. LTD.	INDIA
8.	JAKSON ENGINEERS LTD.	INDIA
9.	JEEVAN DIESEL & ELECTRICALS LTD.	INDIA
10.	KIRLOSKAR OIL ENGINES	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
11.	SUDHIR GENSETS LTD.	INDIA
12.	TOYO DENKI POWER SYSTEMS PVT. LTD.	INDIA
13.	WARTSILLA INDIA LTD.	INDIA
14.	MITSUBISHI CORPORATION	JAPAN
15.	TOYO ELECT. MFG. CO. LTD.	JAPAN
16.	ASEA BROWN BOVERI	SWEDEN
INDUCTION MOTORS – LV (415 V) (SAFE/HAZARDOUS AREA)		
1.	ASEA BROWN BOVERI LTD.	INDIA
2.	BHARAT BIJLEE LTD.	INDIA
3.	SIEMENS LTD.	INDIA
4.	CG POWER AND INDUSTRIAL SOLUTION LIMITED	INDIA
5.	KIRLOSKAR ELECTRIC COMPANY LTD.	INDIA
6.	EATON	INDIA
7.	HAVELLS	INDIA
8.	HEM	INDIA
INDUCTION MOTORS – HV (FOR SAFE / HAZARDOUS AREA)		
1.	BHEL (ELECTRICAL MACHINES DIVN.)	INDIA
2.	CG POWER AND INDUSTRIAL SOLUTION LIMITED	INDIA
3.	KIRLOSKAR ELECTRIC COMPANY LTD.	INDIA
4.	TOSHIBA MITSUBISHI ELECTRIC INDUSTRIAL SYSTEMS CORPORATION (Excluding flameproof motors of frame size more than 900)	INDIA
5.	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
6.	JEUMONT INDUSTRIE	FRANCE
7.	TOSHIBA CORPORATION	JAPAN
8.	MITSUBISHI CORPORATION	JAPAN
HV & LV POWER, CONTROL AND EARTHING CABLES, FLEXIBLE CABLES/WIRES		
1.	RAVIN CABLES LIMITED	INDIA
2.	KEC INTERNATIONAL LIMITED (FORMERLY RPG CABLES LIMITED)	INDIA
3.	KEI INDUSTRIES LTD.	INDIA
4.	NICCO CORPORATION LIMITED	INDIA
5.	TORRENT CABLES LIMITED	INDIA
6.	UNIVERSAL CABLES LTD.	INDIA
7.	POLYCAB INDIA LIMITED	INDIA
HV SWITCHBOARD		
1.	ABB LTD.	INDIA
2.	AREVA	INDIA
3.	SIEMENS LTD.	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
4.	LARSEN & TOUBRO LTD. (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
5.	JYOTI LIMITED	INDIA
SWITCHBOARDS – LV (415 V) (MCC/PCC/PMCC/EPMCC)		
1.	LARSEN & TOUBRO LTD. (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
2.	ABB	INDIA
3.	INTERLEC	INDIA
4.	AREVA	INDIA
5.	SIEMENS LTD.	INDIA
6.	GE	INDIA
UPS SYSTEM		
1.	EMERSON NETWORK POWER (INDIA) PVT. LTD.	INDIA
2.	DB POWER ELECTRONICS PVT. LIMITED	INDIA
3.	GE POWER CONTROLS INDIA PVT. LTD.	INDIA
4.	HITACHI HI-REL POWER ELECTRONICS PVT. LTD.	INDIA
5.	KERALA STATE ELECTRONICS DEV. CORPN. LTD.	INDIA
6.	ASEA BROWN BOVERI	SWEDEN
7.	GENERAL ELECTRIC CO.	USA
BATTERY CHARGER		
1.	CHHABI ELECTRICALS PVT. LTD.	INDIA
2.	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LTD.)	INDIA
3.	AMCO POWER SYSTEMS LTD.	INDIA
4.	UNIVERSAL INDUSTRIAL PRODUCTS	INDIA
5.	CHLORIDE POWER SYSTEMS AND SOLUTIONS LTD. (FORMERLY CALDYNE)	INDIA
6.	HBL NIFE POWER SYSTEMS LTD.	INDIA
7.	KERALA STATE ELECTRONICS DEV. CORPN. LTD.	INDIA
BATTERY		
1.	AMCO POWER SYSTEMS LTD.	INDIA
2.	HBL NIFE POWER SYSTEMS LTD.	INDIA
3.	EXIDE INDUSTRIES LIMITED	INDIA
AC VARIABLE FREQUENCY DRIVE		
1.	ASEA BROWN BOVERI LTD.	INDIA
2.	LARSEN & TOUBRO LTD. (EL. PRODUCTS DIVN.) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
3.	SIEMENS LTD.	INDIA
4.	MITSUBISHI	INDIA
5.	FUJI ELECTRIC DRIVES	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
6.	ROCKWELL AUTOMATIC INDIA LTD.	INDIA
7.	DANFOSS INDUSTRIES PVT. LTD. (UPTO 1400KW)	INDIA
8.	TMEIC INDUSTRIAL SYSTEMS INDIA PVT. LTD. (UPTO 5000 KVA)	INDIA
9.	YASAKAWA	INDIA
10.	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
POWER & DISTRIBUTION TRANSFORMERS		
1.	ALSTOM LIMITED (AREVA T&D)	INDIA
2.	BHARAT BIJLEE LTD.	INDIA
3.	CG POWER AND INDUSTRIAL SOLUTION LIMITED	INDIA
4.	EMCO LTD.	INDIA
5.	INDCOIL TRANSFORMERS PVT. LTD.	INDIA
6.	KANOHAR ELECTRICALS LIMITED (UP TO 10MVA)	INDIA
7.	KIRLOSKAR ELECTRIC COMPANY LTD.	INDIA
8.	VOLTAMP TRANSFORMERS LTD.	INDIA
NEUTRAL EARTHING RESISTOR		
1.	SHRIHANS	INDIA
2.	RSI SWITCHGEAR PVT. LTD.	INDIA
3.	ELECMECH CORPORATION	INDIA
4.	RESITECH ELECTRICALS PRIVATE LIMITED	INDIA
CONTROL & RELAY PANEL		
1.	AREVA	INDIA
2.	ASEA BROWN BOVERI LTD.	INDIA
3.	LARSEN & TOUBRO LTD. (EL. PRODUCTS DIVN.) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
4.	SIEMENS LTD.	INDIA
5.	SCHWEITZER ENGINEERING LABORATORIES	INDIA
HT CABLE JOINTING KITS		
1.	RAYCHEM RPG LTD.	INDIA
DRY TYPE TRANSFORMERS		
1.	INDCOIL TRANSFORMERS PVT. LTD.	INDIA
2.	KALPA ELECTRICAL PVT. LTD. (UP TO 100 KVA)	INDIA
3.	IMP POWER LTD.	INDIA
4.	MEHRU ELECTRICALS (FORMERLY AUTOMATIC ELECTRIC LTD.)	INDIA
5.	GUJARAT PLUG-IN DEVICES PVT. LTD. (UP TO 300 KVA)	INDIA
6.	ESENNAR TRANSFORMERS (P) LTD.	INDIA
FLAMEPROOF LOCAL CONTROL STATION, JUNCTION BOX, LIGHTING FITTING,		

ITEM	NAME OF THE VENDOR	COUNTRY
PLUG, SOCKET, HAND LAMP, ACCESSORIES LIGHTING, DISTRIBUTION BOARD & CONTROL PANEL		
1.	FCG FLAMEPROOF CONTROL GEARS PVT. LTD.	INDIA
2.	BALIGA LIGHTING EQUIPMENTS LTD.	INDIA
3.	SUDHIR SWITCHGEARS PVT. LTD.	INDIA
4.	FLAMEPROOF EQUIPMENTS PVT. LTD.	INDIA
5.	FLEXPRO ELECTRICALS PVT. LTD.	INDIA
STREET/FLOOD LIGHTING FIXTURES		
1.	CG POWER AND INDUSTRIAL SOLUTION LIMITED	INDIA
2.	PHILIPS INDIA LTD.	INDIA
3.	BAJAJ ELECTRICALS LTD.	INDIA
4.	WIPRO LIGHTING	INDIA
5.	HAVELL'S INDIA LTD.	INDIA
LIGHTING POLES		
1.	BHARATI EXPORTS	INDIA
2.	METALITE INDUSTRIES	INDIA
3.	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.	INDIA
4.	SADHANA ENGINEERING CORPORATION	INDIA
HOSE PROOF/WEATHERPROOF INDUSTRIAL LIGHTING FIXTURES, LAMPS & TUBES		
1.	BAJAJ ELECTRICALS LTD.	INDIA
2.	CROMPTON GREAVES LTD.	INDIA
3.	PHILIPS INDIA LTD.	INDIA
4.	WIPRO LIGHTING	INDIA
HOSE PROOF LOCAL CONTROL STATION/INDUSTRIAL TYPE SWITCH SOCKET & PLUG		
1.	BALIGA LIGHTING EQUIPMENTS LIMITED	INDIA
2.	FLAMEPROOF EQUIPMENTS PVT. LIMITED	INDIA
3.	FCG POWER INDUSTRIES LTD.	INDIA
4.	FCG FLAMEPROOF CONTROL GEARS PVT. LTD.	INDIA
CABLE TRAYS		
1.	GLOBE ELECTRICAL INDUSTRIES	INDIA
2.	METALITE INDUSTRIES	INDIA
3.	STEALITE ENGINEERING CO.	INDIA
4.	RUKMINI ELECTRICALS & COMPONENTS PVT. LTD.	INDIA
5.	PAREKH ENGINEERING COMPANY	INDIA
6.	SADHANA ENGINEERING CORPORATION	INDIA
7.	INDIANA ENGG. WORKS PVT. LTD.	INDIA
8.	PREMIER POWER PRODUCTS (CALCUTTA) PVT.	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
	LTD.	
FRP CABLE TRAYS (COOLING TOWER AREA)		
1.	EPP COMPOSITES PVT. LTD.	INDIA
2.	ERCON COMPOSITES (UPTO 600 MM WIDE)	INDIA
3.	SUMIP COMPOSITES PVT. LTD.	INDIA
HV/MV BUS DUCTS		
1.	BEST & CROMPTON ENGG. CO.	INDIA
2.	POWERGEAR LIMITED	INDIA
3.	SPACEAGE SWITCHGEARS LIMITED	INDIA
4.	INTERLEC	INDIA
FLOOR MOUNTED DISTRIBUTION BOARDS		
1.	ELECMECH CORPORATION	INDIA
2.	INTRELEC	INDIA
3.	CONTROLS & SWITCHGEAR CO. LTD.	INDIA
4.	GLOBE ELECTRICAL INDUSTRIES	INDIA
5.	REUNION ELECTRICAL MANUFACTURERS (P) LTD.	INDIA
6.	UNIVERSAL INDUSTRIAL PRODUCTS	INDIA
7.	VIDHYUT CONTROL (INDIA) PVT. LTD.	INDIA
WALL MOUNTED DISTRIBUTION BOARDS		
1.	ELECMECH CORPORATION	INDIA
2.	INTRELEC	INDIA
3.	CONTROLS & SWITCHGEAR CO. LTD.	INDIA
4.	GLOBE ELECTRICAL INDUSTRIES	INDIA
5.	REUNION ELECTRICAL MANUFACTURERS (P) LTD.	INDIA
6.	HAVELLS INDIA LTD.	INDIA
7.	INDO ASIAN FUSEGEAR LTD.	INDIA
8.	LEGRAND INDIA LTD.	INDIA
SOFT STARTERS		
1.	YASAKAWA	INDIA
2.	ABB	INDIA
3.	LARSEN & TOUBRO LTD. (EL. PRODUCTS DIVN.) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
4.	ROCKWELL AUTOMATION INDIA LTD.	INDIA
5.	SIEMENS LTD.	INDIA
6.	DANFOSS INDUSTRIES PVT. LTD. (UPTO 800KW)	INDIA
7.	TMEIC INDUSTRIAL SYSTEMS INDIA PVT. LTD. (UPTO 6000KW MOTORS)	INDIA
PAGING EQUIPMENT/PA SYSTEM		
1.	CG POWER AND INDUSTRIAL SOLUTION LIMITED	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
2.	PHILIPS INDIA LTD.	INDIA
3.	TATA TELECOM LIMITED	INDIA
4.	NEUMANN GMBH ELEKTRONIK	GERMANY
5.	MOTOROLA SINGAPORE PTE LTD.	SINGAPORE
6.	GAI TRONICS SRL	UK
7.	ARMTEL LLC	RUSSIA
8.	MOTWANE	INDIA
9.	BOSCH	INDIA
PROGRAMMABLE LOGIC CONTROLLER (ELECTRICAL)		
1.	ASIA BROWN BOVERI LTD.	INDIA
2.	SIEMENS LTD.	INDIA
3.	ROCKWELL AUTOMATION INDIA PVT. LTD.	INDIA
4.	LARSEN & TOUBRO LTD. (EL. PRODUCTS DIVN.) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
5.	HONEYWELL AUTOMATION INDIA LIMITED	INDIA
EARTHING & LIGHTNING PROTECTION MATERIAL – (GI) WIRE/STRIP		
1.	ANAND ELECTRIC TRADING CO.	INDIA
2.	BHARTI EXPORTS	INDIA
3.	C&S ELECTRIC LTD.	INDIA
4.	JAYANT METAL MFG. CO.	INDIA
5.	METALITE INDUSTRIES	INDIA
6.	PREMIER POWER PRODUCTS (CALCUTTA) PVT. LTD.	INDIA
CATHODIC PROTECTION SYSTEM CONTRACTOR		
1.	CONSTRUCTION GUILD PVT. LTD.	INDIA
2.	ELECTRO PROTECTION SERVICES INDIA PVT. LTD.	INDIA
3.	SARK EPC PROJECTS PVT. LTD.	INDIA
4.	UNDERGROUND PIPELINE & NDT SERVICES PVT. LTD.	INDIA
FIRE ALARM SYSTEM		
1.	BOSCH LTD.	INDIA
2.	TYCO FIRE PROTECTION PRODUCTS	INDIA
3.	HONEYWELL	INDIA
CAPACITORS		
1.	BHEL (ELECTRICAL MACHINES DIVN.)	INDIA
2.	CG POWER AND INDUSTRIAL SOLUTION LIMITED	INDIA
3.	SHREEM CAPACITORS PVT. LTD.	INDIA
4.	UNIVERSAL CABLES LTD.	INDIA
5.	EPCOS	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
PROTECTIVE RELAYS		
1.	AREVA	INDIA
2.	ASEA BROWN BOVERI LTD.	INDIA
3.	LARSEN & TOUBRO LTD. (EL. PRODUCTS DIVN.) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)	INDIA
4.	SIEMENS LTD.	INDIA
5.	EASUN REYROLLE LIMITED	INDIA
6.	SCHWEITZER ENGINEERING LABORATORIES	INDIA
LIFT		
1.	OTIS ELEVATORS CO. (I) LTD.	INDIA
2.	FUJI ELECTRIC SYSTEMS CO. LTD.	JAPAN
3.	SCHINDLER AG	SWITZERLAND
4.	THYSSENKRUP	INDIA
AIR PRESSURIZATION / VENTILATION SYSTEM		
1.	CARRIER	INDIA
2.	BLUE STAR LTD.	INDIA
3.	VOLTAS LTD.	INDIA
HIGH MAST LIGHTING		
1.	CROMPTON GREAVES LTD.	INDIA
2.	PHILIPS INDIA LTD.	INDIA
3.	BAJAJ ELECTRICALS LTD.	INDIA
FLAMEPROOF CABLE GLAND		
1.	BALIGA LIGHTING EQUIPMENTS LIMITED	INDIA
2.	COMET BRASS PRODUCTS	INDIA
3.	COMET INDUSTRIES	INDIA
4.	DOWELL'S ELECTRICALS	INDIA
5.	FCG FLAMEPROOF CONTROL GEARS PVT. LTD.	INDIA
6.	FCG POWER INDUSTRIES LTD.	INDIA
7.	FLAMEPROOF EQUIPMENTS PVT. LTD.	INDIA
8.	FLEXPRO ELECTRICALS PVT. LTD.	INDIA
GI PIPES & CONDUITS		
1.	BHARTI EXPORTS	INDIA
2.	INDIAN TUBE CO. (TATA DIV. OF TUBES & PIPES)	INDIA
3.	JINDAL PIPES LTD.	INDIA
4.	MEGHJYOT ENTERPRISES	INDIA
5.	RUKMINI ELECTRICALS & COMPONENTS PVT. LTD.	INDIA
6.	STEELCRAFT	INDIA
PVC PIPES & CONDUITS		
1.	A.K.G.	INDIA
2.	FINOLEX INDUSTRIES LTD. (PIPES & PVC DIVN.)	INDIA

ITEM	NAME OF THE VENDOR	COUNTRY
3.	KALINGA CABLES & CONDUIT CO.	INDIA
4.	POLYPACK	INDIA
5.	PRAKASH INDUSTRIES LTD.	INDIA

MAKE OF HV & LV SWITCHBOARDS & DISTRIBUTION BOARDS COMPONENTS		
S.N.	**Component Description**	**Manufacturers / Vendor**
1.	HIGH VOLTAGE CIRCUIT BREAKER	ABB LTD. (VD4) / AREVA / SIEMENS LTD. (NX AIR) / LARSEN & TOUBRO LTD. (VHIH) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / JYOTI LTD.
2.	AIR CIRCUIT BREAKER	L&T (OMEGA) (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS (SIEPAN 8PO) / GE POWER / ABB (EMAX)
3.	MCB / MPCB / MCCB / ELCB / RCCB	LEGRAND / SCHNEIDER / ABB / SIEMENS
4.	SWITCH	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM POWER / ABB
5.	FUSE	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM POWER / ABB
6.	CONTACTOR	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ABB
7.	THERMAL O/L RELAY	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ABB
8.	PROTECTIVE RELAYS	SCHNEIDER ELECTRIC / ABB / SIEMENS / L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SCHWEITZER ENGINEERING LABORATORIES
9.	AUXILIARY RELAYS	ABB / SCHNEIDER / SIEMENS
10.	TIMERS	ALSTOM POWER / SIEMENS / ABB / SCHNEIDER / L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)
11.	SINGLE PHASING PREVENTOR	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ABB
12.	CURRENT TRANSFORMER	SIEMENS / INDCOIL / PRECISE / KAPPA ELECTRICALS / AREVA / PRAGATI / JYOTI / ABB / SCHNEIDER
13.	POTENTIAL TRANSFORMER	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM

		POWER / KAPPA ELECTRICALS / INDCOIL / AREVA / PRAGATI / JYOTI / ABB / SCHNEIDER
14.	CONTROL TRANSFORMER	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM POWER / KAPPA ELECTRICALS / INDCOIL / ABB
15.	INSTRUMENTS (METERS)	IMP / AE / SCHNEIDER / L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / ABB / SIEMENS
16.	PUSH BUTTONS	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM POWER / ABB / SCHNEIDER
17.	CONTROL SWITCHES	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM POWER / KAYCEE / ABB
18.	SIGNAL LAMPS	L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / ALSTOM POWER / BINOY / ABB
19.	CABLE GLANDS	BALIGA / COMET / FCG / ELECTROMAC
20.	CABLE LUGS	DOWELL / FORWARD ENGG. INDUSTRIES / POWER ENGG. CO. / S J METAL INDUSTRIES (JAINSON)
21.	TERMINAL BLOCKS	ELMEX / SIEMENS / L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / CONNECTWELL / WAGO / PHOENIX
22.	MULTIFUNCTION METER	SCHNEIDER ELECTRIC / ABB / L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED) / SIEMENS / SATEC / CONSERV
23.	ALARM ANNUNCIATOR	PROTON / APLAB
24.	INSULATING SLEEVE / SHROUD	RAYCHEM
25.	TRANSDUCER	AE / SIEMENS / ABB / L&T (A UNIT OF SCHNEIDER ELECTRIC INDIA PRIVATE LIMITED)

MAKE OF CP SYSTEM EQUIPMENT/COMPONENT		
S.N.	**DESCRIPTION OF MATERIAL**	**MANUFACTURERS / VENDOR**
1.	TRANSFORMER RECTIFIER UNIT	ADVANCE ELECTRONIC SYSTEMS / RAYCHEM RPG / KRISTRON SYSTEM
2.	TEST STATIONS / ANODE JUNCTION BOX/CATHODE JUNCTION BOX	AES / CORROSION CONTROL SERVICES, MUMBAI / CORR-TECH INTERNATIONAL, AHMADABAD / SUKRIT INDUSTRIES /

	(WEATHERPROOF)	UNDTS / SARK EPC
3.	TEST STATIONS / ANODE JUNCTION BOX / CATHODE JUNCTION BOX (FLAMEPROOF)	FCG / FEPL / FLEXPRO / BALIGA
4.	PERMANENT REFERENCE ELECTRODE	BORIN USA / M.C. MILLER USA / M/S ELECTROCHEMICAL DEVICES USA / HARCO USA / CER ANODE USA
5.	SURGE DIVERTER FOR M IJS	DEHN GERMANY / OBO BETTERMANN GERMANY
6.	MONOLITHIC ISOLATING JOINTS	AES / ALFA ENGINEERING / SRL, ITALY / ZUNT, ITALY / R.M.A. ITALY / ADVANCE PRODUCTS, USA
7.	CABLES	RAVIN CABLES LIMITED / KEC INTERNATIONAL LIMITED (FORMERLY RPG CABLES LIMITED) / KEI INDUSTRIES LTD. / NICCO CORPORATION LIMITED / TORRENT CABLES LIMITED / UNIVERSAL CABLES LTD. / POLYCAB INDIA LIMITED
8.	CALCINED PETROLEUM COKE BREEZE	GOA CARBON (GOA) / INDIA CARBON (CALCUTTA) / PETRO CARBON & CHEM. COMPANY HALDIA
9.	ZINC GROUNDING ELECTRODE / CELL / ZINC RIBBON ANODE	SARGAM METALS CHENNAI / SCIENTIFIC METALS KARAIKUDI / SHAKHTI ENTERPRISE
10.	MAGNESIUM ANODES (FOR TCP)	SARGAM METALS CHENNAI / SCIENTIFIC METALS KARAIKUDI / SHAKHTI ENTERPRISE
11.	MMO TUBULAR ANODES	CERANODE (USA) / TITANOR COMPONENTS (INDIA) / MATCOR- USA / M/S ELTECH. NETHERLANDS / XIAN ANODES / MAGNETOCHIEME, HOLLAND
12.	FACTORY PREPACKAGED MMO WIRE ANODE / CONDUCTIVE POLYMERIC ANODE	SEAL FOR LIFE INDIA PVT. LTD. / MATCOR
13.	SOILD STATE DECOUPLER	DAIRYLAND, USA / KRISTRON / DEHN / RUSTROL
14.	DIGITAL MULTI METER	BECKMANN / FLUKE / MOTWANE
15.	DC CLIP-ON METER	HCK (GERMANY) / KYORITSU ELECT (JAPAN) / FLUKE / SWAIN

NOTE:

1. Make of the equipment not indicated and any other make for the specified equipment shall be subject to owner's / consultant's approval.

4.0 CIVIL & STRUCTURAL VENDOR LIST

GENERAL NOTES:

a) Only 'First' Quality materials shall be used

b) OWNER / CONSULTANT reserve the right to choose any of the approved make / vendor as per this list. Make of the item not indicated and any other make for the specified item shall be subject to owner's / consultant's approval.

c) Specifications of manufacturer's items shall be checked against tender item / specifications before selecting any product or brand name. In case of any discrepancy, tender item / specifications shall prevail, and any such brand of item shall not be used which is not conforming to tender specifications even if it is listed in this vendor list.

d) In case of non-availability of any material among approved vendors / makes in a particular site / region, alternate vendor / make conforming to IS / BS etc. Shall be used subject to approval by OWNER / CONSULTANT.

SL. NO.	ITEM	NAME
1.0	**FLOOR FINISHING**	
1.1	CEMENT TILES (FLOOR/WALL)	a) EUROCON b) ALTRA TILE PVT. LTD. c) DAZZLE
1.2	TERRAZZO TILES	A) NITCO B) HINDUSTAN TILES
1.3	CERAMIC TILES	**a.** SOMANY CERAMICS **b.** H&R JOHNSON CERAMICS **c.** KAJARIA CERAMICS

		d. ORIENT CERAMICS
1.4	HEAVY DUTY FLOOR TILES	A) BHARAT TILES B) RESTILE CERAMICS C) PELICAN CERAMIC INDUS. D) PAVIT E) SONA TILES
1.5	INDUSTRIAL FLOOR HARDENER ADMIXTURE	**a)** PIDILITE INDUSTRIES **b)** SIKA **c)** CICO.
1.6	PVC ROLLS	A) PREMIER VINYL B) ARMSRONG INARCO C) RMG POLYVINYL
1.7	PVC TILES	A) ARMSTRONG
1.8	PVC TILES/ROLL ANTISTATIC	A) PREMIER VINYL B) RMG POLYVINYL C) ARMSTRONG
1.9	ACID RESISTANT TILES(BATTERY ROOM)	A) H&R JOHNSON OR APVD. EQUIV.
1.10	MOSSAIC TILE	A) ITALIS B) SPECIFIC GLASS MUSSAIC INDIA LTD.
2.0	**WOODWORK**	
2.1	FLUSH DOOR	A) GREEN B) CENTURY DOORS C) KITPLY PRODUCTS
2.2	PLY WOOD/BLOCK BOARD	A) CENTURY B) KITPLY PRODUCTS C) GREEN PLY
2.3	PARTICLE BOARD (EXTRA GRADE)	A) BHUTAN BOARD B) NOVAPAN INDIA LTD.
2.4	MDF BOARD/MD PARTICLE BOARD (EXTRA GRADE)	A) NUCHEM LTD. B) MANGALAM TIMBER PRODUCTS LTD. C) WESTERN BIO SYSTEMS LTD.
2.5	DECORATIVE LAMINATES	A) CENTURY B) GREENPLY INDUS. LTD. C) MERINO D) ARCHID
2.6	MARINE PLYWOOD	A) CENTURY

		B) GREENPLY INDUS. LTD. C) MERINO D) ARCHID
2.7.0	**DOORS & WINDOWS FITTINGS**	
2.7.1	MORTICE LOCKS WITH HANDLES	A) GODREJ & BOYCE B) EVERITE AGENCIES (P) LTD. C) DOORSET
2.7.2	CYLINDRICAL PIN TUMBLER LOCK WITH KNOBS	A) GODREJ & BOYCE B) EVERITE AGENCIES (P) LTD. C) DOORSET
2.7.3	HYDRAULIC DOOR CLOSER (OVER HEAD/ FLOOR)	A) OZONE B) EVERRITE AGENCIES (P) LTD. C) HARDWYN
2.7.4	MISC. DOOR FITTINGS HINGLE, TOWER BOLTS, LATCHES, SOPPER, STAYS, ALDROPS ETC.	A) EVERITE AGENCIES (P) LTD. B) EBCO DINSUTRIES D) OZONE E) HARDWYN
2.7.5	THREE WAY BOLTING LOCKING DEVICE HANDLE	A) SRIMA SALES & SERVICES B) DHIMAN INDUSTRIES
2.7.6	PANIC BAR LATCH (FOR EMERGENCY DOOR)	A) SRIMA SALES & SERVICE
2.7.7	UPVC WINDOWS	A) FENESTA B) ENCRAFT C) WINDOW MAGIC
2.7.8	FASTENERS	A) HILTI INDIA PVT. LTD. B) FISCHER
3.0	**STEEL / ALUMINIUM DOORS, WINDOWS & VENTILATOR**	
3.1	PRESSED STEEL DOORS WINDOWS & SECTION DOORS WINDOWS/ROLLING SHUTTER	A) RAYMUS ENGINEERS B) DHIMAN STEEL C) RDG ENGINEERING D) SUPER STEEL WINDOW CO. E) SKS STEEL INDUS.
3.2	ALMUNIUM / DOORS/ WINDOWS SECTIONS	A) JINDAL ALUMINIUM LTD. B) HINDALCO INDUSTRIES C) INDAL
3.3	FIRE-PROOF DOORS(APPROVED)	A) NAVAIR INTERNATIONAL B) RDG ENGINEERING
3.4	PVC DOORS / WINDOWS	A) SINTEX OR APPVD EQUIV.
3.5	PVC WATER TANKS	A) SINTEX OR APPVD EQUIV.
4.0	**PLASTERING**	
4.1	WATERPROOFING/ COMPOUND IN CEMENT PLASTER	A) STRUCTURAL WATER PROOFING CO. (P) LTD. B) PIDILITE INDUSTRIES C) SIKA D) KRISHNA CONCHEM

5.0	**ROOF TREATMENT (WATER PROOFING)**	
5.1	BRICK BAT COBA	A) INDIA WATER PROOFING CO. B) OVERSEAS WATERPROOFING CORPN.
5.2	ACRYLIC BASED CEMENTATIOUS PRIMER COATING FOR ROOF WATERPROOFING	A) STRUCTURAL WATER PROOFING CO. (P) LTD. B) SIKA QUALCRETE LTD. C) PIDILITE INDUSTRIES D) KRISHNA CONCHEM
5.3	APP MODIFIED POLYMERIC WASTER PROOFING MEMBRANE	A) PIDILITE INDUSTRIES LTD. B) SIKA
5.4	PU BASED WATERPROOFING	A) PIDILITE INDUSTRIES LTD. B) SIKA C) BASF D) FOSROC
6.0	**PAINTING WORKS**	
6.1	PLASTIC EMULSION (INTERIOR/EXTERIOR)	A) ICI INDIA LTD. B) BERGER PAINTS LTD. C) ASIAN PAINTS LTD. D) SHALIMAR PAINTS E) KANSAI NEROLAC PAINTS LTD. F) M/s. Johnson & Nicholson
6.2	DRY OILBOUND DISTEMBER	A) ASIAN PAINTS LTD. B) KANSAI NEROLAC PAINTS LTD.
6.3	INDUSTRIAL / EPOXY/ ALIPHATIC ACRYLATE/ SYNTHETIC ENAMEL PAINTS	A) ICI/AKZO NOBEL INDIA B) BERGER PAINTS LTD. C) ASIAN PAINTS LTD. D) SHALIMAR PAINTS E) INTERNATIONAL MARINE COATINGS PVT. LTD. F) KANSAI NEROLAC PAINTS LTD. G) BOMBAY PAINT H) KRISHNA CONCHEM
6.4	WATERPROOFING CEMENT PAINT	A) KILLICK NIXON LTD. B) RAJDOOT PAINTS
6.5	WOOD MELAMINE POLISH	A) ASIAN PAINTS B) SHALIMAR PAINTS C) WEMBLY PAINTS
6.6	WATERPROOFING TRANSPARENT EXTERIOR WALL COATING (OVER PAINTED SURFACE)	A) PIDILITE INDUSTRIES B) SIKA C) KRISHNA CONCHEM
6.7	FIRE PROOF COATING	A) NAVAIR INTERNATIONAL OR

		APPVD. EQUIV.
7.0	**ROOFING SHEETS & ACCESSORIES**	
7.1	ASBESTOS SHEETS	A) ETERNIT EVEREST LTD. B) CHARMINAR INDUSTRIES C) VISAKA
7.2	C.G.I. SHEETS	A) ISPAT INDUSTRIES LTD. B) STEEL AUTHORITY OF INDIA C) TATA STEEL D) JINDAL
7.3	PRECOATED G.I. PROFILE SHEETS FOR ROOFING & WALL CLADDING	A) ISPAT INDUSTRIES LTD. B) LLOYD INSULATION (I) LTD. C) STEEL AUTHORITY OF INDIA D) TATA STEEL E) JINDAL
7.4	ALUMINIUM SHEET (PLAIN/PROFILE)	A) INDIAN ALUMINIUM CO. LTD. OR APPROVED EQUIVALENT
7.5	FIBRE GLASS SHEETS & PANELS (MACHINE MOULD)ED	A) SIMBA FRP (P) LTD. B) GE INDIA C) DUROPLAST
7.6	PROOFING J/L HOOKS, BOLTS & OTHER ACCESSORIES (POLYMER COATED)	A) KATALIST CONSULTANT (P) LTD. B) ADVANCED MACHINE
8.0	**SANITARY PLUMBING FITTINGS & FIXTURES**	
8.1	SANITARY FITTINGS (W.C. WASH BASIN, URINAL ETC.)	A) HINDUSTAN SANITARY WARE & INDUS. LTD. B) PARRYWARE SANITARY WARE C) MADHUSUDAN CERAMICS D) NYCER CERAMICS
8.2	PLUMBING FITTINGS & FIXTURES	A) JAGUAR B) CERA C) HINDWARE
8.3	GLASS/MIRROR (SHEET/ FLOAT/ TOUGHENED/ LAMINATION	A) GUJARAT GUARDIAN LTD. B) SAINT GOBAIN C) ASAHI FLOAT
8.4	GI PIPES	A) JINDAL B) SURYA C) PRAKASH D) SWASTIK
9.0	**FALSE CEILING, FALSE FLOORING & UNDERDECK INSULATION**	
9.1	FLASE CEILING / WALL CLADDING (ALUMINIUM STRIP/ TRAY TYPE)	A) INTERARCH BUILDING PRODUCTS (P) LTD. B) HUNTER DOUGLAS C) MASCOT OVERSEAS

9.2	FALSE FLOORING	A) MULTI INTERIORS PVT. LTD. B) BESTLOCK SYSTEM & CONCEPTS C) LLOYD INDUSULATION (I) LTD. D) UNITED INSULATION E) A.R. & BROTHERS
9.3	UNDERDECK/WALL HEAT INSULATION	A) BAKELITE HYLAM LTD. B) U.P. TWIGA F.G. LTD. C) LLOYD INDULATION (I) LTD. D) SUPEREME E) PIDILITE
9.4	OVERDECK HEAT INSULATION	A) LLOYD INSULATION (I) LTD. B) BEST PLASTRONICS LTD. C) PIDILITE INDUSTRIES LTD
9.5	GYPSUM BOARD TILES (FIBRE GLASS REINFORCED)/ PRIMA BOARD ARMSTRONG FALSE CEILING	A) SAINT GOBAIN
10.0	SPECIALITY PRODUCTS (CEMENT ADDITIVES/ ADMIXTURES / CORROSION INHIBITORS / SBR LATEX & ACRYLIC POLYMERS / EPOXY LATEX POLYMERS / FOOD GRADE EPOXY SURFACE TREATMENT/ EPOXY & CEMENTITIOUS GROUT/ EPOXY BONDING AGENTS & ANCHORS / SEALING / COATING	A) PIDILITE INDUSTRIES B) SIKA C) KRISHNA CONCHEM D) FOSROC E) BASF
10.1	EPOXY FLOOR COATING (BATTERY ROOM)	A) SIKA B) FAIRMATE C) CIPY POLYURETHANE D) KRISHNA CONCHEM
10.2	EPOXY PHENOLIC CHEMICAL RESISTANT COATING & MORTAR(SCREED) FOR FLOOR & WALLS	A) KRISHNA CONCHEM B) SIKA C) FOSROC D) BASF E) CIPY POLYURETHANE
10.3	CONCRETE REPAIR & REHABILITATION PRODUCTS	A) KRISHNA CONCHEM B) SIKA C) FOSROC D) BASF E) PIDILITE
10.4	PREMIXED CEMENTITIOUS MORTARS & MICROCONCRETE	A) KRISHNA CONCHEM B) SIKA C) FOSROC

		D) BASF E) PIDILITE
10.5	GLASS/CARBON FIBRE WRAPPING FIBRE / LAMINATE / EPOXY	A) KRISHNA CONCHEM B) SIKA C) FOSROC D) BASF
10.6	CORROSION PROTECTION ANODES & CAPLETS	A) KRISHNA CONCHEM B) SIKA C) FOSROC D) BASF
11.0	**MISCALLANEOUS ITEMS**	
11.1	WOOD PRESERVATIVE	A) ASCU HICKSON LTD.
11.2	WALL SURFACE TEXTURED COATING	A) JOTUN B) SPECTRUM PAINTS C) BAKELITE HYLAM D) OIKOS
11.3	EXTERNAL ACRYLIC WALL COATINGS	A) KRISHNA CONCHEM B) SIKA C) FOSROC D) BASF E) PIDILITE F) ASIAN G) BERGER
11.4	PVC PLUMBING FITTINGS	**a)** SUPREME **b)** POLYPAC **c)** ASTROL
11.5	REINFORCED FIBRE GLASS WATERPROOFING FELT	A) SIKA B) U.P. TWIGA F.G. LTD.
11.6	ANTI TERMITE TREATMENT	A) PCI OR APPRVD EQUIV.
11.7	MATERIAL TEST HOUSE	A) IIT MADRAS B) GOVT APPROVED AGENCY
12.0	CEMENT	A) ACC B) J K CEMENT C) BINANI CEMENT D) JP CEMENT E) GUJARAT AMBUJA F) ALTRA TECH CEMENT G) BIRLA CORPN. LTD. H) GRASIM I) SHREE
12.1	SULPHUR RESISTANT CEMENT	A) SAURASHTRA CEMENT LTD. B) SHREE DIGVIJAY CEMENT
13.0	RCC DESIGN MIX	AP GOVT APPROVED AGENCY

14.0	WRAPPING COATING (I/C TAPE & PRIMER) IWL OR APPROVED EQUIPMENT	A) IWL OR APPROVED EQUIVALENT
15.O	FIRE PROOFING MATERIAL	A) CAFCO B) CARBOLINE
16.0	STRUCTURAL STEEL / CS PLATE	HEAVY SECTIONS MORE THAN 150 MM A) SAIL B) TATA STEEL C) RINL LIGHT SECTIONS LESS THAN 150 MM D) JINDAL E) ESSAR F) ISPAT INDUSTRIES
16.1	MS PIPES (HAND RAIL APPLICATION)	**a)** SURYA **b)** PRAKASH **c)** JINDAL
17.0	TMT BAR / REBAR	A) SAIL B) TATA STEEL C) RINL D) SHYAM STEEL INDUSTRIES LIMITED E) ELECTROSTEEL STEELS LTD F) SHRI RATHI STEEL LTD. G) SRMB SRIJAN PRIVATE LIMITED
18.0	GRATINGS/HANDRAILS	A) INDIANA GRATINGS B) WESTCOAST ENGINEERING C) GREATWELD GRATING D) KANADE ANAND UDYOG
19.0	WELDING ELECTRODE	A) ADOR B) ESAB C) D & H D) HANOVAR

5.0 MECHANICAL – PIPING

CS WELDED PIPES TO API 5L SPIRAL LONG. WELDED		
Sl.No	**Vendor's Name**	**Country**
1	HEAVY METAL PIPE CENTRE (UPTO 24" (UPTO SCHXXS)	INDIA
2	JINDAL PIPES LTD. (2" TO 14")	INDIA
3	JOTINDRA STEEL & TUBES LTD. (½" TO 14")	INDIA
4	KALPESH TUBE(INDIA), (TRADER)	INDIA
5	LALIT PIPES & PIPES LTD.. (16" to 64" thickness upto 20mm)	INDIA
6	MUKAT PIPES LTD.	INDIA
7	P.K.FORGE & FITTING INDUSTRIES	INDIA

8	PRATIBHA INDUSTRIES LTD. (16" to 24" thickness 6mm to 14.27mm)	INDIA
9	RATNAMANI METALS & TUBES LTD.	INDIA
10	SAGAR STEEL CORPORATION (TRADER)	INDIA
11	SAIL	INDIA
12	SURINDRA ENGINEERING CO. PVT. LTD.	INDIA
13	SURYA ROSHINI LTD (GR. A 3” TO 4”, GR. B, 6” TO 14”)	INDIA
14	THE BENGAL MILL STORES SUPPLY CO.(TRADER)	INDIA
15	WELSPUN GUJARAT STAHL ROHREN LIMITED (FOR ANJAR AND DAHEJ PLANTS) (UPTO 72” 50 MM THK FOR DAHEJ PLANT AND UPTO 100” 30 MM THK. FOR ANJAR PLANT.)	INDIA
16	PHOCEENNE	FRANCE
17	ETS TROUVAY & CAUVIN	FRANCE
18	MANNESMANN HANDEL AG	GERMANY
19	THYSSEN-KRUPP STAHLUNION GMBH	GERMANY
20	DALMINE SPA	ITALY
21	RACCORTUBI SRL	ITALY
22	KOSEI SANGYO LTD	JAPAN
23	MARUBENI ITOCHU STEEL	JAPAN
24	MITSUBISHI CORPORATION	JAPAN
25	NIPPON KOKAN	JAPAN
26	NIPPON STEEL CORPORATION	JAPAN
27	NISHITANI & CO. LTD.	JAPAN
28	NISSHO IWAI CORPORATION	JAPAN
29	OKURA & CO. LTD.	JAPAN
30	SOJITZ CORPORATION	JAPAN
31	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
32	HYUNDAI CORPORATION	KOREA
33	BRITISH STEEL CORPORATION	U.K.
34	CORUS TUBES LIMITED	U.K.
35	SAW PIPES USA, INC	U.S.A
CS/AS/LTCS SEAMLESS PIPES		
1	BHEL	INDIA
2	CHETAN STEELS (Upto 12”, SCH80)	INDIA
3	HEAVY METAL & TUBES (Upto 8”, thickness upto 18.26mm)	INDIA
4	HEAVY METAL PIPE CENTRE (UPTO 24" (UPTO SCHXXS)	INDIA
5	INDIAN TUBE CO. (TATA DEV. OF TUBES & PIPES)	INDIA
6	ISMT LIMITED	INDIA
7	JINDAL SAW LTD.	INDIA
8	MAHARASHTRA SEAMLESS LTD.	INDIA
9	P.K.FORGE & FITTING INDUSTRIES	INDIA
10	RATNADEEP METAL & TUBES PVT. LTD.	INDIA
11	SAINEST TUBES PVT. LTD. (½ “ NB TO 3” UPTO SCH. 160	INDIA

	(ASTM A 106 GR. B, A333 GR. 1 & 6 & A335 GR. P11))	
12	PHOCEENNE	FRANCE
13	ETS TROUVAY & CAUVIN	FRANCE
14	MANNESMANN HANDEL AG	GERMANY
15	HORST KURVERS GMBH	GERMANY
16	DALMINE SPA	ITALY
17	GAM RACCORDI S.P.A	ITALY
18	IBF SEAMLESS PIPES SPA	ITALY
19	RACCORTUBI SRL	ITALY
20	MARUBENI ITOCHU STEEL	JAPAN
21	MITSUBISHI CORPORATION	JAPAN
22	NIPPON STEEL CORPORATION	JAPAN
23	NISHITANI & CO. LTD.	JAPAN
24	NISSHO IWAI CORPORATION	JAPAN
25	OKURA & CO. LTD.	JAPAN
26	SOJITZ CORPORATION	JAPAN
27	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
28	HYUNDAI CORPORATION	KOREA
29	AB SANDVIK STEEL	SWEDEN
30	VOMAL INTERNATIONAL LIMITED	U.K.
31	CORUS TUBES LIMITED	U.K.
32	BRITISH STEEL CORPORATION	U.K.
SS SEAMLESS/ WELDED PIPES		
1	APEX TUBES	INDIA
2	BHANDARI FOILS & TUBES LIMITED (SEAMLESS UPTO 4" (SCH. 80) & WELDED UPTO 20" (THK. <= 8	INDIA
3	CHOKSI TUBE COMPANY LTD.	INDIA
4	CHETAN STEELS (UPTO 6” SCH. 40)	INDIA
5	HEAVY METAL & TUBES (UPTO 8" (THICKNESS UPTO 18.26 MM))	INDIA
6	HEAVY METAL PIPE CENTRE (UPTO 8" (UPTO SCH80S) (PDIL APPROVED MANUFACTURER'S MAKE ONLY))	INDIA
7	JINDAL SAW LTD.	INDIA
8	KRYSTAL STEEL MANUFACTURING PVT. LTD. (UPTO 2" (MATERIAL UPTO GRADE SS 321))	INDIA
9	MARDALE PIPES PLUS LTD.	INDIA
10	MODERN TUBE INDUSTRIES LTD. (Upto 2" (upto SS Grade 321))	INDIA
11	NUCLEAR FUEL COMPLEX	INDIA
12	P.K.FORGE & FITTING INDUSTRIES	INDIA
13	PRAKASH STEELAGE LTD. (Seamless: upto 12” & Welded: upto 24”)	INDIA
14	QUALITY STAINLESS PVT. LTD.	INDIA

15	RAJENDRA MECHANICAL INDUSTRIES LTD.	INDIA
16	RATNAMANI METALS & TUBES LTD.	INDIA
17	RATNADEEP METAL & TUBES PVT. LTD.(SMLS. 6",WELDED 2")	INDIA
18	SANDVIK ASIA PVT. LTD. (¾" TO 2" (THK: UPTO 8.74 MM))	INDIA
19	SANGHVI METALS (TRADER)	INDIA
20	SCORODITE STAINLESS (INDIA) PVT. LTD. (UPTO 2" (UPTO SS GRADE 321))	INDIA
21	SUBHLAXMI METALS & TUBES PVT. LTD. (Seamless: upto 2" & Welded: upto 8")	INDIA
22	SURAJ STAINLESS LIMITED	INDIA
23	THE BENGAL MILL STORES SUPPLY CO.(TRADER)	INDIA
24	ZHEJIANG JIULI STAINLESS STEEL PIPE CO. LTD.	CHINA
25	ETS TROUVAY & CAUVIN	FRANCE
26	PHOCEENNE	FRANCE
27	H. BUTTING GMBH & CO. (SEAMLESS : UPTO 30" (UPTO 16MM THK) & WELDED: UPTO 72" (UPTO 64MM)	GERMANY
28	HORST KURVERS GMBH	GERMANY
29	MANNESMANN HANDEL AG	GERMANY
30	THYSSEN-KRUPP STAHLUNION GMBH	GERMANY
31	DALMINE SPA	ITALY
32	GAM RACCORDI S.P.A	ITALY
33	IBF SEAMLESS PIPES SPA	ITALY
34	RACCORTUBI SRL	ITALY
35	MARUBENI ITOCHU STEEL	JAPAN
36	MITSUBISHI CORPORATION	JAPAN
37	NIPPON STEEL CORPORATION	JAPAN
38	NISHITANI & CO. LTD.	JAPAN
39	NISSHO IWAI CORPORATION	JAPAN
40	OKURA & CO. LTD.	JAPAN
41	SOJITZ CORPORATION	JAPAN
42	SUMITOMO METAL INDUSTRIES LTD.	JAPAN
43	AB SANDVIK STEEL	SWEDEN
44	T.T.I. – TUBACEX TUBOS INOXIDABLES, S.A.	SPAIN
45	SOSTA BV (UPTO 72" (THICKNESS UPTO 25.4 MM))	NETHERLAND
46	VOMAL INTERNATIONAL LIMITED	U.K.
47	CORUS TUBES LIMITED	U.K.
48	BRITISH STEEL CORPORATION	U.K.
49	HYUNDAI CORPORATION	KOREA
SS SEAMLESS TUBES		
1	ANIL METAL CORPORATION	INDIA

2	APEX TUBES PVT. LIMITED (UPTO 50.8 MM OD (THICKNESS UPTO 4.00 MM))	INDIA
3	BHANDARI FOILS & TUBES LIMITED (UPTO 50MM OD)	INDIA
4	HEAVY METAL & TUBES (UPTO 8" (THICKNESS UPTO 18.26 MM))	INDIA
5	KRYSTAL STEEL MANUFACTURING PVT. LTD. (UPTO 50.8 MM OD (MATERIAL UPTO GRADE SS 321))	INDIA
6	MODERN TUBE INDUSTRIES LIMITED (UPTO 50.80 MM OD (UPTO SS GRADE 321))	INDIA
7	PRAKASH STEELAGE LTD. (Seamless: upto114 mm OD, Thickness upto 6 mm)	INDIA
8	RATNAMANI METALS & TUBES LTD.	INDIA
9	SANDVIK ASIA PVT. LTD. (OD UPTO 60.33 (THK: UPTO 8.74 MM))	INDIA
10	SCORODITE STAINLESS (INDIA) PVT.LTD. (UPTO 50.80 OD (UPTO SS GRADE 321))	INDIA
11	SURAJ STAINLESS LIMITED	INDIA
12	T.T.I.-TUBACEX TUBOS INOXIDABLES, S.A.(OD 15.8 MM TO 250.0 MM, WALL THK.1.0 MM)	SPAIN
FITTINGS: CS/AS/SS SEAMLESS & FORGED		
1	AMFORGE INDUSTRIES	INDIA
2	ANIL METAL CORPORATION	INDIA
3	CHETAN STEELS (UPTO 6” SCH. 80)	INDIA
4	COMMERCIAL SUPPLYING AGENCY	INDIA
5	CSA FITTINGS (Forged ½” to 2”-upto 900#, Seamless: 2” to 8”-upto SCHXXS)	INDIA
6	EBY FASTENERS	INDIA
7	EBY INDUSTRIES	INDIA
8	FIT-TECH INDUSTRIES (Forged/Seamless -upto 24”, Welded upto 48”)	INDIA
9	FLASH FORGE(P) LTD.(Forged upto 4”-upto 900#, Seamless/welded: up to 42”)	INDIA
10	GUJARAT INFRAPIPES PVT. LTD.	INDIA
11	KALPESH TUBE(INDIA),(TRADER) (UPTO A MAX ORDER VALUE RS.25.0 LAKH)	INDIA
12	M.S FITTINGS MANUFACTURING CO. PVT LTD.	INDIA
13	MARDALE PIPES PLUS LTD.	INDIA
14	NAVKAR FORGINGS & FITTINGS PVT. LTD	INDIA
15	NL HAZRA (upto SCH80)	INDIA
16	P.K TUBES & FITTINGS PVT. LTD.	INDIA
17	P.K FORGE & FITTING INDUSTRIES	INDIA
18	PARAS FITTINGS PVT. LTD. (Forged: CS ½” to 2” & CS Seamless: 2” to 8”- upto SCHXXS)	INDIA

19	PARMAR TECHNO FORGE (Elbow, Tee, Reducer- ½" to 12" & Cap upto 18")	INDIA
20	PERFECT MARKETTING PVT. LTD.	INDIA
21	PETROCHEM INDUSTRIES (Seamless: Upto 16" (All Fittings) & upto 36" (caps) SCH : XXS /80S, Forged: upto 3"-6000#)	INDIA
22	RAJENDRA FORGE INDUSTRIES (CS: UPTO 12" SCH 40 & SS: 6" SCH 40S)	INDIA
23	S & G ENGINEERS (P) LTD.	INDIA
24	SAGAR STEEL CORPORATION (TRADER)	INDIA
25	SANGHVI METALS (TRADER)	INDIA
26	SAWAN ENGINEERS	INDIA
27	SHIVANANDA PIPE FITTINGS LTD.,	INDIA
28	STEWARTS AND LLOYDS OF INDIA LIMITED	INDIA
29	TEEKAY TUBES PRIVATE LIMITED	INDIA
30	THE BENGAL MILL STORES SUPPLY CO.(TRADER)	INDIA
31	TOPAZ PIPING INDUSTRIES	INDIA
32	TUBE BEND (CALCUTTA) PVT. LTD. (CS FITTINGS ONLY)	INDIA
33	TUBE PRODUCTS INCORPORATE	INDIA
34	ZOLOTO INDUSTRIES (upto 6" (only CS Galv.))	INDIA
35	PHOCEENNE	FRANCE
36	ETS TROUVAY & CAUVIN	FRANCE
37	VALLOUREC	FRANCE
38	SEIKMANN ANLAGEN-TECHNIK GMBH.	GERMANY
39	TPS-TECHNITUBE ROHRENWERKE GMBH	GERMANY
40	MANNESMANN HANDEL AG	GERMANY
41	HORST KURVERS GMBH	GERMANY
42	PETROL RACCORD S.P.A. (Seamless: 1" to 42" (Elbow) & 1" to 56" Tee/Reducer/Cap))	ITALY
43	DALMINE SPA	ITALY
44	GAM RACCORDI S.P.A	ITALY
45	IBF SEAMLESS PIPES SPA	ITALY
46	IND MECCANICA BASSI LUIGI & C. SPA	ITALY
47	MANTOVANI SPA	ITALY
48	RACCORTUBI SRL	ITALY
49	TECHNO FORGE SPA	ITALY
58	MARUBENI ITOCHU STEEL	JAPAN
51	NIPPON KOKAN	JAPAN
52	NISHITANI & CO. LTD.	JAPAN
53	NISSHO IWAI CORPORATION	JAPAN
54	OKURA & CO. LTD.	JAPAN
55	SOJITZ CORPORATION	JAPAN
56	SUMITOMO METAL INDUSTRIES LTD.	JAPAN

57	HAITIMA CORPORATION	TAIWAN
58	CORUS TUBES LIMITED	U.K.
59	BRITISH STEEL CORPORATION	U.K.
60	EUROTUBE LIMITED	U.K.
61	VOMAL INTERNATIONAL LIMITED	U.K.
62	BONNEY FORGE	U.S.A.
FORGED FLANGES		
1	AJAY FORGING PVT. LTD	INDIA
2	AMFORGE INDUSTRIES	INDIA
3	ANANDMAYEE FORGINGS PVT. LTD.	INDIA
4	C D ENGINEERING	INDIA
5	CHAUDHARY HAMMER WORKS (P) LTD.	INDIA
6	CHETAN STEELS (UPTO 6", 150#)	INDIA
7	`ECHJAY INDUSTRIES LTD	INDIA
8	FERROUS ALLOYS FORGING PVT. LTD	INDIA
9	GOOD LUCK ENGINEERING CO. (½"-12" (UPTO 2500#), 14"-16" (UPTO 900#), 18"-32" (UPTO 600#), 34"-48" (UPTO 300#),	INDIA
10	J.K FORGINGS	INDIA
11	KUNJ FORGINGS PVT. LTD.(MATERIAL CS/SS/AS) (upto 60" (upto 300#) & upto 12" (upto 2500#))	INDIA
12	MAHESH INDUSTRIES (Upto 8" -150#, material ASTM A105 only)	INDIA
13	P.K TUBES & FITTINGS PVT. LTD. (Upto 24"(upto1500#) & Upto 12"(upto2500#) Spectacle Blind and Spacer & Blinds only)	INDIA
14	PARAMOUNT FORGE (CS,AS & SS : ½" TO 42" (UPTO 600#), ½" TO 24" (UPTO 900#, ½ " TO 16" (UPTO 1500#), ½" TO 12" (UPTO 2500#)).	INDIA
15	PERFECT MARKETING (P) LTD.	INDIA
16	PUNJAB STEEL	INDIA
17	R D FORGE (A UNIT OF R D CHEMICALS PVT LTD) (Upto 54" (150#), 42" (upto 600#), 20" (upto 1500#) & 12" (2500#))	INDIA
18	RAJENDRA FORGE INDUSTRIES (CS & SS : UPTO 12", 300#)	INDIA
19	S & G ENGINEERS (P) LTD.	INDIA
20	SANGHVI FORGINGS & ENGINEERING LTD	INDIA
21	SANGHVI METALS (TRADER)	INDIA
22	SAWAN ENGINEERS	INDIA
23	TECHNO FORGE LTD. (UPTO 42" (UPTO 300#), UPTO 24" (600#), UPTO 20" (900#), UPTO 16" (1500#),	INDIA
24	TUBE BEND (CALCUTTA) PVT LTD	INDIA
25	PHOCEENNE	FRANCE
26	ETS TROUVAY & CAUVIN	FRANCE
27	HORST KURVERS GMBH	GERMANY
28	I.S. INTERNATIONAL	ITALY
29	MANTOVANI SPA	ITALY

30	OFFICINE NICOLA GALPERTI & FIGLIO S.P.A	ITALY
31	RACCORTUBI SRL	ITALY
32	NICHINAN SANGYO CO. LTD.,	JAPAN
33	NISHITANI & CO. LTD.	JAPAN
34	SOJITZ CORPORATION	JAPAN
35	VOMAL INTERNATIONAL LIMITED	U.K.
GATE/ GLOBE/ CHECK VALVES CS/SS/AS < 900 LBS		
1	AV VALVES LTD. (CAST UPTO 42" ,150#) 28" 300#, 24" (600#) & FORGE UPTO 2" (800#)	INDIA
2	ADVANCE VALVES (2"-80" (Upto 600#) Dual Plate Check Valves only)	INDIA
3	ASSOCIATED TOOLINGS (I) PVT. LTD.	INDIA
4	AUDCO INDIA LIMITED (L&T VALVES DIVN.)	INDIA
5	AUTOCAP INDUSTRIES (1/2" to 2" 800# (only CS & SS)	INDIA
6	BELL- O-SEAL VALVES LTD.(FOR ZERO LEAKAGE , HAZARDOUS FLUIDS.)	INDIA
7	BHEL (VALVES DIVISION)	INDIA
8	BRIGHTECH VALVES AND CONTROLS PVT. LTD. (Upto 8" x 300#)	INDIA
9	CHEMTECH INDUSTRIAL VALVES PVT. LTD.	INDIA
10	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD. (<=300#, (only CS))	INDIA
11	DATRE CORPORATION LTD. (Upto 300#, 2" to 8" (Gate), 2" to 6" (Globe & Check Valves))	INDIA
12	DEWRANCE MACNEILL & CO. LTD.	INDIA
13	ECONO VALVES PVT. LTD.	INDIA
14	EXPERT ENGINEERING ENTERPRISES	INDIA
15	FLOCON SYSTEMS PVT. LTD. (CS upto 6" – 1500#)	INDIA
16	FLOVEL VALVES PVT. LTD.(SINGLE DISC , DULA PLATE & NOZZLE CHECK VALVES ONLY : UPTO 48" (150#) & 24 (UPTO 600#)	INDIA
17	FLUIDTECH EQUIPMENT PVT. LTD. (CAST # CS & SS 2" TO 12" 150# & 2 " TO 8" 300 # AND FORGED (CS AND SS) ½" TO 2" (800#)	INDIA
18	FORWARD ALLOYS & CASTINGS (UPTO 14")	INDIA
19	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: upto 24"(150#), 20"(300#), 10" (600#) & Forged : upto 2" (800#)	INDIA
20	HAWA ENGINEERS LTD. (Gate Valves: upto 40"(150#), upto 26" (300#), upto 24" (600#), upto 2" (800#); Globe Valves: upto 20"(150#), upto 16" (300#), upto 12" (600#), upto 2" (800#), Check Valves: upto 36"(150#), upto 24" (300#), upto 16" (600#), upto 2" (800#) (Dual Plate: 36" (150#)	INDIA
21	HAWA VALVES INDIA PVT. LTD. (CS upto 6", 150#)	INDIA
22	HI-TECH VALVES PVT. LTD. (CS,<=800 #, SIZE ½-2, <=300#	INDIA

	FOR SIZE 2-6")	
23	INTERVALVE INDIA LTD. (CAST UPTO 24" (UPTO 300#) & UPTO 12" 600# , FORGED UPTO 2" (800#))	INDIA
24	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 48" (150#) & 24" (UPTO 600#) & FORGED UPTO 2" (800#))	INDIA
25	KIRLOSKAR BROTHERS LTD.(CS UPTO 12" , 300#)	INDIA
26	KSB PUMPS LIMITED (VALVES DIVN)	INDIA
27	LARSEN & TOUBRO LIMITED (1/2" TO 24")	INDIA
28	LEADER VALVES LTD. (Casting<=20"-600#, 300-150#, Forging<=2"-800#)	INDIA
29	M.H. VALVES PVT. LTD. (1/2" to 1 1/2"-800#, 2" to 6"-600#)	INDIA
30	MICON ENGINEERS (HUBLI) [PVT. LTD.(Cast: Upto 12" (150# & 300#), 6" (600#) & Forged: upto 2" (800#))	INDIA
31	MICROFINISH VALVES LTD.	INDIA
32	NSSL LTD. (UPTO 80" (150#), 56" UPTO 600# & FORGED UPTO 2" (800 #))	INDIA
33	NITON VALVES INDUSTRIES PVT. LTD.	INDIA
34	OSWAL IND. LTD. (UPTO 48" (150#), 32" (300#) & 24" (600#)	INDIA
35	S & M INDUSTRIAL VALVES LTD. (CS Gate & Globe Valves 2" – 24" <=300#)	INDIA
36	SHALIMAR VALVES PVT. LTD. (Cast Upto 24" (Upto 600#), Forged: ½" to 1 ½" (800#))	INDIA
37	SHREERAJ INDUSTRIES (CS upto 150#)	INDIA
38	STEEL STRONGVALVES (I) PVT. LTD. (Upto 42")	INDIA
39	VENUS PUMP & ENGINEERING WORKS.	INDIA
40	VIBA FLUID CONTROL	INDIA
41	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast UPTO 36" (150#); 24" (300#); 12" (600#) & Forged: Upto 2" (800#))	INDIA
42	ZED VALVES CO. PVT. LTD. (Upto 14" (600#))	INDIA
43	ZOLOTO INDUSTRIES. (40 MM TO 200 MM(ONLY CS & SS))	INDIA
44	VELAN INC. (UPTO 48" , 600#)	CANADA
45	BOTELI VALVE GROUP CO. LTD.(Cast Upto 56" (150#), 36" (300#), 24" (600#) & Forged: Upto2" (800#))	CHINA
46	ZHEJIANG JIEHUA VALVE CO. LTD.	CHINA
47	PEMTO VALVE	GERMANY
48	CESARE BONETTI SPA (Cast Upto 42" (Upto 300#), 24" (600#) Forged: ½" to 1 ½" (800#))	ITALY
49	FASANI S.P.A.	ITALY
50	FRIULCO SPA (UPTO 48" (150#), 32" (Upto 600#)	ITALY
51	GTC ITALIA, S.R.L.	ITALY
52	MANTOVANI SpA	ITALY
53	OMB S.P.A.	ITALY

54	PETROL VALVES S.R.L.	ITALY
55	MATSURA H. P MACHINE WORKS CO.LTD.	JAPAN
56	NISHITANI & CO. LTD.	JAPAN
57	SOJITZ CORPORATION	JAPAN
58	REDPOINT ALLOYS BV	NETHERLAND
59	WALTHAN & WEIR	SPAIN
60	POYAM VALVES (AMPO S.CCP.) (Size upto 60” (Rating upto 800#)	SPAIN
61	BABCOCK BORSIG ESPANA , S.A	SPAIN
62	SUFA LIMITED	U.A.E.
63	BEL VALVES	U.K.
GATE/ GLOBE/ CHECK VALVES CS/SS/AS > =900 LBS		
1	A V VALVES LIMITED (Cast Upto 24” (900# & 1500#), 8” (2500#) Forged: Upto 2” (2500#))	INDIA
2	ADVANCE VALVES (2”-36” (900#) 2”-24” (1500#), 2”-12(2500#) Forged: Upto 2” (2500#)) FOR DUAL PLATE CHECK VALVES)	INDIA
3	ASSOCIATED TOOLINGS (I) PVT. LTD. (½” TO 2” (900# & 1500#))	INDIA
4	AUDCO INDIA LIMITED (L&T VALVES DIVN.)	INDIA
5	BHEL (VALVES DIVISION)	INDIA
6	FLOVEL VALVES PVT. LTD. (Dual Plate Check Valves: Upto 24” (900#)	INDIA
	HAWA ENGINEERS LTD. (Gate Valves: upto 20”(900#), upto 10” (1500# & 2500#); Globe Valves: upto 8”(900# & 1500#), upto 1” (2500#); Check Valves: upto 10”(900#), upto 6” (1500#), upto 1” (2500#)	INDIA
7	HAWA VALVES INDIA PVT. LTD. (Forged upto 2”, 1500#)	INDIA
8	INTERVALVES INDIA LTD.(Forged: Upto 2” (1500#))	INDIA
9	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 12” (1500#),10” (2500#) & FORGED UPTO 2” (2500#))	INDIA
10	KSB PUMPS LIMITED (VALVES DIVN)	INDIA
11	LARSEN & TOUBRO LIMITED (1/2" TO 2")	INDIA
12	LEADER VALVES LIMITED (1500# & 2500# UPTO 12", FORGING UPTO 2" 2500#)	INDIA
13	METROPOLITAN INDUSTRIES (SIZE=200mm, rating=2500 lb)	INDIA
14	MICON ENGINEERS (HUBLI) PVT. LTD. (FORGED: UPTO 2" (1500#))	INDIA
15	NSSL LIMITED. (CAST: Upto 36"(900#), 24” (upto 2500#) & FORGED: Upto 2” (Upto 2500#))	INDIA
16	OSWAL INDUSTRIES LTD. (Upto 12” (900# & 1500#))	INDIA
17	SHALIMAR VALVES PVT.LTD.(CAST: UPTO 20"(900#), FORGED: ½" TO 1 ½" (1500#))	INDIA

18	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast UPTO 12" (upto 2500#) & Forged: Upto 2" (1500#), 1" (2500#))	INDIA
19	VELAN INC. (UPTO 24" (Rating upto 2500#))	CANADA
20	BOTELI VALVE GROUP CO. LTD.(Cast Upto 16" (Upto 1500#), 12" (2500#) & Forged: Upto 2" (1500# & 2500#))	CHINA
21	ZHEJIANG JIEHUA VALVE CO. LTD.	CHINA
22	BFE BONNEY FORGE VALVE LICENSEE	ITALY
23	CESARE BONETTI SPA (Upto 24" (Upto 2500#)	ITALY
24	FASANI S.P.A.	ITALY
25	FRIULCO SPA (UPTO 32" (900#); 24" (1500#); 14" (2500#))	ITALY
26	GTC ITALIA S.R.L.	ITALY
27	OMB S.P.A.	ITALY
28	PETROL VALVES S.R.L.	ITALY
29	VALVITALIA SPA	ITALY
30	MATSURA H. P MACHINE WORKS CO.LTD.	JAPAN
31	NISHITANI & CO. LTD.	JAPAN
32	BABCOCK BORSIG ESPANA, S.A.	SPAIN
33	POYAM VALVES, (AMPO S. COOP.) (SIZE UPTO 30" (RATING UPTO 2500#))	SPAIN
34	SUFA LIMITED	U.A.E.
35	BEL VALVES	U.K.
BALL VALVES (SOFT SEATED)		
1	A V VALVES LIMITED (Upto 12" (Upto 600#))	INDIA
2	AIRA EURO AUTOMATION PVT. LTD. (Upto 6", Rating 150# & 300#),	INDIA
3	AQUA VALVES PVT. LTD.	INDIA
4	BRIGHTECH VALVES & CONTROLS PVT. LTD. (4" x 150# for CS, AS & SS material)	INDIA
5	CHEMTECH INDUSTRIAL VALVES PVT. LTD.	INDIA
6	CRAWLEY & RAY (FOUNDER & ENGINEERS) PVT. LTD. (DN25)	INDIA
7	DELVAL FLOW CONTROLS PVT. LTD. (Upto 12" (Upto 900#))	INDIA
8	FLOCON SYSTEMS PVT. LTD. (CS upto 6", 150#)	INDIA
9	FLOW CONTROL	INDIA
10	FLOWCHEM INDUSTRIES (UPTO 300# and upto 10")	INDIA
11	FLUIDTECH EQUIPMENT PVT. LTD(UPTO 4" (300#))	INDIA
12	FORWARD ALLOYS AND CASTINGS (Upto 900#)	INDIA
13	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12" (Upto 300#), 4" (Upto 900#) & Forged: Upto 2" (800#))	INDIA
14	HAWA ENGINEERS LTD. (Upto 16" (150# & 300#), Upto 12" (600# & 900#))	INDIA

15	INTERVALVE INDIA LTD. (Forged: Upto 2" (800#), Cast: Upto 12" (Upto 300#))	INDIA
16	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 28" (upto 600#),12" (900# , 1500#) & 10" (2500#))	INDIA
17	KSB PUMPS LTD. (VALVES DIVN.) (CS upto 100DN, 20 bar)	INDIA
18	LEADER VALVES LTD. (Casting upto 600#, 6" & forging upto 800#, 2")	INDIA
19	MICON ENGINEERS (HUBLI) PVT. LTD. (Cast: Upto 6" (150# & 300#) & Forged: Upto 2" (800#)	INDIA
20	MICROFINISH VALVES (P) LTD.	INDIA
21	NSSL LTD. (Upto 12" (150# & 300#))	INDIA
22	OSWAL IND. LTD. (Upto 24" (150#, 300# & 600#))	INDIA
23	SHALIMAR VALVES PVT. LTD. (Upto 18" (600#) Material: CS/AS/SS)	INDIA
24	VIBA FLUID CONTROL (Upto 300#)	INDIA
25	VIRGO ENGINEERS LTD. (Upto 16" (upto 600#))	INDIA
26	WEIR BDK VALVES (Cast: Upto 30" (150# & 300#), 20" (600#), 16" (900#), 12" (1500#) & Forged: Upto 2" (800#))	INDIA
27	XOMOX SANMAR LTD.(FISHER XOMOX)	INDIA
28	BHDT GMBH	AUSTRIA
29	BOTELI VALVE GROUP CO. LTD. (Upto 32" (150# & 300#), 30" (600#), 24" (900#)	CHINA
30	ZHEJIANG JIEHUA VALVE CO. LTD.	CHINA
31	VELAN INC.(UPTO 16", 600#)	CANADA
32	ETS TROUVAY & CAUVIN	FRANCE
33	PERRIN GMBH (2500#, SIZE UPTO 24")	GERMANY
34	FRIULCO SPA (UPTO 48" (150# & 300#); 20" (upto 1500#); 12" (2500#))	ITALY
35	CESARE BONETTI SPA (Cast: Upto 4" (150#) & Forged: Upto 1" (800#) Floating only)	ITALY
36	GTC ITALIA S.R.L	ITALY
37	MANTOVANUI SPA	ITALY
38	PIBIVESSE SRL (UPTO 48" , 600#)	ITALY
39	PETROL VALVES S.R.L	ITALY
40	METSO AUTOMATION	SINGAPORE
41	POYAM VALVES (AMPO S. COOP.) (Size upto 42" (Rating upto 2500#))	SPAIN
42	HATIMA CORPORATION	TAIWAN
BALL VALVES (METAL SEATED)		
1	AIRA EURO AUTOMATION PVT. LTD. (Upto 6", Rating 150# & 300#),	INDIA

2	BRIGHTECH VALVES & CONTROLS PVT. LTD. (4” x 150# for CS, AS & SS material)	INDIA
3	DELVAL FLOW CONTROLS PVT. LTD. (Upto 12” (Upto 900#))	INDIA
4	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12” (Upto 300#), 4” (Upto 900#) & Forged: Upto 2” (800#))	INDIA
5	HAWA ENGINEERS LTD. (Upto 16" (150# & 300#), Upto 12" (600# & 900#))	INDIA
6	INTERVALVE INDIA LTD.(UPTO 12” , 150#).	INDIA
7	JC VALVES & CONTROLS INDIA PVT. LTD. (CAST UPTO 28” (upto 600#),12” (upto 1500#), 10” (2500#))	INDIA
8	MICON ENGINEERS (HUBLI) PVT. LTD. (Cast: Upto 6” (150# & 300#) & Forged: Upto 2” (800#)	INDIA
9	MICROFINISH VALVES (P) LTD.	INDIA
10	NSSL LIMITED (Upto 12" NB, (150# & 300#))	INDIA
11	OSWAL INDUSTRIES LTD. (UPTO 24" (150#, 300#, & 600#))	INDIA
12	VIRGO ENGINEERS LTD. (UPTO16" (UPTO 600#))	INDIA
13	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Cast: Upto 30" (150# & 300#); 20" (600#), 16” (900#), 12” (1500#) & Forged: Upto 2” (800#)	INDIA
14	VELAN INC. (SIZE UPTO 16" (Rating Upto 600#))	CANADA
15	BOTELI VALVE GROUP CO. LTD. (Upto 32” (150# & 300#), 30” (600#), 24” (900#)	CHINA
16	ALFA VALVOLE SRL	ITALY
17	CESARE BONETTI SPA (UPTO 24" (150#) & 4" (UPTO 1500#) TRUNNION MOUNTED ONLY)	ITALY
18	GE POWER (NUOVO PIGNONE SPA)	ITALY
19	GTC ITALIA, S.R.L.	ITALY
20	PETROL VALVES S.R.L	ITALY
21	PIBIVIESSE (48”, 600#)	ITALY
22	VALVITALIA SPA	ITALY
23	PERRIN GMBH (SIZE UPTO 24" (RATING UPTO 2500#))	GERMANY
24	RED POINT ALLOYS BV	NETHERLAND
25	FRIULCO SPA (UPTO 48" (150# & 300#); 20" (UPTO 1500#); 12" (2500#))	ITALY
26	POYAM VALVES, (AMPO S. COOP.) (SIZE UPTO 42" (RATING UPTO 2500#))	SPAIN
27	METSO AUTOMATION	SINGAPORE
28	ORBIT VALVES PLC	SINGAPORE
BUTTERFLY VALVES		
1	A V VALVES LIMITED (UPTO 48" (150#))	INDIA
2	ADVANCE VALVES (RUBBER LINED AND METAL SEATED)	INDIA
3	AIRA EURO AUTOMATION PVT. LTD. (Upto 48”, Rating upto 300#)	INDIA

4	AUDCO INDIA LIMITED (L&T VALVES DIVN.)	INDIA
5	BDK PROCESS CONTROL PVT LTD. (UPTO 1600MM)	INDIA
6	CHEMTECH INDUSTRIAL VALVES PVT LTD	INDIA
7	CRAWLEY & RAY (FOUNDER & ENGINEERS) PVT. LTD. (40mm-1000mm)	INDIA
8	DELVAL FLOW CONTROLS PVT. LTD. (Upto 24” (Upto 300#))	INDIA
9	FLOCON SYSTEMS PVT. LTD. (CS upto 12”, 150#)	INDIA
10	FLUIDTECH EQUIPMENT PVT. LTD. (CS upto 12” (300#))	INDIA
11	FOURESS ENGINEERING (I) LTD.	INDIA
12	HAWA ENGINEERS LTD. (2" to 48”(PN10/PN16/150#/300#))	INDIA
13	HAWA VALVES INDIA PVT. LTD. (CS UPTO 6", 150#)	INDIA
14	HI-TECH BUTTERFLY VALVES INDIA PVT. LTD (<300#,<30"(TEFLON/RUBBER) ,<72"(METAL))	INDIA
15	INSTRUMENTATION LTD. (PALAKKAD)	INDIA
16	INTERVALVE INDIA LTD. (Upto 72” (150#) & Upto 16” (300#))	INDIA
17	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 20” (150#) & 10” (300#))	INDIA
18	L&T LTD (1/2" TO 24")	INDIA
19	LEADER VALVES LTD.(150#, upto 16”)	INDIA
20	MATHER & PLATT (INDIA) LTD. A SUBSIDIARY OF WILO SE GERMAN (UPTO DN 1600,PN10, Double flange type)	INDIA
21	METROPOLITAN INDUSTRIES (SIZE=2000mm)	INDIA
22	MICON ENGINEERS (HUBLI) [PVT. LTD.(Upto 24” (PN10 & PN16))	INDIA
23	VENUS PUMP & ENGINEERING WORKS (upto 600NB, 150#)	INDIA
24	VIRGO ENGINEERS LTD. ((Triple offset only): 3” to 24”, Upto 600# (CS/SS))	INDIA
25	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (Upto 56” (Upto 250#), 24” (300#))	INDIA
26	XOMOX SANMAR LIMITED (FISHER XOMOX)	INDIA
27	TOMOE VALVE CO. LTD. (Upto 48”(150# & 300#), Upto 24”(600#, 900# & 1500#))	JAPAN
28	BHDT GMBH	AUSTRIA
29	VELAN INC. (Size upto 48”(Rating upto 600#)	CANADA
30	BOTELI VALVE GROUP CO. LTD. (Upto 36” (150# & 300#)	CHINA
31	ZHEJIANG JIEHUA VALVE CO. LTD.	CHINA
32	GRISS SAPAG INDUSTRIAL VALVES	FRANCE
33	ADAMS ARMATUREN	GERMANY

34	GTC ITALIA, S.R.L.	ITALY
35	HAITIMA CORPORATION	TAIWAN
36	WEIR VALVES & CONTROLS DIVISION.	U.K
37	LEEDS VALVE LTD	U.K
38	CURTIS WRIGHT FLOW CONTROL CORPOARATION	U.S.A.
39	LEAR SIEGLER MEAS. CTRLS. CORP	U.S.A.
40	TYCO INTERNATIONAL INC.,U.S.A.	U.S.A.
41	EMERSON PROCESS MGT	U.S.A.
42	SPX VALVES & CONTROLS	U.S.A.
43	XOMOS (CRANE CO.)	U.S.A.
PLUG VALVES		
1	A V VALVES LIMITED (UPTO 48" (150#))	INDIA
2	AUDCO INDIA LTD (L&T VALVES DIVN.)	INDIA
3	AZ ARMATUREN GMBH (1/2” TO 20”(150#, 300# & 600#), Matl. CS, AS &SS)	INDIA
4	BDK PROCESS CONTROL PVT LTD.	INDIA
5	CHEMTECH INDUSTRIAL VALVES PVT LTD	INDIA
6	CRAWLEY & RAY (FOUNDERS & ENGINEERS) PVT. LTD (DN 200)	INDIA
7	FLUIDTECH EQUIPMENT PVT. LTD. (Upto 4” (300#))	INDIA
8	GURU INDUSTRIAL VALVES PVT. LTD. (Cast CS only: Upto 12” (Upto 300#), Upto 4” (Upto 900#)) & Forged: Upto 2” (800#))	INDIA
9	HAWA ENGINEERS LTD. (1/2” TO 8” (150#))	INDIA
10	JC VALVES & CONTROLS INDIA PVT. LTD. (Upto 12” (Upto 300#))	INDIA
11	L&T LTD (1/2" TO 24")	INDIA
12	LEADER VALVES LIMITED (Upto 6” (Upto 300#))	INDIA
13	WEIR BDK VALVES (A UNIT OF WEIR INDIA PVT. LTD.) (UPTO 16"(150#), 12" (300#), 3" (600#))	INDIA
14	XOMOX SANMAR LIMITED (FISHER XOMOX)	INDIA
15	ZHEJIANG JIEHUA VALVE CO. LTD.	CHINA
16	O.M.S. SALERI DI SALERI P & FIGLI S.M.C.	ITALY
17	POYAM VALVES, (AMPO S. COOP.) (UPTO 30" (UPTO 900#) FOR LIFT PLUG VALVES ONLY.)	SPAIN
FLAT GASKETS		
1	FERROLITE JOININGS (P) LTD.	INDIA
2	GASKETS (INDIA) PVT. LTD	INDIA
3	GOODRICH GASKET PVT. LTD. (UPTO 24")	INDIA

4	HINDUSTAN ASBESTOS & ALLIED PRODUCTS	INDIA
5	HINDUSTAN COMPOSITE LTD.	INDIA
6	HINDUSTAN FERREDO LTD.	INDIA
7	IGP ENGINEERS LIMITED	INDIA
8	MADRAS INDUSTRIAL PRODUCTS(UPTO 48")	INDIA
9	MECHANICAL PACKING INDUSTRIES LTD.	INDIA
10	PACKING & JOINTINGS (P) LTD.	INDIA
11	PERFECT MARKETING (P) LTD,	INDIA
12	PRASHANT ENGG STORES	INDIA
13	REIN TALBROS PVT. LTD.	INDIA
14	SPIRALSEAL GASKETS PVT. LTD. (CAF & Teflon)	INDIA
15	STARFLEX SEALING INDIA PVT. LTD.	INDIA
16	THE BENGAL MILL STORES SUPPLY CO. (TRADER)	INDIA
17	UNIQUE INDUSTRIAL PACKINGS PVT. LTD.	INDIA
SPIRALLY WOUND GASKETS		
1	GASKETS (INDIA) PVT. LTD	INDIA
2	GOODRICH GASKET PVT. LTD.	INDIA
3	IGP ENGINEERS LIMITED	INDIA
4	MADRAS INDUSTRIAL PRODUCTS	INDIA
5	PACKINGS & JOINTINGS PVT. LTD	INDIA
6	PERFECT MARKETING (P) LTD,	INDIA
7	PRASHANT ENGG STORES	INDIA
8	SPIRASEAL GASKETS PVT. LTD.	INDIA
9	STARFLEX SEALING INDIA PVT. LTD.	INDIA
10	THE BENGAL MILL STORES SUPPLY CO. (TRADER)	INDIA
11	UNIQUE INDUSTRIAL PACKINGS PVT.LTD. (UPTO 42"(600#) & UPTO 24" (2500#))	INDIA
12	ZHEJIANG JIEHUA VALVE CO. LTD.	INDIA
EXPANSION JOINTS & BELLOWS		
1	CORI ENGINEERS PVT. LTD.	INDIA
2	D.WREN & CO. (For Rubber & Fabric)	INDIA
3	FLEXATHERM EXPANLLOW PVT. LTD. (Circular: Upto 240", Rectangular No bar for size, (Upto 600#))	INDIA
4	FLEXICAN BELLOWS & HOSES PVT. LTD	INDIA
5	FLUIDYNE ENGG. (I) PVT. LTD	INDIA
6	KELD ELLENTOFT INDIA PVT. LTD	INDIA

7	LONESTAR INDUSTRIES	INDIA
8	MB METALLIC BELLOWS (INDIA) PVT. LTD	INDIA
9	PRASHANT ENGG. STORES	INDIA
10	STANDARD PRECISION BELLOWS	INDIA
11	TUBOFLEX	GERMANY
12	FLEXIDER S.P.A.	ITALY
STRAINERS		
1	CHEMTECH INDUSTRIAL VALVES PVT. LTD	INDIA
2	FLAIR STRAINERS & FILTERS (SIZE UPTO 42" (RATING UPTO 1500#))	INDIA
3	GRAND PRIX ENGINEERING PVT. LTD. (UPTO 60" PIPELINE, UPTO ANSI 1500#)	INDIA
4	GREAVES LIMITED	INDIA
5	GUJARAT OTOFILT	INDIA
6	HAWA ENGINEERS LTD. (1/2” to 24”(150# / 300#)	INDIA
7	KWIKFLO FILTERS PVT. LTD.	INDIA
8	LEADER VALVES LTD. (upto 300# & upto 12” size)	INDIA
9	MULTITEX FILTERATION ENGINEERS LTD	INDIA
10	MOD FABRICATORS	INDIA
11	ZOLOTO INDUSTRIES (15MM TO 100MM)	INDIA
12	BOTELI VALVE GROUP CO. LTD. (Y - TYPE ONLY: 14" (150#) & 3" (300# & 600#))	CHINA
STEAM TRAPS		
1	GREAVES LTD.	INDIA
2	PENNANT ENGINEERING PVT. LTD.	INDIA
3	VIRGO ENGINEERS LTD. (1/2” to 4” (upto 600#) (CS/SS))	INDIA
4	YARWAY CORPORATION	INDIA
5	ZOLOTO INDUSTRIES (15 mm to 25 mm)	INDIA
6	GESTRA AG	GERMANY
7	ARMSTRONG INTERNATIONAL INC.	U.S.A
8	OGONTZ CORPORATION	U.S.A
9	TYCO INTERNATIONAL INC.,U.S.A.	U.S.A
SPRING SUPPORTS		
1	MYRICS PIPING SYSTEM PVT.LTD.	INDIA
2	PIPE SUPPORTS INDIA PVT. LTD.	INDIA
3	PIPING & ENERGY PRODUCTS (P) LTD.	INDIA

4	SARATHI ENGG. ENTERPRISES PVT. LTD.	INDIA
5	SPRING SUPPORTS MFG. CO.	INDIA
6	FLEXIDER S.P.A.	ITALY
FASTENERS		
1	AEP COMPANY	INDIA
2	CAPITAL INDUSTRIES	INDIA
3	CONSOLE ENGG. & FASTNERS INDUSTRIES	INDIA
4	EBY FASTNERS	INDIA
5	FIT TIGHT NUTS & BOLTS LTD.	INDIA
6	FIX FIT FASTENERS MFG. PVT. LTD.	INDIA
7	INDUSTRIAL ENGINEERING CORPORATION (SIZE UPTO 4" (M100))	INDIA
8	MEGA ENGINEERING PRIVATE LIMITED (½" TO 3" MATERIAL: CS/AS/SS)	INDIA
9	METRO MECHANICAL PVT.LTD.	INDIA
10	NAGBHUSHANAM INDUSTRIES	INDIA
11	NIREKA ENGG. CO. PVT. LTD.	INDIA
12	PACIFIC FORGING & FASTENERS PVT. LTD. (M 10 TO M125)	INDIA
13	PERFECT MARKETING (P) LTD,	INDIA
14	PIONEER NUTS & BOLTS PVT. LTD.	INDIA
15	PRECISION AUTO ENGINEERS	INDIA
16	PRECISION ENGINEERING INDUSTRIES	INDIA
17	PTD FASTNERS PVT. LTD.	INDIA
18	SANGHVI METALS (TRADER)	INDIA
19	SUNDARAM FASTENERS LIMITED	INDIA
20	UDHERA FASTENERS	INDIA
FIRE FIGHTING SYSTEM		
1	AGNICE FIRE PROTECTION LTD.	INDIA
2	BHARTIYA CACCIALANZA FIRE SYSTEMS LTD	INDIA
3	BLUE STAR LTD.	INDIA
4	DE'S TECHNICO	INDIA
5	DE'S TECHNICO PVT. LTD.	INDIA
6	FUTECH CONSULTANTS PVT. LTD.	INDIA
7	GENERAL MECHANICAL WORKS	INDIA
8	HD FIRE PROTECTION COMPANY	INDIA

9	LAL ENTERPRISES	INDIA
10	MATHER & PLATT (INDIA) LTD. (A Subsidiary of WILO SE German)	INDIA
11	MX SYSTEMS INTERNATIONAL PVT. LTD.	INDIA
12	NEWFIRE ENGINEERS SERVICES	INDIA
13	PRAGATI ENGG. (PVT.) LTD.	INDIA
14	PYROTEK INDUSTRIES (INDIA) PVT. LTD.	INDIA
15	RADIANT FIRE PROTECTION ENGINEERS	INDIA
16	STEELAGE INDUSTRIES LTD.	INDIA
17	TECHNOFAB ENGG.	INDIA
18	TRI-PARULEX FIRE PROTECTION SYSTEMS	INDIA
19	UNITECH MACHINES LTD	INDIA
20	VIJAY FIRE PROTECTION SYSTEM LTD.	INDIA
HOSE PIPE (METALLIC) & CAM LOCK COUPLING		
1	AEROFLEX INDUSTRIES LIMITED (Size 6mm to 250mm dia. (SS Corrg. Flex. Hose with Braid, Braid & Assembly)	INDIA
2	CHHATARIA RUBBER CHEMICALS INDUSTRIES	INDIA
3	D. WREN & CO.	INDIA
4	FLEXATHERM EXPANLLOW PVT. LTD. (1/2” to 6”)	INDIA
5	GAYATRI INDUSTRIES	INDIA
6	GAYATRI INDUSTRIAL CORPORATION (UPTO 6” ID)	INDIA
7	HELIFEX HYDRAULICS & ENGG CO. LTD.	INDIA
8	SENIOR INDIA PVT. LTD.	INDIA
HOSE PIPE (NON-METALLIC) & CAM LOCK COUPLING		
1	CHHATARIA RUBBER CHEMICALS INDUSTRIES	INDIA
2	D. WREN & CO.	INDIA
3	GAYATRI INDUSTRIES	INDIA
4	GAYATRI INDUSTRIAL CORPORATION (UPTO 8” ID)	INDIA
5	HELIFEX HYDRAULICS & ENGG CO. LTD.	INDIA
6	PADMINI INDUSTRIES LIMITED	INDIA
7	PYROTEK INDUSTRIES (INDIA) PVT. LTD.	INDIA
8	SENIOR INDIA PVT. LTD.	INDIA
MARINE LOADING ARM		
1	UTTAM VALUE STEEL LTD., ENGINEERING DEV. LLOYDS STEEL INDUSTRIES. (8” to 20”)	INDIA
TRUCK/WAGON LOADING ARM		

1	UTTAM VALUE STEEL LTD., ENGINEERING DEV. LLOYDS STEEL INDUSTRIES (2” to 4”)	INDIA
2	WOODFIELD SYSTEMS INDIA PVT. LTD. (Upto size: Core-4” / Jacket:- 6”)	INDIA

NOTE:

Make of the equipment not indicated and any other make for the specified equipment shall be subject to owner’s / consultant’s approval.

NOTES:

Vendor List prepared by Bidder for items not covered in OWNER's Vendor List. While submitting the additional vendor list bidder has to ensure the following points.
As it is not possible to ascertain credentials of all the added vendors by Bidders by Owner, with regard to the additional vendors proposed by Bidder, following prequalification criteria, with respect to Past Performance / Experience for any Equipment/machinery shall be applicable:

1. The Vendor during the last 15 (fifteen) years, should have designed, manufactured and supplied at least TWO similar Plant Equipment or Machinery for similar duties and operating conditions and same should be operating satisfactorily after installation for at least TWO years.

   The LSTK Bidders should satisfy themselves that sufficient documentary proof is submitted such as:

   a. Copy of Purchase Orders with full technical details of the equipment
   b. Certificate from user regarding satisfactory performance.
   c. Accreditation from third party inspection agencies
   d. Availability of After Sales Service and Spares in India.
   e. Availability of ASME Certification and its validity.

   The LSTK Bidder shall certify suitability of such vendors as per above.

2. Supplies from Chinese vendors will be considered provided the references of at least two such supplies in India during last 15 years are furnished along with the satisfactory performance certificate from plant owner for at least two years. The supplies should be under the third party inspection agencies. These vendors also need to be approved by Process licensor.