


 पी डी आई एल PDIL	<u><b>COAL GASIFICATION PLANT FOR Proposed COAL TO SYNTHETIC NATURAL GAS</b></u>  <u><b>OWNER: JV OF GAIL AND CIL</b></u>  <u><b>MASTER INDEX</b></u>	PC217/E/001	0	
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**SUBJECT: COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) for PRODUCTION OF SYNTHETIC NATURAL GAS (SNG).**

**(ITB NO: PNMM/PC-217/E/001 DTD 08.10.2025)**

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## PART - II: TECHNICAL



### SECTION 1.0

#### PROJECT DESCRIPTION

**PLANT: COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) for PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT, AT BARDHAMAN, WEST BENGAL, (INDIA)**

0	30.09.25	16.09.25	Issued for Tender Purpose	SK	TNN	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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## 1.0 INTRODUCTION

M/s GAIL India Limited (GAIL), is a leading Natural Gas company with diversified interest across the Natural gas value chain of trading. Transmission, LPG production & transmission, LNG re-gasification, petrochemicals, City Gas, E&P, etc. GAIL owns & operates a network of around 15,583 km of Natural Gas pipeline spread across the length & breadth of Country.

Coal India Limited (CIL), a Maharatna central public sector enterprise ("CPSE"), was incorporated on 01<sup>st</sup> November 1975 with nationalization of private coal mines by Govt. of India. With a modest production of 79 MT at the year of its inception, CIL today is the single largest coal producer in the world having produced nearly 607 MT and in pursuance of initiatives towards the development of Clean Coal Technology and alternate use of coal, CIL is exploring the possibilities to venture into the coal- to-chemicals sector.



Eastern Coalfields Limited (ECL), fully owned subsidiaries of Coal India Limited was founded in 1975 after Nationalisation of Coal Mines in India. It operates Coal Mines in Jharkhand and West Bengal states of India. The company has its headquarters at Sanctoria, in West Bengal.

India has a reserve of 307 Billion tonne of thermal coal and about 80% of coal produced is used in thermal power plants. With environment concerns and development of renewable energy, diversification of coal for its sustainable use is inevitable. Coal gasification is considered as cleaner option compared to burning of coal. Gasification facilitates utilization of the chemical properties of coal. Syn Gas produced from Coal gasification is usable in producing Synthetic Natural Gas (SNG), energy fuel (methanol & ethanol), ammonia for fertilizers and petro-chemicals. These products will help move towards self-sufficiency under 'Atmanirbhar Bharat Abhiyaan'. In line with the above objective, Ministry of Coal has taken initiative for utilizing coal through coal gasification and achieve 100 MT coal gasification by year 2030.

In order to implement various coal gasification projects, it has been planned to set up various gasification projects in phases. In phase I, the project based on low ash coal available in CIL will be taken up. CIL will take care of mining of coal and marketing of the product and the gasification and product conversion plant will be set up on LSTK contract basis. Considering the low availability of low ash coal, gasification plants will be set up based on high ash coal and with concessions given for commercial mining of coal it is expected to reach the goal of 100 MT gasification by 2030.

In view of above, under the directives of GoI, M/s Coal Gas India Limited (CGIL), a Joint Venture between GAIL & CIL is formed for Setting Up of Coal Gasification Based Synthetic Natural Gas (SNG) Plant. CGIL intends to set-up 80,000Nm<sup>3</sup>/hr (Stream days: 330) Synthetic Natural Gas Plant at Eastern Coalfields Ltd. (ECL), Sanctoria, West Bardhaman District in the state of West Bengal (India) through surface Coal Gasification route with the objective to use coal from Raniganj Coalfields for gasification to produce Syn- gas for Production of Synthetic Natural Gas. The Effective Synthesis Gas (CO + H<sub>2</sub>) required is approximately 3,36,000 Nm<sup>3</sup>/hr.

In this regard EOI was invited for Short listing of Licensor(s) of Coal Gasification Technology for the proposed Coal to Synthetic Natural Gas Plant. Based on the EOI, CGIL have short listed Licensors of Coal Gasification Technology and accordingly, bids are invited for execution of the Coal to Synthetic Natural Gas Project on Lumpsum Turnkey on single responsibility basis. The Project shall be executed based on the following philosophy:

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- a) LSTK-1 which shall comprise of Coal Gasification and Purification Unit.
- b) LSTK-2 which shall comprise of Air Separation Unit (ASU).
- c) LSTK-3 which shall comprise of Methane synthesis section for generation of Synthetic Natural Gas.
- c) Offsite and Utilities packages shall be executed on individual package basis.

The present Tender is for selecting LSTK-1 for executing Coal Gasification, Purification Unit including SRU Unit for the production of effective Syn Gas (CO+H<sub>2</sub>) which shall be the used as feed for the LSTK-3 package for producing synthetic Natural Gas.

Based on the lowest LSTK bidder's price, Detailed Feasibility Report (DFR) will be finalized. Subsequently, a decision will be made to place the order with the lowest Lump Sum Turnkey (LSTK) bidder for the execution of the project on single point responsibility basis.

Based on the shortlisted licensor(s) for coal gasification, bids will be invited for executing the project on LSTK basis. The Detailed Feasibility Report (DFR) will be finalized based on **the price of the lowest LSTK bidder. Subsequently, a decision will be made to place the order with the lowest Lump Sum Turnkey (LSTK) bidder for the execution of the project.**

**1.1 Projects & Development India Ltd. (PDIL)** has been retained by **M/s Coal Gas India Limited** as Project Management Consultant for selection of a suitable LSTK Contractors for execution of the project on a Lump-Sum Turnkey basis with Single point responsibility.

**1.2 LSTK CONTRACTOR** is advised to visit and examine the site conditions and obtain for itself on its own responsibility all information that may be necessary for preparing the bid and entering into the Contract. Claims of any kind due to variation or ignorance of site conditions and environmental conditions will not be eligible in any circumstances.



## **2.0 Plot Area:**

Coal Gasification Plant shall be built in the earmarked area as given in the overall site plan for CGIL Project (Refer: Annexure-I,PC217-0000-0001 Rev-0).LSTK CONTRACTOR should ensure that the available area should be used in the most optimum way.

## **2.1 Plant Site:**

The proposed project is located at Bahadurpur in the eastern part of Raniganj Coalfield in Asansol sub-division of Paschim-Bardhaman district of West Bengal. The proposed area lies within the latitude 23°41' 32" N to latitude 23°42'13"N & longitude 87°09'05"E to longitude 87°09'38"E. The proposed site is at a distance of 30 Kms from Asansol and 35 km from Durgapur Township, both of which are well-connected with Eastern Railway lines (Howrah-Delhi) of Indian Railways, as well as by the Howrah-Delhi Grand Trunk Road (N.H.-2) which is 10 km away from the proposed site. Raniganj-Suri Road (N.H.-60) which is around 2.5 km away from the proposed site is the closest major roadway. Kazi Nazrul Islam (Andal) Airport, the closest airport, is 26.5 km away. Nearest port is the Dr. Shyama Prasad Mukherjee Port Trust (Kolkata Port Trust) which is 209 km away.

Total land required for the proposed project would be around 232 Acres including Green belt. Presently land available to ECL is 190 Acres (i.e. 77 Hectares). Land acquired is a lateritic terrain with quarried surfaces up to a depth of 2 to 3 meters and need slight leveling Additional land, around 60 acres (i.e. 24 Hectares) adjacent to the existing needs to be procured.LSTK-1

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Block area shall be as marked in the attached Plot Plan. LSTK Bidder to ensure that all the proposed facilities shall be accommodated within the marked area.

#### 2.1.1 A brief status of infrastructure at Proposed site is furnished below:

Proposed site is adjacent to Asansol and Durgapur. Presently, no township has been considered. A few nearby facilities available are as indicated below:

- i. S.Bazari Area Hospital
- ii. Sub- divisional Hospitals in Asansol & Durgapur.
- iii. Police stations at Kenda (4 Kms) and Jamuria (8 Kms) .
- iv. SBI & PNB Banks are at Haripur (6 kms), BOI at Kenda (4 kms).
- v. Telephone exchanges are at Bahula (9 kms) and at Raniganj .
- vi. Post office at Bahadurpur (2 kms).
- vii. Kazi Nazrul Islam (Andal) Airport, the closest airport, is 26.5 kms away.
- viii. Nearest port is the Dr. Shyama Prasad Mukherjee Port Trust (Kolkata Port Trust) which is 209 kms away.
- ix. While the nearest school from the site is Bahadurpur High School 1.6 kms away; also schools are available at Ukhra (13 kms), at Raniganj (13 kms ), at
- xi. Durgapur and Asansol (30 kms).
- xii. The nearest colleges are TDB College & Khandra College, which are 13 kms & 13.6 kms away respectively.
- xiii. Shopping malls, cinema halls, parks and other recreational venues are available in the cities of Raniganj, Asansol and Durgapur.

#### 2.1.2 Transport Facilities:

Howrah-Delhi Grand Trunk Road (N.H.-2) is passing through the proposed site. Nearest railway station is Asansol which is at a distance of 30 km.

#### 2.1.3 Source of Coal



For the proposed project, required quantity of Coal shall be made available from Sonepur Bazari mine of Eastern Coal field Raniganj through 7.5 Km long conveyor and shall be delivered at the storage point to site. Ultimate and Proximate Analysis of Coal, proposed to be used for this Project is attached as Annexure-I of Sec.4.0.

Licensors should be capable of providing Basic Design Package for Coal Gasification and associated equipment including Coal Preparation (without blending with other feedstocks like petcoke, biomass, etc.) for Gasifying Washed coal from Raniganj Coalfields with ash content upto 20% on commercial basis. Approximate Coal Analysis of coal from Raniganj Coalfields is enclosed at Annexure-I of Sec.4.0 for reference.

## 2.2 Process Technology: Coal Gasification

Based on the EOI Coal Gas India Limited have shortlisted the following Gasification Licensors. Accordingly, the process for coal gasification shall be based on any of the following Technology:

- i. **M/s Air Products and Chemicals Inc (APCI), USA.**
- ii. **M/s Choren Industrietechnik GmbH, Germany**
- iii. **M/s China Petrochemical Tech Co. Ltd (SinopecTech), China**
- iv. **M/s Zhongshi Chemical Engineering Constructon Co. Ltd, China**

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LSTK -1 bidder shall select any one of the above gasification Licensor refer Notes below:

s

**Notes:** 1. *Licensor Interface & Coordination*

- a) *Bidder shall tie up(enter into contracts) with any one of the above Short Listed/Prequalified Gasification Licensors to arrange Process License and Basic Design Package (comprising of supply of proprietary equipment, catalysts & chemicals, services during detailed engineering, Heat mass Balance, PFDs, P&IDs, PDS of LLIs / Equipment, Cause and effect, Instrument PDS and the services for HAZOP, SIL study, pre-commissioning, commissioning and PGTR etc.) of proven performance for Gasifying specified **washed coal having ash content upto 20% (Air dried Basis)** after washing on commercial basis, for supplying raw Syn Gas of suitable composition to produce Synthetic Natural Gas (SNG) of 80000 Nm<sup>3</sup>/hr Capacity.*
  - b) *OWNER / PMC specialist shall be deputed to licensor's office for an extended duration to ensure that the BDEP received is complete in all respect and without any data inconsistency. OWNER / PMC shall participate during PFD, Process datasheet and P&ID review at licensors offices including review of BDEP prepared by process licensor.*
2. *Bidder shall directly deal with the Licensor for Fee and other commercial aspects.*



LSTK contractor shall procure license & basic engineering package and assistance during construction, commissioning & operation from any of the Process Licensors for the proposed plant.

**Process units:**

Coal Gasification Plant shall be capable of handling washed coal having ahs content upto 20% after washing on Air Dried Basis from Ranigunj Coalfields.

List of probable process units for the Coal Gasification Complex along with their capacities:

Sl. No.	Process Unit	Capacity	Designer/Licensor
1)	Feed Coal Preparation based on washed Coal supply at Battery Limit (B.L.)	To be filled by LSTK	Coal Gasification Licensor / LSTK CONTRACTOR
2)	Coal Gasification	To be filled by LSTK	Coal Gasification Licensor
3)	Gas Cooling & Cleaning	To be filled by LSTK	
4)	Gas Purification ( Acid Gas Removal Section), Gas Liquor Seperation,	Purified Gas(CO+H <sub>2</sub> ) of approx. 336000 Nm3/hr (LSTK	LSTK CONTRACTOR Based on Basic Engineering / Design from respective reputed system suppliers (with assistance of coal gasification

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Sl. No.	Process Unit	Capacity	Designer/Licensor
		Contractor confirm) to	licensor, if required).
5)	Sulphur Recovery Unit	To be filled by LSTK	

### 2.3 Utility & Other Facilities:

Major facilities are described as under:

#### 2.3.1 Demineralised water system

DM water (if required) to be supplied by Owner, 3 months prior to the end of Mechanical Completion period for pre-commissioning by owner at Coal Gasification Plant B.L. However, required DM water prior to this period will be arranged by LSTK-1 contractor.

#### 2.3.2 Drinking and Service water system

Treated water from the raw water treatment system is used as make-up to the drinking and service water systems. The service water system takes treated raw water for supply to hose stations, etc. by dedicated service water pumps and a distribution pipe network. Water for gardening is also supplied from this system. During construction till mechanical completion, construction water shall be provided on chargeable basis at one point within battery limit refer. cl. no. 2.8 of SSC Part-I of this NIT and LSTK contractor has to arrange for its own drinking water requirement. After-that owner shall supply required Drinking Water and Service Water to LSTK-1 Contractor at Coal Gasification Plant B.L.

Water requirement will be made available from Damodar River through pipeline of 13 Km length from site. Pre-treatment of raw water has been considered for process use.



#### 2.3.3 Cooling water system

Cooling water shall be supplied by Owner at Coal Gasification Plant Battery Limit. If any further treatment is required for usage as cooling water, the same shall be in the scope of LSTK-1 contractor.-

#### 2.3.4 Condensate Polishing Unit

Condensate generated in Coal Gasification Unit along with other steam condensate generated in LSTK B/L shall be sent to Owner's Condensate Polishing Unit in Coal to Syn. Gas complex for further treatment and reuse.



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#### 2.3.5 Steam and Power generation

**Power:** It is envisaged that entire power requirements will be made available from the West Bengal State grid through dedicated Grid.

For construction power and construction water required till mechanical completion refer cl. no. 2.8 of SSC Part-I of this NIT.

Power required for Plant start-up & operation for Coal Gasification Plant shall be supplied by Owner at a single point at substation located at LSTK-1 B/L.

**Steam:** H.P steam requirement for Process use shall be generated in Steam Generation Plant (Separate LSTK Contractor's Scope). Start-up steam required shall be provided by Owner. LSTK-1 contractor to indicate the quality, flow rate & duration for same.

LSTK-1 Contractor to maximise the use of generated steam inside their B.L. However, available surplus steam may be exported outside B.L. if it matches with the main Steam header parameters indicated in Section-2.0 of Part-II Technical. No steam credit shall be given to the LSTK Contractor.

#### 2.3.6 Plant and Instrument air system

Plant air and Instrument air will be provided to the LSTK-1 Contractor by owner at the Coal Gasification Plant B.L at one place. Proper instrument air storage and Plant air & Instrument air distribution network shall be envisaged for the Coal Gasification Plant. Please refer Section-2.0 of Part-II Technical for plant and instrument air specification.

#### 2.3.7 Nitrogen & Oxygen system

Nitrogen and Oxygen shall be made available at LSTK-1 Contractor battery Limit. Proper Nitrogen and Oxygen storage and distribution network shall be envisaged for the Coal Gasification Plant. Please refer Section-2.0 of Part-II Technical for Utility Nitrogen and Oxygen specification.



#### 2.3.8 Sulphur Recovery Unit (SRU) & Sulphur Storage

Recovery of Sulphur from H<sub>2</sub>S generated in Acid Gas Removal Unit and transportation of liquid Sulphur to storage shall be in LSTK Contractor's scope. LSTK Contractor shall construct the sulphur storage area. Liquid Sulphur gets solidified during storing and same shall be dispatched through trucks by owner. In Sulphur storage area provision for future installation of Pastillation unit shall be considered.

#### 2.3.9 By Product Handling System

##### 2.3.9.1 Ash Handling System

LSTK Contractor shall construct the Ash Handling System suitable for the proposed both Gasifiers bottom ash & fly ash and transfer to Ash pond/ Storage for disposal by Owner.

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#### 2.3.10 Solid Waste Disposal



LSTK Contractor shall provide the disposal procedure for hazardous solid waste generated in their B/L. and shall also provide enabling infrastructure to dispose-off the solid waste.

**Annexure-I**

TM	ON AIR DRY BASIS			ON EQUILIBRATED BASIS		
	M%	A%	GCV	M%	A%	GCV
10.46	5.73	16.12	6173	6.09	16.06	6149

V.M	32.15
FIXED CARBON	45.7



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## PART II: TECHNICAL



### SECTION – 2.0

#### RAW MATERIAL, PRODUCT AND UTILITY SPECIFICATIONS

**PLANT: COAL GASIFICATION PLANT FOR  
GENERATING SYNTHETIC NATURAL GAS**

**PROJECT: SYNTHETIC NATURAL GAS PRODUCTION  
THROUGH COAL GASIFICATION ROUTE AT  
BARDAHMAN, WEST BENGAL (INDIA).**

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## 1.0 Coal

Specification of Washed Coal fed to Coal Gasification Plant for production of Purified Synthesis Gas is as follows:

Available coal analysis is attached herewith as Annexure-II of Sec.4.0

## 1.1 Oxygen:

Gaseous Oxygen shall be made available at the battery limit at the specified condition indicated Below:

HP GASEOUS OXYGEN UNDER OWNER'S SCOPE			
	Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	--/45/--	
	Temperature, °C (Min/ Nor/ Max)	--/25/--	
	Purity (Vol %)	99.6	
	Quantity Nm <sup>3</sup> /h(min/Nor/Max)	Bidder to indicate for PDC Case	Bidder to indicate for EDC Case



## 2.0 Fluxant

Purity 95 wt. % (Min.)



Appearance: Powder/ Solid Lumps

## 3.0 UTILITIES (indicative specification)

3.1	H.P Steam Under Owner's Scope		
			Design
	Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	105/ 107/ 110	130
	Temperature, °C (Min/ Nor/ Max)	510/515/520	545
	Silica as SiO <sub>2</sub> , ppm	< 0.02	
	pH	9-9.5	
	Conductivity, μS/cm	< 0.2	
3.2	M.P Steam Under Owner's Scope		
		Normal	Design
	Pressure, kg/cm <sup>2</sup> g	40	44
	Temperature, °C	380 ± 5	425
3.3	L.P Steam Under Owner's Scope		
			Design
	Pressure, kg/cm <sup>2</sup> g (Min/Nor/Max)	3.5/4.0/4.5	6.0

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	Temperature, °C (Normal)	180	250
3.4	Cooling Water (Added With Suitable Chemicals) Under Owner's Scope		
	Supply Header Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	-/4.5/-	
	Return Header Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	-/3.0/-	
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10	
	Supply Header Temperature, ° C	33	
	Mechanical Design Temperature, ° C	70	
	ΔT	10 °C max.	
	Relative Humidity at Site	100% (max.)	
	Analysis of Cooling Water (indicative)		
	pH	6.5-7.5	
	Conductivity, μ mho/cm	500	
	Turbidity, NTU	< 8	
	Total Alkanity as CaCO <sub>3</sub> , ppm	300 max.	
	P. Alkanity as CaCO <sub>3</sub> , ppm	Nil	
	Total Hardness as CaCO <sub>3</sub> , ppm	1000 max.	
	Ca Hardness as CaCO <sub>3</sub> , ppm	500 max.	
	Mg Hardness as CaCO <sub>3</sub> , ppm	550 max.	
	Chloride as Cl, ppm	300 max.	
	TDS, ppm	2800 max.	
	Total iron as Fe, ppm	1 max.	
	Corrosion Rate, ppm	< 1.5 MPY	
	Silica as SiO <sub>2</sub> , ppm	125 max.	
	Nitrate as NO <sub>3</sub> , ppm	300 max.	
	Sulphate as SO <sub>4</sub> , ppm	800 max.	
	SRB count	< 20 per 100 ml.	
	Total Suspended solids (TSS)	< 25 ppm	
	Manganese as Mn	<0.1	
	Free Chlorine, ppm	0.2-0.4	
	Phosphate as PO <sub>4</sub> (Orth), ppm	7-11	
	Total Phosphate, ppm	8-14	
	Turbidity, NTU	< 10	
	<b>Notes:</b> LSTK contractor shall limit the pressure drop of 1.5 kg/cm2 (Max) between supply and return cooling water header within his battery limit. LSTK contractors to consider the following Fouling factors: a. Cooling water (CS/SS, shell side) = 0.0006/0.0002 m <sup>2</sup> °C h/Kcal b. Cooling water (CS/SS, tube side) = 0.0004/0.0001 m <sup>2</sup> °C h/Kcal		
3.5	Nitrogen Under Owner's Scope		
A	LP Nitrogen		
	Pressure, kg/cm <sup>2</sup> g (Min/Nor/Design)	6.0/8.0/9.0	

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	Temperature	Ambient		
	N <sub>2</sub> , Vol %, min	99.99%		
	O <sub>2</sub> , Vol ppm	< 10		
B	HP Nitrogen			
	Pressure, kg/cm <sup>2</sup> g (Min/Nor/Design)	--/82/--		
	Temperature	80		
	N <sub>2</sub> , Vol %, min	99.99%		
	O <sub>2</sub> , Vol ppm	< 10		
3.6	Instrument Air Under Owner's Scope	Min.	Nor.	Max.
	Pressure, kg/cm <sup>2</sup> g	6.0	8.0	10.0
	Supply Temperature, °C	Ambient	Ambient	50
	Mech. Design Pressure, kg/cm <sup>2</sup> g	10.5		
	Mech. Design Temperature, °C	65		
	Dew point	-40° C at 8 kg/cm <sup>2</sup> g		
	Quality	Free of dust, water drops & oil		
	Storage Capacity (8 to 6 Kg/Cm <sup>2</sup> g depressurization) (Storage Tank Under LSTK Contractor's Scope)	15 minute		
3.7	Demineralised Water Under Owner's Scope			
	Pressure @ B/L, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4.0/ 5.5/ 6.0		
	Temperature, °C (Normal)	Ambient/40 (max)		
	Mech. Design Pressure, kg/cm <sup>2</sup> g	10		
	Mech. Design Temperature, °C	70		
	pH	6.5-8.5		
	Total Hardness, ppm wt.	Zero		
	Total Dissolved Solids, ppm wt (max.)	0.1		
	Conductivity at 20 deg C, micro mho/cm (max.)	<0.2		
	M Alkanity as CaCO <sub>3</sub> , ppm wt.	Nil		
	Chlorides, ppm wt.	Nil		
	Iron as Fe, ppm wt. (max.)	0.01		
	Silica as SiO <sub>2</sub> , ppm wt. (max.)	0.02		
	Oil, ppm wt.	Nil		
	Sodium as Na, ppm wt. (max.)	< 0.1		
3.8	Boiler Feed Water Under LSTK Contractor's Scope			
	Total Hardness as CaCO <sub>3</sub> , ppm	Nil		
	O <sub>2</sub> , ppm	<0.005		
	CO <sub>2</sub> , ppm	< 1		

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	Silica as SiO <sub>2</sub> , ppm	< 0.02
	pH	9-9.5
	Conductivity, μS/cm	< 0.5
	Oil, ppm	< 0.1
	Permanganate, ppm	< 5
<b>3.9</b>	<b>Boiler Blow Down (Boiler CBD) Under LSTK Contractor's Scope</b>	
	pH	9.0-10.0
	Silica as SiO <sub>2</sub> , ppm	< 0.5
	Conductivity, μS/cm	< 50
	Phosphate, ppm	2-5
<b>3.10</b>	<b>Service Water Under Owner's Scope</b>	
	Colour (Hazen Unit or True Colour Unit)	< 5.0
	Smell	Agreeable
	pH	7.0-8.5
	Taste & Odour	Unobjectionable
	TDS, mg/l	< 150
	Turbidity, NTU	< 1.0
	Total Hardness, mg/l	< 85
	Chloride (as Cl), mg/l	< 15
	Sulphate (as SO <sub>4</sub> ), mg/l	< 60
	Total Iron (Fe), mg/l	< 0.01
	Dissolved Silica, mg/l	< 4
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4.0/6.0/8.0
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.5
	Mechanical Design Temperature, deg C	65
<b>3.11</b>	<b>Process Water/ Raw water (after treatment) Under Owner's Scope (Tentative)</b>	
	pH	7 – 8.5
	Chlorides, mg/l	20
	Sulphates, mg/l	-
	Silica, mg/l	5
	Iron, mg/l	0.2
	Manganese, mg/l	-
	Total Suspended Solids, mg/l	5
	Total Dissolved Solids, mg/l	100
	Oil & Grease, mg/l	Traces

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	Ammonia, mg/l	Traces
	Alkanity, mg/l as CaCO <sub>3</sub>	68
	Calcium Hardness, mg/l as CaCO <sub>3</sub>	100
	Total Hardness, mg/l as CaCO <sub>3</sub>	150
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4/ 6/ 8
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.5
	Mechanical Design Temperature, deg C	65
<b>3.12</b>	<b>Drinking Water UNDER OWNER'S SCOPE</b>	
	Colour	< 5.0
	Smell	Agreeable
	pH	7.0-7.5
	Taste & Odour	Unobjectionable
	TDS, mg/l	< 150
	Turbidity, NTU	< 1.0
	Total Hardness, mg/l	< 85
	Chloride (as Cl), mg/l	< 15
	Sulphate (as SO <sub>4</sub> ), mg/l	< 60
	Total Iron (Fe), mg/l	< 0.01
	Dissolved Silica, mg/l	< 4
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4/ 5.5/ 6.0
	Supply Temperature, deg C	Ambient
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.0
	Mechanical Design Temperature, deg C	65
	<b>Note:</b> Drinking water of quality conforming to IS: 10500-1991 shall be provided by the Owner to LSTK Contractor at the Battery Limit.	
<b>3.13</b>	<b>Pre-Treated Condensate Under LSTK Scope</b>	
	pH	8.5 - 9.5
	Conductivity, μS/cm	0.2
	Total Dissolved Solids (TDS), PPM (Max.)	0.5
	Silica (SiO <sub>2</sub> ), PPM (Max.)	0.02
	Iron (Fe), PPM (Max.)	0.02
	Copper (Cu), PPM (Max.)	0.003
	Sulphate (SO <sub>4</sub> <sup>2-</sup> ), PPM (Max.)	0.02
	Chloride (Cl <sup>-</sup> ), PPM (Max.)	0.1
	Quantity, M <sup>3</sup> /hr	(To be specified by LSTK CONTRACTOR)
<b>3.14</b>	<b>Plant Air Under Owner's Scope</b>	
	Moisture	Saturated

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	Oil Content	Nil
	Supply Pressure, kg/cm <sup>2</sup> g (Min/ Nor/ Max)	4.0/7.0/8.0
	Supply Temperature, deg C (Min/ Nor/ Max)	40/40/50
	Mechanical Design Pressure, kg/cm <sup>2</sup> g	10.5
	Mechanical Design Temperature, deg C	65
<b>3.15</b>	<b>Fire Water **</b>	
	Pressure kg/cm <sup>2</sup> g	Min. 7 (As per NFPA/TAC)
	Temp. deg C	Ambient
	** Fire water header of LSTK area shall be connected to Fire water ring main header of the complex.	
<b>3.16</b>	<b>LDO *(Light Diesel Oil)/ Natural Gas Fuel</b>	
	Quality	IS-15770 latest revision/IS 15958:2012 latest revision
	Pressure kg/cm <sup>2</sup> g	ATM
	Temp. deg C	Ambient
	• During start-up/ Shutdown, LDO shall be used. During normal operation, Fuel gas generated within LSTK area shall be used.	
<b>3.17</b>	<b>Power (Indicative Only) {Refer Section- 5.4 Design Philosophy Electrical for detailed distribution}</b>	
	Power for electric drives and lighting shall be as per sec. 5.4. 'DESIGN PHILOSOPHY – ELECTRICAL'.	

## 4.0 SPECIFICATION OF PRODUCT



### 4.1 PURIFIED SYN GAS (CO+H<sub>2</sub>)

The product Purified Syn Gas (CO+H<sub>2</sub>), which (Feed stock for the production of Synthetic Natural Gas) shall be produced in the Coal Gasification Plant.

#### Typical Analysis of Purified Syn Gas:

Sl. No	Components	Composition
1.0	Hydrogen(H <sub>2</sub> ), (vol. %, min.)	73-75
2.0	Carbon Monoxide(CO), (vol. %, min.)	23-25
3.0	Carbon Di-oxide(CO <sub>2</sub> ), (vol. %, min.)	<0.5
4.0	Nitrogen(N <sub>2</sub> ), (vol. %, min.)	<0.9
5.0	Argon (Ar), PPMv (max.)	0.5-0.75



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6.0	Mercury (Hg), PPMv (max.)	Nil
7.0	Pressure at B.L., Kg/cm <sup>2</sup> g, Max.	30
8.0	Temperature at B.L. Deg. C, Max.	45
9.0	Quantity Nm <sup>3</sup> /hr	3,36,000

## 4.2 CARBON DI-OXIDE

This Carbon dioxide generated in the Purification section shall be internally used for conveying of feed coal and purging purpose in Coal Gasification Unit. Following Typical Analysis of Carbon dioxide is indicated below:

Sl. No.	Components	Composition
1.0	Carbon dioxide (CO <sub>2</sub> ), Vol % (min).	98.5 (min., dry)
2.0	Hydrogen (H <sub>2</sub> ), Vol % (max)	0.1 (dry)
3.0	Nitrogen (N <sub>2</sub> ), Vol % (max)	1.0 (dry)
4.0	Argon (Ar) Vol % (max)	0.01 (dry)
5.0	Carbon Mono-Oxide (CO) Vol % (max)	0.15 (dry)
6.0	Moisture Vol %	Saturated
7.0	HCN PPM by Vol	1
8.0	Methanol PPM by Vol	100 (max, dry)
9.0	Sulphur (COS+H <sub>2</sub> S) PPM by Vol	5 (max)

## 4.3. Deleted

## 4.4 ELEMENTAL SULPHUR

Elemental Sulphur is a co-product from the coal gasification plant and shall be sold in market.

The product Elemental Sulphur will meet the following specification after degassing:

State	:	Solid
H <sub>2</sub> S content	:	10 ppm weight max.
Purity	:	Min. 99.9% wt% on dry basis
Colours	:	Bright yellow
Pressure	:	Not Relevant

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## PART - II: TECHNICAL



### SECTION - 3.0

#### CONTRACTOR'S SCOPE OF WORK

**PLANT: COAL GASIFICATION PLANT  
FOR GENERATING SYNTHETIC  
NATURAL GAS**

**PROJECT: SYNTHETIC NATURAL GAS  
PRODUCTION THROUGH COAL  
GASIFICATION ROUTE AT  
BARDAHMAN, WEST BENGAL (INDIA).**

0	30/09/2025	16/09/2025	Issued for Tender Purpose	SK	TNN	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



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SL. NO.	DESCRIPTION	SHEET NUMBER
1.0	General	3
2.0	Other requirements	5

## **LIST OF ATTACHMENT**

SL. NO.	DESCRIPTION	NUMBER OF SHEETS

	<b><u>COAL GASIFICATION PLANT FOR PROPOSED COAL TO SYNTHETIC NATURAL GAS</u></b>  <b><u>OWNER: COAL GAS INDIA LIMITED</u></b>  <b><u>CONTRACTOR'S SCOPE OF WORK</u></b>	PC217/E/001/P-II/SEC-3.0	0	
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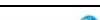

## 1.0 GENERAL

LSTK CONTRACTOR shall supply & install Coal Gasification Plant on a site at, Bahadurpur in the eastern part of Raniganj Coalfield Asansol sub-division of Paschim-Bardhaman district of West Bengal as per the requirements and specifications.

- 1.1** Scope of work of the LSTK Contractor shall include supply of Process License from any of the shortlisted licensor(for Coal Gasification) as mentioned in Chapter 1.0 Project Description, Basic Design and Detailed Engineering, Procurement, Supply, Fabrication, Inspection by Third Party Inspection Agency (TPI) as applicable, Expediting, Route survey for Over Dimensional Consignments (ODCs), Insurance, Transportation of all equipment / materials to work site, Storage, construction and erection of all civil, mechanical, electrical and instrumentation works, assembly and Installation, obtaining all necessary statutory approvals, Testing, Mechanical Completion, Pre-Commissioning, Commissioning, Sustained Load Test Run, Performance Guarantee Test Run (PGTR), six months assisted supervisory operation including Total Project Management and handing over of the plants and facilities under contractor's scope of work duly completed on single point responsibility basis.

- 1.2** The following plants and facilities shall be under the scope of the LSTK Contractor for Coal Gasification Plant depending up-on the Coal Gasification Technology opted by LSTK Contractor :

- a) Crushers for coal -100mm to -30mm
- b) Crushers for Fluxant to make -30mm.
- c) Coal (-100 mm) / Fluxant (-200 mm) size Storage for 7 days.
- d) Coal Milling & Drying (CMD) of Coal/ Fluxant (automatic system shall be considered
- e) Feed Pressurizing & Feeding Arrangement and Pneumatic Transfer (automatic system shall be considered) – (2W+2W).
- f) Coal Gasification Unit – (2W+0S) or (3W+0S)
- g) Deleted
- h) Deleted
- i) Gas purification unit to produce Purified Syn. Gas ((H<sub>2</sub>-CO<sub>2</sub>) / (CO+CO<sub>2</sub>) =3)) for production of Synthetic Natural Gas (SNG).-(1 train).
- j) Sulphur Recovery Unit (SRU Oxy-Claus based process) (2 trains) and Storage.
- k) Slag/ Slag-fine/ Fly-ash Handling & Transportation to Ash pond/ disposal area. Slag-fine may be recycled to Coal Milling & Drying unit (CMD).
- l) For Slag/ Fly-ash handling, four nos. dumper of 40 Tonne capacity each.
- m) Two nos. Pay Loader of 5 ton capacity each.
- n) Deleted
- o) Electrical Sub-station.
- p) Control room.
- q) Chemical laboratory building along with instruments & laboratory chemicals for a period of six month from completion of Sustained load.
- r) Pre-Treatment of effluent generated from all units of LSTK B/L (1 train).
- s) First fill of all catalyst, chemicals & consumables and requirement during Pre-Commissioning, Commissioning, Sustained Load Test Run and Performance Guarantee Test Run (PGTR).
- t) After PGTR, 6 months supervisory Operation & Maintenance assistance
- u) Supply of chemicals and consumables required for a period of six months from completion of Guarantee Test Run.
- v) Fire fighting & safety system for LSTK's scope of work as per requirement of NFPA.

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- w) Instrument Air storage Tank for 15 minutes' operation from 8 to 6 kg/cm<sup>2</sup>g depressurization.
- x) Emergency Power requirement within LSTK battery limit shall be furnished by LSTK Contractor. Owner shall supply emergency power as per LSTK's requirement.
- y) BFW preparation is under the LSTK contractor's scope including De-aerator.

(Note: LSTK contractor's scope shall also include submission of procedure for safe disposal of hazardous solid waste.)

For Better understanding of process Units considered under LSTK-1 Scope refer Attachment-1 of Section 8.0 of Part-II Technical.



**1.3** The following Offsite & Utility plants shall be excluded from the scope of LSTK contractor of Coal Gasification Plant:

- a) Coal handling and Transportation from Pithead to LSTK B/L.
- b) Ash disposal from Ash pond.
- c) Solid Sulphur dispatch.
- d) Hazardous solid waste disposal.
- e) Raw water storage & pumping.
- f) Water pre-treatment plant.
- g) DM & condensate polishing unit.
- h) Common Effluent Treatment Plant.
- i) Steam and Power Generation Plant including Emergency power.
- j) Non Plant Buildings
- k) Mechanical work shop building with machineries.
- l) Electrical work shop building along with instruments & machineries.
- m) Instrument work shop building along with instruments & machineries.
- n) Railway Siding
- o) Yard Piping for facilities outside LSTK contractor's scope
- p) Instrument & Plant air system

**1.4** Following raw material & utilities shall be made available to the LSTK contractor at one point of Coal Gasification Plant Battery Limit, 3 months prior to the end of Mechanical Completion period for pre-commissioning by owner at Coal Gasification Plant B.L. However, required utilities prior to this period will be arranged by LSTK contractor.

- a) Coal and Fluxant
- b) Oxygen
- c) Nitrogen
- d) Cooling Water
- e) Treated water
- f) DM water
- g) Steam
- h) Fire water
- i) Electrical Power
- j) Instrument Air
- k) Plant Air

Note: 1. Washed Coal with Ash content upto 20 % Air dried Basis shall be supplied by owner at Coal Gasification section B.L.

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- Note: 2. Some of the utilities like Oxygen, Nitrogen Instrument Air, DM Water, cooling water, Drinking Water, Electricity to be supplied by Owner, 3 months prior to the end of Mechanical Completion period for pre-commissioning by owner at Coal Gasification Plant B.L. However, required utilities prior to this period will be arranged by LSTK contractor.
- Note: 3. Slag/ Slag fine/ Flyash generated from the Gasifiers shall be transported suitably from Gasification area to the dedicated adjacent Slag/ Slagfine/ Flyash pond/ storage area within Battery Limit of the Complex or for direct dispatch outside by LSTK contractor for further evacuation by the Owner.
- Note: 4. LSTK Bidder shall collect data on Coal sizing and detailed specifications as mentioned in Annexure-II of Section 4.0 of Part-II Technical.
- Note: 5. LSTK Contractor shall provide Purified Syn. Gas  $((H_2-CO_2)/ (CO+CO_2) =3)$  of 3,36,000 NM<sup>3</sup>/hr & CO<sub>2</sub> gas for Conveying purpose on 100% Plant Capacity.
- Note: 6. **Gasifier Configuration:** For Gasifier configuration, please refer Clause No.-2.2.7 of Section-4.0 Design Basis Part-II Technical.

#### **Coal, Slag/ Slagfine/ Flyash/ handling Equipment:**

Please refer Clause No.-2.2.10 of Section-4.0 Design Basis Part-II Technical



#### **Sulphur Recovery Unit Configuration:**

Please refer Clause No.-2.2.11 of Section-4.0 Design Basis Part-II Technical

- Note: 7. Construction Power required for Coal Gasification Plant till mechanical completion shall be provided at single location within battery limit on chargeable basis.
- Power required for Plant start-up & operation for Coal Gasification Plant shall be supplied by Owner at a single point at substation located at LSTK B/L.
- Note: 8. Handling & Transportation of coal from the pit head of designated mines till washery unit and further transportation of washed Coal to B.L. of Coal Gasification Island is under Owner's scope. Coal Gasification LSTK Contractor shall be responsible for pre-treatment of coal as required for its Gasification process.
- Note:9. LSTK Contractor to ensure availability of more than two vendors for all the Licensor's proprietary item/equipment.
- Note:10. LSTK Contractor shall also submit the Isometric & 3D modelling as part of the Technical package to Owner

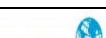

## **2.0 OTHER REQUIREMENTS**

- 2.1 Tie-up/ hook-up with designated tie-up points for hooking up to other systems executed by other agencies. Perform construction management and supervision of all equipments, material and works.
- 2.2 Provide and perform comprehensive quality assurance, quality control and inspection of all equipments, materials works - both in manufacturing shop and at work site.

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- 2.3 Provide all manpower, materials, consumables, construction equipment / machines, tools, instruments, storage, fabrication, facility and all other services and inputs etc. necessary to perform the work and complete the plant.
- 2.4 Comply with all Central, State & Local Govt. regulations, laws and requirements applicable to the work and seek & obtain approvals/ clearances from such statutory bodies/ agencies, as required. Scope of COAL GAS INDIA LIMITED in this regard will be only to provide authorization in favor of LSTK CONTRACTOR for which all the necessary paper work will be done by LSTK CONTRACTOR.
- 2.5 Provide necessary temporary construction facilities like fabrication, storage, illumination etc. and removal of temporary arrangement to make the space reusable.
- 2.6 Comply with all safety practices for and during work as per applicable standards.
- 2.7 Strictly comply with applicable codes and standards of Engineering, Fabrication, Inspection, Construction etc.
- 2.8 Arrange services of Manufacturer's installation/ commissioning Engineer(s) at Site during Mechanical Completion/ Pre-commissioning/ Commissioning/ GTR of all the major equipment and systems.
- 2.9 Provide all the temporary connections/ supplies required for testing/ pre-commissioning activities and also to provide all instrument metering systems required for measurements of various parameters/ testing during test runs.
- 2.10 Arrange spare parts for start-up/ pre-commissioning / commissioning/ Sustain Load Test Run/ PGTR/ Six month supervisory operation of plants. All such spares are to be available at site prior to commissioning/ start up of the plant including various test runs.
- 2.11 Perform testing, flushing, cleaning and pre-commissioning, start-up/ commissioning.
- 2.12 Submission of final drawings and documents shall be as per Section No 9.0 (Drawings and Documents) of Part-II Technical.
- 2.13 Project Management and planning, scheduling and monitoring/comprehensive reporting services, periodic reviews, meeting notes with : Coal Gas India Limited / PMC.
- 2.14 The scope of work as described above shall be supplementary to the scope of work mentioned under various parts of Tender Document. In case of any contradiction between the two, the stipulations mentioned under various disciplines shall be governing. In this regard, : Coal Gas India Limited interpretation shall be final and binding to LSTK CONTRACTOR.
- 2.15 Transportation of all the materials supplied by Coal Gas India Limited, if any, from : Coal Gas India Limited store to LSTK CONTRACTOR's Store/ work site including loading/ unloading.
- 2.16 Total painting including special paints, color coding, insulations, refractory, CS / S.S. name plates etc. as per applicable standards.
- 2.17 Any other work not specifically mentioned above but required for completeness of the plant shall be undertaken by the LSTK Contractor.
- 2.18 HAZOP/HAZAN/SIL Study is under LSTK contractor's scope. LSTK CONTRACTOR shall



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implement the recommendations if any, of HAZOP / HAZAN/ SIL Study, without any additional cost / time schedule implication to Coal Gas India Limited / PMC.

- 2.19 LSTK CONTRACTOR shall adhere to Design Control exactly as per provisions of ISO 9001:2015. LSTK CONTRACTOR shall submit required records as evidence for review by Coal Gas India Limited / PMC as and when required, and shall carry out changes based on Coal Gas India Limited / PMC review.
- 2.20 LSTK contractor shall supply the spares, lubricants, chemicals and other consumables in the LSTK price for the six months after Guarantee Test Run in addition to the Pre-commissioning/ Commissioning/ Sustained Load Test Run spares and consumables. Quantity of spare, lubricant, chemicals & consumables shall be based on 100% plant operation. For subsequent two year requirement, LSTK contractor to provide the list along with price of recommended spares and consumables. However, price is not to be included in the lump sum price.
- 2.21 Owner desires six months (after GTR) supervisory Operation & Maintenance assistance with designated selected manpower defined by Owner in below table. LSTK Contractors shall indicate the man-day/ man-month rate in Schedule of Rate.

**Manpower required for O&M assistance**

Sr. No.	Discipline	Designation	No. of personnel	Qualification	Experience
1.	Chemical	Overall Manager	01	B.Tech, Chemical Engg.	Min. 10 year
2.	DCS Operator	Super-Wiser	01	Diploma/ B.Sc	Min. 10 year
3.	Electrical	Super-Wiser	01	Diploma/ B.Sc	Min. 10 year
4.	Instrument	Super-Wiser	01	Diploma/ B.Sc	Min. 10 year
5.	Mechanical	Super-Wiser	01	Diploma/ B.Sc	Min. 10 year

Note-1 The manpower mentioned in Sr. 1, 2 & 4 must have the experience of Licensor's Gasification Plant, Gas cleaning & Purification.

Note-2 Instrument discipline personal must have the experience of DCS, field & other instruments.

- 2.22 LSTK contractor shall arrange complete manpower including Licensor's manpower mutually agreed by Owner, Licensor & LSTK Contractor for Pre-Commissioning/ Commissioning/ Sustained Load Test Run/ GTR and Operation & Maintenance.
- 2.23 LSTK contractor shall follow the Licensor's advice to depute the Licensor's manpower with respect to numbers, discipline & experience for Safe and trouble free Pre-Commissioning/ commissioning/ Sustained Load Test Run/ GTR of plant.
- 2.24 Procurement of Laboratory Equipments, Installations, Pre-Commissioning, Commissioning is in the Scope of LSTK Contractor.
- 2.25 LSTK Contractor shall furnish the list of Laboratory Equipments to be procured based on licensor's list with bid. Laboratory Equipment's manufacturers will be based on licensor recommended list. For non license area, LSTK contractor shall furnish the laboratory equipment list along with details.
- 2.26 Chemicals, consumable, calibration gases required for Pre-Commissioning/ Commissioning of Laboratory shall be in LSTK Contractor's scope.
- 2.27 Six month Chemical, Consumables, Calibration Gases, and any other Consumable for Laboratory shall be in LSTK Contractor's Scope.**



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## PART - II: TECHNICAL



### SECTION 4.0

#### DESIGN BASIS

**PLANT: COAL GASIFICATION PLANT FOR GENERATING SYNTHETIC NATURAL GAS.**

**PROJECT: SYNTHETIC NATURAL GAS PRODUCTION THROUGH COAL GASIFICATION ROUTE AT BARDAHMAN, WEST BENGAL (INDIA).**

0	30/09/2025	16/09/2025	Issued for Tender Purpose	SK	TNN	MN
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



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## LIST OF ATTACHMENT

SL. NO.	DESCRIPTION	NUMBER OF SHEETS
1.0	Annexure-I Coal Analysis	1

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## 1.0 GENERAL

This document (Design basis) indicates the requirements for design of Coal Gasification based Pure Syn Gas ( $\text{CO}+\text{H}_2$ ) Generation facilities to be constructed by LSTK-1 CONTRACTOR on LSTK basis.

## 2.0 REQUIREMENT PERTAINING TO COAL GASIFICATION BASED PURIFIED SYN GAS SUPPLY

Coal Gasification Plant is the source of raw syn Gas followed by purification section to produce purified syn Gas ( $\text{CO}+\text{H}_2$ ) which shall be used in the methane synthesis section (Under LSTK-2) for the production of Synthetic Natural Gas in the proposed Complex along with gaseous Carbon Di-oxide to be used for conveying purpose inside the Battery limit of LSTK-1. Syn. Gas generated in Coal Gasification Plant at required battery limit condition are sent to the Synthetic Natural Gas Generation Section. LSTK-1 CONTRACTOR is required to construct the Coal Gasification Plant to meet requirement of specified Syn. Gas at a required rate, purity, composition, pressure and temperature to the Methane Synthesis Section complex continuously during the on-stream days of the Complex.

**2.1** LSTK Bidder shall ensure involvement of Gasification Licensor during Process Integration for Coal Gasification Plant including Gas Purification, SRU, etc. to ensure the overall integration & optimization of all other Licensor's unit within the LSTK-1 Contractor BL.

**2.2** Capacity of Coal Gasification based Synthesis Gas ( $\text{CO}+\text{H}_2$ ) / Carbon Di-oxide Gas generation Facility.

The Coal Gasification Plant shall be designed to meet the following quantity requirement of Synthesis Gas ( $\text{CO}+\text{H}_2$ ), Suitable quantity of Carbon Di-oxide to be used for Conveying medium for feed within the Gasification Unit and Utility Nitrogen. LSTK CONTRACTOR shall specify the supply quantities of other products.

### 2.2.1 Purified Synthesis Gas (As per composition mentioned at Section -2):

Continuous Normal requirement:	<b>336000</b> $\text{NM}^3/\text{hr}$	(100%)
Maximum requirement:	<b>369600</b> $\text{NM}^3/\text{hr}$	(110%)
Minimum requirement:	<b>168000</b> $\text{NM}^3/\text{hr}$	(50%)



### 2.2.2 Carbon di-oxide Gas (100% pure) (dry):

Continuous Normal requirement:	<b>BY LSTK-1 Bidder</b> $\text{NM}^3/\text{hr}$	(100%)
Maximum requirement:	<b>BY LSTK-1 Bidder</b> $\text{NM}^3/\text{hr}$	(110%)
Minimum requirement:	<b>BY LSTK-1 Bidder</b> $\text{NM}^3/\text{hr}$	(50%)

### 2.2.3 Deleted

### 2.2.4 Deleted



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### 2.2.9 Carbon di-oxide Compressor Configuration Under LSTK-1 Scope :

CO<sub>2</sub> compression – Total requirement of CO<sub>2</sub> for conveying of coal in Coal Gasification unit and Purging Purposes shall be fulfilled by CO<sub>2</sub> generated in the syn gas purification section, the configuration of CO<sub>2</sub> compressor shall be (2W+1S) compressors trains for Working gasifiers.

50% of the Total CO<sub>2</sub> compressor shall be steam turbine driven and rest will be motor driven.

The pressure/ Temp. Operating Conditions required for production of CO<sub>2</sub> as follows:

Sl. No	Service	Operating Conditions	Temperature (DegC)	Pressure (Kg/cm <sup>2</sup> g)
I.	<b>HP /CO<sub>2</sub></b>	Within ISBL of LSTK-1 for gasifiers	100	52
II.	<b>VHP CO<sub>2</sub></b>	Within ISBL of LSTK-1 for gasifiers	120	82

The above parameters are typical; LSTK Contractor may configure the parameters according to the requirement for coal conveying.

### 2.2.10 Coal, Slag/ Slagfine/ Flyash handling Equipment:

#### Coal / Fluxant:

Coal/ Petcoke received in battery limit by Dumper/ Conveyor Belt shall be crushed through Crusher from -100mm to -30mm size and transferred to covered storage.

Fluxant received in battery limit by Dumper shall be crushed through Crusher to -30mm size and transferred to covered storage.

For Coal/Fluxant storing, one no. of stacker & re-claimer for stacking & re-claiming in storage area of suitable capacity to be provided by the LSTK Contractor. There shall be two/three operating as per Licensor's Design Specification and one common stand-by Coal Milling and Drying (CMD) system.

#### Slag:



Bottom Slag shall be transferred to either (1) to overhead bunker for dispatch outside by truck or (2) to Slag/ Ash pond by belt conveyor.

#### Slagfine:

Slagfine may be recycled to CMD or transferred to Slag/ Ash pond through belt conveyor.

#### Fly Ash:

Fly ash shall be transferred to either (1) to overhead bunker for dispatch outside by truck or (2) to Slag/ Ash pond by belt conveyor.

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Slag/ Slagfine / Flyash generated from each Gasifier shall be handled separately through dedicated handling system and shall be routed to service wise common conveying systems.

### 2.2.11 Sulphur Recovery Unit (based on Oxy-claus process) Configuration:

Sulphur recovery unit shall be based on gasifier feed coal quality and shall be installed in two trains (each of 50% design capacity). Design of the unit should take care minimum/maximum sulphur in the feed when Gasifier is running on 100% coal. LSTK Contractor to consider recovery of Sulphur as 99.9% No credit shall be given for sulphur recovery.

Following min. facilities may be considered common for both the trains:-

- Combustion air blowers can provide the common discharge for both trains of SRU.
- Acid gas Knock out drum and Sour gas knock out drums can be shared after which the acid gas can be split for both trains of SRU's.
- Sulphur Pit for SRU can be shared for sulphur run down flow from each locks can flow into common pit.
- De-aerator for feeding BFW into steam drums and condensers can be given as common
- All utilities header such as HP steam, LP steam, BFW, condensate recovery system can be given in sharing mode with separate tap-off for each vessel/equipment.



## 2.3 Quality Specification

Tail Gas treating unit which can be used for recovery of H<sub>2</sub>S from tail Gases. Tail gas from final condenser for Both SRU train can be combined and can be passed thru common TGTU followed by common Incinerator/boiler and stack. H<sub>2</sub>S gas recycled from TGTU can be sent back to common Acid gas KOD inlet.

**2.3.1** Product Purified Syn. Gas produced from the plant shall cater to the following minimum specification:

Parameter	Unit	Value
Hydrogen (H <sub>2</sub> )	Vol %, min.	73-75
Carbon Mono-oxide(CO)	Vol %, min.	23-25
Carbon Di-Oxide(CO <sub>2</sub> )	Vol %, min.	<0.5
Nitrogen (N <sub>2</sub> )	Vol %, min.	<0.9
Argon (Ar)	PPM by Vol(Max)	0.5-0.75
Mercury (Hg)	PPM by Vol(max)	Nil
Pressure	Kg/Cm <sup>2</sup> g, Max	30
Temperature	°C, Max	45
Quantity	Nm <sup>3</sup> /MT of Feed Coal	(to be confirmed by LSTK-1 Contractor)

**2.3.2** Carbon Di-Oxide gas will be used in LSTK 1 package for conveying of feed coal and purging purpose. Following specification will be required:

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Sl. No.	Components	Composition
1.0	Carbon dioxide (CO <sub>2</sub> ), Vol % (min).	98.5 (min., dry)
2.0	Hydrogen (H <sub>2</sub> ), Vol % (max)	0.1 (dry)
3.0	Nitrogen (N <sub>2</sub> ), Vol % (max)	1.0 (dry)
4.0	Argon (Ar) Vol % (max)	0.01 (dry)
5.0	Carbon Mono-Oxide (CO) Vol % (max)	0.15 (dry)
6.0	Moisture Vol %	Saturated
7.0	HCN PPM by Vol	1
8.0	Methanol PPM by Vol	100 (max, dry)
9.0	Sulphur (COS+H <sub>2</sub> S) PPM by Vol	5 (max)

**2.3.3** By-product Sulphur (solid) produced from the plant shall cater to the following minimum specification:



Parameter	Unit	Value
Sulphur (S)	Wt. %(min, dry)	99.9
Hydrogen Sulphide (H <sub>2</sub> S)	Wt.ppm(max, dry)	10
Ash	Wt.ppm (max)	200
Pressure	Kg/Cm <sup>2</sup> abs	Atmospheric
Temperature	°C	Ambient
Physical Appearance		Solid lumps

**2.3.4** Deleted

**2.3.5** By-product Flyash/ slag/ Slagfines (solid) produced from the plant shall cater to the following minimum specification:

Parameter	Unit	Value
<b>Flyash/ Slag/ Slagfines</b>	Wt. %	(To be specified by LSTK CONTRACTOR)
Moisture (H <sub>2</sub> O)	Wt. %	(To be specified by LSTK CONTRACTOR)
Carbon Content	Wt. %	Fly Ash: <5 Slag: <2 Slag fines: <30
Pressure	Kg/Cm <sup>2</sup> abs	(To be specified by LSTK CONTRACTOR)
Temperature	°C	(To be specified by LSTK CONTRACTOR)
Physical appearance		(To be specified by LSTK CONTRACTOR)

Note: - LSTK Contractor shall arrange to design the Plant in such a way that no Nitrogen Oxide (NO<sub>x</sub>) is present in process gas stream (Raw Syn. Gas "H<sub>2</sub>+CO") leaving Gasification Licensor's Area.

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## 2.4 Feed stock for Coal Gasification Plant:

Coal Gasification Plant shall be designed to use following as feed stock.

- Washed Coal (Ash content upto 20%)
- Fluxant (Powder/ Lumps) purity 95% (Min.)

**Normal feedstock –Washed Coal (ash content upto 20% wt.),** available coal analysis is attached herewith as **Annexure-I. LSTK Contractor shall accordingly design the plant so as to meet the performance guarantee.** LSTK Contractor shall take care of any possible variation in coal analysis of Coal as per Annexure-I during design of Coal Gasification Plant.

**NOTE: LSTK Contractor to submit data / information for all the Cases (PDC & EDC). However, for BID evaluation purpose, Washed Coal with ash 20% case (PDC) will be considered.**

Washed Coal as specified above shall be supplied at the Battery Limit of Coal Gasification Plant by Owner.

To ensure continuous feed supply at a constant rate at battery limit of Coal Gasification Plant through conveyor belts, proper facility shall be put up by others for storage / transfer of coal, and fluxant from respective storage areas to above mentioned Battery Limit.

Coal Gasification Plant should be able to respond to the operational interruption in Synthetic Natural Gas plant without jeopardising the plant safety.

### 2.4.1 Sulphur storage: Offsite storage facility (shaded with proper concrete dyke) shall be provided by LSTK CONTRACTOR. Provision of space for future installation of full capacity Pastillation Unit shall be considered:

- Storage Capacity = Fifteen day's production
- Storage area = ---- m<sup>2</sup> (To be specified by LSTK CONTRACTOR)
- Storage pressure = Atmospheric
- Operated/maintained by = OWNER
- Unloading facility from pipeline = by LSTK CONTRACTOR at B.L. of Storage.



Storage for solid Sulphur will be an open pit with two arms for min. 15 days storage.

The open pit shall have two compartments along with ramp provision for pay loader and truck loading arrangement. The open pit should have proper water drainage system. Flooring & dyke wall should be anti-corrosive. Dyke height will be min. 2 meter.

Transfer of liquid Sulphur from inter-mediate storage (i.e. Sulphur pit including de-gasifier) located at LSTK B.L. to above mentioned storage shall be the responsibility of LSTK CONTRACTOR. One Tank Truck lorry loading bay with covered shed for liquid sulphur to be provided by LSTK Contractor.

### 2.4.2 Ash/Slag storage/ disposal: Offsite storage facility for Ash/Slag shall be provided by others:



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- Storage Capacity = Thirty day's production
- Storage area = -----m<sup>2</sup> (To be specified by LSTK CONTRACTOR)
- Storage pressure = Atmospheric
- Operated/maintained by = OWNER.
- Transfer of ash/ slag from Gasification B.L. to storage shall be the responsibility of LSTK CONTRACTOR.

**2.4.3** Storage of 7 days (min.) for Alkali and Acid for wet scrubbing & primary water treatment in Gasification Licensor's area shall be considered in LSTK Contractor's scope.

### 3.0 GENERAL REQUIREMENTS

#### 3.1 Plant On-stream factor:

Plant design and engineering are to be carried out for achieving a high degree of operational reliability. The plants are to be designed with high on-stream factor (not less than 330 days in a year) with minimum continuous operating cycle of 1 year between turn around.

#### 3.2 Turn-Down ratio\*:

The Purified Syn Gas / Carbon di-oxide /Sulphur / Ash / Slag Units shall be designed to operate and demonstrate for 12 hrs. Stable operation with turn-down ratios as given below:

- Purified Syn Gas : 50% of plant design capacity
- Sulphur : LSTK Contractor to suitably design considering Gasifier operation on 100% ROM Coal

NOTE: \*- LSTK Contractor shall demonstrate that above mentioned ISBL Plants are capable of producing indicated turn down capacity for 12 continuous hours / as mutually agreed upon by LSTK Contractor/ Owner/ PMC. For details, please refer Section 8.0 of Part-II Technical.

#### 3.3 Capacity Utilization:



Complex will run at its Nameplate Capacity (i.e. 100%) on and from the first year of operation since commissioning. If required, the plant may be run at it's design capacity (i.e. 110%) as well as at its Turn down capacity (as specified in Cl. No. 2.2 of this section).

#### Catalyst

Plant shall be designed to achieve rated throughput at design controlling temperature and pressure conditions even at catalyst End of Run (EOR) conditions.

#### Catalyst Handling System

The system shall have adequate flexibility to handle catalyst of different size and geometry and with suitable flexible hoses, pipe section for loading and evacuating from respective converter/ reactor of different services. A portable separator shall be provided for reuse of partially discharged catalysts.

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### 3.4 Plant Availability:

Plant availability factor for producing Purified Syn. Gas, Carbon Di-oxide, Sulphur, Flyash/ Slag/ Slagfines should be 100% excluding the planned shutdowns as per the OWNER's requirements.

### 3.5 FLARE

The entire flaring requirement for the Coal Gasification Plant shall be provided by the LSTK CONTRACTOR up to the battery limit to cater the discharge of mitigated flare load from the unit. All hydrocarbon / combustible gases and vapours (sour & sweet gases) shall be relieved to the flare through separate knock out drums (sour & sweet). LSTK CONTRACTOR to consider Flare Knock-out Drums for Coal Gasification Plant within the battery limit of their unit.



### 3.6 Shift Conversion Section

The system shall be installed in single train. Mercury Guard bed is to be provided upstream of Shift Conversion Section. Shift Conversion section shall be designed for the End of Run (EOR) condition of catalysts.

### 3.7 Acid Gas (H<sub>2</sub>S / CO<sub>2</sub>) Removal:

LSTK Contractor shall provide H<sub>2</sub>S / CO<sub>2</sub> removal units with conventional & well proven design in single train. Selective removal of H<sub>2</sub>S and CO<sub>2</sub> gases are required for utilization in SRU and Conveying Purpose inside battery Limit. A typical design of Acid gas removal unit is as described. The system shall be optimised for low energy consumption, The system shall be designed to maximise re-use of condensate generated within the system. Make-up The design of Tower Internals shall consider high efficiency Norton or equivalent type distributors compatible with high efficiency type of tower packing. To achieve minimum carryover of solution with process gas or H<sub>2</sub>S or CO<sub>2</sub>, suitable washing arrangement at Absorber and Regenerator top shall be provided. The Acid Gas removal shall be such that the Desired M value  $\{(H_2-CO_2)/(CO+CO_2)\}$  of ~3.0 in the Purified Syn gas, shall be maintained. Major circulation pumps shall be on two (2) working and one (1) standby philosophy.

All pumps shall be electric motor driven. Difference of NPSH<sub>a</sub> to NPSH<sub>r</sub> should be minimum 1.0 meters. Cartridge type filters and/or activated carbon beds shall be used to maintain solution quality. Anti foam and corrosion inhibitor injection system shall be provided. Split range full capacity vents shall be provided on the CO<sub>2</sub> product line as well as absorber outlet process gas line. The CO<sub>2</sub> removal system should not have positive water balance. In case vanadium pent-oxide is used in the system as corrosion inhibitor then facility for aeration of solution also should be given. Full capacity vent is to be provided on H<sub>2</sub>S product line and shall be connected to the incinerator / flare complying statutory requirements. Carbon Mono-oxide emission limit shall be <625 PPMv.

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### 3.8 Synthesis Gas Purification:

The system shall be installed in single train. If applicable, Catalyst shall be designed for end of run (EOR) condition of catalyst.

### 3.9 BFW/ Steam System:

Each BFW pumps shall provide 60 % of the feed requirement. De-aeration shall be in single train. Boiler feed water treatment shall be based on volatile treatment. BFW pump shall be interchangeable for feeding steam generation system of any of the gasifier train.

### 3.10 Drives:



The selection of drives shall be preferred as follows. However LSTK Contractor may adopt any other configuration (Pump/Compressor, Turbine/Motor) as recommended by the Process Licensor for the sake of energy optimisation with proper justification.

Boiler feed water pumps (2W+2S)	2W Steam turbine + 2S Electric motor Driven
Operating L.O. Pumps for compressors (1W+1S)	Electric motor drive (Both Pumps shall have normal & emergency power supply)

Compressors shall be provided with Dry Gas Seals wherever applicable. Re-acceleration requirement based on respective Licensor's guidelines (as applicable) to be considered by LSTK Contractor."

### 3.11 Plant Equipment Metallurgy:

Gasification Unit	As per Licensor's specification
CO <sub>2</sub> Regenerator: From Top dished head up to 100 mm below top packing bed	SS 304
Packing & Tower internals of Towers of CO <sub>2</sub> /H <sub>2</sub> S Removal Section	SS 304
CO <sub>2</sub> O/H Condensers/ CO <sub>2</sub> Cooler Re-boilers, Shift gas coolers	SS304 for Parts coming in contact with moist CO <sub>2</sub> gas or solution
Sulphur/ H <sub>2</sub> S	NACE shall be followed wherever required
MOC of De-Aerator	Storage Vessel: CS Stripping Section: SS

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### 3.12 Critical Piping

Gasification Unit	As per Licensor's specification
Process Gas exit catalytic reactors	Material Superior to C - ½Mo
Wet CO <sub>2</sub> gas, rich CO <sub>2</sub> loaded solution	SS 304
DM water	SS 304
Process condensate	SS 304/SS 304L
Instrument air	SS 304
Lube oil and seal oil	SS 304
Phosphate/ Hydrazine / Antifoam Solution	SS 304
High pressure steam for temperature above 460°C	9Cr.-1Mo
High pressure steam for temperature above 425°C	1.25Cr -0.5Mo
Medium & Low pressure steam temperature < 425°C	A106 Gr.BSmls

In general the following may be offered for cooling water service:

- All exchangers with cooling water service shall have cooling water on tube side
- All such exchangers shall have SS 304 tubes. The tube size shall not be less than ¾"

### 4.0 Effluents from Coal Gasification Plant

Contractor will provide primary treatment and indicate composition and quantity of effluent at the B.L. of their system for further treatment at Owner's ETP.

LSTK Contractor shall guarantee the liquid pollution levels as per limits and gaseous pollution levels as per requirement of Central and West Bengal State Pollution Control Authority.



Note: The standards to be met shall be as per latest revision and each parameter should conform to the stipulated standard as per CPCB/SPCB whichever is more stringent.

### 5.0 SAFETY, HEALTH & ENVIRONMENT:

#### 5.1 General

LSTK CONTRACTOR & his employees shall–

- Comply with the conditions of the EC (Environmental Clearance), NOC/ Consent to Establish, Air & Water Consents, Hazardous Waste Authorization and the standards stipulated in the Gazette Notifications for the concerned industry.
- Follow all the relevant rules & regulations like The Factories Act, The Environment (Protection) Act etc.
- Implement recommendations of EIA Report & Risk Analysis Report.

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## 5.2 Safety

LSTK CONTRACTOR & his employees shall-

1. Observe own/ Licensor's safety rules & regulations during construction, erection pre-commissioning, commissioning-
2. Observe 'No Smoking' strictly in the LSTK premises. Any person who is found smoking or in the possession of match box or lighter or any other means of ignition in the Coal Gasification Complex or in the Production plant shall be turned out of the Plant gate. Suitable action as decided by the OWNER's management shall also be taken.
3. Maintain good standards of housekeeping.
4. If required, Take all safety precautions and obtain permission from the fire & safety department before carrying out any hot job.
5. Deploy a qualified safety officer to monitor the safety performance.
6. Report all accidents to the Fire & Safety Department and fulfil all legal formalities.
7. Enlist all chemicals on stock with their respective MSDS.
8. Take due insurance cover for affecting neighbourhood (damage, loss & injury to people, property & environment) due to any untoward incident.

## 5.3 Traffic Safety



LSTK CONTRACTOR & his employees shall –

1. Maintain the speed limit of 25 Km/hr inside the Plant premises.
2. Avoid traffic congestion and abide by the traffic rules by deploying trained and licensed drivers.

## 5.4 Environment

LSTK CONTRACTOR & his employees shall –

1. Shall avoid wastage of drinking water, etc. .
2. Transfer only neutralized effluent to the Effluent Treatment Plant of the OWNER as specified in cl.4.0 above
3. Install Hydrocarbon (HC) leak detectors at strategic locations in the plant area.
4. Install SO<sub>2</sub>, NO<sub>x</sub>, CO online analyzers in all the stacks for computerized monitoring as stipulated in the EC. Stack heights shall be as specified in the EIA Study

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conducted for the OWNER's Plant and stacks shall have proper sampling & monitoring facilities.

#### Stack Emission Limit

SO <sub>2</sub>	<100 mg/ Nm <sup>3</sup>
NO <sub>x</sub>	<100 mg/ Nm <sup>3</sup>
Particulate Matter	<30 mg/ Nm <sup>3</sup>
CO	<100 mg/ Nm <sup>3</sup>
Sulphur	< 20 PPMv
Methanol	< 50 Mg/Nm <sup>3</sup>
Pressure	Atmospheric

Carbon Mono-oxide emission limit shall be 350 PPMv (max) for Shift Coverion Section. Above values are indicative. LSTK Contractor to follow the latest norm of CPCB/ OSPCB. State PCB or Central PCB norms whichever is more stringent shall be complied by LSTK Contractor.

- Monitor fugitive emission of Hydrocarbon (HC) / VOC & Benzene through Portable Monitor at periodicity as per the Gazette Notification (latest) under the heading Fugitive Emission (Standards for Equipment Leaks Pt. No.7).

#### Limit of VOC & Benzene Concentration

	VOC ppm*	Benzene ppm*
Pump/ Compressor	5000	2000
Valves/ Flanges	3000	1000
Other Components	3000	1000

\* Above figures are based on gazette notification-18<sup>th</sup> March'08 however LSTK Contractor have to follow the latest one. LSTK Contractor to follow the latest norm of CPCB/ OSPCB. State PCB or Central PCB norms whichever is more stringent shall be complied by LSTK Contractor.



## 6.0 UTILITIES:

Some of Utilities as specified in the ITB shall be supplied to LSTK CONTRACTOR by the OWNER. The characteristics of utilities are provided in Section 2.0 of Part II Technical.

## 6.1 Cooling Water shall be provided at a single point on the battery limit by Owner:

Treated Process Water/ Service water Characteristics (**Tentative**):

Attribute	Units	Range / Limits
pH		7 – 8.5
Chlorides	mg/l	20
Silica	mg/l	5
Iron	mg/l	0.2
Total suspended solids	mg/l	5
Total dissolved solids	mg/l	100

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Oil & grease	mg/l	Traces
Ammonia	mg/l	Traces
Alkalinity	mg/l as CaCO <sub>3</sub>	68
Calcium Hardness	mg/l as CaCO <sub>3</sub>	100
Total hardness	mg/l as CaCO <sub>3</sub>	150

## 6.2 De-Mineralised Water:

Characteristics:

Attribute	Units	Value
pH	-	6.5 – 7.5
Hardness	ppm wt	Zero
Total dissolved solids	ppm wt	0.1 max
Conductivity at 20 °C	micromho/cm	0.2 max
M alkalinity as CaCO <sub>3</sub>	ppm wt	Nil
Chlorides	ppm wt	Nil
Iron as Fe	ppm wt	0.01 max
Silica as SiO <sub>2</sub>	ppm wt	0.02 max
Oil	ppm wt	Nil
Sodium as Na	ppm wt	0.1 max

Note: \*- Surplus Steam may be exported to LSTK B.L., if it matches with the main steam header parameters as mention in Section 2.0 of Part-II Technical. **No steam credit shall be given to the LSTK Contractor.**

## 6.3 Drinking water:

Characteristics – Drinking Water Quality Limits:



S.No	Parameter	Units	Value
1	pH		7 – 8.5
2	Colour,		< 5.0
3	Smell		Agreeable
4	Taste & odour		Unobjectionable
5	Turbidity	NTU	< 1.0
6	Total Dissolved solid	mg/l	< 150
7	Total Hardness	mg/l	< 85
8	Chloride ( as Cl)	mg/l	< 15
9	Sulphate ( SO <sub>4</sub> )	mg/l	< 60
10	Total Iron(Fe)	mg/l	< 0.01
11	Dissolved Silica	mg/l	< 4

Drinking water of quality conforming to IS: 10500: 1991 during plant operation only shall be provided by the OWNER to LSTK CONTRACTOR. During construction till mechanical completion, LSTK contractor has to arrange his own construction and drinking water requirement.

## 6.4 Steam:

### 6.4.1 Surplus Steam export to the OWNER shall be accepted:



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The quantity and quality of export steam shall adhere to the following specifications:

Description	Units	Value
Quantity	Min / Nor / Max, Kg/Hr	LSTK Contractor to specify
Pressure	Min / Nor / Max, Kg/cm <sup>2</sup> g	LSTK Contractor to specify
Temperature	Min / Nor / Max, °C	LSTK Contractor to specify
Quality	Refer Clause no. - 3.1, 3.2, 3.3 Section-2.0 of Part-II Technical	

**6.4.2** Start-up Steam as specified in Clause no. - 3.1, 3.2, 3.3 of Section-2.0 of Part-II Technical shall be arranged by OWNER. Quantity, duration and frequency to be furnished by LSTK Contractor.

## **6.5 Pre-Treated Condensate:**

### **6.5.1** Pre-Treated Condensate export to the OWNER:

The quality of export Pre-Treated Condensate shall adhere to the following specifications:

Quality required	Units	Value
pH		8.5 - 9.5
Conductivity	µS/cm	0.2
Total Dissolved Solids(TDS)	ppm (max)	0.5
Silica (SiO <sub>2</sub> )	ppm (max)	0.02
Iron (Fe)	ppm (max)	0.02
Copper (Cu)	ppm (max)	0.003
Sulphate (SO <sub>4</sub> <sup>2-</sup> )	ppm (max)	0.02
Chloride (Cl <sup>-</sup> )	ppm (max)	0.1
Quantity	M <sup>3</sup> /Hr	(To be specified by LSTK CONTRACTOR)

## **6.6 Power Supply:-**

Refer Clause No. 1.5 of Design Philosophy-Electrical for power tapping terminal point for Normal Power & Emergency Power by LSTK Contractor.

Philosophy adopted by owner for use of power for electric drives and lighting shall be:

- Refer Clause No. 3.1 of Design Philosophy-Electrical

Rest information regarding fault level is already covered against Clause No. 3.2 of Design Philosophy-Electrical.

**NOTE: Design Philosophy (Electrical) to be followed if any discrepancy found with Design Basis.**



## **7.0 CLIMATIC DATA:**

Bidder to collect the below mentioned climatic data from concerned IMD office:

### **7.1** Wind

Wind Load Design: as defined in IS: 875 Part 3



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## 7.2 Air Temperature

### 7.2.1 Atmospheric Air Composition

## 7.3 Relative Humidity

## 7.4 Rainfall

## 7.5 Barometric Pressure

## 7.6 Seismic Design Code

The earthquake seismic zone shall be III. Refer Section-5.5 (Design Philosophy – Civil & Structural Works) Part II-Technical.

## 7.7 Plant Elevation

The final plant elevation shall be established in consultation with owner / consultant based on overall project requirement.

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## PART II: TECHNICAL



### SECTION – 4.1

#### BATTERY LIMIT INTERFACE

**PLANT: COAL GASIFICATION PLANT FOR GENERATING SYNTHETIC NATURAL GAS**

**PROJECT: SYNTHETIC NATURAL GAS PRODUCTION THROUGH COAL GASIFICATION ROUTE AT BARDAHMAN, WEST BENGAL (INDIA).**

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2.0	Battery Limit Conditions	3

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## 1.0 BATTERY LIMIT INTERFACE:

### 1.1 Interface Engineering:

LSTK Contractor shall carry out all interface engineering for complete compatibility with PDIL/ Coal Gas India Limited design with respect to location/ specification for all incoming and outgoing pipelines from Coal Gasification Plant.

### 1.2 Battery Limit Isolation:

LSTK Contractor shall provide double block and bleed arrangement with spectacle blind for all process and steam streams coming into and going out of the Coal Gasification Plant. For other utilities, LSTK Contractor shall provide isolation valves within their plant battery limit.

### 1.3 Metering System:

LSTK Contractor shall provide metering system for all incoming and outgoing process and utility streams as indicated in the instrument specification of the ITB.

## 2.0 BATTERY LIMIT CONDITIONS:

### 2.1 Feedstock supplied to **Coal Gasification Plant** shall be as follows:

Coal Analysis: - Refer, Annexure-I of Section- 4.0 Part-II Technical, for ECL coal (representative analysis considered to be confirmed by LSTK Contractor)

Fluxant: - (purity >95%).

### 2.2 Purified Syn. Gas :

Temperature and pressure condition of Purified Syn. Gas required at Coal Gasification plant battery limit shall be as follows:



Stream / Condition	Min	Normal	Max	Mech. Design
<b>Purified Syn. Gas</b>				
Header pressure, (kg/cm <sup>2</sup> g)		30	-	By LSTK
Supply temperature, (deg C)	-	-	45	As per Design guidelines 5.1

### 2.3 Carbon Di-oxide:

Excess Carbon Dioxide shall be vented at suitable height .

### 2.4 Utility Nitrogen Gas:

Temperature and pressure condition of Nitrogen at Coal Gasification plant battery limit shall be as follows:

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<b>LP Nitrogen</b>	
<b>Pressure, kg/cm<sup>2</sup>g (Min/Nor/Design)</b>	<b>6.0/8.0/9.0</b>
<b>Temperature</b>	<b>Ambient</b>
<b>N<sub>2</sub>, Vol %, min</b>	<b>99.99%</b>
<b>O<sub>2</sub>, Vol ppm</b>	<b>&lt; 10</b>
<b>HP Nitrogen</b>	
<b>Pressure, kg/cm<sup>2</sup>g (Min/Nor/Design)</b>	<b>--/82/--</b>
<b>Temperature</b>	<b>80</b>
<b>N<sub>2</sub>, Vol %, min</b>	<b>99.99%</b>
<b>O<sub>2</sub>, Vol ppm</b>	<b>&lt; 10</b>

## 2.5 Sulphur (Liquid):

Temperature and pressure condition of Sulphur required at LSTK-1 plant Battery limit shall be provided as follows:

Stream / Condition	Min	Normal	Max	Mech. Design
<b>Sulphur (Liquid)</b>				
Supply pressure, (kg/cm <sup>2</sup> abs)		5.5*	6.9*	8.4/FV*
Supply temperature, (deg C)		155*	165*	180*

Note: - \* - figures are indicative. However Licensor's specifications to be followed.

FV = Full Vacuum

## 2.6 Flare: LSTK Contractor shall have to consider flaring requirement and piping up to LSTK B/L of Coal Gasification Plant.



Condition		Mech. Design
Pressure (sour gas)	*	*
Pressure (sweet gas)	*	*

\* To be specified by LSTK Contractor

## 2.7 Cooling water shall be supplied by Owner for use in Coal Gasification Plant temperature and pressure condition of Nitrogen at Coal Gasification plant battery limit shall be as follows:

Condition	Min	Normal	Max	Mech. Design
Supply pressure, kg/cm <sup>2</sup> g	-	<b>4.5</b>	-	10
Return pressure, kg/cm <sup>2</sup> g	-	<b>3.0</b>	-	10
Supply temperature, °C	-	33	-	70
Return temperature, °C	-	43	-	70

\* To be specified by LSTK Contractor

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**Note:** LSTK Contractor shall limit pressure drop of 1.5 Kg/cm<sup>2</sup> (max) between supply and return CW header within its battery limit.

**2.8 De-Mineralised Water: make-up DM water shall be provided from balance of plants by OWNER to LSTK Contractor.**

Condition	Min	Normal	Max	Mech. Design
Supply pressure, kg/cm <sup>2</sup> g	4.0	5.5	6.0	10.0
Supply temperature, °C	-	Ambient		65

**2.9 Service Water: to be provided by the Owner to the LSTK Contractor**

Condition	Min	Normal	Max	Mech. Design
Supply pressure, (kg/cm <sup>2</sup> g)	4.0	6.0	8.0	10.5
Supply temperature (deg C)	Ambient	Ambient	Ambient	65

**2.10 Drinking water: to be provided by the Owner to the LSTK Contractor**

Condition	Min	Normal	Max	Mech. Design
Supply pressure, kg/cm <sup>2</sup> g		6.0	6.5	12.5
Supply temperature, (deg C)		Ambient	Ambient	65

**2.11 Instrument Air: to be provided by the Owner to the LSTK Contractor**



Condition	Min	Normal	Max	Mech. Design
Header pressure (kg/cm <sup>2</sup> g)	6.0	8.0	10.0	10.5
Supply temperature (deg C)	Ambient	Ambient	50	65

**2.12 Plant air: to be provided by the Owner to the LSTK Contractor**

Condition	Min	Normal	Max	Mech. Design
Header pressure (kg/cm <sup>2</sup> g)	4.0	7.0	8.0	10.5
Supply temperature (deg C)	40	40	50	65

**2.13 Steam:**

Steam Level	Pressure (kg/cm <sup>2</sup> g)				Temperature (deg C)			
	Normal	Max	Min	Design	Normal	Max	Min	Design
HP	107	110	105	130	515	520	510	545
MP	40	*	*	44	380 ± 5	*	*	425
LP	4.0	4.5	3.5	6.0	180	*	*	250
HP Saturated)	107	110	105	130	315	317	314	342

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\* To be specified by LSTK Contractor

#### 2.14 Electric Power: to be provided by the Owner to the LSTK Contractor

Power Supply	Voltage	Phase	Frequency
Normal Power (2 Nos.)	33000 V $\pm$ 10%	3	50 Hz $\pm$ 5%
Emergency Power (1 No.)	11000 V $\pm$ 10%	3	50 Hz $\pm$ 5%

#### 2.15 Treated Condensate export from Coal Gasification Plant BL (applicable for Gas purification unit):

Description	Pressure (kg/cm <sup>2</sup> g)				Temperature (deg C)			
	Min	Max	Normal	Design	Min	Max	Normal	Design
Treated Condensate			8	12			45	65

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#### 2.16 Liquid Effluent from Coal Gasification Plant BL applicable for Gas purification unit:

Description	Pressure (kg/cm <sup>2</sup> g)				Temperature (deg C)			
	Min	Max	Normal	Design	Min	Max	Normal	Design
Liquid Effluent			3	8			Amb.	65

Note: Coal Gasification Complex shall be designed based on Zero Liquid Discharge philosophy.

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## PART II: TECHNICAL

### SECTION – 5.1



#### DESIGN PHILOSOPHY - PROCESS

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**PROJECT: SYNTHETIC NATURAL GAS PRODUCTION THROUGH COAL GASIFICATION ROUTE AT BARDAHMAN, WEST BENGAL (INDIA).**

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## 1.0 GENERAL



The plants shall be designed to operate safely and satisfactorily at a capacity of 50% (turn down capacity) to 110 % (i.e. Design Capacity). Equipment and machinery shall be provided so that the plants can operate for at least two years without major overhaul or inspection. All design shall conform to the latest edition of the applicable sections of ASME, ASTM, IEEE, NFC, TEMA, AISI, NEMA, AISC, ACI, OSHA, UBE and other governing codes or standard practices. Any other equivalent and acceptable Code of Standard practice may be adopted with the approval of the Process Licensor. For Gasifier, Licensor's recommendations shall be followed. In addition, the following state/local Codes/laws shall supplement:

a)	Pressure Vessels/ Formed ends	ASME, Section VIII, DIV.I / Indian Standard IS 4049.
b)	Boilers	Indian Boiler Regulations Act
c)	Buildings & Structural	Relevant Indian Standard (BIS)
d)	Electricity	Indian Electricity Rules.
e)	Sanitary	Relevant Indian Standard (BIS)
f)	Safety	a) PESO b) NFPA
g)	Water Pollution	Relevant Indian Standard (BIS) / Central Pollution Control Board/ West Bengal State Pollution Control Board limits norms set by Ministry of Environment & Forest, MINAS

## 1.1 System of Measurements:

The system of measurement metric shall be as follows:

Parameter	Preferred Units	Alternative Units
Temperature	°C	
Pressure - absolute	kg/cm <sup>2</sup> abs	
Pressure - gauge	kg/cm <sup>2</sup> g	
Flow (liquid)	m <sup>3</sup> /hr	kg/hr
Flow (gas)	Nm <sup>3</sup> /hr	kg/hr
Flow (steam)	kg/hr	
Length, Level	mm	M
Time	hr	sec, min
Heat	kcal	Gcal

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Parameter	Preferred Units	Alternative Units
Power	kW	
Fouling resistance	m <sup>2</sup> hr °C / kcal	
Pipe size / diameter	Inches (in)	Mm
Mass	kg	
Liquid relative density	sp gr T°C/15.6°C	
Liquid density	kg/m <sup>3</sup>	
Vapor flowing density	kg/m <sup>3</sup>	
Furnace draft	mm of WC	
Storage tank pressure	mm of WC	
Vacuum	mm of Hg, mm WC	
Standard vapor	Nm <sup>3</sup> /hr at 0°C & 1.033 kg/cm <sup>2</sup> a	
Standard liquid	m <sup>3</sup> /hr at 15.6°C	
Thermal conductivity	kcal/hr-m-°C	
Heat Transfer coefficient	kcal/hr-m <sup>2</sup> -°C	
Enthalpy, Entropy	kcal/kg	
Heat rate	10 <sup>6</sup> kcal/hr or MM kcal/hr	Gcal
Viscosity	cP	
Kinematic Viscosity	cSt	
Sound Pressure	dB(A)	
Sound Power	dB(A)	

## 2.0 DESIGN PRESSURE

### 2.1 General Rule:

Design pressure of Process Static Equipment shall be based on the maximum Operating Pressure. Malfunction and Equipment failure shall be taken into consideration by safety devices. Design pressure shall be selected from the list below. Alternatively LSTK Contractor shall select the design pressures as recommended by the process licensor.

- For max operating pressure below 2 kg/cm<sup>2</sup> g use 3.5 kg/cm<sup>2</sup> g
- For max operating pressure between 2 kg/cm<sup>2</sup>g and 15 kg/cm<sup>2</sup>g use Max. Operating Pressure + 1.5 kg/cm<sup>2</sup>
- For Max. Operating Pressure between 15 kg/cm<sup>2</sup> g and 100 kg/cm<sup>2</sup> g use Max. Operating pressure x 110 %
- For Max. Operating Pressure equal and above 100 kg/cm<sup>2</sup> g use the Maximum Operating Pressure + 10 kg/cm<sup>2</sup> g. Alternatively LSTK Contractor shall select the maximum operating pressure as recommended by the process licensor.

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## 2.2 **Equipment under Vacuum:**

Equipment normally operated under vacuum is designed for full vacuum and for the highest pressure it can experience in case of vacuum failure. Equipment containing a fluid with a vapour pressure at ambient temperature lower than atmospheric pressure which can be isolated shall be equipped with vacuum breaking device or else be designed for full vacuum. Equipment subject to vacuum due to mal-operation or failure shall be equipped with vacuum breaking devices or else be designed for full vacuum.

## 2.3 **Complete Systems:**

Several pieces of Equipment protected by the same relief valve shall have a design pressure of at least the set pressure of the relief valve.

## 2.4 **Equipment on the Discharge of a Pump:**

Equipment which may have to bear the shut-off pressure of a pump shall have a design pressure equal to or higher than the shut-off pressure. Pump shut-off pressure shall be estimated according to Clause 7.0.

## 2.5 **Reactor Loops and Similar Process Systems:**

For reactor loops and similar process systems the recommendations of API RP 521 Appendix F (latest edition) and API RP 520 Appendix B (latest edition) will be followed.



## 2.6 **Thin walled Tanks and Vessels:**

Atmospheric thin walled tanks and vessels shall have a design pressure equal to the highest pressure imposed upon discharge of the pressure relief device. The design pressure for vacuum shall be equal to the lowest pressure imposed upon suction of the vacuum relief device.

## 3.0 **DESIGN TEMPERATURE**

Design temperature for process equipment shall be whichever is higher:

- Maximum operating temperature + 15 °C
- Boiling temperature at design pressure of process medium inside, if applicable.
- Design temperature shall be rounded up to full 5°C steps.

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- d) Design minimum temperature shall be specified only if the minimum operating temperature is below 0 °C. Design minimum temperature shall be 5 °C less than the minimum operating temperature. Special attention shall be given to low boiling liquids.
- e) For piping, design temperature shall be determined according to ASME B 31.3.

Alternatively LSTK Contractor shall select the design temperature as recommended by the process licensor.

#### 4.0 CORROSION ALLOWANCE

Materials of construction and corrosion allowance for all Equipment and machinery shall be for a design life of 25 years (except for heat exchanger tubes). However, minimum corrosion allowance for carbon steel (including 0.5 Mo alloy steels) shall be:



Pressure Vessels and other applicable Equipment	3 mm
Storage Tanks	1.5 mm
Piping	1.5 mm
Removable parts or internals (on each side in Contact with operating fluid)	0.75 mm
For stainless steel/titanium	0 mm
Carbon steel with epoxy resin coating	3 mm

#### 5.0 HYDRAULIC RETENTION TIME

Hydraulic retention time (Hold-up Requirements) is defined between low level (LL) and high level (LH).

Type of Service	Retention Time
Feed Surge drum	30 minutes (*)
Reflux only	5 minutes (*)
Column Feed on flow control	15 minutes (*)
On cascade level/flow control	8 minutes (*)
Re boiling by Fired Heater	8 minutes (*) on feed to heater
Re boiling by Thermo siphon	10 to 30 seconds on circulation
PRODUCTS to storage	
Without Pump	5 minutes (*)
With Pump	7 minutes (*)
Feeds and Products feeding another Unit	
On flow control	15 minutes (*)
On cascade/level flow control	8 minutes (*)
Tanks capacities	LSTK Contractor to confirm
Steam drum (LHH – empty) Min	10 minutes
Deareator Min	30 minutes (*)

In the case of pumps ensuring several services such as reflux and liquid distillate to storage, the

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residence time of the corresponding vessel will be whichever is greater from the above list.

(\*) To be advised by LSTK Contractor.

## 6.0 HEAT EXCHANGERS

In general heat exchangers shall be designed to 110 % of their operating duty/flow.

Columns overhead coolers shall be designed to 120 % of their operating duty/flow.

Large heat exchangers shall be split into two or more shells for easy operation and maintenance. As far as possible AES type of exchangers shall not be used.

## 7.0 PUMPS

Normally pumps shall be designed to 110 % (else as defined in individual sections) of their maximum required flow rate in worst case of operation. Pumps for fractionation column reflux, pump round and re-boiler, flow rates shall be designed to 120% of their maximum required flow rates.



The shut-off pressure shall be estimated according to the following criteria whichever is higher:

- Differential head at rated flow x 120 % + LH (level high) suction static head + max operating pressure suction side.
- Differential head of pump at rated flow + LHH (level high high) suction static head + design pressure suction side x 120 %. No over design shall be applied to the rated pressure.

BFW pumps shall be designed for 120% of their maximum required flow rate in worst case of operation. Pump drives shall be preferably electric motor driven, wherever is applicable and Steam Turbines shall be preferably of Back-Pressure type.

## 8.0 COMPRESSORS

In general, compressors shall be designed to a minimum of 110 % (else as defined in the individual sections) of their maximum required flow. However, they are subject to special considerations according to the process. All vent valves and anti-surge valve shall be of leakage Class-V.

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## 9.0 PRESSURE RELIEF VALVES

Pressure relief valves shall be supplied with locked open isolating valves. Pressure relief valves for operational failure shall have installed spares. Also PRV on fire case with Hydrocarbon service shall have installed spare. LSTK Contractor shall take care of any additional requirement as per guidelines of the process licensor. The set pressure of pressure relief valves shall be equal to the design pressure of the equipment. All safety valves will have bypass with exception of safety valves which are only for fire cases and if there is more than one safety valve. All pressure relief blows out lines of process gas and syn. gas should be connected to the flare.

## 10.0 COLUMNS AND VESSELS

### 10.1 Nozzle:

- Minimum size 3/4" (for S.S shall be 1 inch).
- Nozzle rating according to one of connected piping.

### 10.2 Manhole:

- Manhole size 24" (\*)
- Manhole installation for Tray Tower

For tray towers, manholes shall be provided at top, bottom, feed point and draw-off point of tower and after each 20 trays or after every 15 m elevation distance, whichever is lesser as minimum.

(\*) In case there is restriction for diameter, minimum 20" may be used.



### 10.3 Hand hole or Inspection hole:

- Preferable Size 8 inches
- Minimum Size 6 inches

### 10.4 Vent and Drain:

Vent and drain for vessels will normally be provided at the minimum length on overhead or bottom line in accordance with the following table:

Volume or diameter of vessel (m <sup>3</sup> or	Vent diameter	Drain diameter
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mm)	(inches)	(inches)
V < 75	2	2
75 < V <= 220	3	3
220 < V <= 420	4	4
V > 420	6	4

Note: Vent and drain connections are not necessarily located on vessels.

All Columns shall have high efficiency demister for removal of moisture and entrainment.

#### 10.5 **Steam Out:**

Steam out nozzles shall be sized as follows:

Type of Application	Nozzle Size (inches)
Drums and heat exchangers (when applicable)	2
Column diameter (m), D	
a) D <= 4	2
b) 4 < D <= 5.5	3
c) D > 5.5	4

#### 10.6 **Storage (Chemical/Catalyst/Additives):**

LSTK Contractor shall consider all facilities necessary for safe loading, unloading, storage, transportation of chemical/ catalyst/ additives within the plant Battery limit during Construction stage.



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## PART-II: TECHNICAL



### SECTION – 5.2

#### DESIGN PHILOSOPHY - INSTRUMENTATION

**PLANT: COAL GASIFICATION PLANT FOR  
GENERATING SYN GAS (CO+H<sub>2</sub>) FOR  
PRODUCTION OF SYNTHETIC NATURAL  
GAS (SNG)**



**PROJECT: COAL BASED SYNTHETIC NATURAL GAS  
(SNG) PROJECT AT BARDHAMAN, WEST  
BENGAL, INDIA**

1	24.09.25	24.09.25	Issued for Tender	KM	KM	RKR
0	06.06.25	06.06.25	Issued for Tender	KM	KM	RKR
P	07.02.25	07.02.25	Issued for Review	KM	KM	RKR
`	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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1.	Instrumentation And Controls
2.	Scope
3.	Control Philosophy (General)
4.	Basis Of Design
5.	Instrumentation Code And Practices
6.	Hazardous Area Classification & Electrical Execution
7.	Electrical Supply
8.	Field Instruments
9.	Primary Differential Producers
10.	Other Flow Meters
11.	Level Instruments
12.	Level Gauge Glass
13.	Pressure Instruments
14.	Temperature Instruments
15.	Control Valves
16.	PRESSURE REDUCING AND DESUPERHEATER STATION
17.	Pressure Relieving Devices
18.	Solenoid Valves
19.	Control And Shutdown System
20.	Emergency Shutdown System (ESD)
21.	Control Room
22.	Package Unit Instruments
23.	Noise Immunity Of Electronic Instruments
24.	Local Control Panels
25.	Installation
26.	Fire And Gas Detection System
27.	Operator Training Simulator
28.	Factory Acceptance Test (FAT)
29.	Site Acceptance Test (SAT)
30.	CCTV
31.	Telephone Exchange
32.	Local Area Network (LAN) for CR
33.	Compressor Control System
34.	Instrument Workshop



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### LIST OF ATTACHMENTS

ANNEXURE NUMBER	DESCRIPTION	NUMBER OF SHEETS
1	Instrument Accuracies	
2	Instrument Process Connections	
3	System Configuration	

### General Specifications

GSTD-0001 GENERAL SPECIFICATION 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-0120 GENERAL SPECIFICATION MOTORISED ACTUATOR  
 GSTD-0201 GENERAL SPECIFICATION FOR DCS & PLC SYSTEM  
 GSTD-0202 GENERAL SPECIFICATION FOR PLC SYSTEM  
 GSTD-9998 INSPECTION AND TEST REQUIREMENTS

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## 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.
- b) SAFETY PLC (TMR or Better) based Emergency Shutdown System.
- c) All Field Instruments including control valves and safety valves.
- d) Compressor Controls System (CCS)

CCS will continuously monitor and control centrifugal compressors through performance control (including energy efficiency), remote adjustment of speed set point and anti-surge protection. Moreover a CCS may be interfaced with a Machine Monitoring Systems (MMS) for machinery protective functions and with a Safety Instrumented System (SIS) for all safety and shutdown actions.

- e) Analyser Systems inside Analyser shelter (SS). Analyzer shelter shall be provided and analyzers shall be kept in Analyzer shelter Ex proof.
- f) CCTV system as per attached specification in tender.
- g) Operator training simulator (OTS) system (with all the hardware, software, monitors and other accessories) shall be totally independent and separate from the plant DCS/ESD system.
- h) Fire and Gas System.
- i) Suitable Clean Agent System as per NFPA 2001 shall be provided for Control Rooms.
- j) Gas Detectors
- k) EPABX system including handsets.
- l) LOCAL AREA NETWORK (LAN) for Main Control Room
- m) For Feed stock (ROM Coal, Flaxant), Lime Handling) Conveyor system: Local PLC along with UPS, Air conditioner, etc. to be housed in a local control room.

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Selected Instrument shall be latest & proven model with minimum one year proven track record (PTR) in an hydrocarbon industry like Fertilizer, Refinery, Petrochemical and Gas Processing Plant, Power Industry under similar process conditions for at least 8000 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, Power Industry for at least 8000 hrs (as collaborated by user certificate).



PTR for field instruments shall be considered min for 8000 hours and PTR for System oriented items like , 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

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 CONSULTANT.
- 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 ISA5.2 with functional descriptions, Configuration diagram, Control room layout, Electrical load list, Cable schedule, Cable tray/trench layout, Instrument air requirement, Nameplate schedule, JB schedule, Instrument location layout, Electrical instrument signal interface, Instrument

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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 CONSULTANT.

- 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. 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, compressors, service boilers, etc.



In case of contradiction/conflict among documents, Bidder shall refer to Consultant for clarification. However, most stringent specification shall be followed with Consultant's approval. Consultant 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

At Vendor Premises:

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Training Services for Owner personnel for all items (DCS, ESD,ITCC,FGS, PLC, sub system, MMS,Mass spectrometer/Gas chromatograph ,any other system package):

for operator - 20 days (4 members) minimum

At Site:

Training Services for Owner personnel for all items (DCS, ESD,ITCC,FGS, PLC, sub system, MMS, any other system package):

- 1) Operation: for operator - 10 days (5 members) minimum
- 2) Start-up: for operator - 10 days (5 members) minimum

## 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.

At Vendor Premises:

Training Services for Owner personnel for all items (DCS, ESD,ITCC,FGS, PLC, sub system, MMS Mass spectrometer/Gas chromatograph,any other system package):

for Engineer - 20 days (4 members) minimum



At Site:

Training Services for Owner personnel for all items (DCS, ESD,ITCC,FGS, PLC, sub system, MMS, any other system package):

- 1) Operation: for Engineer - 10 days (5 members) minimum
- 2) Start-up: for Engineer - 10 days (5 members) minimum

## 3.0 CONTROL PHILOSOPHY (GENERAL)

- 3.1 Design and installation of instrumentation shall comply with codes and recommendations listed in item 5.0.

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3.2 The Instrumentation shall be designed to provide stable and accurate plant control ensuring safe plant operation and to facilitate plant maintenance, Control and Monitoring. The operating interface to the process shall display units, presenting overview, group and point displays as well as process graphics with live data. The operator will manipulate all facilities through dedicated operator's keyboard.

All elements of the Control function (DCS) and Interlock function (ESD) are to be completely separate and segregated. All Control and monitoring functions are to be implemented in DCS and all Interlock and trips, safety, shutdown or plant trip logic functions are to be implemented in ESD.

The emergency shutdown system shall be implemented in either dedicated SIL-3 PLC and the regulatory control / monitoring in the controller sub-system of DCS including non-critical interlocks like for Drives, small pumps etc.

3.3 Symbols of DCS, ESD system shall be totally separate.

3.4 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.



3.5 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 a dedicated Digital output via interface relay shall be wired to ESD as a Digital Input for override purpose. 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 licensors' 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 soft type. One hardkey shall be provided in Auxiliary console for the Activation of the MOS. Process override switches (POS) shall be soft type as well as Handkey.



3.6 All system/marshalling cabinets for DCS/ ESD/ PLC/ MMS/ ITCC/ Compressor Controls System/Speed/Antisurge and their PCs shall be housed in Control Room only.

3.7 Appropriate furniture including chairs, tables etc (Owners choice) of reputed make as per specifications for Control Room and other places shall be provided by the bidder. Chairs shall be high back with revolving type.





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- 3.8 ESD shall be SIL-3 certified as per standard IEC 61508. All sensors / software switches for 2 out of 3 voting system shall be triplicate for critical trips. If necessary, Annunciator window for trip groups shall be provided for monitoring. Field switches shall be avoided to the extent possible. All trips shall be manipulated via software switches with inputs field transmitters for trip purposes and utilities packages.
- 3.9 Centralised Air Conditioning shall be provided for control room building.
- 3.10 MMS probes and proximeters alongwith Condition monitoring system for all plants shall be used for machine monitoring of compressors, with LED/TFT 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 with 2oo2 trip facility. All monitors shall be located in Control Room. All vibration, axial displacement and speed signals are connected with DCS through hardwired.
- 3.11 There shall be Machine Monitoring system enterprise license with minimum 2 user/client license. MMS shall be required for machines with capacity greater than 1 MW and for all critical pumps/compressors/turbines/ID-FD fans which directly or indirectly related to trip/shutdown of plant.
- 3.12 The alarm and shut-down system shall be fail safe type and utilising field contacts that open in alarm conditions.
- 3.13 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.
- 3.14 Fire and Gas (FGS) PLC: TMR or Better PLC for FGS of the same type as the ESD system as per ITB.
- 3.15 For Compressors provision of SOE with 1 msec shall be there.
- 3.16 MMS/VMS: Two X-Y probes at each radial bearing and three axial displacement probes at each thrust bearing along with Condition Monitoring software and hardware shall be required along with RTD, temperature element at Radial and thrust bearing

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with temperature monitors with tripping facility. Proximeter to be provided on General bearing or oil filled bearing and Accelerometer to be provided on Ball bearing

- 3.17 Anti Surge Controller and Speed Governing System as per attached specification.
- 3.18 HVAC in CR: Two separate DUCTS for console room and Cabinet Room should be there with flow regulators to maintain different temperatures.
- 3.19 DIs/DOs from MCC to DCS/ESD shall be with relays only also IRC/IRP shall be Separate for DI's & DO's and AI's / AO's. IRP/IRC shall be placed in MCC only
- 3.20 Alarm and Annunciation System:  
  
Annunciation system is used to indicate and sound alarm for any process abnormality, trip/status change.  
  
An Annunciator window on aux console 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 switches to be included in operator action log.
- 3.21 If applicable, Speed Monitoring is required also for ID, FD Fan, Cooling Water Pumps, etc. Their RPM indication and trip philosophy is required from control room.
- 3.22 There shall be panel segregation for various I/Os meant for DCS and ESD system. Also there shall be panel segregation for diff. type of I/Os for DCS, ESD and other control system.
- 3.23 All Servers shall have Raid-5 architecture as a minimum and Operator Station with a minimum Raid-1 architecture.
- 3.24 Bidder shall provide one documentation node. Vendor shall be responsible to supply completely engineered documentation node including necessary hardware of proper size and the software necessary to meet the requirements of the node..
- 3.25 Bidder shall provide AIMS meeting the specification and PTR requirement.
- 3.26 IAMS (Assest management) System shall be considered and provided by contractor for all (SMART) 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. Standalone HART is to be considered if HART protocol is not available in I/O cards of DCS / PLC / ESD platform.
- 3.27 The minimum instrument accuracy shall be as defined in Annexure-1.

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3.28 The MMS vendor/LSTK shall submit clause wise compliance of API 670 latest edition.

3.29 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.

3.30 **Interfacing with DCS and Other systems at Control Room (CR)**

All DCS, Control Systems, ESD/PLC system, All Analyser PLC/ Microprocessor based system, Any Analyser system like Mass Spectrometer, CCTV, Fire and Gas System PLC, Any Package PLC shall be connected to Main DCS and Other systems at Control Room 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 with all the necessary hardware and software support.

Suitable graphics pages shall be built in main DCS for viewing these data. Suitable hardware and software required for interface of these with main control system shall be provided by the LSTK bidder.

3.31 **Interfacing with Central Control Room (CCR)**

Suitable Hardware, software & support (erection, commissioning) required for the interface of the Coal Gasification Plant Control system; with 2 nos. Operator Stations placed in different Control Room within the plant complex though redundant fiber optic cable communication, shall be in the scope of the Bidder.

**4.0 BASIS OF DESIGN**

**General**



Instrumentation for the proposed Coal Gasification 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:

Instrument Design Philosophy Section 5.2

General Standard specification attached

Licensors's recommendation

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#### 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 the 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 like control valves/On-off Valves being used for Control functions (DCS) and Interlock functions (ESD) shall 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. Speed Monitoring is required wherever VFD is used. Their RPM indication and trip philosophy is required from control room.
6. For Molten Sulphur transfer, Coriolis type mass flowmeter with +/-0.1% accuracy shall be provided.
7. For by product Ash/slag, (solid) flow measurement shall be provided, if applicable.
8. For by product Sulphur, (solid) flow measurement shall be provided
9. All limit switches shall be proximity sensor type.
10. Cable entry to control room, analyser shelter, substations shall be through MCT blocks.
11. Entry into the Marshalling Panels in the control room shall be through bottom mounted MCT blocks/Gland Plates.

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12. Bidder shall provide MCT frame of SS316 material (along with 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.
13. No head mounted temperature transmitters are to be used.
14. General Earthing & Instrument Earthing shall be provided separately..
15. No Direct Process Switches (Pressure/Level/ Flow/Temp.) shall be used. However, if it's not possible to install transmitter for particular application online pressure/level switches (float type) may be used if the need arise. This shall be discussed during detail engineering on case to case basis.
16. 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.
17. All field transmitters for pressure, d/p, level and flow shall be microprocessor based (dual compartment) 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.
18. "HART" management / maintenance System (HMS) is required.  
  
Hart maintenance/management system (HMS) shall be used for remote calibration, configuration viewing/modifications, diagnostics & performance monitoring of HART/ field instruments. At least one HMS system shall be supplied.
19. Bidder's to recommend 2 years Operational Spares and submit Itemised List with validity of 2 Years.
20. Redundant Bulk Power supply with diode arrangements shall be provided for field instruments.
21. 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.
22. Local / Remote Selection Switch

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- 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 START / STOP from DCS
  - d. In LOCAL mode, both START and STOP shall be possible only from LOCAL.
  - e. Auto / Manual selection shall be in DCS / Local.
23. Trip solenoid valves 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.
  24. 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.
  25. 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. Passive alarms shall warn about the burn-out.
  26. Each hand held communicator o (HHT) loaded with latest HART software shall be provided with minimum of 1 GB removable, plug in type memory bank, which can store a minimum of 1000 transmitters configuration data.
  27. Hydrastep type level instruments shall be provided for level measurement in high pressure boiler drums.
  28. Control room Floor level shall be 1.5 meter from the Finished floor Level.
  29. All Analysers, GCs, Mass-Spectrometer shall be Ex-proof irrespective of area of installation.
  30. 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 irrespective of licensor's data sheet.
  31. All control valves / On-Off Valves / MOVs shall be flanged type.



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32. Control valve/On-Off valve, pneumatic valve shall be designed for minimum 4 Kg/cm<sup>2</sup> air pressure.
33. All Safety Valves / Thermal relief valves shall be flanged type only.
34. Thermocouples shall be duplex type.
35. Thermowell flange rating shall be 1 1/2" SS316 minimum.
36. Temperature transmitter shall be used for both open loops & Closed loops.
37. Guided wave radar type instruments (SMART) shall normally be used for level measurement,. Differential pressure transmitter (Capillary type) shall be used 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 not be used. Remote Seal PT/DPT shall be with minimum 5 mtrs Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball type Isolation Valve. For Vessel/Equipment requiring more than 5 m capillary electronic remote seal (ERS) shall be provided.
38. Air distribution pots shall be of Stainless Steel. Inst. Impulse pipes for process parameters shall be in accordance with piping specifications.
39. Main instrument air header and Branch header material : SS304
40. Main instrument air header shall be at least 2" (SS) minimum depending on requirement. It shall have 1" minimum takeoff (SS) with ball type isolation valve (SS304) & further distribution for each instrument through separate 1/2" SS line with 1/2" SS Ball valve single piece design with SS handle & with 6 mm OD SS316 tubing.
41. All the instruments shall be SIL certified.
  - 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
42. Hart Compatible gas-detectors to be provided.



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43. Separate Tapping shall be used for each instrument coming for trip, control & monitoring, local display.
44. 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.
45. For double acting valve, air accumulator shall be used for achieving fail safe operation.
46. FRP Canopies, 2" Pipe mountable, are required for Transmitter, JBs, LCPs, Control Valve positioner, Temp Elements, Proximity level switch, remote mounted electronics, Mass flowmeter, Ultrasonic flowmeter
47. Temperature, Pressure & Flow instruments provided in buried vessel shall be located above ground level. IP 67 shall be provided if instruments are under water.
48. System / Marshalling/ CCTV / Packages cabinet size shall be 2100 (H) X 1200 / 800 (W) X 800 (D).
49. All field transmitters shall be dual Compartment Type.
50. For Monitoring & Control, separate nozzles/ takeoff shall be taken for all loops.. No More than 3 set of taps are allowed.
51. 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 design temperature) remote feedback shall be used for the smart positioner.
52. Valve signature software is required for all Control Valves.
53. For all Local panels rain cover to be provided.
54. For Analysers separate feeders to be directly taken from PDB. No sub-branching allowed at any place.
55. In general separate junction boxes shall be used for the following:
  - a) 4-20 mA DC signals (IS)
  - b) 4-20 mA DC signals (non-IS)
  - c) Power supply to various instruments.
  - d) Gas Detectors



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- e) Vibration signals
  - f) Telephone System
56. Separate junction boxes shall be used for signals connected to PLC/ESD and to DCS. No signal shall be shared between them in the field junction boxes.
  57. Only metal tube Rotameter with transmitter shall be considered. Glass tube Rotameter shall not be used.
  58. All Instrument Hookups shall be approved by owner/PMC..
  59. Partial stroke testing shall be provided for shutdown valves. For shutdown valves, Proximity type switches shall be provided for open & close status in addition to Smart positioner.  
  
Valve Vendor shall supply the complete testing assembly duly tubed/piped/wired on a SS mounting plate thickness 3.2 mm suitable for 2" pipe stanchion mounting. Standard pre designed rigidly mounted components shall also be acceptable for PST assembly.
  60. 2003 Trip Loop in ESD shutdown loop as a complete system shall be SIL3 compliant.
  61. BPS for 24V DC shall be provided for each process controllers separately as per segregation philosophy having redundant bus bar
  62. For safety of conveyors and personnel, all conveyors shall be provided with safety switches like zero speed switch, belt sway switch and pull cord. In addition to these there shall be provision of audible warning (Hooter) of starting of conveyor. Pull cord switches, Bay Sway Switches, Zero Speed Switches & vertical ground take-up switch shall be considered as safety control of the conveyor system and shall be interface with local PLC.
  63. Mushroom type Emergency PB station with hooters shall be mounted along with conveyor belt (every 20-25 meter of distance) and at strategic location for any emergency situation like all TT towers, filling area, stitching area, wagon loading area, truck loading area etc
  64. Valves specified for "Oxygen Service" shall be cleaned, labeled and packaged in accordance with CGA G-4.1 or equivalent. All metals in contact with oxygen in the main flow stream should be of appropriate materials suitable for the given oxygen service. Non-metals materials shall be avoided for use in valve seats or other parts exposed to the flow stream.

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65. The radioactive type level instruments shall be applied for pulverized coal and flyash vessel in gasification plant. All Statutory approvals required for these instruments shall be in LSTK contractor scope.
66. Special coal feed control valves ,diverter valves for coal feed systems and Rotating-disc valves for gasification Lock hopper systems shall be as per licensors recommendation in consultation and approval from Consultant
67. Satellite Rack Room can be considered for some units depending on distance from coal storage and handling.
68. Pressure and Differential pressure transmitters (including seal type) 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, Accuracy as per Annexure-1, Rangeability 1:100(for normal transmitters),1:40(for DPT) , Local Display configurable, SS MOC, Double Compression SS cable glands, EExib IIC/T6, IP67, Wetted MOC SS316L, SS316 MOC Manifold, Housing die cast Aluminium with corrosion resistant paint, Universal Hart Protocol with Latest Revision is required.

## 5.0 INSTRUMENTATION CODE AND PRACTICES



S.No.	Description	Standards / Codes	
1	AGA-American Gas Association		
1.1	Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids- Part 1: General Equations and Uncertainty Guidelines	AGA Report No-3	Part-1
1.2	AGA Report No. 7, Measurement of Natural Gas by Turbine Meter	AGA Report No-7	
1.3	AGA Report No-9, Measurement of Gas by Multipath Ultrasonic Meters	AGA Report No-9	
2	ASME- American Society of Mechanical Engineers		
2.1	Pipe Threads General Purpose (Inch)	B 1.20.1	
2.2	Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/ Inch Standard	B 16.5	
2.3	Metallic Gaskets for pipe Flanges- Ring Joint, Spiral- wound and Jacketed	B 16.20	
2.4	Valves-Flanged, Threaded and Welding End	ASME B 16.34	
2.5	ASME Boiler and Pressure Vessel Code (BPVC), Section VIII, Division 1: Rules for Construction of Pressure Vessels	ASME BPVC-VIII-1	

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2.6	Boiler and Pressure Vessel Code (BPVC), Section I: Rules for Construction of Power Boilers	ASME BPVC-I
2.7	Thermowells Performance Test Codes	PTC 19.3 TW :2016
2.8	Orifice Flanges	ASME B.16.36
3	ANSI/FCI-American National Standards Institute/Fluid Control Institute	
3.1	Control Valve Seat Leakage	FCI 70-2
4	API-American Petroleum Institute	
	Manual on Installation of refinery Instruments Part I and Control System	API-RP-550
4.1	Part-I Sizing and Selection	API STD 520
	Part-II Installation	API RP 520
4.2	Guide for Pressure Relieving and Depressurising Systems- Petroleum Petrochemical and natural gas industries-Pressure relieving and Depressurising Systems	API STD 521
4.3	Flanged Steel Pressure Relief Valves	API STD 526
4.4	Seat Tightness of Pressure Relief Valves	API STD 527
4.5	Manual of Petroleum Measurement Standards	API MPMS
	Vocabulary	API MPMS 1-Vocabulary
	Proving Systems	API MPMS 4 Chapter-4
	Metering	API MPMS 5 Chapter-5
4.6	Process Measurement Instrumentation- Part I - Process Control and Instrumentation	API RP 551
4.7	Transmission Systems	API RP 552
4.8	Venting Atmosphere and Low Pressure Storage Tanks	API 2000
4.9	Fire test for quarter turn valves and valves equipped with Non-metallic seats	API 607
4.10	Metal Ball Valves — Flanged, Threaded and welding ends	API 608
4.11	Valve Inspection & tests	API 598
4.12	Specifications for Fire Test of valves	AP 6FA
5	BS-British Standards	
5.1	Multi-Element Metallic Cables Used in Analogue and Digital Communication and Control- Part 7: Sectional Specification for Instrumentation and Control Cables	BS EN 50288-7
6	EN-European Standards	



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6.1	Metallic materials- Types of inspection documents	BS EN 10204:2004
6.2	Dial Thermometer	EN-13190
6.3	Conductor of Insulated Cables	EN 60228
7	IEC-International Electrotechnical Commission	
7.1	Explosive Atmosphere-Part 0: Equipment- General Requirements	IEC 60079-0
7.2	Intrinsic safety code and practice	IEC 79.11/
7.3	International Boiler Regulation	IEC-79.14
7.4	Electrical Insulation - Thermal Evaluation and Designation	IEC 60085
7.5	Tests on Electric and Optical Fiber Cables under Fire Conditions - Part 1-1: Test for Vertical Flame Propagation for a Single Insulated Wire or Cable-Apparatus	IEC 60332-1-1
7.6	Degree of protection provided by enclosures.(IP code)	IEC 60529
7.7	Industrial Process Control Valves - Part 2-1: Flow Capacity - Sizing Equations for Fluid Flow Under Installed Conditions	IEC 60534-2-1
7.8	Industrial Process Control Valves- Part 2: Flow Capacity - Section Three - Test Procedures	IEC 60534-2-3
7.9	Industrial Process Control Valves - Part 2-4: Flow Capacity - Inherent Flow Characteristics and Rangeability	IEC 60534-2-4
7.10	Industrial Process Control Valves - Part 2-5: Flow Capacity - Sizing Equations for Fluid Flow Through Multistage Control Valve with Interstage Recovery	IEC 60534-2-5
7.11	Thermocouple Tolerances	IEC 60584-2
7.12	Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors	IEC 60751
7.13	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques Set (Contains 30 sections)	IEC 61000-4
7.14	Functional Safety of Electrical/ Electronic/ Programmable Electronic Safety related system	IEC-61508
7.11	Testing of Fire Resistant Cables	IEC 60331
7.12	Functional Safety-Safety Instrumented Systems For The Process Industry Sector	IEC 61511



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7.13	Security for Industrial Automation and Control Systems	IEC 62443
7.14	Electric and optical fibre cables-test methods for non-metallic materials-Part 201: General tests-Measurement of insulation thickness	IEC 60811-201
7.15	Electrical Installation of Cables	IEC 60092
7.16	Test on Gases Evolved during Combustion of materials from Cables- Part-1,2	IEC 60754
8	IS-Indian Standard	
8.1	PVC insulated (heavy duty) electric cables working Part I -voltage up to and including 1100V	IS-1554
8.2	Specification of Thermal Evaluation and Classification of Electrical Insulation	IS-1271
8.3	Specification for pressure and vacuum gauges	IS-3624
8.4	PVC insulation and sheath of electric cables.	IS-5831
8.5	Specifications for Thermocouples	IS-7358
8.6	Thermocouple compensating cables.	IS-8784
8.7	Mild Steel wires, formed wires and tapes for armouring of cables	IS 3975
8.8	Elastomeric insulation and sheath of electric cables	IS 6380
8.9	Cross-Linked Polyethylene insulated PVC sheathed cables	IS 7098
8.10	Method of test for cables	IS 10810
9	ISA-International Society of Automation.	
9.1	Binary logic diagrams for process operations	ISA 5.2 (1976) (R1992)
9.2	ISA 7.0.01 Quality Standard for Instrument Air	ISA 7.0.01
9.3	Standards related to control valves	ISA-75.xx
9.4	Instrumentation Symbols & Identification	ISA 5.1
9.5	Instrumentation Loop Diagrams	ISA 5.4
9.6	Annunciator Sequence & Specifications	ISA S18.1
9.7	Environmental conditions for Process measurement & control systems - Temperature &	ISA-S71.01



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	Humidity	
9.8	Environmental conditions for Process measurement & control systems - Airborne Contaminants	ISA-S71.04
9.9	Hardware Testing of Digital Process Computers (Codes of Practice for Testing Computer Based Systems)	ISA-RP-55.1
9.10	Binary Logic Diagrams for Process Operation	ISA S-5.2
9.11	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic and Computer Symbols	ISA S-5 3
9.12	Environmental conditions	ANSI/ ISA S71.04
9.13	Control Valve Equations	ANSI/ ISA S75.01
9.14	Control Valve Procedure Capacity Test	ANSI/ ISA S75.02
9.15	Face-to-Face Dimensions for Flanged Globe Style Control Valve Bodies	ANSI/ ISA S75.03
9.16	Control Valve sizing	ISA-S 75.01
9.17	Instrumentation specification formats	ISA-S20
10	ISO - International Organisation for Standardization	
10.1	Measurement of Fluid Flow by Means of Pressure Differential Devices- Part 1: Orifice Plates, Nozzles and Venturi Tubes Inserted in Circular Cross-Section Conduits Running Full	ISO 5167-1
10.2	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 2: Orifice Plates	ISO 5167-2
10.3	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 3: Nozzles and Venturi Nozzles	ISO 5167-3
10.4	Measurement of Fluid Flow in Circular Cross-Section Conduits Running Full Using Pressure Differential Devices - Part 4: Venturitube	ISO 5167-4
10.5	Testing of valves-Fire type-testing requirements	ISO 10497
10.6	Industrial Valves-Measurement, test, and qualification procedure for fugitive emission	ISO 15848
11	Enclosures for Industrial control and systems.	ICS-6

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12	NFPA-National Fire Protection Association	
12.1	Purged and pressurized enclosures for electrical equipment.	NFPA-496
12.2	Ed. Firing system	NFPA 852007
12.3	Classification of hazardous area	NFPA 70-1984 Art 500 Vol.6
13	Standard Material Requirements - Sulfide Stress Cracking- resistant Metallic Materials for Oil field Equipment	NACE MR0175 (95)
14	Oil Industry Safety Directorate	OISD
15	Occupational Safety and Health Authority	OSHA
16	Oxygen Pipeline and Piping Systems	EIGA 13/20
16.1	Design, Manufacture, Installation, Operation, and Maintenance of Valves Used in Liquid Oxygen and Cold Gaseous Oxygen Systems	EIGA 200/17
16.2	Cleaning Equipment for Oxygen Service	CGA G-4.1

## 6.0 HAZARDOUS AREA CLASSIFICATION & ELECTRICAL EXECUTION

6.1 Irrespective of area classification, the execution of instrumentation shall be as per area Zone 2, group IIC, T6, EExia and Protection:

Electrical / Electronic instruments IP 67

Sensors; RTD, T/C, etc. IP 67

Local Gauges; PG, etc. IP 67

Pneumatic instruments IP 67



Solenoid valves IP 67

Local Panel / Skid Mounted Panels IP 65

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, Gas detectors, 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:

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Transmitters, positioners, I/P converters, etc.:	EEx ia IIC T6
Switches:	EEx de IIC T6
Analysers and Panels:	EEx p IIC T6
solenoid valve	EExia IIC T6
Junction Boxes and Cable Glands:	EEx d IIC T6

## 7.0 ELECTRICAL SUPPLY

The electrical supply will be as follows:

Distributed Control System, trip system, and Control Room Instruments	: 115 V AC
Solenoid Valves	: 24V D.C
Local Panels	: 115 V AC/24 V D.C
Local Illumination, equipment for air conditioning, space heaters, ventilation of Local panels and similar purposes	: 230 V AC
Field-mounted Transmitters and switches	: 24V D.C. intrinsic safe
Safety Circuits	:115 V AC

The 115 V AC supply will be an uninterrupted power supply (UPS) of 115V +/- 10%, 50Hz +/- 3%.

Where 24V DC is needed, it will be generated by a local rectifier units, which will be part of the instrumentation supply. The power supply to these units shall be taken from the UPS.



Wherever 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.

There shall be minimum 4 separate earth pits for System, Panel /power / Intrinsic safe and non intrinsic safe signals with different cable color codes All earth shall be less than 2 Ohm or OEM specific, if better.

The size of earthing Cable from control room to earth pit shall be min. 50 sq.mm 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 color identification from electrical earth.

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



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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.

UPS battery back-up shall be as per Electrical specification for UPS 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

In general CPCB guidelines, (latest edition) to be followed. CEMS must have flow (velocity) and Temperature measurement device installed.

All gas analysers shall be housed in pressurised shelter(s) conforming to Namur recommendations. Purge type analysers 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.

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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..



Additionally, Analysers should have provision of Ethernet (preferred) or Modbus RS485, 2 way communication ports to connect serially with plant-wide Analyser Management System (AMS). 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, , rated as a minimum 24 V DC 500mA and suitable for I.S use.

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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 unless otherwise specified in the data sheet.

All consumables including buffers, calibration gases, reagents, filters, probes, tapes, desiccants etc. shall be supplied for 2 year period on a deferred delivery basis as approved by Owner.

For all IR / NDIR/ UV based analysers, Calibration Gas cylinders shall be used

All Analysers including stack analysers shall be placed in the analyser shelter only. SOx and NOx analyser shall be located in analyser shelter.



ADSU shall be as per GSTD-0003. It shall have latest Console PCs with 24” TFT, COLOR, LED, one in shelter and one located in control room as per GSTD-0003.

Analyzers for all stacks shall be supplied as per CPCB latest 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 analyzers to the CPCB/PPCB portal with min. 20% spare points for future use. Analyzer shall have RS485/ Ethernet / Modbus connectivity.

Analyzers for fugitive emission of Hydrocarbon (HC) / VOC & Benzene at periodicity as per the Fugitive emission standards shall be in bidder’s scope.

Service, Accuracy, repeatability, Span & Zero drift speed of response Analyser’s performance quality shall be in line with the following as a minimum:

Service	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

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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 chemiluminescent 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/GC is considered as per licensor recommendation, then a dedicated laptop for programming of Mass-spectrometer shall be provided along with required software/cable. The lap top shall be with latest Intel hardware, OS and MS office software at the time of supply



### **Analyser Shelter**

Number of analyser shelter, location of analyzer shelters and number of analysers along with no. of analyzers installed in each of these shelters shall be decided based upon:

- Allowable transportation time for each sample.
- Available space requirement for analyzer shelter room.
- Accessibility with respect to approaches & obstructions.
- Space required for equipment maintenance and calibration.
- Proving the analyzers as per process requirements specified by process licensor.
- Analyser shelter shall be provided for CEMS and GC /mass spectrometer

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 house

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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. PLC shall have redundant CPU. PLC shall be mounted in Ex-proof enclosure. PLC fault shall be annunciated
- 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 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
- Cable Entry into Analyser shelter shall be through MCT blocks.
- One Analyser PLC for each Analyser shelter shall be provided with redundant connectivity to CR.
- If more than 1 analyser shelters are coming then CDSU shall be considered in Control room.

## 8.2 Flow Instruments

### 8.2.1 Flow Transmitters

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

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24V D.C. Protection against short circuit and reverse voltage shall be provided. Bodies shall normally be in di cast Aluminium with corrosion resistant paint with SS316 internals. Integral 3- valve manifold shall be used for mounting transmitters on manifold for ease of maintenance. Material of manifold in general shall be SS316 but may vary depending upon service. Digital output indication shall be preferable on the integral output meter with the transmitter. All DP flow transmitters shall have sq.root extraction function.

Pressure elements in austenitic stainless steel is a requirement in hydrogen services. 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. Process connection size shall be 1/2" NPT through oval flanges.

#### 8.2.2 **Rotameter**

Rotameter 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, 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 Rotameter shall be metal tube type with transmitter.

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. 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- latest edition

The flow range shall be selected such that normal flow rates are between 50% and

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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 H<sub>2</sub>O with standard selection at 2500 mmH<sub>2</sub>O.

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/Cm <sup>2</sup> g)	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)

Orifice assembly shall be provided with two sets of "Flange Taps" located in

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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.

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 normally be AISI 316 steel unless special materials are required for the service. Dimensions and calculations shall be in accordance with ISO 5167-latest edition. 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-latest edition 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 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 316 SS. Process connection shall be 1/2" NPT (F). 3-valve manifold with 1/2" NPT connection shall be used with the meter.

## 10.0 OTHER FLOW METERS



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#### 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. The sensing element shall be straight/U-tube, matl. 316 in general. For custody transfer applications all mass flowmeters shall be wet calibrated from certified NABL laboratory.

#### 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. For custody transfer applications all vortex flowmeters shall be wet calibrated from certified NABL laboratory

Insertion type vortex meter may be used in utility services for line size more than 6" in place of Pitot /Annubar/Pitot venturi tubes.

#### 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 applicable standard. For custody transfer applications all ultrasonic flowmeters shall be wet calibrated from certified NABL laboratory



For all gas services flow meters, either being used as custody transfers, Guarantee flow measurement purposes or for mass balance purpose, shall be minimum 4-path with diagnostics, non-insertion probe type Ultrasonic flow meters based on Time-to-Flight measuring principle, having total RMS accuracy of +/-0.25% or better.

For flare, Ultrasonic insertion type 1 path, with accuracy of 2% and for Cooling water, Ultrasonic flowmeter (Clamp-on) with accuracy of 0.5% to be used.

#### 10.4 **Electro-Magnetic Flowmeter**

Electromagnetic flowmeter shall be used for the measurement of flow with high accuracy for highly viscous and corrosive services. For custody transfer applications all electro-magnetic flowmeters shall be wet calibrated from certified NABL laboratory.

#### 10.5 **Solid Flow Measurement**

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For measurement of Feedstock (Coal/ Petcoke/ Flaxant), solid flow measurement with microwave type shall be provided.

## 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

Radar Level Transmitter shall be based on "Time Domain Reflectometry (TDR)". 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 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 Radars level instruments. Material of wetted parts/sensor/Horn shall be SS 316 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

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centring disc or weight shall be SS 316 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. For solid measurements high frequency type Radar shall be used.

### 11.3 **Boiler Drum Level Measurement**

For drum level, following minimum measurements are envisaged:

- Bi colour/Magnetic Drum level gauge on both sides of drum.
- 3 Nos. differential pressure type drum level transmitters from 3 separate nozzles for (2oo3) trip signals.
- Hydra-step type (electric resistivity type) level instruments with both local indication and remote indication at CR/DCS shall be provided for drum level of steam drum. These shall be in addition to conventional level measuring instruments in compliance to IBR requirement.

All Instruments shall be spaced equidistance on the drum and shall cover maximum operating range of drum.

All level instruments shall be provided with same centre to centre distances.

For boiler drum applications special approval of IBR has to be taken for level instruments

## 12.0 **LEVEL GAUGE GLASS**

### 12.1 **Gauge Glasses**



Glass gauges shall be avoided and magnetic type level gauges shall be used if suitable to process condition. If unavoidable Gauge Glasses shall normally be reflex type for all process services, except for boiler drums bicolour 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.

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.

For cold services where temperature is below 0 deg C a non-frosting gauge will be used.

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Glass tube level gauges shall be avoided.

Permanent platform shall be provided for level gauge above the height of 1.5m for maintenance & operation purpose.

### 13.0 **PRESSURE INSTRUMENTS**

#### 13.1 **Pressure Transmitters**

Pressure Transmitters and differential pressure transmitters shall be modern inherent motion-free type. Bodies shall normally be in stainless steel with pressure elements in SS316. Pressure elements in austenitic stainless steel are requirement in hydrogen services. Two valve integral manifold of SS316 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 at least 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 Hart V protocol.. Process connection size shall be 1/2" NPT.

#### 13.2 **Pressure Gauges**

Gauges for process and utility services shall be industrial SS Bourdon gauge/diaphragm or spring bellows type as per process requirement with the case in stainless steel. The gauge for 60 kg/cm<sup>2</sup> 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. 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.

#### 13.3 **Pressure Switch**

Direct mounted pressure switches shall not be used and transmitters shall be used.

#### 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

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sensor material is not available in highly corrosive services.

Remote Seal PT/DPT shall be with minimum 5 mtrs Capillary with SS armoured in PVC sheath of Protection with DRIP RING and with Ball type Isolation Valve. For Vessel/Equipment requiring more than 5 mtrs capillary electronic remote seal (ERS) shall be provided.

All catalyst vessel's dP measurement shall be with ERS (electronic remote seal).

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.

## 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 ordinary SS material can be used below 400 degree C. The nominal wire diameter shall be approximately 0.19 x sheath OD.

In general type K thermocouples shall be used according to IEC 584. All temperature elements shall be duplex type, one connected and the second one shall be used as spares.

Skin thermocouples as well as multipoint thermocouples shall be used for equipment shell temperature measurement as per requirement.

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
NiCrSiI - NiSiI (ISA-Type-N)	0 to 1200 °C
Platinum Rhodium-Platinum (ISA-Type-S or B)	600 to 1600°C

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#### 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 confirm to DIN 43760/IEC 751. The nominal wire diameter shall be approximately 0.19 x sheath OD

#### 14.3 **Temperature Transmitters**

Temperature transmitters shall be Remote mounted type (on 2" Pipe), Smart with latest HART protocol and integral digital output meter.

Head mounted transmitters shall not be used.

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 as mentioned in Annexure-1 Transmitter shall have automatic cold junction compensation for thermocouples.

Burnout protection (selectable Up Scale / Down Scale) must be provided for temperature transmitters.



Temperature transmitters shall be provided for all temperature elements in closed loops and loops connected to PLC/Interlocks.

No temperature switches are to be used. The same is to be achieved through transmitters which shall be directly connected as analog input to DCS / PLC.

#### 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.

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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**

Flanged thermowells shall be of 1 1/2" size. screwed thermowells shall be of 1" NPT(M). Flanges rating, facing and material shall be in accordance with the equipment or piping standard.

Thermowell material in general shall be of AISI 316 SS.



Special thermowell with purged termination box shall be provided for multipoint thermocouples.

Immersion length of thermowells for different line sizes shall be as follows:-

<u>Line Size</u>	<u>Immersion length (U)</u>
4" to 6"	280 mm
8" and above	320 mm
Vessels	400 mm

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 70% 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.

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Cases wherein thermowell fails stress and WFC, modifications as mentioned below in order to pass thermowell in their order of preference shall be followed:

- Material: Alternative material with increased mechanical properties shall be considered.
- 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)
- Tip Dia: Increase tip diameter of thermowell (Same shall be within limits as per latest PTC 19.3 standard)
- Root Dia : Increase root diameter of thermowell (Same shall be within limits as per latest PTC 19.3 standard)
- 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/helical 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.



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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 AISI B16.104-1976. However, in general, the globe valves used shall be of class IV leakage minimum as per ANSI B6.104 in general. For vent services the leakage class shall be class V or VI depending upon process requirement.

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. Stainless steel bodies shall be acceptable in place of alloy steel bodies, if not available, for low temperature application.

On line replaceable trims shall be considered for all high pressure valves of butt-weld or socket weld connections.

Split body design for ball valves acceptable where top entry ball design has not been considered for economical reasons. 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/cm<sup>2</sup>g. 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.

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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.

Butterfly valves shall be used for high flow, low pressure drop below 10 kg/cm<sup>2</sup>g.

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. or 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<sup>2</sup> and shall be designed with 1.3 times factor of safety.

Handwheel (Side-mounted) for all regulating control valves shall be as per process requirement and licensors's recommendation.

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%.

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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 latest edition.



Direction of flow indication shall be engraved or embossed on the body.

Stroke time of the antisurge valves shall be 2-3 seconds and for critical services shall be as defined by process licensor or as mentioned in individual data sheet.

#### 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 ANSI B16.104/FCI 70.2
- Performance tests and Functional tests
- Leakage test from actuators and seals and packings

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- 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 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..
- 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.



## 15.3 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/cm<sup>2</sup>g. For larger dP shut offs, higher spring range/higher areas shall be considered.
- 15.3.2 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.
- 15.3.3 Air filter Regulator filter to be 5 micron. Miniature type, plastic body & drain assembly etc as parts of air filter regulator are not acceptable.
- 15.3.3.1 Actuator / Positioner make shall be as per approved vendor list or valve OEM make.

## 15.4 Motorised Actuator (MOV)

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- 15.4.1.1 Each MOV actuator shall include the motor, actuator unit, gears, position indicators, limit switches, hand wheel, electrical starter and controls, terminal box etc. as a self-contained unit. The actuator shall be sized to provide adequate torque and / or thrust to ensure the complete intended travel of the valve under the worst operating and electrical power supply conditions.
- 15.4.1.2 The enclosure of the complete MOV actuator including motor, integral starter, control transformer unit and all control devices shall have minimum IP-65 degree of ingress protection.
- 15.4.1.3 Direction of operation of the hand wheel / wrench shall be in clockwise direction while closing the valve.
- Motor:-
- 15.4.1.4 3-Phase squirrel cage induction type unless specified otherwise in the data sheet. It shall have totally enclosed non-ventilated construction.
- 15.4.1.5 The motor shall be provided with thermostat / thermister embedded in the hot spots of motor winding for protecting the motor.
- 15.4.1.6 The motor shall be able to operate the actuator at 75% of rated voltage.
- 15.4.1.7 The motor shall have class "H" insulation with temperature rise limited to class "B" limits.
- 15.4.1.8 The rated torque output of electric actuator shall be at least 1.3 times the break torque required to operate the valve under max. Differential pressure corresponding to the valve class rating. [Vendor shall submit the break torque of the valve & rated torque output of selected actuator for each MOV].
- 15.4.1.9 Encoder for Position sensing.
- 15.4.1.10 Torque and Travel Limit Switches: Electronic torque limit switches shall be provided to protect the motor over-loading by cutting-off the power supply to motor during opening and closing operations. The switches shall be provided with requisite number of potential free contacts for valve actuator operation and for indication on remote panels as specified in data sheet. Instead of mechanical torque limit switches, magnetic pulse counter / encoders to measure and control the stroke of actuator shall be provided, wherever this feature exists in the manufacturer's design.
- 15.4.1.11 Control Facilities:

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The internal controls and monitoring circuits shall be incorporated within the integral starter along with transformer and control unit of valve actuator. Following remote control and monitoring facilities are to be provided as a minimum:-

- MOV open command
- MOV close command
- MOV open status indication
- MOV close status indication
- Position status of Remote / Local / Off selector switch

Remote control facilities shall be provided for all the actuators. The remote control circuits shall be powered from internally derived control supply voltage. In order to cater to remote control and indication requirements for "Position of Remote / Local / Off selector switch" an additional Monitoring relay / auxiliary relays shall be provided as a part of the valve actuator. As an alternative , a common status contact indicating the availability of the MOV actuator for remote control may be provided by the monitoring the following :-

- Loss of one or more phase of power supply
- Loss of control circuit supply
- Selector switch in local mode
- Local stop push button set to "OFF"
- Motor thermostat tripped
- Any other local fault / abnormal condition



15.4.1.12 **Hand operation:** - A hand wheel with hand / auto lockable lever shall be provided for emergency operation of the MOV. The energisation of the motor shall automatically re-engage power operation

## 16.0 PRESSURE REDUCING AND DESUPERHEATER STATION

16.1 Desuperheater design shall ensure that temperature at the outlet shall be maintained within + /- 5 deg. C of desired outlet temperature, unless otherwise specified by the Licensor.

16.2 Separate liquid injection valve and steam valve, if provided must be installed along with block and bypass valves.

16.3 The body and trim material of construction shall be suitable for the service. In general trim including spray nozzle shall be fully stellited.

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16.4 The PRDS/ DS in steam application shall be IBR certified including valve in boiler feed water line.

16.5 The CV shall be calculated in accordance with manufacturer's calculation procedure and selected based on following points:

- Valve sizing shall be based on the maximum capacity of 1.25 times the normal flow or 1.1 times the max. Flow, whichever is greater.
- The minimum flow capacity shall be suitable for rangeability of 30:1. The valve stroke shall not be less than 20% opening at the minimum flow capacity.
- Fluid velocity at the outlet shall be selected suitably in consideration of the property of fluid, the differential pressure of the valve and the line size etc.
- Noise level at 1 meter downstream of DS and at distance of 1 meter from the pipe surface at normal flow shall not exceed 85 DBA.

16.6 A manual operator, limit switch, solenoid valve or any other auxiliary devices shall be provided.

16.7 Mfr. Standard manual operator / Hand wheel shall be provided.

16.8 Direction of flow shall be permanently affixed on DS body.

## **17.0 PRESSURE RELIEVING DEVICES**



### **17.1 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

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16% - Gas , Vapour and liquid where ASME Pressure Vessel Code applies and the system is protected by means of multiple valves.

## 17.2 **Nomenclature**

Nomenclature used shall be in accordance with API RP 520.

## 17.3 **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.

Steam jacketing may be considered necessary 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 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 is permitted above 200°C for open bonnets.

Blowdown shall be between 5% to 7% for gas service and 10% for liquid service. For steam services under Power Boiler Code as per ASME the blowdown shall be 3% - 4%.



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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.

#### 17.4 **Rupture Discs**

Rupture discs may be used in lieu of or in combination with safety and relief valves, where applicable or required. 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.

#### 17.5 **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.

#### 17.6 **Thermal Relief Valves**



For thermal relief of accumulated liquids in pipelines and vessels shall be used in general. Thermal relief valves shall be flanged type

#### 17.7 **Centre-to-Face**

Centre-to-face dimensions shall be in accordance with API 526.

#### 18.0 **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

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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. All SOV's body, trim, coil housing and spool piece MOC shall be SS316 only Solenoid valves will be powered by 24V DC, and insulation class 'H'. 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

## 19.0 CONTROL AND SHUTDOWN SYSTEM

### CONTROL AND SAFEGUARDING DESIGN CRITERIA

#### EXPANDABILITY

Systems shall be designed with 20% 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 20% 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 20 % as a minimum.

Apart from DCS system operator stations and engineering stations, there shall be min. 2 (two) nos. of VIEW Only remote monitoring client software facilities with normal PC via Ethernet LAN connected with DCS network, in the proposed DCS. These are required to be installed at other control room .All hardware software required shall be in bidder scope

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

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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.

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, except the redundancy at I/O cards levels. 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, 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. 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. 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 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:

Feed Coal preparation ,Coal Gasification, Gas cooling & cleaning, Pre treatment, CW system, Condensate polishing Unit, Acid gas removal section, Gas Liquor Separation, Ash handling section, Sulphur Recovery Unit (SRU), etc

**LVS (large Video screen)** shall be LED type with DLP based technology. Resolution of each screen - Minimum 1920 x 1080 pixels and shall support an aspect ratio of 16:9. Configuration of LVS shall be Double tier with screens seamlessly combined with provision of expansion of one screen on each side.

4 Nos. (70") LVS with 2x2 configuration

Necessary hardware and software shall be provided with the LVS for connectivity to the DCS system. Provision for projecting any of the screen from DCS OS/ES to

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screen of LVS shall be provided.

Facility of projecting a particular display on a selectable area of the screen upon activation of a predefined event shall be provided.

Master Control Unit- Master Control unit shall be provided for controlling this LVS in control room.. It shall be capable of projecting HMI displays over a part a part of screen to multiple screens. Any configuration of windows shall be possible. Facility for overlay shall be provided. Minimum Hardware Specs of Master Controller as follows:

Processor: Intel Xeon Dual / Quad (Min 3GHz), RAM: 16GB Min, Hard disk: 500GB min, Network Port: Min. 3 No's, of speed 10 / 100 / 1000 MBPS, OS: Genuine

Windows

## 19.2 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

## 19.3 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)

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#### 19.4 **DCS Operator Interface**

For Details of OS/ES please refer Annexure -3 System configuration.  
2 Nos. auxiliary bay for housing instruments, push buttons, alarm panels etc.

4 Nos. (70") LVS with 2x2 configuration

##### **Other Devices**

2 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 PSA Unit (redundant)

1 No. Interface for machine monitoring system (redundant)

2 Nos. Ethernet connectivity (spare)

2 Nos. Modbus connectivity (spare)

#### 19.5 **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 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. Some marshalling/I/O racks may be installed in remote safe areas by extending the system bus, especially in MCC rooms where lot of inputs from drives shall directly be terminated in the marshalling I/O racks.

#### 19.6 **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,

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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.

Redundant communication from controller to IO cards shall be criss-cross so that failure from one card or controller shall not affect the other cards connected with that controller and vice versa

## 19.7 **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.

### 19.7.1 **I/O Segregation:**



The I/O card segregation for DCS shall be. 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.

### 19.7.2 **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.

### 19.7.3 **DCS/ESD requirements**

- a) All DCS/ESD 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, 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.
- c) DCS shall be a large and expandable type system available with the vendor.

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- 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. System shall be fully open with DDE/OPC&ODBC compliant. System availability shall be better than 99.999%.
- f) One OPC server shall be provided with DCS/PLC system with OPC connectivity to ERP/MIS system/data exchange. Vendor shall also provide necessary software / hardware (OPC server & software) and manpower support / assistance for establishing connectivity of the system with ERP & other systems.
- 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

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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) ,

Panels shall made of Industrial grade material- Grade D as per IS 513, (Thickness- Door 2mm, side panels, top cover, bottom cover, rear cover, bottom cover 1.5mm thick, Mounting plate 3mm, gland plate 1.5 mm) manufacturing as per IEC 62208 standard and mechanical impact resistance as per IEC 62262 protection class and option for two levels of mounting inside enclosure and option for baying. Panels should have a temperature withstand range from -30 degree to 80 degree without any change in properties and avoids entry of external substances/ dust/ water. Complete panels/enclosures for project plant shall be RoHS compliant, UL certified and shall be tested/certified according to UL 60950-1 standard, IEC 61439-1 standard, UL508A standard and IEC 60297-3-100 standard

Surface finish shall be RAL 7035. Enclosure Corrosion protection shall be provided as per EN-IS 12944-6/ DIN 55634 standard. All Panels shall be IP65 certified

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 digital governors, Machine monitoring system hardware panels, etc.



Fan-and-filter units with diagonal fan technology shall be used. The Fan must have UL approval and shall have air flow volume as per cabinet requirement

For Outdoor cabinets mounted in non-AC areas, Energy efficient panel AC shall be provided with fully wired ready for connection (plug-in terminal strip) Protection category for Panel AC shall be minimum IP-54. For Chemical / Corrosive area, Panel AC shall be suitable as per environmental condition with protection category UL type Nema 4/4X.

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 and D/A of system I/O cards shall have resolution of min. 13 bits**



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- 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 : 1:1 (Criss-cross)  
(CPU for control, I/O communication, network communication)
- b. Input / output cards : Redundant  
closed loops
- c. Communication Bus : 1:1
- d. I/O communication modules with CPU : 1:1  
(I/O bus between CPU and I/O with all necessary hardware)
- e. Main data highway : 1:1
- f. Communication Cards : 1:1
- g. System Device : 1:1
- h. Power supply : 1:1  
(Power supply for all CPUs, I/O power supply modules)
- i. Serial (RS-485) Modbus (For Interlock PLC) : 1:1
- j. In case of client-server system, : 1:1  
server shall be redundant (Raid-5 Configuration)

I/O bus and I/O interface card at controller rack shall be redundant and shall be in criss-cross configuration.

Connectivity from Upstream redundant device to downstream redundant device shall be through redundant device or cable.

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### **Loading philosophy (with 20% installed spares and 20% future expansion)**

Control Processor	50%
Communication Processor	50%
Communication Bus	50%

#### **19.8 Scanning Time**

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 loops  
 1sec. for all other acquisition loops  
 40 msec. for Vibration loops

#### **19.9 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  
 Burner Management System  
 Machine monitoring system  
 FGS

Analyser system

Any other PLC system provided in packages.

Any other system from where data has to be sent to control system.



Customer LAN through hardware firewall.

Other Interfacing shall be as per project requirement.

At least 4 Nos. redundant foreign device interface shall be provided as spare in both for future use.

#### **19.10 DCS System Power Supply**

The system shall be powered from uninterrupted power supply at 115V A.C. The

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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.

#### 19.11 **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 Gland Plates.

#### 19.12 **Consumables**

One No. Spares like printer cartridges with each printer to be provided.



### 20.0 **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 OR BETTER technology. The emergency ShutDown 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

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

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independent of other systems.

The following shall be adhered to while selecting the TMR OR BETTER system

- a) TMR OR BETTER 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 OR BETTER buses shall be applied.
- d) TMR OR BETTER analogue inputs and outputs shall be applied.
- e) TMR OR BETTER digital inputs shall be applied.
- f) TMR OR BETTER digital outputs shall be applied.
- g) Redundant communication interfaces shall be supplied. Redundant communication from controller to IO cards/bus shall be criss-cross so that failure from one card or controller shall not affect the other cards connected with that controller and vice versa
- 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/SGS 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.

PLC shall be with at least 3/4 sets of CPU's & other supporting module corresponding to front and & back end.

Scan time shall be maximum 250 msec. CPU shall be TMR or Better. 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**

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Following system redundancy shall be available as a minimum.

- |   |                   |
|---|-------------------|
| 1. Controller<br>(CPU for control, I/O communication,<br>network communication)                       | 1:1 (Criss cross) |
| 2. Communication Bus  | 1:1               |
| 3. I/O communication modules with CPU<br>(I/O bus between CPU and I/O<br>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<br>(Power supply for all CPUs,<br>I/O power supply modules)                           | 1:1               |

However, lamp drive cards, supporting mosaic need not be redundant also. Active isolator / barriers 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.



The system shall include an event recording system, 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) | : Red    |
| Equipment in operation (alarms and pilot lights)   | : White  |
| Ready (standby of equipment)                       | : Green  |

The critical trip shall be displayed on Annunciation window.

Consumables like printer paper, cartridges, fuses etc shall be supplied along with the ESD system for a minimum period of one year duration.

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Some of the ESD requirements have been covered in DCS sections also.

- a) ESD system shall be fail safe, 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 SIL-3 as a minimum, as per IEC61508, irrespective of plant's safety integrity level.. 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 ESD only, irrespective of process safety integrity level of the plant.
- e) The ESD shall have scan time of 250 msec and SOE with 1 msec resolution.
- f) I/O segregation and channel density as specified in DCS section.



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 2003 voting logic shall be provided in Auxiliary console for the Activation of the MOS.

- g) 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 24" TFT/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/DCS 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.

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- h) 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.
- i) All interlock and control transmitters shall be separate right from field junction box to ESD/DCS marshalling panels.
- j) 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.
- k) 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.
- l) 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.
- m) 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 IRP.
- n) Centralized DCS and Centralized ESD marshalling panels shall be separate.
- o) Centralized DCS and Centralized ESD system hardware panels shall be separate.
- p) All major machines/units' 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.
- q) Smart barriers with line monitoring features shall be used and shall be taken as DI in the system
- r) OEM commissioning engineers shall be present for all the commissioning activities for specialized instrumentation systems like ITCC/ antisurge /Performance controllers, Condition monitoring Systems, Governor and Gas Chromatographs Gas Analyser, DCS, ESD etc. The OEM engineer for DCS, ESD shall be present for 2 month after

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successful commissioning of the plant or as per ITB time whichever is more.

- s) 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 Antisurge/ Performance controllers, Condition monitoring Systems, Speed Governor and Gas Chromatographs shall also be imparted to OWNER's personals at sub vendor's works for minimum 10 man days (1 week for 2 persons) on each system, by CONTRACTOR.

## 20.2 **ESD Cabinets**

### 20.2.1 **ESD 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, 115 VAC, etc. both for inputs as well as outputs.

The terminals shall be cage clamp type single tier design (double tier design shall be avoided). Terminal stack for each unit shall be supplied with approx. 20% 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.

### 20.2.2 **ESD 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



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- Ease of modification and expansion

### 20.2.3 **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 20% 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

### 20.2.4 **Power Supply**

An uninterrupted Power Supply to ESD shall be provided to the power distribution cabinet of ESD at 115 VAC +/- 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.

Earthing /Grounding bus bars for terminating shields of the cables shall be provided on the cabinet.

### 20.2.5 **Annunciator**

Annunciator shall be LED(24") type mounted on aux console

### 20.2.6 **DCS & PLC, Spare Philosophy:**

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Installed Spares	I/O Level	20%
	Marshalling	20%
Spare Space	I/O Level	20%
	Processor	50%
	Marshalling	20%
	Rack	

## 21.0 CONTROL ROOM

Main Control room (CR) shall be completely blast proof building. All doors of Control Room 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 reputed makes.

Local control room should be provided For Feed stock (Pet Coke, ROM Coal, Flaxant), Lime Handling.



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, Shift Incharge Room, Manager Room, Meeting Room, Instrument Calibration room, rest rooms etc. shall be accommodated in the control room building in general. Two separate DUCTS for console room and Cabinet Room should be there with flow regulators to maintain different temperatures

The instrumentation cable entry and all other cable entries (UPS room, HVAC etc) to the control room shall be through MCT (multi-cable transit). Cable way in control room shall be below access level through cable trays

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, 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.

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The false ceiling for air conditioning shall be at a height of 3 metres

**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
- Shall have BIFMA X5.5 Test Certificate for Control Desk
- 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)

iv) The Console shall be designed with vertical and horizontal cable trays to allow for continuous cable management between the cabinets. Wire shall be routed into the cabinet through gland plate. All bolts shall be of SS material to avoid rust due to environment.

**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.

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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 tapping 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 hole 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 tapings.
- 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.

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## 22.0 PACKAGE UNIT INSTRUMENTS

22.1 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 information necessary 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 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).

22.2 Vendor's scope supply includes:

22.2.1 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.



22.2.2 Gauge Board to be located near each machine with local gauges mounted on it.

22.2.3 All instrument erection materials such as cables, pipes, pipe fittings, supports, trays, conduits, junction boxes etc.

22.2.4 Tools for service calibration and maintenance

22.2.5 Spares parts for Commissioning.

22.2.6 Engineering documentation

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22.27 Mandatory spares,for all packages shall be supplied as per Instrument spares list attached with the NIT.along with the main item.

## 22.3 **Process Alarm, Motor Alarm and Shut Down System**

### 22.3.1 **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 visa versa. A passive alarm shall warn about the burn-out.

The alarm and shut-down system of the compressor and turbine shall be co-ordinated to accommodate all the relevant equipment for compressor, as well as for turbines, within the main panel in the local control room.

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.

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.

### 22.3.2 **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" TFT 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.

### 22.3.3 **Power Supply**

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The internal power packs shall have an output of 24V DC, full wave rectified, generated from the 230V AC supply with 50% loading.

#### 22.3.4 **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.

#### 22.3.5 **Display and Colour Coding**

Annunciator window engraving shall include a brief state description and the Tag No. Each window shall measure approx. 24x48 mm and be engraved with a character size and style and state description to be read from a distance of 3 meters with normal eyesight.

The window colour shall be specified for OWNER's approval.

Each window shall be back lighted by two lamps. The lamps shall be underrated for extended lifetime. MTBF shall not be less than 7000 hr.

#### 22.3.6 **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.

#### 22.3.7 **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 acknowledge state - no flashing device operates when subsequent trips occur. On

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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.

#### 22.3.8 **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.

#### 22.3.9 **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.

#### 22.3.10 **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.



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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.

#### 22.3.11 **Monitoring and Protection of Machine( rotary,turbines/Compressor Train/Pumps etc.)**

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.

It shall be either through ITCC (Integrated Turbine Compressor Controls) or individual dedicated control systems for antisurge and for Speed governor and overspeed protection.

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.

#### 22.3.12 **Sensors**

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.

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

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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.



Key phasor measurement shall be provided for compressor and turbine.

22.3.13 . The monitors for the machinery protection system shall be installed on the panel in the local compressor 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.

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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 hardwired. 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.

Transient Data Manager shall be provided for monitoring data from all compressors.

VMS/MMS I/O modules shall be with Barriers 4-20mA for DCS. MMS to be provided with CMS 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).

## 22.3.14



### **Speed Control of Turbines**

The speed control system shall be designed to provide maximum economy of operation and high reliability with a minimum of maintenance, and shall fulfil the requirements in API standard 512.

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.

The speed governor shall be electronic type and have remote speed setting from the main panel and the control room as well.

The system shall be digital governor suitable of providing an accurate speed control.. The governor shall be installed in the CR with serial communication to DCS.

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. Hazardous area classification of the field devices shall be suitable for plant hazardous area classifications. The required power supply to these units shall be fed from central cabinet room PDBs. Dual redundant 24 V DC bulk power supply for these systems, if required. These power supply units shall be installed in PDB located at central cabinet room and required power cables (with proper sizing and armouring) shall be laid in overhead cable trays/ducts between PDB and field devices.

The steam inlet and extraction valve shall be cam or bar lift multi valves to provide maximum efficiency for all turbine load conditions. Because of the well known wear and vibration problem with mechanical linkage system to those valves, special attention shall be paid to the design of these systems.

The points mentioned below shall be carefully observed when designing the control system.

The valves shall be positively held stems to prevent spinning, chattering and sticking.

Surface hardened stainless steel bushings shall guide the valve stems into lapped seats, sealing the valves against leakage.

All linkage shall be external to provide greater accessibility and freedom to perform visual inspection.

each cam or bar shall be individually adjustable to give the desired rate of opening and to provide maximum efficiency during all loads.

External location of cams or bars and visible valve stems with position indication shall be foreseen.



## 22.3.15

### **Over-speed Trip Systems for Turbines**

To protect the operating personnel and equipment, the turbine shall be equipped with a 2003 overspeed trip device that shuts down the turbine, when rotating speed exceeds the maximum speed by approximately 10 percent. The emergency governors shall operate totally independent of the normal controlling speed governor.

The whole overspeed trip system ( 2003) shall be very carefully designed to ensure that the turbine will trip in all situations of overspeed, especially the time lag in the mechanism shall be kept to an minimum, ensuring very fast operating of the trip and throttle valves. The trip valve shall be provided with a limit switch for indication of closed position (running light) in the control room.

The following shall be provided as a minimum:

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- 3 Speed probe required for measurement & control –

- 3 Speed probes for 2oo3 trip.-

Control Speed measurement shall be through Magnetic Pickup.

The system shall close not only the trip and throttle valve, but also steam admission valves.

A hand trip device for emergency manual tripping shall be located in front of the turbine where it is readily accessible.

It shall be possible to verify trip set points while the turbine is coupled to the compressor.

The secondary hardware of these system shall be installed in central cabinet room in a standard panel of 1200mm (W) x800mm (D) x 2100mm (H) or with RAL7035 color shade.

A dedicated laptop for programming and back up of all machines' 2 out of 3 devices shall be provided along with required software/cable. The lap top shall be with latest Intel hardware, OS and MS office software at the time of supply.



#### 22.3.16

#### **Control and Anti-surge Control**

The typical surge protection control systems are to be shown on respective P&I diagrams. The control system shall be electronic with the controllers installed in the main panel. The controllers shall be with bumpless change over from manual to auto and vice-versa and wherever required anti reset wind up feature shall be provided. It is extremely important that all instruments are carefully specified for high quality and fast action. The scanning time for digital controllers shall not be more than 20 msec.

The valves in anti-surge service shall be with linear characteristic and high energy absorption trim and suitable for continuous operation for long periods with partly open valves. The noise level must not exceed 85 dB.

The valve shall be provided with limit switches, handwheel, and mechanically adjustable limitation of the valve capacity. It is also important that the valves have a very high stroke speed and still are stable in operation. The valve capable of recirculating 100% of the designed flow rate shall normally a full stroke speed in the order of one second. Complete designed data for the anti-surge valves would be submitted for review and approval by CONSULTANT.

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The secondary hardware of these systems shall be installed in central cabinet room in standard panel, 1200mm (W) x800mm (D) x 2100mm (H) with RAL7035 color shed.

BIDDER to supply suitable cables between field sensors and control room.

#### 22.3.17 **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.

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.

#### 22.3.18 **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, one turbine driven and one 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

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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.

22.3.19

### **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 for alarm on the main panel. In addition, the low switch shall start the spare pump.

Operation at 230 VAC 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 50°C. The solenoids shall be with class "H" high temperature insulation. The valves for instrument air shall be designed for 10 kg/cm<sup>2</sup>g at 70°C and the operating differential shall be from 0 to 10 kg/cm<sup>2</sup>.

"Running" "ready to start" and "On Auto" lights shall be provided for the Seal oil pumps in the main panel.

23.0

### **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.



24.0

### **LOCAL CONTROL PANELS**

All local panels under the scope of package vendor 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 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.

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- 24.2 The panels shall have environmental protection conforming to IP 65 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.
- 24.5 115 V 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 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 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 INSTALLATION**
- 25.1 INSTRUMENT LOCATION**
- 25.1.1 The location of instruments, control valves. Including junction boxes shall permit easy access from grade, permanent platforms or stairways for operation, inspection and maintenance.
- 25.1.2 The use of portable ladder or mobile platform shall be limited to access root valves, thermowells and line mounted flowmeters.



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25.1.3 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.

25.1.4 Permanent accessway/platform shall be provided for Instrument mounted on top of Tank, vessels etc. Access via oing from Handrail is not acceptable.

25.1.5 Permanent access to be provided for laying of Instrument main cable tray.

## **25.2 INSTRUMENT CABLE**

### **25.2.1 Overhead Runs**

Instrument main cable tray from field junction boxes to main control building or local control room shall generally be laid in aboveground cable tray.. 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.

Aluminium perforated cable trays with adequate supports shall be used for instrument signals. 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 2M. 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.

Alternatively, cable ducts of suitable size shall also be considered for main cables. When common cable ducts are used for running both power and signal cables, necessary air gap partition shall be used to segregate the cables.

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## 25.2 CABLES

The primary insulation material shall be XLPE (cross linked polyethylene) for all types of multi pair cables

Inner and outer jacket shall be made of extruded flame retardant 90 ac PVC to IS-5831 latest edition.

All cables shall be FRLS as per standard IEC 332-3 Part 3 Cat. A latest edition. Fire resistance cables whenever specified shall be as per me 331 Cat. A latest edition.

The insulation grade shall be 600 V/1000 V as a minimum and shall meet insulation resistance, voltage and spark test requirements as per BS-5308 Part-2 latest edition.

All cables shall be armoured. Armour over inner jacket shall be of galvanised steel wire/flat as per IS-1554 part I latest edition / IEC 502 latest edition. 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  $40 \mu\text{H} / 0$  for cables with  $1.5 \text{ mm}^2$  conductor and  $0.25 \text{ pH} / 0$  for cables with  $0.5 \text{ mm}^2$  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.

### 25.2.4 Instrument Signal Cable

- Single pair shielded signal/alarm cables shall be used between field instruments switches and junction boxes/local control panels.
- Multipair individually and overall shielded signal/alarm cables shall be used between junction boxes/local control panels and control room.
- The single pair/triad cables shall be  $1.5 \text{ mm}^2$  conductor size made of annealed electrolytic copper conductor of 7 strands with each strand of 0.53 mm diameter. Multipair cables with  $0.5 \text{ mm}^2$  conductor size shall have 7 strands of annealed electrolytic grade copper conductor with each strand of 0.3 mm diameter. Multi triad

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cable or multi pair cable with 1.5 mm<sup>2</sup> 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 0.5mm<sup>2</sup> 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.

#### **25.2.5 Cables and Multicore Cables for Solenoids etc.**

Cables and multicore cables for such items as flame detectors shall normally have a conductor size of 1.5 mm<sup>2</sup>. However, conductor sizes for power cables shall be co-ordinated with the Electrical Group to avoid too many different cable types.

#### **25.2.6 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 latest standards.
- 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 latest edition.

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- 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 and 100 % surface. Minimum shield thickness shall be 0.05 mm for single pair and 0.075 mm for multipair cable. Drain wire shall be 0.5-mm<sup>2</sup> 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.



### 25.2.7 Power supply Cables

All power supply cables shall be as per IS-1554 Part I latest edition and shall have copper conductors. Minimum conductor size shall be 2.5 mm<sup>2</sup>. The cables shall be PVC insulated and armoured. The higher size conductors shall be used in case 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.

### 25.3 JUNCTION BOX

- a) Junction box shall be of SS304 for IS signal and for Non IS signals Die-Cast Aluminium (copper free) with Anti-corrosive paint shall be provided. Junction boxes shall be certified for weather proof for IS signal. For non IS signals, Junction boxes shall be flame proof for IEC Zone 2 & Gas group IIC Ex. Proof. Junction box shall have screwed covers. All entries to junction box shall be side or bottom. All Junction boxes shall IP 67 certified.
- 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

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- DCS
  - ESD
  - F&G
- iii) Type of protection
- Non IS, Ex d
  - 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 plugs. All Cable entry shall be at the bottom only,.
- 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 JB's, T/C head etc to be plugged with metallic plugs. The metallic plugs, Junction box hinges, Handle, DIN rail, Allen screws shall be SS 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.

## 25.4



### 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

## 25.5

### INSTRUMENT VALVES AND MANIFOLDS

- a) Contractor shall supply instrument valves (miniature type) and valve manifolds wherever required.



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- 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 SS 316 unless otherwise specified. Superior trim material shall be selected as requirement by process conditions. Packing material in general shall be of PTFE.

## 25.6

### 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 SS tube & SS 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.

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- 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
- 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.

## 25.7 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, 1/2" OD, seamless tubes, laid in perforated aluminium trays. All intermediate fittings shall be double compression, SS316 MOC,. Solenoid valve operated condensate auto draining points to be provided on the header at regular intervals.

## 26.0 FIRE AND GAS DETECTION SYSTEM (FGS)

### GENERAL:



The FGS shall be a distributed system covering all process units and comprising the following components. Integration of non process-related facilities will also be considered when requirements of these facilities are defined:

Fire Alarm System shall also cover all the buildings including all Control Rooms

Fire and Gas (FGS) PLC : TMR or Better PLC for FGS of the same type as the ESD system as per ITB. This shall include smoke detectors and all points of ISD/UV/ Manual call points shall be fully addressable.

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.

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- 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 LVS of 70" 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.. In the Control Room 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:



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- 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.
- LVS located in the fire station,.
- 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 latest edition shall be provided for All Control Rooms.

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## 26.1 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.

Gas Detectors will be required at least in the following Area:

- 1) Coal Gasification Plant
- 2) Gas Purification System & Gas Liquor separation (CO shift, H<sub>2</sub>S removal, CO<sub>2</sub> removal, SRU, Nitrogen wash)
- 3) Storage section
- 4) Analyser Shelters
- 5) HVAC of Control Room
- 6) All Substations
- 7) Battery Sections
- 8) Other area where Hazardous gases will be present.

Bidder to list out sufficient Gas Detectors (each type), Hooters, Beacons to cover the entire plant in consultation with PMC/Owner

Calibration Gas supply for 1 year to be provided by the LSTK contractor.

## 27.0 OPERATOR TRAINING SIMULATOR

### 27.1 System Description



System will be a high fidelity customized process simulator. The scope of the simulator is training of fresh and experienced operators on the followings:

- DCS console operation philosophy
- Process upset and emergency operation
- Steady state operation
- Shutdown and start-up
- Operation concepts and principles

The simulator scope will not include:

- Actual plant optimization

Simulator will be developed based on process design data, not on actual operating data. The resulting accuracy will be therefore not respondent to optimisation purposes.

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Furthermore, simulator models will be based on static design data. The resulting accuracy will be therefore greater for steady state situations and lower during dynamic transients.

For OTS Training:

- 1) Operator - 5 days (2 members) minimum, for Engineers - 5 days (2 members) minimum
- 2) Instructor - 6 days (4 members) minimum
- 3) System maintenance - 6 days (6 members) minimum
- 4) System configuration - 6 days (7 members) minimum.

## 27.2 Description of the Simulated Process



Model shall perform also the simulation of following situations, in order to allow training on the emergency procedures:

- Start up
- Shut down
- Failure of main instruments - valve and transmitter
- Loss of various compressors
- Loss of various pump
- Loss of power supply
- Loss of cooling water

## 27.3 OTS Hardware

Hardware architecture will be composed of the followings:

- 1 (one) simulation computer and instructor workstation including 24" LED monitor and A3 colour printer
- Terminals will be "emulated consoles", imitating aspect and functionality of real DCS consoles and using actual or look-alike operator keyboard.
- 1 Licensor Model PC
- 2 (Two) Field Operator Station with 24" DUAL LED monitor for operation of the field equipment and for displaying Emulated ESD Panels (switches, lights, etc) in graphical form.
- 1 No. Engineering. Station With 24" LED monitor Station

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- All of the accessories necessary to get the full functionality of the system (magnetic storage devices, touch screen, mouse etc if present on the DCS, cables, etc.).

#### 27.4 OTS Software

The package will include:

- General purpose operating system license
- Real time dynamic simulation package for the considered processes, including graphic displays and a set of preconfigured typical drills
- Engineering/development facilities to allow the user to develop and modify the simulation model.
- Report and alarm logging facilities

#### 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;

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#### 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
- AMS 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.

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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

All Cameras shall be installed in outdoor and PTZ type.

No. of cameras shall be sufficient for surveillance of all the units of the plant and shall be decided in consultation with PMC/Owner.



Bidder shall give a CCTV system which shall have complete provision of connecting sufficient numbers of camera in consultation with PMC/Owner.

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:

- IP based Colour electronics Digital Video Camera Unit. With day and night viewing under very low light conditions.
- Video management software, Video analysis system along with LED monitors
- Server with video management software recording, storing and playing, Colour Video Monitors, Mouse-Keyboard, PC for System Administration / Management / Maintenance etc.
- Enterprise Level Server and Storage
- CCTV System cabinet (same shall be matched with Marshalling and System Cabinet specification mentioned elsewhere in tender)
- Power supply distribution board
- Coaxial cables, control cables, optical cables, connector etc. of required type & size, cable glands, connectors and other accessories
- Network switches (Layer-2 Managed)
- 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.

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- 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
- n) Data storage of minimum 90 days to be provided.



### 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 1/2.8" CMOS sensor with wide dynamic range and resolution 2 Mp as a minimum with Full HD 2MP minimum resolution 30x 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

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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.

### 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 Zoom shall be there.

### 30.6 Wiper and Washer

Wherever 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 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. Inbuilt Wiper shall be provided from OEM.

### 30.7 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.

### 30.8 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.

### 30.9 Camera Mounting



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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.

### 30.10 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:

- Camera Units
- Monitors
- No. of views on one monitor
- Recording Commands
- Pan-tilt Control
- Sequential Switching of image on monitors
- 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.

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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.

### 30.11

#### 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 90 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.

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- 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..

### 30.12 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.

### 30.13 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.

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- d) Upon detecting a fault, the system shall be able to automatically send an E-mail alert.

### 30.14 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.

No interacing to be done with DCS system. It shall be independent system.

### 30.16 CCTV CABINETS

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. The CCTV cabinets

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specification shall same as of Marshalling & System cabinet mentioned in the NIT elsewhere.

The color of the CCTV cabinets shall be matched with the existing cabinets at control room.

### 30.17 OPTICAL FIBER CABLE



The Optical Fiber Cable (OFC) used for the CCTV system shall conform to the following specification as a minimum:

- The OFC shall be CSTA (corrugated steel tape armored, electrolytically chrome plated low carbon steel) armored cable.
- 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.
- 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.
- The number of fibers in the OFC shall be decided depending upon the requirement with 8 fibers as a minimum.
- 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.
- The tensile performance shall be as per IEC-794-IEI and with tensile load of 9.81 W Newton with attenuation change -S 0.05 dB/km at 1310 nm. W is weight of OFC/km.

### 30.18 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

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router and bridge that provides high bandwidth connections into backbone networks for remote sites. It shall be managed switch (L2).

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.

### 30.19 POWER SUPPLY

The system shall operate on 115 VAC (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 system shall have the capability for future expansion to add cameras and additional storage in video recorders.

## 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 latest standards as applicable. As a minimum, the following standards shall apply:

- IS: 2148 Flameproof enclosures for electrical apparatus.
- IS:13346 General requirements for electrical apparatus for explosive gas atmospheres.
- IS:5572 Classification of hazardous areas (other than mines) for electrical installation areas having flammable gases & vapors.
- IEC:79 (Applicable parts) Electrical apparatus for explosive gas atmosphere.

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- 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 telephone 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 IPPBX, and shall comply with the entire telecommunication carrier's requirements; technical compatibility between the public and private networks shall be ensured.

### 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 Flameproof to Ex-d IIC/T6 and weatherproof to IP67 as per IEC529, irrespective of plant's hazardous area classification.

All the outdoor equipments shall have certification for use in Zone-2, Gas group IIC/T6, 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.  $\pm 10\%$
- b) Supply frequency 50 Hz  $\pm 3\%$

### 31.4 DETAILS OF DESIGN

DESIGN SPECIFICATIONS:

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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 capacity shall be decided in consultation with PMC/Owner. 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 IPPBX and a Main Distribution Frame (MDF) shall be located at the control room. There shall be 100% redundancy(criss-cross) between IPPBX and MDF.

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 as 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.



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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.

It shall be possible to interface the system with Fire Alarm system via RS485 serial interface over MODBUS protocol and with the central IPPBX system 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-54 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, colour 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 with same colour 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.

### **32.0 LOCAL AREA NETWORK (LAN) FOR CR**

The Bidder shall lay the LAN required for Main CR area.

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## BASIS OF DESIGN

The system shall have as a minimum the following for CR:

1. Manageable L2- 48 port switch with 1G/10G port with 48 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. 24 Nos 3 m/Cat 6A patch cords
5. 24 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.
8. Provision for LAN /telephone sockets in all rooms in all Plant buildings.

### 33.0



#### Compressor Controls System (CCS)

CCS will continuously monitor and control centrifugal compressors through performance control (including energy efficiency), remote adjustment of speed set point and anti-surge protection. Moreover a CCS may be interfaced with a Machine Monitoring Systems (MMS) for machinery protective functions and with a Safety Instrumented System (SIS) for all safety and shutdown actions.

DCS shall provide the integrated operator interface for start-up, shutdown and continuous control, through delicately configured graphic displays.

CCS and its associated hardware shall be totally independent from all other DCS hardware, with the exception of communication links, and will not require the correct operation of any other system to fulfil its own functions.

The architecture shall be based on redundant data communication, control processors and power supplies. A failure of a single supply voltage shall not cause any disturbance in system function A dedicated and independent CCS shall be provided for each compressor or each compressor train requiring CCS control in each plant area. This includes all System hardware and software, I/O and marshalling cabinets. There shall be no common equipment shared between two or more plant area, with the only exception of control, maintenance and supervision networks, and Engineering Workstation's (EWS) which will be common to all Systems present in the

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same DCS Area. Systems and Engineering Workstations shall be on-line for monitoring, diagnostics, configuration and software maintenance.

The Human-Machine Interface (HMI) for CCS, as per all DCS sub systems and applications, will be through DCS Operator Consoles in CR. These will include DCS Operator Workstations, auxiliary panels containing hardwired buttons and lamps, peripherals such as printers, and communication equipment.

For this purpose each CCS shall interface the respective DCS plant area through redundant communication link. No interface with auxiliary panels shall be foreseen for CCS. Interface with all other systems, including compressors local panels, shall be via hardwired signals. All interconnecting type and quantity among the CCS and other systems/subsystems shall be shown on the above mentioned drawings.

#### **34.0 Instrument Workshop**

Instrument Workshop is in the LSTK bidder's scope. Bidder shall provide all the workshop equipment required for maintenance and calibration of the instruments.



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## **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% FS
Conductivity , pH meters	+/- 0.5 % of Reading
Belt weighers	+/- 0.5 % of range
Differential pressure & Pressure transmitter - SMART	± 0.050% of span within TD ratio of 1: 100 or better
Diaphragm seal transmitter & Pressure transmitter - SMART	± 0.10% of span within TD ratio of 1: 100 or better
Rotameter with transmitter	± 2.0% FS Note (1)
Vortex flow meter	± 0.7 % FS
Positive displacement flow meter	
- Raw material and Product	± 0.2% FS
- Others	± 0.5% FS
- Turbine meter or Mass flow meter	
- Raw material and Product	± 0.2% FS
- Others	± 0.5% FS
- Electromagnetic type flow meter	± 0.5% FS
- Mass flow meter (Coriolis Type)	± 0.1% FS
- Ultrasonic type flow meter(clamp on)	± 0.5% FS
- Ultrasonic type flow meter( 5 – path)	± 0.25% FS
- Ultrasonic type flow meter( 1 – path)	± 2% FS
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% FS
- Displacement type level transmitter	± 0.2% FS (Smart)
- Tank gauge (Custody Transfer)	± 1 mm with +/- 1 mm resolution

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- 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
- 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% FS
- Small size pressure gauge	± 3.0% FS
- Draft gauge	± 3.0% FS
- Receiver gauge	± 1.5% FS
- 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, or Vendor's standards as approved by Purchaser.  
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.

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## **ANNEXURE -2**

**Field instrument connections shall be as follows.**

<b>Instrument Type</b>	<b>Process / Vessel Connection</b>	<b>Instrumentation Connections</b>
DP Flow Instruments	½" NPT (M)	½" NPT
External Displacer on Vessel	2" Flanged	2" Flanged
Internal Displacer	4" Flanged	4" Flanged
External Ball Float on Vessel	2" Flanged	2" Flanged
Internal Ball Float	4" Flanged	4" flanged
Magnetic Level Gauge	2" Flanged	2" Flanged
D/P Level	½" NPT (M)	½" NPT
D/P Level with Remote Seal Diaphragm	3" Flanged	3" Flanged
D/P Level Direct Vessel Mounted	2" Flanged	2" Flanged
RADAR – Direct Mount on vessel	3" flanged	3" flanged
GW RADAR – Side/Side Chamber Mounted on vessel	2" flanged	2" flanged
Internal GWR on Equipment	4" Flanged	4" flanged
Special Level Instrument on Equipment (Ultrasonic)	2" flanged	2" 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 (Ultrasonic) on Atmospheric tank / Pressurized Equipment	2" flanged	2" flanged
Pressure Instruments	½" NPT (M)	½" NPT
Press.Gauge	½" NPT (M)	½" NPT
Pressure with diaphragm seal,	2" Flanged / 3" Flanged	2" Flanged / 3" Flanged



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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	1.5" Flanged	1.5" Flanged
Thermowell	1 ½" Flanged	1 ½" Flanged
Multipoint Temperature Element for Tanks	2" Flanged / 3" Flanged	2" Flanged / 3" Flanged
Standpipe	3" Flanged	-

Note:-

- 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). However, as an exception to this, three transmitters on clean gas services from one orifice (with two pairs of tapping) is acceptable, where multiple (2 out of 3, etc.) transmitters are to be installed.
- 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.
- Min. 3" Flanged remote Seal connection.
- All type of instrument tapping flange rating shall be as per Line/vessel rating. However for pressure rating of 900# class and above, RTJ flange shall be used. At few locations, double isolation valves shall be used as per table given below.

INSTALLATION RATING	PRESSURE TAPPINGS	LEVEL TAPPINGS	FLOW ELEMENTS	CONTROL VALVE
150# 300 #	SINGLE	SINGLE	SINGLE	SINGLE
600 #	DOUBLE	SINGLE	DOUBLE	SINGLE
900 # / 1500 # / 2500 #	DOUBLE	DOUBLE	DOUBLE	SINGLE

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### **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 5.2 (e.g. , CCTV, FGS system, etc. requirements). Any other system required has also to be provided by LSTK bidder.

#### **Coal Gasification Plant**

##### **DCS**

- 5 Nos. Operator Stations with, 24" TFT, COLOR, LED type dual monitors (stack type)
- 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
- 2 Nos. ES/OS dual personality, 24" TFT, COLOR, LED type
- 1 No. Supervisor Station
- 1 No. Annunciator with LED type (24")
- 1 No Auxiliary Console

##### **ESD**

- 1 No. ES/OS dual personality, 24" TFT, COLOR, LED type
- 1 No. SOE PC, 24" TFT, COLOR, LED type

##### **Printers**



- 1 No. A4 Heavy duty Black and white Laser printer
- 1 No. A3 Heavy duty Colour Laser printer
- 4 Nos. (70") LVS with 2x2 configuration

#### **PURIFICATION UNIT**

##### **DCS/ESD**

- 3 Nos. Operator Stations, 24" TFT, COLOR, LED type dual monitors (stack type)
- 1 Nos. Operator Stations( compressors), 24" TFT, COLOR, LED type
- 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, 24" TFT, COLOR, LED type
- 1 No. SOE PC, 24" TFT, COLOR, LED type
- 1 No. Annunciator with LED type (24")



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### **SULPHUR RECOVERY UNIT**

#### **DCS/ESD**

2 Nos. Operator Stations, 24" TFT, COLOR, LED type dual monitors (stack type)

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, 24" TFT, COLOR, LED type

1 No. SOE PC, 24" TFT, COLOR, LED type

1 No. Annunciator with LED type (24")

#### **COAL/PETCOKE/LIME HANDLING**

1 Nos. ES/OS dual personality, 24" TFT, COLOR, LED type

1 Nos. Operator Stations, 24" TFT, COLOR, LED type dual monitors (stack type)

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

#### **Printers**

1 No. A4 Heavy duty Black and white Laser printer

1 No. A3 Heavy duty Colour Laser printer

#### **Common Stations**

1 No. AIMS PC with 1 TB Harddisk, 24" TFT, COLOR, LED type

1 No. Instrument Asset Management System with HMS, 24" TFT, COLOR, LED type

1 No. OPC Server with interface package station, 24" TFT, COLOR, LED type

1 No. Documentation Node 24" TFT, COLOR, LED type

1 No. Fire wall / DMZ

1 No. Terminal Server, 24" TFT, COLOR, LED type

Any other compressors ES/OS 24" TFT, COLOR, LED type

MMS SERVER 24" TFT, COLOR, LED type

OTS Hardware and software mentioned in clause 27.3



Mass-spectrometer/GC (if applicable) with Laptop

CCTV System

1 No. CCTV server 24" TFT, COLOR, LED type

55" CCTV monitor

FGS system:

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1 No. Unified Gateway Service Both Way system with OPC with 24" TFT Color LED monitor with requisite software/hardware for Remote Viewing.

2 Nos. View station for top management connected to PLANT LAN via Firewall / OPC, 24" , COLOR, LED type.

All hard disks of above mentioned systems shall be SSD instead of HDD



Suitable Hardware, software & support (erection, commissioning) required for the interface of the coal gasification Plant Control system; with 2 nos. Operator Stations placed in different Control Room within the plant complex through redundant fibre optic cable communication.

Provision of additional 200 IOs wired upto Marshalling Cabinet/System cabinet separate from Spares shall be considered to integrate other Packages inside complex. It shall also be considered in Controller loading

Connection to supervisory station (owner side) shall be ensured by LSTK contractor. Requisite software/hardware shall be LSTK contractor scope.

#### **Analyser PLC**

One Analyser PLC with laptop for each Analyser shelter shall be provided with redundant connectivity to Control Room.

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## **Annexure – 4**

### Indicative Sample format for PTR

[illegible]

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# GENERAL SPECIFICATION

## FOR

### ANALYSER SHELTER

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### **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.

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#### 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

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## 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).



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## 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 *Institute*/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 *NPS* 2 through *NPS* 24

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

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ASTM A269 Seamless Welded Austenitic 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 than 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 than 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 for 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

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- 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:
- Compliance to the specifications.
  - 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.
  - Proven references for each offered analyser shelter inline with clause 1.2.3 of this specification.
  - General arrangement / Layout drawing of each shelter.
  - List of utilities with expected consumption of each shelter.
  - 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:
    - 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.
    - 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.
  - 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.
  - 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.

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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 normally performed in the protection of the 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.

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#### 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

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 20%** 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.

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- 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:

- 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.
- 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 20 % 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

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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/m<sup>2</sup>. 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.



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## 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.



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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 1 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 of rain 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 by simple push, fitted with panic bar for use in case of emergency. The main door shall be provided with outside pad lock holes. Warning light 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.

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2.2.11 A nameplate with the analyzer shelter number shall be fixed near the main 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 shelter 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)

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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 T4 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 of pressurisation 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  $24^{\circ}\text{C} \pm 2^{\circ}\text{C}$
  - ☐ Pressure 5 – 10 mmwc
  - ☐ Humidity 50% RH  $\pm 5\%$

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

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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 5mmH<sub>2</sub>O 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 20m<sup>3</sup> 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 Zone 1 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

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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-erosive 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.

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2.6.2.7 All equipment shall be suitable for operation in their respective area classification. For Analyser shelters located in classified area (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<sub>2</sub>S, SO<sub>2</sub>, NO<sub>x</sub> 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 of dust.

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 Analyzer 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 H<sub>2</sub>S, SO<sub>2</sub>, NO<sub>x</sub> 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:



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Dry bulb temperature       $26^{\circ}\text{C} \pm 1^{\circ}\text{C}$

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 ( $\text{g}/\text{m}^3$ )		INSIDE (PPM by Vol.)
	Yearly Average	Max. (8 hr. average)	
S O <sub>2</sub> / SO <sub>3</sub>	100	13000	< 0.010
NO <sub>x</sub>	100	9500	< 0.05
H <sub>2</sub> S	TRACES	13900	< 0.003
* Cl <sub>2</sub>	TRACES	2900	< 0.001
* NH <sub>3</sub>	TRACES	TRACES	< 0.5
SPM	400	15000	< 200 $\text{g}/\text{m}^3$
RSPM	250	-	< 100 $\text{g}/\text{m}^3$ (< 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

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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) 115VAC 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  $\pm 10\%$  and supply frequency fluctuation of  $\pm 3\text{Hz}$  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 115V 50Hz and 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.

Vendor shall furnish the list of utilities required with expected consumption.



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## 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

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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 1" 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 1" 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 1/8"OD SS tube 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 ANSIASME B I. 20.1.

b) Flanged end connections shall be as per ANSIASME 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 ANSIASME B 16.5. The face finish 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:

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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 1 meter all around the footprint of analyzer shelter.

2.14.2 Analyser shelter shall be supplied with base channel of min. 150 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:

- All surfaces including structures shall be sand blasted and grinded smooth and free of scale, rust etc.
- Chemical treatment shall be done to remove rust, oil, entrapped impurities and other foreign materials.
- 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:


- Tag number as per purchaser's data sheet.
- Manufacturer's serial number (If any).
- Manufacturer's name/trade mark.
- Area classification in which the shelter can be used.
- 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 H<sub>2</sub>S
- 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.

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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 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 3.1B 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/cm<sup>2</sup>(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.

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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/cm<sup>2</sup>(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/cm<sup>2</sup>(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/cm<sup>2</sup>(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 not exceed  $\pm 2.0$ mm.

### 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.

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#### 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.

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## 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. Flashing 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 and lamp 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.



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### **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 eliminate interference. The trunking shall be sized with at least 20% 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:

115VAC  $\pm$  3%, 50 Hz  $\pm$  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 T4, these shall be supplied by vendor.



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Vendor shall calculate the expected load, for each supply voltage, with a 20% allowance for future expansion; these calculations shall be supplied to the client. All distribution boards shall have 20% 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 20% 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 for Zone 1 IIC T4 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 zone 1 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 2.5mm<sup>2</sup> and also for all fire and gas detector cable size shall be 2.5mm<sup>2</sup> and other instrument signal wiring shall be 1.0mm<sup>2</sup> 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.

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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 16mm<sup>2</sup> 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 16mm<sup>2</sup> 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 6mm<sup>2</sup>. Provision shall be made for site connection of two 70mm<sup>2</sup> earth conductors to the earth bar. Earth continuity shall be ensured throughout the analyzer houses including all doors and framework.

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## 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.

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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.

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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.

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# REQUIREMENTS FOR ANALYSER SYSTEM

FOR

ANALYSER SHELTER

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## **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.

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- 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 shall 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.



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- i. Wherever it is necessary to maintain the handling system at elevated temperature to properly condition the sample ,it shall be 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  $26 \text{ degc} \pm 2 \text{ deg c}$  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 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.

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## 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.

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- 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 building. 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 the event. This vent shall be in addition to the analyser vent.

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- 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 furnish 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.

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- 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 along with 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.

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#### 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 warning 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 contract 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.

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- 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 for testing, 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 / shelter, 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 a minimum of interference with other concurrent construction and commissioning activities.

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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 / piping etc. 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..
- 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.



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- 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 designed pressure.

## 12.0 TRAINING:

Contractor shall be responsible to train the Owner / 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 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 each part 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

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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 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.

#### **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 personnel 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.


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### 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'.

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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.

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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 technical specifications 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



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- 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;

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- 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

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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 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 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


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- 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.

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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 115V AC 5 Amperes.

#### 2.1.11 Statutory Regulatory Compliance

The design of analysers shall be in compliance to EPA, TUV or any other recognized regulations applicable in the country of origin. 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 115V 50Hz power supply.

2.1.14.2 The analyser performance shall be within the specified limits when the supply voltage varies by  $\pm 10\%$  of specified value and supply frequency varies by  $\pm 3$  Hz of specified value.

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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.

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- 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:



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- 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.



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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

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- 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  $\pm 1\%$  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

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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/CO<sub>2</sub> 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 SO<sub>x</sub> 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.

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2.4.7 Unless otherwise specified, analysers shall meet the following performance requirements:

Zero/span Drift	:	$\pm 1\%$ of full span/week
Repeatability	:	$\pm 0.5\%$ full scale or better.
Response time overall	:	less than 90 seconds for 90% of final reading.
Linearity	:	$\pm 1\%$ 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-NO<sub>2</sub>, 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	:	$\pm 1\%$ of full span/week
Repeatability	:	$\pm 0.5\%$ full scale or better.
Response time overall	:	less than 90 seconds for 90% of final reading.
Linearity	:	$\pm 1\%$ 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.

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Zero/span Drift	:	$\pm 1\%$ of full span/week
Repeatability	:	$\pm 1\%$ full scale or better.
Response time overall	:	less than 30 seconds.
Linearity	:	$\pm 1\%$ 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 stackanalyser 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.

### 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.

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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.

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- 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.

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



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- 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:
- Dimensional verification certificate for each analyser.
  - Material test report as per clause 2.2 of EN10204 for all wetted parts.
  - Manufacturer's test reports as per clause 3.1B of EN 10204 for various bought out components.
  - Leak test report for complete analyser system including sample handling system using Nitrogen or instrument air at 1.5 times the maximum working pressure.
  - Calibration report for each analyser as per clause 4.3 of this specification.
  - Repeatability test for each analyser as per clause 4.4 of this specification.
  - Power supply variation check.
  - Test certificates for zero, span, carrier and fuel gases as applicable.
  - 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:
- Check/adjust zero by connecting zero gas and span by connecting span gas.
  - Check again zero by connecting zero gas after (a) above. Also repeat span gas check.
  - 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.
- 24 hours by manufacturer and report to be submitted for review.
  - 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:

- Physical dimensional verification and workmanship.



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- 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.

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# GENERAL SPECIFICATION


## FOR

## ANALYSER SYSTEM

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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.

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- 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.

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**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
- 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.

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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.


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- 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.
- Carrier gas and fuel gas (wherever required) with dual manifold cylinders configuration.
  - 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.




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- 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:
- The field testing, commissioning and final acceptance
  - 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;
- Accuracy/Precision of the calibration gas.
  - 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:
- 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.
  - It is intended to operate the analysers even during the ventilation failure, hence it required that all analysers shall be suitable for hazardous area.
  - 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.
  - 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:

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- 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.

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#### 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


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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.

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- 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.

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## 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/repared 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.

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- 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.


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# GENERAL SPECIFICATION

## FOR


# PROCESS STREAM ANALYSER



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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'.

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National Fire Protection Association

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.

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- 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) Reference 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.


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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.

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### 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.

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## 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 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 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 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.

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## 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) 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



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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
  - 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 110VAC 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 110V 50Hz power supply.

2.1.13.2 The analyser performance shall be within the specified limits when the supply voltage varies by  $\pm 10\%$  of specified value and supply frequency varies by  $\pm 3$  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.

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2.1.14.1 Unless otherwise specified, the following shall govern;

- a) Threaded connections shall be NPT to ANSIASME B1.20.1.
- b) Flanged connection shall be as per ANSIASME 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 ANSIASME B16.5. 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 ANSIASME B16.20.

2.1.14.2 End connection of sizes 6 mm or 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 proof Ex (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 shall be informed 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) shall be 1/2" NPT (F).
- c) Cable entry for multi-pair signal cables (Multiple output) shall be 1/4" NPT (F).

2.1.15.5 All enclosure entries including sample, utilities, cables etc. shall be clearly identified by

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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 cabinet/box 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.

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- 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 steam or electric power as specified in purchaser's data sheet. Heating shall be controlled such that the sample temperature is maintained typically around +200°C 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

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conditions, if applicable:

- a) Failure of heat 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 preinstalled in free standing 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.

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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  $\pm 1\%$  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 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 :  $\pm 1\%$  of full scale  
 Zero drift :  $\pm 1\%$  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.

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2.4.2 Analyser shall have precise temperature controller which shall be able to maintain temperature within  $\pm 0.1^{\circ}\text{C}$  to ensure stable detector operation.

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	:	$\pm 1\%$ of FSR
Repeatability	:	$\pm 1\%$ 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	:	$\pm 2^{\circ}\text{C}$ within a range of $60^{\circ}\text{C}$ to $65^{\circ}\text{C}$ (Dew point)
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$\pm 3^{\circ}\text{C}$  within a range of  $-66^{\circ}\text{C}$  to  $-110^{\circ}\text{C}$

Repeatability	:	$\pm 0.5^{\circ}\text{C}$ in range of $60^{\circ}\text{C}$ to $65^{\circ}\text{C}$ $\pm 1.0^{\circ}\text{C}$ in range of $-60^{\circ}\text{C}$ to $-110^{\circ}\text{C}$
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	:	$\pm 5\%$ of reading
Repeatability	:	$\pm 1\%$ 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.



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### 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 with LCD/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	:	±1% 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.

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2.6.4.3 The analyser shall have integral electronics with built in LCD/LED display. Electrochemical analyser shall meet the following performance characteristics as a minimum:

Accuracy	:	$\pm 1\%$ of full scale.
Repeatability	:	$\pm 1\%$ 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


- The sensor assembly shall consist of the measuring cell, heater assembly, temperature sensor and connections for reference and calibration gases.
- The measuring cell shall be a zirconia sensor specific for oxygen measurement.
- The sensor shall be suitable for operating sample temperature up to 700°C.

##### 2.6.5.4.2 Control Electronics

- 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.
- Sensor temperature shall be maintained through temperature controller. Temperature sensor shall preferably be ISA type K thermocouple.
- Temperature controller shall cut-off power to heater in case of thermocouple burns out.
- 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.

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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.

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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.IB 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.

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- 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.

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# GENERAL SPECIFICATION

## FOR

### CALIBRATION GAS REQUIRMENT

### & UTILITY CONSUMPTION

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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/Carrier 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 analyser. 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 in 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 in fortnight interval as a minimum.
  - e) Calibration gas cylinders shall be preferably of SS316 material. Aluminium gas cylinders are not 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

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## 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.	<b>Note 2</b>				
2.	<b>Note 2</b>				

(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.	<b>Note 2</b>				
2.	<b>Note 2</b>				

### 2 Instrument Air:

S. No.	Item	Normal (Nm3/hr)		Maximum (Nm3/hr)	
1.	<b>Note 2</b>				
2.	<b>Note 2</b>				

**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**



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# GENERAL SPECIFICATION FOR MASS SPECTROMETER

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### **1.0 GENERAL**

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### 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

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be 115 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 containing Ammonia vapours and Urea dust.

#### 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. Compression fittings

Double ferrule compression fittings must be utilized.

##### b. Pressure regulators

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.

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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:

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- 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 analyzer shall be the slipstream from this filter. By-passed sample shall be returned to process or to flare / 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**

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Where two or 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 H<sub>2</sub>S content) are sampled.

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- 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 H<sub>2</sub>S) 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 liquid 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 / 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.



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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).

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### 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

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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 be provided 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 maintain 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 be utilized). Heating shall be done using a radiator adequately sized by Vendor. Internal

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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 H<sub>2</sub>S", 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.

- Sampling and return line lengths
- Proposed lines size (to be confirmed by Vendor)
- Sample composition
- Sample take-off point temperature and pressure
- Sample return point temperature and pressure
- Sample take-off point density.
- Sample take-off point viscosity.
- 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.

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### 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 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).

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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.
- 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.

### 3.2. Mass spectrometer

Mass spectrometer is common for all sample points.

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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.

### 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



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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:



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#### 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.

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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 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.

## 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

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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.

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## 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

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## 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.

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## GENERAL SPECIFICATION FOR MOTORISED ACTUATOR

## CONTENTS

SECTION NUMBER	DESCRIPTION
1.00	GENERAL
2.00	CODES AND INDUSTRY STANDARDS
3.00	MOTORISED ACTUATOR
4.00	INSPECTION, FACTORY TESTS & APPROVAL
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	<b>Actuator torque Specification</b>	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 INSTITUTE (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, T4.**

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<sub>3</sub>, CO<sub>2</sub> 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 gear case.

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 T4 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 required.
- 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 lamicaid 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.

## Annexure – I 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												




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# **GENERAL SPECIFICATION** **FOR** **DISTRIBUTED CONTROL SYSTEM & PLC SYSTEM**

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#### 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

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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  
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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 Protection 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




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	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	
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:

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- 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

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(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.


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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.

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- 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

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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**

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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**

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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



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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

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### **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 Deleted**

### **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 Deleted**

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### **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**

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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

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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;

- 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.
- 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.
- 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.
- 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.
- Processor system of programmable logic controller shall have capability to execute additional 20% logics.
- 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
- 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

- The system shall be provided with a minimum of 50% spare memory capacity, as required for application program and data base to meet specified functional requirements.
- 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.
- 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

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- 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**

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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.

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#### **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 Deleted**

#### **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.



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## 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;

$$\text{Availability} = \frac{\text{Meantime Between Failure (MTTF)}}{\text{MTTF} + \text{Mean time to repair (MTTR)}}$$

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.

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#### 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
SO <sub>x</sub>	<10ppb
No <sub>x</sub>	<5ppb
H <sub>2</sub> S	<5ppb
Cl <sub>2</sub>	<10ppb
SPM	<0.2gm/m <sup>3</sup>

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	1 No.
	Rack Room	
Corrosion Switch Unit	Rack Room / Satellite	3 Nos.
	Rack Room	

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		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.

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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


- Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.
- For conventional instrumentation, entity concept shall be used for selecting proper barriers / isolators.

##### 5.1.8.3 **Deleted**

#### 5.1.9 Repeat Signals

5.1.9.1 Unless otherwise specified in the job specifications, following philosophy shall be followed for repeat signals;

- Whenever repeat contact outputs are required as per job specifications following philosophy shall be followed;
  - For intrinsically safe input contacts, isolating barrier with dual contact output shall be utilized.
  - For all other contact inputs, repeat contact shall be provided using electro magnetic relays.
- Whenever repeat analogue outputs are required as per job specifications, following philosophy shall be followed;
  - For intrinsically safe analogue inputs, isolating barrier with dual analogue outputs shall be utilized.

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- 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;

- The foreign devices shall either be configurable from DCS engineering consoles or from the dedicated engineering consoles of each foreign device.
- Unless specifically indicated otherwise, each foreign device shall be integrated with DCS through MODBUS (RTU) protocol using redundant interface unit.
- Operator console shall display information in the similar fashion irrespective of source of information. Source of information shall be transparent to the operator.
- The process alarms and diagnostic alarms shall be presented on the operator console in the similar fashion as DCS alarms.
- Whenever specifically indicated, the time of all foreign devices shall be synchronized with DCS clock or GPS, as specified in the job specification.
- 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;

- 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.
- All fieldbus segments at control system end.
- All power incoming cable (115 V AC ) UPS or non UPS, at the power supply distribution cabinet.

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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.


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- 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 be 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.

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- 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;
- Noise level shall not exceed 55dBA for equipments installed in console room, engineering room and computer room.
  - Noise level shall not exceed 65dBA for equipments installed in rack room and satellite rack room (SRR).
  - 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.



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#### 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.

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- 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),

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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 annunciations, 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.

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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	$\pm \frac{1}{2}$ LSB
Accuracy	$\pm 0.1\%$ 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	$\pm 1$ LSB
Accuracy	$\pm 0.25\%$ 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.

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#### 5.3.15.2 Analogue Input / Output modules (conventional / smart)

The input module shall meet the following requirements;

- 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.
- The input module shall support field powered transmitter i.e 2-wir, 3-wire or 4 wire system.
- Input faults such as open circuit, short circuit and earth fault shall be detected by I/O module.
- The output module shall provide 4-20mA output driving up to 600ohms of total loop resistance at 24V DC.
- The system shall provide 24V DC for loop powered 2-wire transmitter and shall also loop power the 2-wire outputs.
- Input / Output module shall not have more than 16 inputs or outputs.


#### 5.3.15.3 Analogue Input / Output module with HART

- The Analogue Input / output modules for HART signal shall meet all requirements specified in clause 5.3.15.2 above.
- 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 Deleted

#### 5.3.15.5 Temperature Input Module

- 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.
- The module shall have 12 bit resolution with digital accuracy of  $\pm 1^{\circ}\text{C}$
- The RTD input module shall accept 100ohm platinum resistance temperature detector (Pt 100) in 3-wire or 4-wire configuration.
- The module shall be capable of linearising the RTD input.
- The module shall have 12 bit resolution with digital accuracy of  $\pm 0.28^{\circ}\text{C}$

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#### 5.3.15.6 Serial Interface Modules

- Serial Interface modules shall be capable of communicating with RS232C, RS422 or RS485 signals.
- Unless otherwise specified, all serial interface modules shall be configured in redundant configuration.

#### 5.3.15.7 Discrete Digital Input / Output Module


- 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.
- The input module shall also be suitable to accept inputs from proximity switches or from open collector output from proximity input barrier.
- The digital output module shall provide output contact rated for 220V AC 10 Ampere 110V AC 5 Ampere or 110V DC 0.3 Ampere.
- The type of contact output ie. normally open or normally closed shall be user selectable.
- Maximum number of inputs or outputs shall not exceed 32.

#### 5.3.16 Deleted

#### 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;

- Control algorithms  
Proportional (P), Proportional – Integral (PI), Proportional – integral – derivative (PID), adaptive gain, feed forward, cascade, split-range etc.
- Dynamic Functions  
Lead-lag, dead time, timers, counters etc.
- Signal Selector  
High selector, low selector, high-low selector.
- Calculation Blocks

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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.

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- 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;
- Control function parameters
  - Processor cycle time for each loop tagwise.
  - Macro-cycle time for foundation fieldbus HI segment as per segment loading.
  - 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.



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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.

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- 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.

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- 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

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5.4.2.1 Each operator console shall consist of the following;

- 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.
- 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.
- 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.
- 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;


- Data connectivity between CDAS and other sub-systems (i.e. operator sub-system, engineering sub-system, IAMS etc.)
- Database storage and engineering functionality as per Clause 5.4.2.3 of this specification.
- Historisation of data related to associated operator consoles.

This server can also be used for functions like;

- Plant history
- Connectivity to information network or OPC node.
- Running specific applications like generating advance controls, MIS reports, IAMS, AIMS etc.

##### 5.4.2.2.3 Option III

- 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

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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.

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- 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

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- 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:

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- 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.



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- 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 of 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.

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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:

- 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.
- 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.

- At intervals 1 second or higher for the real time trend.
- 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.

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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

- 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.
- 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.
- 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.
- 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:

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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.

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- 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

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- 5.4.4.2 The system shall have a report builder and report scheduler which shall have following capabilities;
- 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.
  - The system shall be able to generate reports as per operator command either on-demand or on predefined time.
  - 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
  - The generation of on demand report shall not affect any scheduled report.
  - 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;
- Basic arithmetic calculations such as averaging, summing, multiplication, division etc.
  - Advanced calculations like efficiency calculations, conditional calculations etc.
  - Extended log reports such as weekly and monthly reports.
  - 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.

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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;

- All tag numbers, analogs as well as digitals, shall be available for hourly log.
- All flow tag numbers and other selective tag numbers shall be available for daily log report.
- Only selective tag numbers shall be available for weekly and monthly report.
- 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.

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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.



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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

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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

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5.4.9.1 The servers provided as part of standard system architecture shall have fault tolerant architecture with a minimum availability of 99.9999%. The design requirements of each server shall be dependent on its functional requirements such as;

- Guaranteed throughput performance.
- Continuous and consistent data connectivity even during fault.
- Continuous and consistent processing of data even during fault.
- 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);

- Number of operator workstation (clients)

Consider 1.2 times the specified number of operator workstations rounded to next higher whole number for each type.

- Number of Engineering workstations (clients)

Consider 1.2 times the specified number of engineering stations round to next higher whole number.


- Number of Controller and data acquisition nodes

Consider 1.4 times the specified number of CDAS nodes.

- 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.

- 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.

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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 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 a 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)                | : | 33% of 'A' |
| with over view display.                               |   |            |
| b) Number of operator console VDU's (WS) with         | : | 33% of 'A' |
| trend displays.                                       |   |            |
| c) Number of operator console VDU's (WS) with graphic | : | 33% of 'A' |
| displays.   |   |            |

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


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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;
- 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.

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- 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 Deleted

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#### 5.5.8.3 Deleted

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#### 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.

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- 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 **Deleted**
- 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;
- Communication system status display
  - 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.

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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



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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 data 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.

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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.

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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 attenuation. 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;

- Multi-processor design for high performance operation.
- 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;

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- 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

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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 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	:	10 (when specified)
Such as RTU's		
- c) Follow up rate of data read / write shall be considered for sizing;

OPC client data read (cache read)	:	1000 per second
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- 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 : max. 5 seconds  
 (This includes data display update for real time data)  
 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.

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- 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 swapped 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

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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 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.

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

- PLC system configuration / architecture shall be as specified in the job specification. For emergency shutdown system application specified with SIL 3 classification, the system configuration shall be TMR QMR, FMR or VMR
- 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.
- 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 asynchronously w.r.t control processor and other I/O processors. However, I/O modules configured in redundant configuration, shall have their processors properly synchronized.



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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
- Each I/O module shall have a LED per channel to indicate the status of each Input/Output.
  - 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


- Input module shall be capable to accept input from transmitters (.e.g. 4 – 20mA ).
- The module shall have 12 bit A/D resolution accuracy of  $\pm 0.25\%$  of full scale over the entire range, unless otherwise specified.

- 5.9.9.2.10
- Output contacts from the PLC shall be potential free dry contacts with contact rating as per para of this specification. Wet contacts/ powered contacts / TTL outputs etc. shall not be acceptable. Vendor must provide arc suppression device for each output contact.
  - 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.


- Each output shall be short circuit proof and protected by fuse. Visual indication of fuse blown must be provided for each module.
- When specified contact output module shall have monitored output features like 5.9.9.2.8(b).

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- 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.

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- 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 24" 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;

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- 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

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- 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.
- 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.
  - For the triple redundant system, each processor shall have a separate set of PLC communication subsystem.
  - For the QMR, VMR, FMR systems each I/O subset shall have separate communication interface and bus for connecting to respective CPU module.
  - 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.
- .
- 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:
- Display of all input points under alarm/first out alarm connected to PLC or generated by PLC on the main operator console.
  - Generate shutdown reports on the logging printer of Distributed Digital Control System.
  - To receive certain operational commands from the operator console for the operation of certain output devices connected to PLC.
  - 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.

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#### 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

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- 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

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otherwise. A separate SOE PC with 24" 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 :-
- 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.
  - The hardware used shall allow unrestricted transfer of digital signal without degrading the analog data i.e process variable.
  - 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:-




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- (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.

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- 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;
- All smart and field-bus based instruments connected to Distributed Control System or Programmable Logic Controller.
  - Conventional (non-smart / non field-bus) instruments connected to DCS or PLC or any other dedicated instruments.
  - Field Instruments other than (a) and (b) above eg. local gauges etc.

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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 parallelly 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 24" colour TFT monitor along with a keyboard and a printer.

5.13.4 The system shall support multiple authorisation levels for carrying out configuration changes 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

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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;

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- 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.

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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.  |

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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


- AIMS shall display alarms gathered from all Nodes / subsystems seamlessly and shall be displayed on any display irrespective of source or location.
- 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.
- AIMS displays shall be in graphic form with user friendly displays, color modifiers etc.
- 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

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- 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.



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- 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 text (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.

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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 realised 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.

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- 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;
- The system shall be capable of interaction with DCS via a serial port or by OPC connectivity.
  - 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.
  - The AIMS console shall be server based machine and shall have 21" LCD display screen with keyboard, mouse and read / write DVD drive.
  - 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).
  - 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

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- 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 **Deleted**

#### **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;

- The maximum number of inputs for I/P module shall be 32.
- 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)
- 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.

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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:

- Display important operational data of the plant /unit for ready reference like daily production, shutdown required /requested etc.
- Display operational situations like start up or shutdown to enable mangers / operators to discuss without disturbing the unit operator.
- Display any operator screen on the large screen.
- To provide real time clear luminous view of the unit to share information's between operators, unit managers and refinery manager.
- 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:

- The screen design shall be based on single chip DLP technology.
- 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

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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

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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.

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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 Deleted.

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	:	115V AC $\pm 10\%$
Frequency	:	50 Hz $\pm 3$ 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;



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- 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  $\pm$ 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  $\pm$  10%

Frequency : 50Hz  $\pm$  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

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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 annunciators 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

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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;

- All nuts, bolts, screws, washers (lock or flat) and hinges shall be of stainless steel. All fastening links shall also be of stainless steel.
- 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

- 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.
- 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.

- 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.
- 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.
- 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

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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 least 10,00,000 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

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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.

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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.


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#### 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.

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#### 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.



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- 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.

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- 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.

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## **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

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- 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;

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- 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

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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:



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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

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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.

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- 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.

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f) **Deleted**

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;

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- 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

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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.

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- 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.

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- 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.



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- 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


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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:-

	<b>Type of Instrument</b>	<b>Mode of Signal Generation</b>
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  $\pm 1.0\%$  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**

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- 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;
- Hardware verification as per final Bill-of-material.
  - Visual and mechanical checking for proper workmanship, identification, ferruling, nameplates, etc.
  - System configuration as per approved configuration diagram.
  - Checking of correct functioning of all keyboards and dual function keys.
  - Checking of proper operation of hardcopy unit and all printers including printing of Alarms and Events on the Alarm & Event (A&E) printer.
  - Demonstration of all system diagnostics.
  - Checking of correct changeover of redundant devices.
  - Checking of redundancy for LAS functionality for fieldbus segments.
  - Checking of communication between DCS, PLC and other foreign devices.
  - Checking of proper functioning of all disc drives, historical trend-points, alarm summary and alarm history.
  - Verification of proper functioning of assignable trend recorder
  - Printing of Configuration and Configuration changes on C&M printer.
  - 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.

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Vendor's personnel shall be present during the test. Any malfunctioning of the system components shall be replaced/repared 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.

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## **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:


- Six months of formal class-room instructor experience.
- Complete and thorough technical knowledge of the equipment and system supplied under the contract and skilled experience in their programming, maintenance and operation.
- 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**

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- 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:
- Functional flow-charts, descriptive material, program source listings applicable to all operating and application software and diagnostics programs.
  - Schematic drawings of each assembly of the hardware for the course on maintenance.
  - 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:
- Actual operation, detection and correction of faults in equipments.
  - Familiarisation with maintenance procedures for the system offered.
- 2.2.7.3 Some of the topics covered in the course shall include:
- Fundamentals of the system
  - Equipment logic diagrams
  - Diagnostic procedures
  - Peripherals maintenance
  - 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:
- An operator console with a VDU, operator key board and engineering keyboard.
  - Controller with auto backup facility.
  - One each of the varieties of PCBs used in data acquisition.
  - Signal simulator.
- 2.2.8.2 Vendor to provide the details of the kit offered alongwith the proposal.



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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:

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- 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,

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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.
- Part-I, containing all system hardware and software requirements is furnished along with Material Requisition.
  - 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.


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## **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.

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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	:	Laboratoire 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	:	Physikalisch Technische Bundesanstalt
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 Überwachungsvereine
UHF	:	Ultra High Frequency


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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

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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: <ul style="list-style-type: none"> <li>a) Design Basis / Statutory regulations</li> <li>b) Data Sheets</li> <li>c) Standard Specifications</li> <li>d) Codes and Standards</li> </ul>
1.1.4	In addition to meeting purchaser's specifications in totality, vendor's extent of responsibility shall also include the following:

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- 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

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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:

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- 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.

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- 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 cover 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

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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

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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 of the 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)



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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:

- 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.
- For all serial input / outputs to the system, 20% spare serial I/O ports of each type of serial input / output shall be provided.
- 20% spare accessories like relays, switches, lamps, fuses, circuit breakers,

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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

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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

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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:

Availability =  $\frac{\text{Mean Time Between Failure (MTBF)}}{\text{MTBF} + \text{Mean time to repair (MTTR)}}$


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

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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	< 0.001ppm by volume
NH3	< 0.5 ppm by volume
SPM	< 200 ug/m'
RSPM	< 100 ug/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

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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 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.

#### 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

- Unless otherwise specified, all instruments in hazardous area shall be intrinsically safe type. Other concepts shall be used when specified.
- For conventional instrumentation, entity concept shall be used for selecting proper

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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 of this 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



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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 in 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.

SI 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	16



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	Redundant (FMR) configuration, Virtual Modular Redundant (VMR)	
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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 mA DC input from smart transmitters (e.g. 4 -20mA HART).
- b) The module shall have 12 bit Analog to Digital resolution accuracy of  $\pm 0.2\%$  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	<b>110 V DC</b> <b>24VDC</b>	0.5 A 2A

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2	All motors/pumps/compressor output cards unless otherwise specified. Category –I Category -II	<b>240 V AC</b> <b>220 V DC</b>	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.

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- 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 than 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 24" 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 of this 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 It shall be possible to print out the ladder/logic diagram on the dedicated PLC printer. The printer in addition shall also print out:
- The diagnostic messages as and when generated and diagnostic reports, when called for.
  - Process alarms connected to the programmable logic controller as and when they

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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 24" 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

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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 in 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	115 V $\pm$ 10%
Frequency	50 Hz $\pm$ 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

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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:
- Long storage historisation
  - Log report generation
  - First out alarm generation
- 4.2.8.6 System diagnostics shall be capable of identifying, locating and reporting the following faults, as a minimum:
- Processor fault

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- 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



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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-5.1 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




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- 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 110V $\pm$ 10% DC/ 24V $\pm$ 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 energised shall exceed 10° C above the ambient temperature. A temperature element (resistance temperature detector) shall be provided in each cubicle for temperature

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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 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 of 250 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.

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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 wiring. 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.

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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

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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 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 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 (copper).

#### 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.

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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 24" 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.



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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) /

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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



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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.

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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 terminals 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.

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## 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 in job 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.

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# INSPECTION AND TEST REQUIREMENTS FOR INSTRUMENTATION


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## 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
1.7	Pneumatic Test
1.8	Seat Leakage Test
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

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## 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

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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

☒ 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 400°C or over)
  - Low temperature service (Iron and steel material of design temperature below minus 11°C containing Al-killed steel)
  - Corrosion-resistant materials

- |      |   |   |
|------|---|---|
| I.   | Temperature detective parts                 | : <input checked="" type="checkbox"/> Flange and Thermowell |
| II.  | Orifice assembly                            | : <input checked="" type="checkbox"/> Flange                |
| III. | Venturi tube, Flow nozzle and Low-loss tube | : <input checked="" type="checkbox"/> Body                  |
| IV.  | Positive displacement flow meter and        | : <input checked="" type="checkbox"/> Body, Strainer and    |

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	Turbine meter		Straightner
V.	Area type flow meter	:	<input checked="" type="checkbox"/> Body and Flange
VI.	Displacement type liquid level meter	:	<input checked="" type="checkbox"/> Chamber and Flange
VII.	Glass Gauge	:	<input checked="" type="checkbox"/> Body and Flange
VIII.	Control valve	:	<input checked="" type="checkbox"/> Valve body, Bonnet, Plug, Seat and Vane
IX.	Safety valve	:	<input checked="" type="checkbox"/> Valve body, Nozzle and Disc
X.	Condensate pot	:	<input checked="" type="checkbox"/> Body
XI.	Gas eliminator	:	<input checked="" type="checkbox"/> 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  
☒ 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  
☒ ASME VIII Division 1 uw-51 "Radiographic & Radioscopic Examination of Welded Joints"

2. Acceptant standards and grade

- Casting : ☐ JIS G 0581  
☒ ASTM E 446-9 or 186-93



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**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


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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

☒ Hydrostatic test with Applicable codes and standards

#### 2. Body of special type

☒ Hydrostatic test

Test pressure and Hold time

☒ 1.5 times of max. Operating pressure / min. 2 kg/cm<sup>2</sup>g

☒ Minimum 5 minutes.

#### 3. Permanent distortion or Leakage

☒ shall not be found

### 1.6.2 Safety Valve or Safety Relief Valve


#### 1. Pressure retaining parts

☒ Hydrostatic test before assembling

##### i. Test pressure and Hold time

☐ 1.5 times of Max. Operating pressure / min. 2 kgf/cm<sup>2</sup>g.

☒ 2.2 times of Max. Operating pressure.

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☒ Minimum 5 minutes.

- ii Distortion or leakage  
☒ shall not be found

2. The out side parts of enclosed type  
☒ Hydrostatic test after assembling

- i. Test pressure and Hold time  
☒ 1.5 times. Nominal pressure of flange  
☐ 2.2 times. Nominal pressure of flange  
☒ Minimum 5 minutes.

- ii. Defects  
☒ Shall not be found

3. Special type valves

☒ 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

☒ Hydrostatic test or Pneumatic test as per applicable codes and standard

- I Test pressure and Hold time  
☒ 1.5 time of Max. Operating pressure / Min. 2 kg/cm<sup>2</sup>g  
☒ Min. 5 minutes
- ii Permanent distortion or Leakage  
☒ 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  
☒ Max. Operating Pressure. (Design press.)  
☒ Minimum 5 minutes
- ii Permanent distortion or Leakage  
☒ Shall not be found

1.8 Seat Leakage Test

1.8.1 Control Valve

Allowable leakage valve / (code):

☒ ANSI B16.104 (FCI 70-2)

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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

☒ 90% of set pressure

###### ii. Leakage

☒ Shall not be found

##### 2. Safety valve for Gas

###### i. Test pressure

☒ 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 (cm <sup>3</sup> /min)
General	16.0 and less	40	11.80
	20.5 and over	20	5.90
Balance bellows	16.0 and less	50	14.75
	20.5 and over	30	8.85

##### 3. Relief safety valves, Vacuum breakers and atmospheric valve

☒ 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.

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- [ ] 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  $\Omega$  or over (instrument panel: 3 M $\Omega$  or over/each panel)
- 2. Signal circuit : 5M  $\Omega$  or more (instrument panel: 3 M $\Omega$  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.


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**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	○	○	○	○ □	—	—	—	—	—	—

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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
		□●T	□●T	□●T							
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	—	—	—

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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
	○	○ □	○ □	○ □	○ □		○ □	○ □			
51 Pilot operated safety relief valve	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
52 Vacuum breaker	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
53 Atmospheric valve	●T ○	●S ○ □	●T ○ □	●T ○ □	●T ○ □	—	●S ○ □	●S ○ □	—	—	—
54 Gas chromatograph	●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 3<sup>rd</sup> 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.



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## SECTION – 5.3.1

### DESIGN PHILOSOPHY – PIPING

**PLANT: - COAL GASIFICATION PLANT  
FOR  
GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC  
NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT AT  
BARDHAMAN, WEST BENGAL, INDIA**

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1.0	Scope
2.0	Design Philosophy
3.0	Codes, standards and supplementary specifications
4.0	General Design
5.0	Design Philosophy / Criteria General
5.1	Equipment Layout
5.2	Plant Layout & Design guidelines
5.3	Unit Piping
5.4	Offsite & Yard Piping
5.5	Flare Piping
5.6	Underground Piping
5.7	Air Systems
5.8	In-Line Instruments
5.9	Sample Connections
5.10	Vents and Drains
5.11	Line Strainers
5.12	Spectacle Blinds
5.13	Flexibility Analysis and Supporting
5.14	Personnel Protection
5.15	Mechanical Handling
6.0	Materials
7.0	Thermal Insulation of Piping
8.0	Painting
9.0	Welding

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LIST OF ATTACHMENTS

ANNEXURE / ATTACHMENT NUMBER	DESCRIPTION
1	Table Of Basic Span
2	Accessibility For Valves & Instruments
3	Maximum spacing of Guides for Vertical & Horizontal Pipes
4	Clearances
5	Job Specific Requirements
6	Design Philosophy for Stress Analysis
7	Design Philosophy for 3D Modeling
8	Hydrotest drain & vent
9	Inspection & Test Plan for Piping items

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## 1.0 SCOPE

The scope of this document is pertaining to the design philosophy, norms 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	Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	Factory-Made Wrought Butt-Welding Fittings
ASME/ANSI B16.10	Face to Face and End to End Dimensions of Valves
ASME/ANSI B16.11	Forged Fittings, Socket- Welding 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 and Welding End
ASME/ANSI B16.47	Large Diameter Steel Flanges
ASME/ANSI B31.1	Power Piping
ASME/ANSI B31.3	Process Piping
ASME/ANSI B 31.3	Process piping-Dust Extraction piping
ASME/ANSI B31.5	Refrigeration Piping
ASME/ANSI B31.11	Slurry Transportation Piping Systems
ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe
ASME/ANSI B36.19M	Stainless Steel Pipe
API 5L	Specification for Line 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

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API 603	Class 150 – Corrosion Resistant Flanged End gate valves.
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 610	Centrifugal pumps and centrifugal pumping systems
API 623	Steel Globe Valves—Flanged and Butt-welding Ends, Bolted Bonnets
API 941	Steels for Hydrogen Service at Elevated Temperatures and Pressures
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 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 B31.4 Liquid Transportation Piping
  - ASME B31.5 Refrigeration Piping
  - ASME B31.8 Gas Transportation Piping
- Materials, design, construction, testing and inspection shall be fully in accordance with the selected specification.
- 2.2 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

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the approval of the owner and include any changes resulting from HAZOP studies and taking into consideration the following:

- General site layout taking into account the topographical geo-technical aspect of the site
- Access for maintenance and fire appliances
- The interdependency of units and buildings with each other within the complex
- Safety escape routes for personnel based on emergency or disaster management plans in the event of environmental upset or fire
- Suitable drainage system of Project site

2.3 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.

#### 2.4 **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 a centrifugal pump, 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
- c) Full vacuum for a system operating below atmospheric pressure

#### 2.5 **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:

- Fluid temperature
- Normal operating temperature of steam

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### 3.0 CODES, STANDARDS AND SUPPLEMENTARY SPECIFICATIONS

- 3.1. 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.
- 3.2 Where conflict occurs, the order of precedence shall be:
- Statutory Regulations
  - National, International and Industry Standards and Codes of Practice.
  - Technical Specifications
- 3.3 Standards, codes and supplementary specifications for piping design shall be applied as follows:
- Process and utility piping to ASME B31.3 Process Piping
  - Power Plant piping to ASME B 31.1
  - Sour service piping to NACE (National Association of Corrosion Engineers) specification MR0175.
  - 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 Protection Association) Codes.
  - Piping fabrication tolerances to ASME B31.3 and PFI (Pipe Fabrication Institute) practice ES-3.
  - Colour coding for identification of piping material to PFI Practice ES-22/ as per owner's approval.
  - Pipe wall thicknesses shall be in accordance with ANSI B36.10 or B36.19.

### 4.0 GENERAL DESIGN

- 4.1 Valve shall be provided at battery limit for respective piping system.
- 4.2 Flanges for process and utility piping shall be in accordance with ANSI B16.5 and ANSI B16.47.
- 4.3 Wherever possible all purchased equipment shall be supplied with flanges that comply with ANSI B16.5.
- 4.4 The minimum size of piping to be used in pipe-racks shall be 2” NB.
- 4.5 With the exception of equipment connections the minimum size of piping shall be ½” NPS.
- 4.6 Pipe sizes 1 ¼”, 2 ½”, 3 ½” and 5” NPS shall not be used except as connections to purchased equipment.
- 4.7 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.
- 4.8 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.

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4.9 In Class 900 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 and bleeds routed to a safe location. Category 'M' substances shall be vented to the flare system.

4.10 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.

4.11 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 to 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 valving and /or blinds as determined by service conditions.

4.12 Criteria for Isolation Valves

Installation (Class Rating)	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	Single	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

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. 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:

- Site Location Plan
- P&I Ds
- Equipment Data Sheets
- Wind Direction
- Overall Plot Plan
- 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;



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- a) Process Requirement -Proper interconnection between equipment as per P&IDs 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/fired heaters
  - 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.

## 5.2 Plant Layout & Design guidelines

### 5.2.1 General

- 5.2.1.1 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.
- 5.2.1.2 Where dynamic loading, limited pressure drop or other severe service condition applies, particular care shall be taken in routing pipe lines.
- 5.2.1.3 Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify or lead to scaling or choking, when the line is idle or even in operation. Sufficient Nitrogen purging points shall also be provided. Supply piping of fuel gas shall be arranged for equal flow distribution.
- 5.2.1.4 Trolley beams, pipe davits, shall be provided with appropriate removable hoists mechanism for charging and discharging catalysts, chemicals, packing rings etc.

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5.2.1.5 Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.

5.2.1.6 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.

- Cooling Water Lines 18" dia. and larger
- Fire water mains
- Drain and Sewer (oily and chemical) lines from catch basin to mains and manholes

5.2.1.7 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.

5.2.1.8 Fire protection system shall be designed as per NFPA, / TAC and as per statutory requirements. Refer Fire Fighting Design Basis.

5.2.1.9 Drip legs and dead ends shall be avoided, especially for piping where solids or fluids may congeal from corrosive condensate.

5.2.1.10 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.

5.2.1.11 All cooling towers shall 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.

5.2.1.12 Locate flare stacks upwind of process units, with a minimum distance of 90 m from process equipment, tanks and cooling towers.

5.2.1.13 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.

5.2.1.14 Piping to be sloped shall be indicated on the P&ID's.

## 5.2.2 Pipe-Rack/T-Post/Small Portals

5.2.2.1 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.

5.2.2.2 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  $\leq 2"$ . 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.

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- 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 3.0M.

### 5.2.3 Towers and Vertical Vessels

5.2.3.1 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,  $(L=\text{height of tower})$ ). 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.

5.2.3.2 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.

5.2.3.3 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.

5.2.3.4 Chemical vessels to be located close to the dosing point to the extent possible & corrosion inhibitors.

### 5.2.4 Re-boiler

5.2.4.1 Re-boiler shall be located next to the tower they serve except fired heater type. 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.

### 5.2.5 Horizontal Vessels

5.2.5.1 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.

### 5.2.6 Pumps

5.2.6.1 Wherever practical, 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 5.2.11.2.

5.2.6.2 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.

5.2.6.3 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.

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5.2.6.4 No monorail should normally be provided for pumps outside rack and sufficient space below rack shall be available for pump maintenance.

#### 5.2.7 Exchangers

5.2.7.1 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.

5.2.7.2 Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher.

5.2.7.3 Likewise Heat Exchanger train should be suitably spaced such that shell/ tube inlet/outlet piping do not foul floating Head Covers creating maintenance problem.

5.2.7.4 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.

#### 5.2.8 Fin Fan Exchangers

5.2.8.1 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.

#### 5.2.9 Furnaces

5.2.9.1 Furnaces are located upwind or side wind of process units to blow any combustible leaks away from the open flame. They are located minimum / 90 M away from storage tanks and 30 M away from control room. Vessels / reactors directly connected to furnace are exception.

5.2.9.2 Furnaces shall be arranged with centreline on a common line in case of circular furnace and wherever a common stack is furnished to cater more than one furnace the stacks shall be located at the end or side which is away from the unit. In case of individual box furnaces, the edge of the furnaces on the rack side shall be matched. F.D. fans shall be located at one corner of furnace area away from equipments handling hydrocarbons. It shall be ensured that there are no working platforms within an elevation of 6.0 M below the tip of stack height inside a 25.0 M radius of the stack. However the stack height shall be governed by statutory authority.

5.2.9.3 For maintenance, vertical tube furnaces must have access to permit a crane to remove and replace tubing. Horizontal tube furnaces must have horizontal free space equal to tube length for tube pulling / maintenance / cleaning.

5.2.9.4 In case of bottom floor fired heaters, there shall be adequate headroom clearance underneath the furnace for removal of burners. In case of wall fired furnaces minimum 2.0 M wide platform with escape route at" each end is necessary.

5.2.9.5 Pits and trenches are not permitted under furnace or any fired equipment. Underground drain points and manhole covers shall be sealed within furnace vicinity.

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5.2.9.6 APHs should be located in such a way that the modules can be removed by crane. However, layout of furnaces, ID / FD fans, stacks and APH etc shall be arranged as per final approved vendor data.

#### 5.2.10 **Compressors and their Prime Movers**

5.2.10.1 Two major types of compressors used in process plants:

1. Centrifugal compressors
2. Reciprocating compressors.

5.2.10.2 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.

5.2.10.3 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.

5.2.10.4 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.

5.2.10.5 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.

5.2.10.6 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.

5.2.10.7 Compressor manufacturer may be consulted for better layout and additional requirement for maintenance. However licensors's requirement, if any, shall also be taken into consideration.

5.2.10.8 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.

5.2.10.9 Layout of compressor house for gasification plant shall be such as to have minimum 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

5.2.10.10 All distances are to be measured from the edge of base plate.

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5.2.10.11 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.

## 5.2.11 Clearance and Accessibility

### 5.2.11.1 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.

### 5.2.11.2 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.

### 5.2.11.3 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.

### 5.2.11.4 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 valving, fan motors and instruments. Access requirements shall conform to paragraph (a) above.
  - c) When fired heaters are located adjacent to one another, they shall have inter-connecting platforms on the upper and lower section. Inter-connecting platforms between towers may be provided taking into consideration expansion of towers.
- 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:



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- a) Points which require occasional operating access including valves, spectacle blind and motor operated valves, and 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.

#### 5.2.12 Valves

- 5.2.12.1 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.
- 5.2.12.2 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.
- 5.2.12.3 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.
- 5.2.12.4 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.
- 5.2.12.5 Double block valves with a bleeder connection shall be provided with interconnecting piping where intolerable contamination could result from valve leakage.
- 5.2.12.6 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.
- 5.2.12.7 All valves shall be so installed that the stems are not below horizontal positions unless otherwise specified.
- 5.2.12.8 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.
- 5.2.12.9 Battery limit valves, if required, shall be grouped together and consideration shall be given to provide a common operation platform.
- 5.2.12.10 Vessel nozzles located below the normal or emergency liquid level shall be provided with the block valves, if practical. Other vessel nozzles shall be provided with block valves only if required for operation.

#### 5.2.13 Control Valves

- 5.2.13.1 All control valves shall be easily accessible from grade or permanent platforms and conveniently located for operations and maintenance.
- 5.2.13.2 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.
- 5.2.13.3 Block valves, bypass valve and drain valve may be omitted at the following conditions:
  - 1) Block valves

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- 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
- a) Where operating conditions of piping for water, brine, non-flammable or nontoxic fluid are mild.

5.2.13.4 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	Bypass 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



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8	8	8	8
	10,12	10	10
10	10	10	10
	12,14	12	12

Control valves, where practicable, shall be installed with the stems vertical.

#### 5.2.14 **Orifice**

5.2.14.1 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.

5.2.14.2 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.

5.2.14.3 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation 4.5m above grade, including installed in pipe racks, shall be accessible from a platform with permanent ladder.

5.2.14.4 Orifice taps, in general, shall be located as follows: (Please also refer specs. for Instrumentation)

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)

Tap orientation shall be shown on piping isometrics. Finally all orifice impulse tapping / spare tapping will have to be seal run.

#### 5.2.15 **Clearances**

Minimum clearances shall be as indicated in Annexure-4.

### 5.3 **Unit Piping**

#### 5.3.1 **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


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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.

### 5.3.2 Pipe Ways/Rack piping

- 5.3.2.1 Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.
- 5.3.2.2 Predominantly process lines are to be kept at lower tier and utility & hot process lines on upper tier.
- 5.3.2.3 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.
- 5.3.2.4 Generally the hot lines and cold lines shall be kept apart in different groups on a tier and bigger size lines shall be kept nearer to the column.
- 5.3.2.5 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.
- 5.3.2.6 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.
- 5.3.2.7 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.
- 5.3.2.8 Anchors shall be provided within unit on all hot lines leaving the unit.
- 5.3.2.9 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.
- 5.3.2.10 Provision of block valves, blinds etc. shall be as per Process Design Basis and P & IDs.
- 5.3.2.11 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.
- 5.3.2.12 Stubs on saline water (if applicable) service shall be from top of main header.
- 5.3.2.13 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.
- 5.3.2.14 Aboveground lines shall be grouped to run on pipe racks or sleepers in so far as practicable.
- 5.3.2.15 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.
- 5.3.2.16 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.
- 5.3.2.17 All process and utility piping will be located aboveground within the plant battery limit, except water mains.

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- 5.3.2.18 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.
- 5.3.2.19 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.
- 5.3.2.20 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.
- 5.3.2.21 Lines carrying molten solids, slurries or highly viscous liquids shall have a sufficient slope for each gravity flow.
- 5.3.2.22 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.
- 5.3.2.23 Piping shall be arranged to facilitate handling of equipment for inspection or maintenance.
- 5.3.2.24 Vapour collecting system shall be routed so that the vapor rises continuously from the vessel being vented to a higher point without pocketing.
- 5.3.2.25 Pockets shall be avoided in lines, particularly those carrying corrosive chemicals, slurries, vents, blow down lines, etc.
- 5.3.3 Column / Vessel Piping Control Valves**
- 5.3.3.1 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.
- 5.3.3.2 Piping shall be grouped as far as possible for the ease of supports and shall run on the rack side of the column.
- 5.3.3.3 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.
- 5.3.3.4 Piping shall be supported from cleats welded on the vessel as far as possible.
- 5.3.3.5 Proper guides at intervals shall be provided for long vertical lines.
- 5.3.3.6 Access platforms/ladders shall be provided along the column for valves and instruments. Minimum width of platform shall be 750 mm clear.
- 5.3.3.7 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.
- 5.3.3.8 Unless specifically indicated in P&ID's control valves shall preferably be kept at grade instead of platform.
- 5.3.3.9 Piping intended for vacuum services shall be routed as short as possible, with minimum bends and flanged joints.
- 5.3.3.10 Piping support cleats shall be designed for safety valves considering impact loading during popping off.

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#### 5.3.4 Exchanger Piping

- 5.3.4.1 Exchanger piping shall not run in the way of built in or mobile handling facilities.
- 5.3.4.2 Wrench clearance shall have to be provided at exchanger flanges.
- 5.3.4.3 Piping shall be arranged so that they do not hinder removal of shell end and channel cover and withdrawal of tube bundle.

#### 5.3.5 Heater/ Furnace Piping

- 5.3.5.1 Arrange piping to permit burner removal by providing break up flanges in the piping.
- 5.3.5.2 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.
- 5.3.5.3 Only flexible metallic SS hoses shall be used for burner piping if required.
- 5.3.5.4 Block valves for emergency snuffing steam valves shall be located minimum 15M away from the heater, preferably on the upwind side of the heater.
- 5.3.5.5 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.
- 5.3.5.6 No piping shall be routed in the tube withdrawal area. If unavoidable, break up flanges shall be provided in the piping for removal.
- 5.3.5.7 All furnaces, if they are located in the same area they should be interconnected with platforms at different locations.

#### 5.3.6 Pump Piping

- 5.3.6.1 Pump drives shall have clear access.
- 5.3.6.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapour pockets.
- 5.3.6.3 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.
- 5.3.6.4 Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.
- 5.3.6.5 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.
- 5.3.6.6 Unless otherwise specified T-type strainers shall be used on pump suction piping for sizes 2" and above.
- 5.3.6.7 Y-type strainers to be used for all sizes in steam services and for pump suction lines 1½ and below.
- 5.3.6.8 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.
- 5.3.6.9 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610(centrifugal pumps and centrifugal pumping systems).

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5.3.6.10 Pump discharge should preferably be routed away from the pump rather than towards the motor side.

5.3.6.11 Pump cooling water connection shall be taken from the top of circulating cooling water header.

### 5.3.7 Compressor Piping

5.3.7.1 Suction lines shall be as short as possible.

5.3.7.2 Suction piping shall have adequate flanged joints for ease of erection and maintenance.

5.3.7.3 Lube oil cooler space shall be provided such as to facilitate tube bundle removal.

5.3.7.4 All operating valves on main suction and discharge piping shall be lined on one side as far as possible.

5.3.7.5 A minimum straight length of suction pipe is to be provided as per manufacturer's recommendation.

5.3.7.6 Piping shall be designed so that forces and moments imposed on the compressor do not exceed the manufacturer's recommendation.

5.3.7.7 Compressor suction lines between the knockout drum and the compressor shall be as short as practicable.

5.3.7.8 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.

5.3.7.9 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.

5.3.7.10 Analog study shall be carried out for complete compressor piping including suction I discharge piping as per P&ID' s and the analog study recommendations if any, shall be implemented.

5.3.7.11 Reciprocating compressor piping should not be supported from compressor shed I platform structure.

5.3.7.12 Pulsation dampers or surge bottles at the suction and discharge of reciprocating and displacement type compressors shall be provided according to manufacturer's recommendations.

5.3.7.13 A suction filter shall be provided in each compressor suction line to completely remove debris from the system.

5.3.7.14 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.

5.3.7.15 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.

### 5.3.8 Piping around Tanks Area

5.3.8.1 Nozzles for level controlling instruments shall be oriented within an angle not exceeding 60 degrees against the fluid inlet nozzles.

5.3.8.2 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.

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- 5.3.8.3 Fluid inlet nozzles shall be located as far apart as possible from fluid outlet nozzles.
- 5.3.8.4 Vessel working platforms where man ways and hand holes are located shall preferably be provided with utility stations.
- 5.3.8.5 The first pipe support from tanks shall be located sufficiently away from the tank to prevent damage caused by settling.
- 5.3.8.6 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.
- 5.3.8.7 Manifolds shall be located outside the tank dyke & by the side of the roads, easily accessible by the walkway.
- 5.3.8.8 Plug valves whenever specified shall be of pressure balance type.
- 5.3.8.9 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.
- 5.3.8.10 Special consideration shall be given as regards to spacing of nozzles while installing special item like hammer blind, MOV etc.
- 5.3.9 **Relief System/blow down System Piping (CBD, OWS, FLARE)**
- 5.3.9.1 Relief of liquids and easily condensable hydrocarbons are usually discharged to a closed system.
- 5.3.9.2 Wherever the inlet line size is higher than the safety valve inlet size, reducer shall be installed adjacent to inlet of safety valve.
- 5.3.9.3 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.
- 5.3.9.4 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.
- 5.3.9.5 Pockets in the flare header and blow down system shall be prohibited.
- 5.3.9.6 Relief valve discharge piping shall be taken to safe location as per following;
- 5.3.9.7 3M above top platform of column or structure, within 6M radius for steam and 8M for Hydro carbon / toxic discharge.
- 5.3.9.8 25M horizontally away from furnace.
- 5.3.9.9 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.
- 5.3.9.10 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.



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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.

- 5.3.9.11 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.
- 5.3.9.12 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.
- 5.3.9.13 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.
- 5.3.9.14 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.
- 5.3.9.15 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.
- 5.3.9.16 All flare headers shall be sloped 1 m per 400 m to 1 m per 1000 m downward to the blow down drum.
- 5.3.9.17 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.

#### 5.3.10 **Steam Piping - Indian Boiler Regulations (IBR)**

- 5.3.10.1 Generally steam lines with conditions listed below fall in the scope of IBR;
  - a) Lines having design pressure (maximum working pressure) Above 3.5 Kg/cm<sup>2</sup> (g)
  - b) Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm<sup>2</sup> (g) & above.
  - c) Lines with pressure less than 1.0 Kg/cm<sup>2</sup> (g) are excluded.
  - d) Users of steam like steam tracing lines, jacket of the steam jacketed lines, and steam heating coil within the equipment are excluded from IBR scope.
  - e) 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.
- 5.3.10.2 IBR requirements (in brief)
  - a) All materials used on lines falling under IBR must be accompanied with IBR Inspection certificate in form IIIA/IIIC, as applicable, in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local IBR inspector is acceptable.

Chief inspector of boilers shall be the inspection authority for Indigenous (Indian) supply. However, for non - indigenous supply, IBR inspection shall be carried out by the inspection agencies approved by IBR (Central Boilers Board).

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- 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.

#### 5.3.11 **Steam Header & Supply Lines / Steam and Condensate Systems**

- 5.3.11.1 Steam piping shall be designed to have complete condensate removal. Drip legs shall be provided with steam traps at low points in the system.
- 5.3.11.2 All steam branch connections shall be taken from the top of the header.
- 5.3.11.3 Return exhaust steam / condensate lines shall connect to the top of the exhaust steam Condensate header.
- 5.3.11.4 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.
- 5.3.11.5 Steam header shall be located generally on the upper tier and at one end of the rack adjacent to columns.
- 5.3.11.6 Branch lines from horizontal steam header, except condensate collection points, shall be connected to the top of the pipe header.
- 5.3.11.7 Isolation valves (if provided) on the branch line shall preferably be provided on the horizontal run and outside the pipe rack.
- 5.3.11.8 All branch lines shall be drainable.
- 5.3.11.9 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.
- 5.3.11.10 All turbines on automatic control for startup shall be provided with a steam trap in the steam inlet line.
- 5.3.11.11 All traps shall be provided with strainers if integral strainers are not provided.
- 5.3.11.12 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.
- 5.3.11.13 Expansion loops are to be provided to take care of the expansions within units.
- 5.3.11.14 Wherever condensate is to be drained, proper condensate draining facility shall be provided.

#### 5.3.12 **Steam Tracing**



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- 5.3.12.1 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.
- 5.3.12.2 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.
- 5.3.12.3 All manifolds shall be installed in vertical position and manifold size shall be 3".
- 5.3.12.4 For steam tracing balanced pressure thermostatic steam trap with 40 mesh strainer to be used.
- 5.3.12.5 Manifolds shall be accessible from grade or from a platform.
- 5.3.12.6 Pockets in steam tracers shall be avoided as far as possible.
- 5.3.12.7 Tracers shall be limited to the following run length upstream of traps:

Size of Tracer	Length of tracer pipe (Meters)				
	Steam operating pressure				
0.5" (Inch)	20 psig	50 psig	100 psig	150 psig	200 psig & above
	30	45	60	75	90

- 5.3.12.8 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.
- 5.3.12.9 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"

- 5.3.12.10 The lead line to manifold, manifold up to the block valves of individual tracer shall be carbon steel of IBR quality.
- 5.3.12.11 Tracer lines shall be provided with break up flanges for main line flange joints and valves.
- 5.3.12.12 All tracers shall have individual steam traps before condensate manifolds.
- 5.3.12.13 Condensate manifold including the last valve on individual tracer shall be of carbon steel.
- 5.3.12.14 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

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up to 4"	1
6" to 16"	2
18" to 24"	3
26" & above	To Calculate

### 5.3.13 Steam Jacketing System

5.3.13.1 A steam jacketed pipe consists of a product line which passes through the centre of a larger diameter steam line.

5.3.13.2 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"

5.3.13.3 For jacketed lines using high pressure steam, actual calculations for core, jacket and feeder pipe shall be performed before finalization of sizing.

5.3.13.4 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.

5.3.13.5 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.

5.3.13.6 Intermediate partial baffles shall be provided if a separate branch portion is to be heated from the main line stream.

5.3.13.7 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.

5.3.13.8 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.

5.3.13.9 Each feed length shall be provided with individual trap before connecting to condensate recovery headers.

5.3.13.10 Balanced pressure I bi-metallic type thermostatic steam traps with 40 mesh strainer shall be used in jacketing.

5.3.13.11 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.

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5.3.13.12 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.

#### 5.3.14 **Water Piping**

5.3.14.1 Water piping shall be designed to minimize the possibility of water hammer.

5.3.14.2 Water main headers may run underground to prevent freezing.

5.3.14.3 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.

#### 5.3.15 **Instrument Air Piping**

5.3.15.1 Instrument air lines shall not be connected to process lines, service lines, and other equipment.

5.3.15.2 Instrument air shall not be used as plant air or service air.

5.3.15.3 Branch lines from 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

#### 5.3.16 **Supports and Anchors**

5.3.16.1 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.

5.3.16.2 Allowable spans between pipe supports shall be determined to keep the maximum deflection within 16 mm.

5.3.16.3 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.

5.3.16.4 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.

5.3.16.5 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.

5.3.16.6 Supports shall not be directly welded to pipes. Where welding is unavoidable, supports having the same chemical composition as pipe shall be carefully welded.

5.3.16.7 All piping shall be properly supported to minimize vibration.

5.3.16.8 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.

5.3.16.9 Expansion joints shall be guided and anchored to the extent necessary for their proper operation and alignment.

5.3.16.10 Anchors shall provide sufficient fixation to substantially transmit all load effects into the foundations.

5.3.16.11 Underground piping shall be given special anchoring consideration for differential settlement.

#### 5.3.17 **Utility Stations**

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5.3.17.1 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) and 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.

5.3.17.2 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.

5.3.17.3 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.

5.3.17.4 The Utility stations shall generally be located adjacent to pipe-rack column.

5.3.17.5 The utility stations shall also be provided on elevated structures like – technological structure, operating platforms of vertical equipments etc.

5.3.17.6 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.

#### 5.4 Offsite & Yard Piping

5.4.1 In general, offsite piping (except tank ages area), electrical cable and instrumentation cable shall also be laid either on pipe rack or pipe sleepers.

5.4.2 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.

5.4.3 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.

5.4.4 Clearances between lines shall be minimum "C" as given below:

$C = (D_o + D_f) / 2 + 25 \text{ mm} + \text{Insulation thickness(es)}$  where,

$D_o$  – 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.

5.4.5 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.

5.4.6 Expansion loops for all lines shall generally be kept at the same location.

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5.4.7 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.

5.4.8 Places where piping is extended to make drain valves accessible – 2 nos. of stiffeners, irrespective of pipe rating, shall be provided.

## 5.5 Flare Piping

5.5.1 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.

5.5.2 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.

## 5.6 Underground Piping

5.6.1 Underground steel piping shall be protected from electric corrosion.

5.6.2 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.

5.6.3 Underground piping shall be sloped to all drain points with a downward slope of not less than 1 m in 150 m.

5.6.4 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.

5.6.5 The following points to be considered in designing of Underground piping;

- i) All Sewage lines (oily and chemical) from catch basin to mains and manholes shall be laid underground.
- ii) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/Maintenance.
- iii) 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.
- iv) 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.
- v) Pipes shall be laid below electrical cables if any.
- vi) Top of underground piping shall be below grade level at least 1 meter deep in case of open areas and 1.5 meter deep for roads.

5.6.6 All underground pipe work shall be provided with following protection:

- i) At location where Underground Piping becomes above ground, Insulating Gasket with material Glass Filled Teflon shall be provided.

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- ii) Cathodic Protection shall be provided to all underground piping. Specification shall be submitted by the Contractor & shall be approved by the Owner.
- iii) Underground piping shall be wrapped & coated and shall be “Holiday Tested” before Hydro Test. (For wrapping/coating specification- refer Design Philosophy-Construction/Erection, Pre-Commissioning, Commissioning and Start-Up).
- iv) All underground pipes shall have Sand Bed, at least 150 MM all around the pipe.
- v) Underground pipe crossing roads, access ways, and rails shall have Hume Pipe Sleeves/casing pipe (R.C.C or C.S).

#### 5.6.7 Piping in Trenches

Where it is impossible to run pipe aboveground or underground, trenches may be used. for piping close to process equipment should be avoided, whenever possible.

The following points to be considered in designing of trench pipes:

Piping located below grade, requiring inspection, servicing or provided with protective heating.

Fire water lines/Process lines. (Ref Fire Fighting Design Philosophy)

Drain lines requiring gravity flow trenches.

Sump for valves and trenches shall be provided.

Suitable draining scheme for trenches shall be provided.

#### 5.7 Air Systems

Branch connections shall be taken from the top of the header. Low points shall be fitted with drains.

#### 5.8 In-Line Instruments

- 5.8.1 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.
- 5.8.2 Relief valves shall be accessible. Relief valves with a centre line elevation over 4.5 M above grade (except in pipe racks) shall be accessible from a platform or permanent ladder.
- 5.8.3 Relief valves that discharge to a closed system shall be installed higher than the collection header, with no pockets in the discharge line.
- 5.8.4 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.
- 5.8.5 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.
- 5.8.6 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.
- 5.8.7 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.



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5.8.8 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.

## 5.9 Sample Connections

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.

## 5.10 Vents and Drains

5.10.1 For hydrotest drain & vent philosophy refer annexure-9.

5.10.2 Process vents and drains shall be indicated on the P&ID's

5.10.3 Vent, drain and sampling valves on process lines, not connected to a piping system, shall be provided with appropriate end closures.

5.10.4 Vents shall be located at high points of pipelines when necessary.

5.10.5 Drains shall be located at low points to empty pipelines or equipment after testing or during maintenance (i.e. for every loop).

5.10.6 All drains and vents shall be provided with valve, except that vents for test purpose for flare lines (header), may be plugged. Exposed threads shall generally be seal welded.

5.10.7 Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the design review.

5.10.8 Vent valves shall be the globe or gate type and drain valves the gate type.

5.10.9 Valved bleeds shall be provided at control valve stations, level switches, level controllers, and gauge glasses.

## 5.11 Line Strainers

5.11.1 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.

5.11.2 Provide permanent Y-type strainers for pump suction piping below 2" NB Thd Or SW.

5.11.3 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.

5.11.4 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.

5.11.5 Allowable pressure drop when specified shall be certified by vendor along with the offer. If asked specifically, vendor shall furnish pressure drop calculations

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- 5.11.6 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.
- 5.11.7 Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.
- 5.11.8 For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.
- 5.11.9 All the strainers shall be hydrostatically tested at twice the design pressure
- 5.12 **Spectacle Blinds**
- 5.12.1 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.
- 5.12.2 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.
- 5.13 **Flexibility Analysis and Supporting**
- 5.13.1 **Pipe Supporting Criteria & General Guidelines**
- 5.13.1.1 Piping system shall be properly supported taking into account the following points:
1. Load of bare pipe + fluid + insulation (if any).
  2. Load of bare pipe + water fill.
  3. Load of valves and online equipment and instrument.
  4. Thermal loads during operation.
  5. Steam-out condition, if applicable.
  6. Wind loads for piping at higher elevation, e.g. transfer lines, column over head lines, flare headers, etc.
  7. Forced vibration due to pulsating flow.
  8. Vibration due to two phase flow.
  9. Loads due to internal pressure.
  10. Any external loads/concentrated loads and cold load of springs.
- 5.13.1.2 Pipe supporting shall preferably follow the minimum basic span as given in Annexure-1 except for flare line in off site on trestles in which case the maximum basic span shall be restricted to 18.0 meters, irrespective of line size.
- 5.13.1.3 For sizes not covered in Annexure-1, basic span shall be established based on project requirement. For piping on rack or sleeper, as a minimum, providing resting support on every grid of pipe rack / sleeper is mandatory. Depending on the pipe size, as a rule, guides shall be provided on straight run of pipes at intervals as specified in Annexure-3 unless specifically becomes non-viable due to flexibility problems.
- 5.13.1.4 Additional supports, guides, anchors, special supports like spring supports and sway braces shall be provided after detailed analysis of piping system to restrict the forces experienced on nozzles of critical items like pumps, compressors, turbines, exchangers, air fin coolers etc.



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- 5.13.1.5 For lines which do not need any support otherwise but become unsupported by opening of flange, etc, during maintenance and thereby may transfer the total load on a small branch off, a permanent support shall be suitably provided which may be a spring support also. Bare pipes of size 14" and above on elevated structures shall be supported with pad or shoe. While bare pipes of size 6" and' above, on sleepers, corrosion pads shall be provided.
- 5.13.1.6 Pads shall be provided for insulated pipes before welding the shoes for sizes 8" & above.
- 5.13.1.7 Adequate stiffening shall be provided for the following:
- Lines in above 600#,
  - Lines having two phases flow,
  - Lines having Pulsating flow such as discharge of reciprocating compressors & reciprocating pumps.
- 5.13.1.8 For pulsating flow lines detailed thermal and vibration analysis by analog study shall be done to decide location of anchor supports and guides etc. Pulsating flow lines shall be as identified by licensors/owner.
- 5.13.1.9 Wherever two phase flow in piping is expected, piping design shall be checked by dynamic analysis to prevent vibrations.
- 5.13.1.10 Pipe support design shall be such that deflection in piping systems due to sustained loads shall not exceed 15mm, in any case, between two adjacent supports.
- 5.13.1.11 As far as possible long trunnion types of supports (more than 0.5 metre) are to be avoided. In case long trunnion support is unavoidable in straight length of pipe, trunnion height to be restricted to 0.5 M and balance height to be made up by providing extended structure.
- 5.13.1.12 In the heaters where steam air decoking provision is there, the main lines and decoking lines should be supported in a way so that either of the lines should not be in the hanging position while connected to other one. Same philosophy shall be adopted for similar type of switch over arrangement.
- 5.13.1.13 Piping passing through the technology structure or passing near the concrete column etc. should have adequate annular space to avoid restriction of line movement during thermal expansion. The gap should take care the thermal expansion along with insulation thickness.
- 5.13.1.14 High density PUF blocks shall be considered for cold piping supports. Use of wood blocks shall be avoided.
- 5.13.1.15 All pipes supports shall be so designed that there is no undue tension on equipment flanges. Flange joints should not move away from each other in case of unbolting of the joint.

#### 5.13.2 **Flexibility Analysis Criteria & General Guidelines**

Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis (Refer annexure)

The directions of forces and moments shall be in accordance with Welding Research Council Bulletin 107 (WRC 107), with the exception that the radial force (P) shall be away from the vessel. All forces and moments shall be assumed to act simultaneously and apply at the nozzle/vessel interface.

Air coolers to API 661 shall be specified with Fx forces and Mz moments increased to 1.2 times the value shown in Figure 8 of API 661 for nozzle sizes 6"NPS and larger to simplify piping flexibility analysis and facilitate piping layout.

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Piping stress analysis and equipment nozzle loading analysis shall be in accordance with ASME B31.3 and the relevant API, ANSI/ISO and NEMA Codes.

#### 5.13.2.1 **API 610 Pumps**

The allowable nozzle loads on centrifugal pumps shall meet the load criteria of API 610. Heavy duty base plate shall be specified where the pump design temperature is in excess of 150°C.

#### 5.13.2.2 **ASME or Manufacturer's Standard Pumps**

The allowable nozzle loads on horizontal centrifugal pumps design to ASME B73.1 shall be specified by the manufacturer. For preliminary layout and analysis NEMA SM 23 criteria shall be used for individual nozzles.

#### 5.13.2.3 **Other Horizontal Centrifugal Pumps**

The allowable nozzle loads shall meet the load criteria specified by the manufacturer.

#### 5.13.2.4 **Vertical Turbine, Can-Types Pumps**

The combined bending and tensional thermal stress in the piping attached to the nozzle shall be limited to 25 percent of the allowable stress range shown in ASME B31.3. The combined stress due to dead load and other sustained loads shall be limited to 25 percent of the allowable hot stress.

#### 5.13.2.5 **Fired Heater**

The allowable heater terminal connection load criteria for each fired heater shall be given in the appropriate purchase specification. In the absence of any allowable nozzle load criteria, the preliminary piping layout may be based on limiting the combined dead load and thermal bending and torsional stress in the piping attached to the heater terminal connections to 25 percent of the allowable stress range shown in ASME B31.1/B31.3. The combined stress due to dead load and other sustained loads shall be limited to 25 percent of the hot stress. A ½" lateral clearance at the nozzle penetration opening (s) shall be assumed for layout and design purposes. Final lateral clearance shall be confirmed by the supplier.

For piping design purposes, differential settlement between items of major equipment on separate foundations shall be taken as 10 mm.

Cold springing in piping shall not be permitted without written permission from the Owner. Cold springing of piping directly connected to rotating equipment is not permitted under any circumstances.

Piping shall be analyzed for expansion, contraction, differential settlement, relief, valve reaction and effects mentioned at CI. 5.13.1.

The design of piping systems shall take into account the different conditions expected during operation, start-up, shut-down, cold branch in case of standby pump, tracing, etc. Hydrocarbon lines shall be designed for steam-out conditions, if specified in line schedule. The use of expansion joints shall be considered only when space or pressure drop limitation does not permit pipe bends. Expansion joint of axial type shall be avoided.

Forces and moments due to weight, thermal loads and other imposed loads on the equipment nozzle must not exceed the allowed loads for the equipment.

Minimum analysis temperature shall be the design temperature of the line as per line list.

#### 5.13.3 **Method of Analysis**

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- 5.13.3.1 Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis.
- 5.13.3.2 The package used shall be latest version of CEASER / AUTO PIPE / SIMPLEX / CAEPIPE. Only one of these packages shall be used for the project & not a combination of the above packages.
- 5.13.3.3 All lines shall be analyzed at design I analysis temperature. In the absence of analysis temperature lines shall be analyzed at design temperature.
- 5.13.3.4 However in case of wide difference in design and operating temperature, temperature for analysis shall be established in process documents. (E.g. flare line)
- 5.13.3.5 All non-critical lines may be analyzed using other methods.
- 5.13.3.6 Special analysis methods shall be followed for lines involving pulsating flow such as those connected to reciprocating pumps & compressors which require acoustical plus analog study by approved agencies and shall require entire system analysis along with piping & equipments.
- 5.13.3.7 Seismic analysis shall be done for line sizes 12" and above.

#### 5.14 **Personnel Protection**

- 5.14.1 Eyewash and emergency safety showers shall be provided in areas where operating personnel are subject to hazardous sprays, emissions or spills.
- 5.14.2 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.
- 5.14.3 Leakage indicating tape and spray impingement shrouds shall be provided at flanged joints in hazardous service.

#### 5.15 **Mechanical Handling**

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. **MATERIALS**

#### 6.1 **General**

- 6.1.1 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.
- 6.1.2 All materials for piping components shall be new and conform to the relevant code and/or specification.
- 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 Electric Resistance Welded (ERW) pipe and fittings shall only be used for category 'D' service as defined by ASME B31.3.
- 6.1.7 Category 'M' and Normal Service piping as defined by ASME B31.3 shall use seamless or 100% radio graphed Electric Fusion Welded (EFW) pipe and fittings.

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- 6.1.8 Only piping materials listed in ASME B31.3 shall be used.
- 6.1.9 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 100% radiography. Flanged connections shall be minimized.
- 6.1.10 All insulation and gaskets shall be asbestos free. Aluminium or copper alloys shall not be used for any component in the piping systems.
- 6.1.11 The use of 1.25Cr-0.5Mo alloy shall be a minimum requirement for piping systems having a design temperature above 425°C.
- 6.1.12 Nelson Curves in accordance with API 941 (Steels for Hydrogen Service at Elevated Temperatures and Pressures) shall be applicable to piping system materials in hydrogen service.
- 6.1.13 The minimum corrosion allowance for any material, other than stainless steel, shall not be less than 1.5 mm.
- 6.1.14 All instrument air pipe line shall be of SS304.
- 6.1.15 All Austenitic Stainless Steel items/parts shall be supplied in solution annealed condition.
- 6.1.16 For all Austenitic Stainless steels, Inter granular Corrosion' (IGC) Test shall be conducted as per following:  
 ASTM A262 Practice 'B' with acceptance criteria of 60 mils/year (max) for casting.  
 ASTM A262 Practice 'E' with acceptance criteria of 'No cracks as observed from 20 X magnification & microscopic structure to be observed from 250 X magnification for other than casting.  
 For IGC test, two sets shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and other set corresponding to the highest rating/thickness. When testing is conducted as per practice "E" photograph of microscopic structure shall be submitted for record.
- 6.1.17 All items of stabilized SS grades, resolution annealing shall be done. It shall be carried out subsequent to normal resolution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 deg. Celsius and 4 hours.
- 6.1.18 For Category 'D' utility piping, where scaling and impurities are to be avoided (such as potable water and deluge water) hot dipped galvanized and threaded fittings may be used in sizes up to and including 4" NB. Galvanized 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.
- 6.2 **PIPE**
- 6.2.1 General
- 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",

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STD for above 2"

For stainless pipes minimum pipe thickness shall be

40S up to 2",


10S for above 2"

The philosophy of minimum thickness/schedule is applicable for both seamless and welded pipes.

The above mentioned minimum thickness/schedule criteria is not applicable to category-D classes.

- 6.2.1.3 All welded pipes shall have uniform negative wall thickness tolerance of 12.5% for wall thickness calculations purpose.
- 6.2.1.4 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.
- 6.2.1.5 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 (line condition) subject to a minimum of 80% class rating. Maximum 10% of corrosion allowance may be reduced in special cases, to optimize the pipe schedules.
- 6.2.1.6 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

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	2500	Above 4"	Line condition
		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

6.2.1.7 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.

6.2.1.8 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" and 48".

## 6.2.2 Pipe Type

### 6.2.2.1 Up to Class 900#

Material	Size	Type
CS, LTCS, AS (except for Cat 'D' fluids & LP hydrocarbon in offsite)	Up to 14"	Seamless
	16" and above	E.F.S.W(Electro Fusion Seam Welded)
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
CS (LP hydrocarbons (offsite))	Up to 6"	Seamless
	Above 6"	E.F.S.W/Welded

### 6.2.2.2 Class 1500# & above

Material	Size	Type
CS, LTCS, AS & SS	Up to 24"	Seamless
	26" and above	E.F.S.W

Note: Instrument impulse piping for steam services shall be Sch160 – ½" Seamless

## 6.2.3 Materials and manufacture

6.2.3.1 Furnace butt-welded, furnace lap-welded, and spiral/Helical welded pipes are not permitted.

6.2.3.2 Unless exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding with 100% radiography for all welds.

6.2.3.3 Double Longitudinal seam 180° apart is allowed for sizes 36" and larger only.



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6.2.3.4 ERW Pipes shall not have any circumferential seam joint in a random length. However, in case of EFW pipe (48" & above), in one random length one welded circumferential seam joint of same quality as longitudinal weld is permitted which shall be at least 2 meters from either end. The longitudinal seams of two portions of same random length shall be staggered by at least 90 degree apart and all welds shall be 100% radiographed. However, circumferential seam joint is permitted only with one longitudinal seam.

6.2.3.5 When galvanizing specified, it shall be coated with zinc inside and outside by hot-dip process to ASTM A53.

#### 6.2.4 Ends

Unless otherwise specified, the ends of piping items shall be to the following standards:

SW/SCRD : ASME B 16.11

FLANGED : ASME B16.5 and ASME B16.47

THREADING : ASME/ANSI B1.20.1 (NPT, Taper threads)

BW : ASME B16.25

Wall thicknesses 22 mm and smaller shall be as shown on Figure 2a and the 22 mm greater on Figure 3a in ANSI B16.25.

#### 6.2.5 Inspection and Tests

6.2.5.1 Hydrostatic tests shall be applied to each length of pipe and be in accordance with the requirements of ASTM A530/A999, as applicable, unless otherwise specified.

6.2.5.2 Water for hydrostatic test of austenitic stainless steel pipes shall not contain chlorides more than 50 ppm in weight.

6.2.5.3 In case of seamless & welded pipes, parent material including weld and heat effected zone for low temperature service shall be impact tested (on charpy v notch) at the lowest design temperature in accordance with requirements of code/ specification.

6.2.5.4 All welded pipes indicated as 'CRYO' & 'LT' shall be impact tested, as per requirement and acceptance criteria of ASME B31.3. The impact test temp shall be -196°C, -80 °C & -45°C, for stainless steel, 3-1/2 Ni steel and Carbon steel respectively unless specifically mentioned.

6.2.5.5 Specified heat treatment for carbon steel and alloy steel solution annealing for stainless steel pipes shall be carried out after weld repairs; number of weld repairs at same spot shall be restricted to maximum two (2) by approved repair procedure.

6.2.5.6 Transverse tension test shall be carried out on pipes of nominal size 8" and above and thickness of Sch.120 and above as per supplementary requirements of respective standards.

6.2.5.7 Check analysis shall be carried out as per ASTM A530 for pipes as per ASTM A312 and pipe size > 8" and thickness > Sch120, Check analysis shall also be carried out as per supplementary requirement S1 of ASTM-A-312.

6.2.5.8 For seamless pipes, each length of pipe with following specifications shall be ultrasonically tested as per ASTM E 213 or ASTM A388.

(a) Size upto 4 inches and Sch > 120

(b) Size > 5 inches and thk > 12 mm.

Any defects producing signal greater than the appropriate reference groove shall be unacceptable. The allowable defect shall be longitudinal flat bottom groove on the outside or inside surface of

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the pipes and length not greater than 25 mm, width not greater than 1.6 mm and depth not greater than the smaller of 1 mm or 5% of the wall thickness.

#### 6.2.6 Marking

Each pipe shall be legibly marked using stenciling or etching on the outer surface of pipes in accordance with the ASTM or API Standard.

### 6.3 Fittings

#### 6.3.1 General

6.3.1.1 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.

6.3.1.2 SW fittings shall be 3000#, 6000# and 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.

6.3.1.3 All branch connections shall be as follows:

Up to 1 1/2" NB: O-Iets/ Tee

2" and above: Tees/O-Iets / Pipe to Pipe with or without reinforcement pad up to 600# rating.

Only Tees/O-Iets above 600# rating.

6.3.1.4 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.

6.3.1.5 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.

6.3.1.6 Long radius butt welding elbows shall be used wherever possible. Unless otherwise specified, flanged elbows shall not be used.

6.3.1.7 All welded fittings shall have maximum negative tolerance equivalent to pipe selected.

6.3.1.8 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.

6.3.1.9 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.

6.3.1.10 All welded fittings shall be normalized for CS and normalized & tempered for AS.

6.3.1.11 All welded fittings shall be 100% radiographed by X-ray for all welds made by fitting manufacturer as well as for welds on the parent material.

6.3.1.12 Bevel ends of all BW fittings shall undergo 100% MP/DP test.

6.3.1.13 All pipes employed for manufacturing of fittings shall be required to have undergone Hydro test to ASTM A530/A999, as applicable.

6.3.1.14 When fluids have the possibility of causing corrosion in crevice, socket welded piping fitting will not be used.



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- 6.3.1.15 Miters may be used in Category 'D' service above 6". For other than Category 'D' fluid in 150# and 300# Class miters can be permitted for sizes above 48". Miters to be designed as per ASME B31.3. However, use of miters shall be minimum. All miters shall be with 100% Radiography.
- 6.3.1.16 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.
- 6.3.1.17 Bushings shall not be used.
- 6.3.2 Materials and Manufacture
- 6.3.2.1 Elbows and tees shall not be machined direct from bar stock.
- 6.3.2.2 Caps shall be of one piece material without welded seams unless prior written approval by the Purchaser has been obtained.
- 6.3.2.3 Nozzle welded type tees (fabricated type tees) are not permitted except for NPS 60 and larger.
- 6.3.2.4 Swage nipples shall be manufactured from seamless pipe in accordance with ASTM A234 or ASTM A403 as applicable.
- 6.3.2.5 Galvanized fittings shall be coated with zinc inside and outside by hot-dip process to ASTM A153 after all forming and heat treatment has been completed.
- 6.3.2.6 All bevelling on galvanized fittings shall be made after galvanizing.
- 6.3.2.7 Large diameter fittings that the material standards (ASME/ANSI) do not cover in size or shape shall be designed in accordance with ANSI B31.3 and be manufactured to have the same quality as the requirements of the applicable material standards.
- 6.3.2.8 The gasket contact surfaces of stub ends shall be flat with face finish between 125 AARH to 200 AARH according to ANSI B46.1.
- 6.3.2.9 Seamless stub ends shall not have any welds on the body.
- 6.3.2.10 Threaded ends shall have NPT taper threads in accordance with ANSI B1.20.1 up to 1.5" NB & IS: 554 from 2" to 6" NB.
- 6.3.2.11 Unless and otherwise specified in the requisition all socket weld and screwed fittings shall be in accordance with ANSI B16.11 to the extent covered in the specification except for unions which shall be in accordance with MSS-SP-83.
- 6.3.2.12 Special fittings like Weldolet, Sockolet, Sweepolet etc which are not covered in ANSI, MSS-SP, shall be as per Manufacturer's Std. Contours of these fittings shall meet the requirements of ANSI 31.3. Manufacturer shall submit drawings/catalogues for approval before manufacturing.
- 6.3.2.13 All welded fittings shall be double welded. Inside weld projection shall not exceed 1.6 mm. However 25 mm from the ends shall be flush smooth.
- 6.3.2.14 Specified heat treatment for carbon steel & alloy steel fittings and solution annealing for stainless steel fittings shall be carried out after weld repairs. Number of weld repair at same spot shall be restricted to maximum two by approved repair procedure.
- 6.3.2.15 All welded stainless steel fittings indicated as "CRYO" shall be impact tested as per requirement and acceptance criteria of ASME B31.3. The impact test temperature shall be -196 °C, -101°C & -45°C. For Stainless Steel, 3-1/2 Ni steel and carbon steel respectively unless specifically mentioned otherwise in MR.
- 6.3.2.16 Thickness/Schedule lower or higher than specified shall not be accepted.

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6.3.2.17 Finished dimensions shall be in accordance with ANSI B16.9, B16.11 and B16.28. Dimensions not specified in the standards may be to the Vendor's standards with the Purchaser's approval.

6.3.2.18 Outside diameters and wall thicknesses shall be in conformance with ASME B36.10 or ASME B36.19.

6.3.2.19 Unless otherwise specified on the purchase order documents, end connections shall be as follows:

Threaded Ends	Taper threads as per ASME B1.20.1
Socket-Welding Ends	ASME B16.11
Bevelled Ends	ASME B16.25, Figure 2a for wall thickness $\leq 22\text{mm}$ ASME B16.25, Figure 3a for wall thickness $\geq 22\text{mm}$

6.3.2.20 Swage nipple dimensions shall be in accordance with MSS SP-95 unless otherwise specified on purchase order documents.

6.3.2.21 Dimensional tolerances on fittings shall be within the limit specified in the applicable ANSI or MSS standards, except that circumferential tolerance at the bevelled end in sizes NPS 26 and larger shall be within the range of -0.2 to +0.3 percent of the nominal circumferential length.

### 6.3.3 Marking

6.3.3.1 Each wrought steel fittings shall be legibly marked using stencilling or etching on the exterior surface of fittings in accordance with the applicable ASTM Standards and MSS SP-25.

6.3.3.2 Each forged steel fittings shall be marked using raised letter forging, low stress round nose stamps or etching on the collar portion of the forging, or the raised boss portion in accordance with the applicable ASTM Standard and MSS SP-25.

6.3.3.3 For fittings of NPS 1-1/2 and under, at least material identification shall be marked but other markings may be on a label or tag.

## 6.4 Flanges

### 6.4.1 General

6.4.1.1 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:

- Where pipelines are connected to at connections with flanged equipment and valves.
- Where frequent dismantling of piping is required.
- Where clearance for dismantling equipment is required.
- Where steel piping is connected to nonmetallic or nonferrous piping.

### 6.4.1.2 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

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Type 304, 316, 347, 321	160
Type 304L, 316L	140

- ii) For RTJ flanges, blinds & spacers, the hardness of the groove shall be specified on the test report
- iii) 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.
- iv) For RTJ flanges, only octagonal section ring joint flanges shall be used.

#### 6.4.1.3 Face Finish

The face finish of flanges/flanged items shall be Serrated type (125-250  $\mu$  AARH) as per ASME B16.5/ ASME B16.47.

#### 6.4.1.4 Type of Flanges shall be as follows:

Rating	Size	Type	Remarks
150	Up to 1.50"	SW RF	
	2" & above	WN RF	
		WN RF/LJ FF	For SS (Utility services)
		WN RF/ Slip-On	If used in CAT 'D' service
300,600	Up to 1.50"	SW RF	
	2" & above	WN RF	except H2 SERVICE
		WN RTJ	For H2 SERVICE
For 900, & Above	All	WN RTJ.	

- i) 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.
- ii) Ring joint type flanges shall be used for services requiring higher degree of tightness, for sub zero temp etc.
- iii) All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Torque wrench I hydraulic bolt tensioner depending upon service criticality.

#### 6.4.2 Materials and Manufacture

- 6.4.2.1 All flanges shall be of forged one piece material (seamless), and plate may not be substituted without written approval from the Purchaser.
- 6.4.2.2 Ring type joint groove facing Roughness shall not exceed (side wall surface of gasket groove) 63 AARH.
- 6.4.2.3 When galvanizing is specified, forged flanges shall be coated with zinc inside and outside by hot-dip process to ASTM A153 after all forming and heat treatment has been completed.
- 6.4.2.4 All threads on galvanized forged flanges shall be cut after galvanizing.

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#### 6.4.3 Dimensions

Flanges shall be designed as follows:

NPS 24 and smaller : ANSI B16.5

Above NPS 24 : ANSI B16.47

Unless otherwise specified, end connections shall be as follows:

- Threaded : Internal taper pipe threads to ANSI B1.20.1
- Socket welding, Slip-on and Lapped joint: ANSI B16.5
- Bevelled : Figure 7 for wall thickness 22mm and smaller

Figure 8 for wall thickness greater than 22mm in ANSI B16.5.

Dimensional tolerances shall be within the limit specified in the applicable standards (ANSI/API).

#### 6.4.4 Inspection and Tests

6.4.4.1 Any flanges do not require hydrostatic testing.

6.4.4.2 One tension test shall be carried out for each heat in each heat treatment charge.

6.4.4.3 Impact test for low temp service shall be carried out at the lowest design temperature and shall meet the requirements of the applicable material specifications.

#### 6.4.5 Marking & Preservation

Each flange shall be marked using low stress round nose stamps on the external rim of flanges in accordance with the applicable ASTM Standards and MSS SP-25.

### 6.5 Gaskets

6.5.1 Gaskets shall be as follows:

Rating	Material/service	Type	Material of construction
150	CS & SS (utilities)	Plain	Asbestos free
150,300,600	CS, AS & LTCS (except H2 service)	Spiral wound	SS304
150,300,600	SS (except H2 service)	Spiral wound	SS316 (where trim material is SS304/316) SS316L (where trim material is SS304L/316L)
300(*),600(*),900 , 1500, 2500	CS	OCTAGONAL RTJ	Soft Iron
300(*),600(*),900 1500, 2500	AS	OCTAGONAL RTJ	5Cr-Alloy steel
300(*),600(*),900 1500, 2500	SS	OCTAGONAL RTJ	SS

\* Only if RTJ is specially mentioned in PMS.

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- 6.5.2 Gasket material shall be asbestos free.
- 6.5.3 Full face gaskets shall have bolt holes punched out.
- 6.5.4 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 unless otherwise specified.
- 6.5.5 Spiral wound gaskets as per ASME B16.20 shall match flanges to ASME/ANSI B16.5 up to 24", and ASME B16.47 for sizes > 24" unless otherwise specified.
- 6.5.6 Inner ring shall be provided for the following:
- As per ASME B16.20 requirement.
  - For sizes 26" & above in all classes.
  - For vacuum and hydrogen service.
  - For SS321, SS347 and H grade SS classes.
  - For classes where temperature is higher than 427°C.
  - For 900# rating and above classes.
- 6.5.7 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.
- 6.5.8 Hardness of RTJ gasket shall be 20 BHN (min) less than the corresponding flange groove hardness.
- 6.6 Stud, Bolts, Nuts and Jack Screws**
- 6.6.1 All bolting shall be as per ASME/ANSI 18.2.1 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.
- 6.6.2 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.
- 6.6.3 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
- 6.6.4 The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.
- 6.6.5 The length of the studs/ bolts should be such that minimum two threads should be out of the nut on either side.
- 6.6.6 All the stud bolt should have metallurgical certificates in case of Alloy/ SS metallurgy with identified color marking at the stud ends/ bolt side face.
- 6.6.7 For Stainless steel flanges fasteners shall also be of Stainless Steel.
- 6.6.8 Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.
- 6.6.9 Tops and Bearing Surface of Nuts in size 5/8 inch nominal size and smaller shall be double chamfered. Larger size nuts shall be double chamfered or have washer faced bearing surface and chamfered top.

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6.6.10 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.

## 6.7 Valves

### 6.7.1 General

#### 6.7.1.1 Type

- SW Valves up to 1 1/2 inch – up to 600# except ball & plug valves which shall be flanged for all sizes.
- Flanged cast valve above 1 1/2” for 150#, 300#, 600#
- Welded Valves- 900# and above

#### 6.7.1.2 Criteria for Body Bonnet Joint & Ends of the Valves

Pipe Rating	Class	Body / Bonnet	Body / Bonnet	Ends	Ends
		Size =< 1.5 “	Size > 1.5 “	Size =< 1.5 “	Size > 1.5 “
150 / 300#		Bolted	Bolted	SW	Flanged
600 #		RTJ	RTJ or Pressure seal	SW	Flanged
900# & Above		Threaded seal welded/ Welded bonnet	Pressure Seal	BW	BW

6.7.1.3 All flanged valves (except forged) shall have flanges integral with the valve body.

6.7.1.4 Yoke material shall be at least equal to body material.

6.7.1.5 Valves shall have pure graphite as gland packing material. Asbestos and other gland packing material shall not be used.

6.7.1.6 Forgings are acceptable in place of Castings but not vice-versa.

6.7.1.7 No Cast Iron/Ductile Iron valves to be used in any service.

6.7.1.8 Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.

6.7.1.9 All “IBR” valves shall be painted red in body–bonnet / body–cover joint.

## 6.7.2 Design

### 6.7.2.1 General

6.7.2.1.1 The minimum body wall thickness for the steel valves in size and/or rating not specified in the applicable standards shall conform to ANSI B16.34 (Standard Class).

6.7.2.1.2 Extension bonnet, when required, shall be integral with the Bonnet but a tube extension may be welded to the bonnet with full penetration welding.

6.7.2.1.3 Body/Disc seat construction is defined as follows:

#### a) Renewable Seat

- A separate seat ring threaded in, rolled in the body or on the disc

#### b) Integral Seat



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- Integral with the body or disc
- A hard faced deposit on the body or disc
- Direct deposition of 13% chromium seat material on the body is not acceptable.
- A separate seat ring continuously welded in the steel body or on the disc.

6.7.2.1.4 If the seat surface with a hard faced deposit is specified, the integral seat is acceptable instead of the renewable seat.

6.7.2.1.5 The seat surfaces with no hard faced deposit shall be the renewable seat except austenitic stainless steel valves.

6.7.2.1.6 If a combination trim, e.g. a hard faced deposit and 13Cr is specified, the former shall be used for the body seat surface and the latter for the disc seat.

6.7.2.1.7 Where a hard faced trim is specified, the back seat of the bonnet may be of a direct weld deposit.

6.7.2.1.8 Unless otherwise specified in the purchase order documents, the use of soft seals in wedge or disc is not acceptable.

6.7.2.1.9 Hand wheels shall not be made of gray iron or non-metallic materials.

#### 6.7.2.2 Steel Gate Valves

6.7.2.2.1 Gate valves shall conform to the following standards:

- General use valves : API 600
- 150Lb stainless steel valves : API 603

6.7.2.2.2 The valves shall be of outside screw-and-yoke type with a rising stem and non- rising hand wheel.

6.7.2.2.3 The valves shall be of a solid wedge type; either a plain solid wedge or a flexible solid wedge.

6.7.2.2.4 The wedges shall have the integral seats. The renewable seats are not acceptable.

6.7.2.2.5 The valves for liquefied petroleum gases shall be provided with a relief hole on the wedge to relieve excess body cavity pressure upstream unless purchase order document requires cavity pressure relief downstream.

#### 6.7.2.3 Steel Globe Valves

6.7.2.3.1 Globe valves shall conform to the standards listed below in so far as applicable:

6.7.2.3.2 General use valves: API 623 / ASME B16.34.

6.7.2.3.3 The disc shall be of the integral type with a spherical seating surface.

6.7.2.3.4 Other type disc will be acceptable except a soft ring seated.

6.7.2.3.5 The disc shall be loosely attached to the stem to allow for proper seating and fitted to receive the locking device which retains the disc on the stem.

6.7.2.3.6 A disk thrust plate shall be provided between the end of the stem and the disc, except for small size valves.

6.7.2.3.7 The disc thrust plate shall have a differential hardness of 50HB minimum for the stem.

6.7.2.3.8 When in the fully open position, the net area between the disc and the seat shall be at least equal to the area of the end port.

#### 6.7.2.4 Steel Swing Check Valves

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6.7.2.4.1 Swing check valves shall conform to the standards listed below in so far as applicable:

6.7.2.4.2 General use valves: API 602 / API 6D / API594/ BS 1868.

6.7.2.4.3 The disc shall be of the integral type with a flat seating face.

6.7.2.4.4 The disc shall be secured to the hinge by a locking device to allow for the self- seating of the disc on the body seat.

6.7.2.4.5 A hinge and hinge pin shall be provided and mounted in the body to permit full movement of the disc.

6.7.2.4.6 If the service requires an outside lever with adjustable weights, damping device, etc., to control the movement of the disc, dual plate type check valves with a spring loaded may be used except that they shall not be used for corrosive services.

#### 6.7.2.5 **Single/Dual Plate Check Valves**

6.7.2.5.1 Single/Dual Plate Check Valves shall conform to API 594. These types of valves may be used for swing check valves in case of space limitation.

6.7.2.5.2 Dual plate Check Valves shall not be used for corrosive services.

#### 6.7.2.6 **Ball Valves**

6.7.2.6.1 Ball valves shall conform to API 6D/API608.

6.7.2.6.2 The ball of Ball valves shall not protrude outside the end flanges.

6.7.2.6.3 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

6.7.2.6.4 The manufacturer shall propose higher ratings at the seat materials specified for Owner's approval.

6.7.2.6.5 The valves shall be of full bore type. For NPS 4 & over they may be of reduced bore type unless otherwise specified. Ball port shall be cylindrical.

6.7.2.6.6 Sealed cavity balls shall be designed to withstand the full hydrostatic body test pressure.

6.7.2.6.7 A relief hole, unless otherwise specified, shall be provided on the upstream-side ball for relieving pressure within the body cavity at the ball close and open positions unless the purchase order document requires it down stream.

6.7.2.6.8 Stem retention shall not depend on the packing gland.

6.7.2.6.9 The stem shall be of anti-blowout type and should be retained by the body back seat for fire safe design.

6.7.2.6.10 Glands shall be of the bolted type. An internal screwed stuffing box is not acceptable.

6.7.2.6.11 Body seat shall be of a renewable seat ring. The wrench shall be designed to make wrench operation ease even when the valves are insulated without any stem or bonnet extensions.



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6.7.2.6.12 The valves shall be fitted with an anti-static device to ensure electrical continuity from the ball to the stem and from the stem to the body.

6.7.2.6.13 The valves used in process services shall be of fire safe design especially for the ball seats, stems and body flanges.

6.7.2.6.14 Ball valves may be used in place of gate or plug valves with the following limitations:

6.7.2.6.15 Operating conditions are within the permissible pressure – temperature range of seat materials.

6.7.2.6.16 Fire safe type is used for hydrocarbon services.

#### 6.7.2.7 **Butterfly Valves**

6.7.2.7.1 Butterfly valves shall conform to API 609.

6.7.2.7.2 The valves shall be of wafer lug type, body threaded, with a tight seal in the closed position. Lug shall have Internal UNC Threads. Lug shall be threaded such that either flange can be dismantled for maintenance.

6.7.2.7.3 Unless otherwise specified, the valves may be seated with concentric location of disc and seat. They shall be provided with a soft seat material built in the body and suitable for the specified conditions.

6.7.2.7.4 The manufacturer shall propose the maximum differential pressure across the disc and the temperature limitation dictated by the soft seal material for Owner's approval.

6.7.2.7.5 Minimum rating for the Butterfly Valve shall be PN 16.

#### 6.7.2.8 **Plug Valves**

6.7.2.8.1 Plug valves may be fully in accordance with manufacturer's standard except for:

Minimum body wall thickness to ANSI B16.34

Face to face dimension to ANSI B16.10

6.7.2.8.2 The valves shall be of reduced bore type.

6.7.2.8.3 The valves shall have PTFE body seats to prevent galling at plug seating. Lubricated plug valves are not acceptable.

6.7.2.8.4 The manufacturer shall propose the temperature limitation dictated by the soft material.

6.7.2.8.5 The plugs shall be fitted with an anti-static device for all services.

6.7.2.8.6 The valves used in process services shall be of fire safe design to API 6D, but limited to gland parts only.

6.7.2.8.7 For Acid service, having temperature higher than 75 DegC Plug Valves to be used & IGC testing to be considered.

#### 6.7.3 **Valve Dimensions**

6.7.3.1 End flanges, when specified, shall be as follows:

- NPS 24 and smaller : ANSI B16.5
- NPS 26 to NPS 60 : ANSI B16.47
- Threaded end (NPT) : ANSI B1.20.1
- Socket welding end : ANSI B16.11
- Butt welding end : ANSI B16.25

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(Wall thickness 22mm and smaller - Fig 2a,

For over 22mm thickness- Fig 3a)

- 6.7.3.2 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.
- 6.7.3.3 Valve under cryogenic service (temp. below -45°C) shall be as per BS-6364 and shall be procured from pre-qualified vendor.
- 6.7.3.4 Generally the valves are hand wheel or lever operated. However, suitable gear operator in enclosed gear box shall be provided for 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

- 6.7.3.5 Spectacle blinds and paddle blinds/spacers shall be provided per the pressure class and size range divisions shown below:

Spectacle Blind	Paddle Blind/Spacer
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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

6.7.3.6 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.

6.7.3.7 Quarter-turn valves shall have "open" position indicators with limit stops.

6.7.3.8 By-Pass

A globe type valve (size as per ASME/ANSI B61.34) 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.

#### 6.7.4 Inspection and Tests

6.7.4.1 Shop inspection and tests shall be carried out to API 598 and related MSS standards.

6.7.4.2 Radiography of Cast Valves

6.7.4.2.1 Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME B16.34.

6.7.4.2.2 The minimum requirement of radiography shall be as under (except as mentioned in Cl.6.7.4.2.3 & Cl.6.7.4.2.4):

Class	Size	Qty.
150	Up to 24"	10%
150	26" & above	100%
300	Up to 16"	10%
300	18" & above	100%
600 & above	All	100%

6.7.4.2.3 Radiography requirement for special/critical piping classes (hydrogen, hydrogen bearing, stress relieved caustic services) shall be as follows:

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Class	Size	Qty.
150	up to 24"	50%
150	Above 24"	100%
300	up to 16"	50%
300	Above 16"	100%

6.7.4.2.4 Radiography requirement for special/critical piping classes (Oxygen, NACE and any other lethal service) shall be as follows:

Class	Size	Qty.
150	All Sizes	100%
300	All Sizes	100%

6.7.4.2.5 The welds of body-to-bonnet and body-to-end flange shall be subjected to 100% NDT; both radiographic and magnetic or liquid penetrant examinations.

6.7.4.2.6 Bevelled ends on each butt welding end valves shall be subjected to 100% radiographic examination and, magnetic particle or liquid penetrant examination.

#### 6.7.4.3 Pressure Tests

6.7.4.3.1 Each Valve shall be pressure tested in accordance with API 598.

6.7.4.3.2 High pressure closure test shall be required for gate and globe valves.

6.7.4.3.3 Water for pressure tests on austenitic stainless steel valves and those having internals of austenitic stainless steel shall not contain chlorides more than 50 ppm in weight.

### 6.8 Special Valves (Orbit, Y-body Globe, Jacketed valves of all types)

6.8.1 Special Valves shall strictly follow the requirements of Valve data sheet, Process data sheet/Specialty data sheet.

6.8.2 Special Valves shall be made out of 100% radiographic casting/ 100% ultrasound forging.

6.8.3 Jacketed Valves shall be tested to 100% DP/ MP check on Jacket welding, 100% radiography test of valve body, 100% hydro test of Jacket.

6.8.4 Large diameter swing check valves shall be equipped with an anti-hunting device, where closing of the check valve could cause a surge.

### 6.9 Traps

6.9.1 Vendor shall also furnish the performance curve indicating the capacity hi mass/hour at various differential pressures across the trap.

6.9.2 Parts subject to wear and tear shall be suitably hardened. Traps shall function in horizontal as well as in vertical installation.

6.9.3 Traps shall have integral strainers.

6.9.4 All traps shall be hydrostatically tested to twice the design pressure.

### 6.10 Hoses

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- 6.10.1 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.
- 6.10.2 All hoses shall be marked with service and working pressure at minimum two ends clearly.
- 6.10.3 Hoses shall be resistant to ageing, abrasion and suitable for outdoor installations.
- 6.10.4 Complete Hose assembly shall be tested at two times the design pressure
- 6.10.5 Steam hoses shall be subject to steam resistance test.
- 6.11 Expansion Joints**
- 6.11.1 The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).
- 6.11.2 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.
- 6.11.3 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.
- 6.11.4 No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable.
- 6.11.5 The out of roundness shall be limited to  $\pm 3\text{mm}$ . This is the max deviation between the max & min diameter.
- 6.11.6 The actual circumference of the welding end shall be maintained to  $\pm 3\text{mm}$  of the theoretical circumference.
- 6.11.7 Apart from the usual requirements, the vendor shall also furnish
- Design calculations to justify stiffness and fatigue life.
  - Axial, lateral stiffness, angular stiffness, effective pressure thrust area.
  - Installation/maintenance manual.
- 6.12 Supports & Spring Assemblies**
- 6.12.1 The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.
- 6.12.2 Testing of springs shall be as per BS1726.
- 6.13 NDT Requirements for piping**
- 6.13.1 Classes in 150# for normal service shall be subjected to 10% radiography and 10%DP/ MP test (for CS&AS) or 10% DP test (for SS).
- 6.13.2 Classes in 300# for normal service shall be subjected to 20% radiography and 20% DP/MP test (for CS&AS) or 20%DP test (for SS).
- 6.13.3 Classes in 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.
- 6.13.4 For hydrogen and hydrogen bearing hydrocarbon services radiography and DP/MP shall be 50% in 150# and 300# class ratings.

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6.13.5 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.

6.13.6 For fire water service, IBR, etc., any statutory NDT requirements, not covered above, shall also be complied.

6.13.7 Classes in Cat-D service shall be subjected to 5% radiography and 10% DP/ MP test (for CS&AS) or 10% DP test (for SS).

#### 6.14 **Special Service Requirements**

##### 6.14.1 **IBR Service**

6.14.1.1 IBR stands for Indian Boiler Regulation. For steam services, it is statutory obligation to meet IBR requirements.

6.14.1.2 For items under IBR, composition restrictions, test reports, painting, etc. shall be as per IBR's stipulations.

6.14.1.3 For carbon steel piping items under IBR, the chemical composition shall conform to the following:

Carbon (Max) 0.25 %

Others (S, P, Mn) As prescribed in IBR regulation.

6.14.1.4 The chemical composition condition as indicated in this clause is not applicable for items other than IBR services.

##### 6.14.2 **Hydrogen services**

6.14.2.1 Testing requirements for piping items intended for use in hydrogen service are specified here. These requirements are applicable in addition to requirements specified in Technical scope/specification elsewhere in this document and the most stringent condition shall prevail.

“Special Requirements for Hydrogen Service (Spec No. API-941)” and ASME B31.12 shall be followed for all Hydrogen and Hydrogen bearing hydrocarbon services.

##### 6.14.2.2 **PIPE, FITTINGS AND FLANGES**

a) All carbon steel pipes, fittings and flanges having wall thickness 9.53 mm (0.375") and above shall be normalized. Cold drawn pipes shall be normalized after the final cold draw pass for all thicknesses.

b) All Alloy Steel (Cr-Mo) pipes, fittings and flanges shall be normalized and tempered. The normalizing and tempering shall be a separate heating operation and not a part of the hot forming operation.

c) Hardness testing to be as per ASTM E110. For carbon steel Pipes & Fittings, hardness of weld and HAZ shall be 200 BHN (max). For alloy steel Pipes & Fittings, hardness of weld and HAZ shall be 225 BHN (max).

d) For all Carbon steel and Alloy steel Pipes, Fittings and Flanges with wall thickness over 20mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and accordance with ASTM A370. Impact energies at 0°Celsius shall average greater than 27J (20ft-lb) per set of three specimens, with a minimum of 20J (15 ft-lb).

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- e) All girth welded joints (longitudinal and circumferential) shall be 100% radiographed in accordance with UW-51 of section VIII, Div-1 and ASME Section V. Radiography shall be performed after post weld heat treatment.

#### 6.14.2.3 VALVES

- a) General
- b) All cast valve flanges & bodies with flange rating of Class 900 or greater shall be examined in accordance with paragraphs 7.2 through 7.5 of Appendix-VII of ASME SEC-VIII, DIV.1, regardless of casting quality factor.
- c) Body / bonnet / cover joints & stuffing box of all valves shall have low emission. One valve per metallurgy, per rating, per size shall be helium leak tested as per ASME Sec.V, Subsection A, Article 10 (Detector Probe Technique), Appendix IV at a minimum of 25% of the allowable (rated) cold working pressure. Selection of valves for helium leak test shall be at random. Test duration shall be as follows:

Test duration in Minutes					
Nominal size	Pressure Class				
	Upto 300	600	800 & 900	1500	2500
Up to 2"	3	6	9	12	12
3" to 6"	6	9	12	15	18
8" to 16"	9	9	12	15	18
18" to 24"	9	12	15	18	21

The valve shall show no leakage. No leakage is defined as a total leakage rate of less than 0.0001 ml/s of helium.

- d) Only normalized and tempered material shall be used in the following specifications:  
 Castings: A217 Gr.WC1, A217 Gr.WC4, A217 Gr.WC5, A217 Gr.WC6, A217Gr.WC9, A217Gr.C5, A217 Gr.C12  
 Forging: A182 Gr.F11 C1.2

#### 6.14.2.4 CS & AS VALVES

- a) Bend test and Magnetic Particle inspection of the entire surface of body and bonnet casting shall be in accordance with ASTM A217. Supplementary requirement S3 & S4 evaluation of magnetic particle, inspection shall be in accordance with MSS-SP-53 except that no linear discontinuities shall be allowed.
- b) Hardness testing to be as per ASTM E110. The Brinell hardness of heat treated casting shall not exceed 200 BHN for carbon steel & 225 BHN for alloy steel.
- c) Repair to defective casting shall be outlined in writing to the purchaser before repair starts. Repair method to be approved prior to welding.
- d) Casting shall be preheated to a minimum of 400°F prior to welding and all Chromium-Molybdenum alloys shall be post weld heat treated after welding is complete. Stress relieving is essential for welds.
- e) Carbon steel shall be normalized and alloy steels shall be normalized & tempered.



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- f) Dye Penetrant test of welds shall be in accordance with ASTM B165 Procedure B-2 and interpretation as per Appendix-8 of ASME-VIII Div.1.
- g) The tensile stress for AS shall be less than 100,000 psi.
- h) Charpy V-notch impact testing is to be done for valve material (average 20 ft-lb for set of 3 [minimum value 15 ft-lb] at 30°F).

#### 6.14.2.5 SS VALVES

- a) Valve casting shall be in solution heat treated and pickled condition.
- b) Critical body and bonnet casing section typically defined by ASME B 16.34 shall be radiographed and shall meet ASTM E446 (up to 2" thick) Category A, B & CA Level 2, Category CB, OC & CD Level 3, Category D, B & F Level 0. For wall thickness 2" to 4.5" comparable plates of ASTM E186 shall be used. ASTM E94 and ASTM E142 shall be used for recommended practice & controlling quality of radiography as guide. The entire surface of all castings shall be dye-penetrant inspected after pickling.
- c) Welds shall be 100% radiographed and evaluated in accordance with paragraph 344.5 of ASME B31.3 with a minimum casting quality factor of 0.95. Dye Penetration test shall be as per ASTM E165 Procedure B-2, Interpretation as per Appendix-8 of ASME-VIII Div.1.

#### 6.14.3 NACE & Sour Service

For items under this category, unless otherwise specified in PMS, NACE:- MR-01-75 shall be followed. Hardness shall be below BHN 200 for C.S. material. Carbon equivalent (CE) shall be limited to 0.43.

#### 6.14.4 CRYO & Fire-Safe

For items to be used under cryogenic conditions, temp below - 45°C and those required to be fire-safe, special designs and tests would be applicable. Pre-qualification criteria need to be specified before execution of job.

#### 6.14.5 Low Temperature service

- 6.14.5.1 Low Temperature Carbon Steel shall be normalized & impact tested.


#### 6.14.6 General requirements

- 6.14.6.1 All alloy steel piping items shall be Normalized & Tempered.
- 6.14.6.2 All alloy steel and higher alloyed piping material shall be subjected to PMI test.

#### 6.15 Inspection of supply items

- 6.15.1 Inspection authority means the Third Party Inspection Agencies (TPIA) approved by the Owner to carryout inspection of materials.
- 6.15.2 The inspecting authority shall have the right to select random samples for check test and reject materials, if samples furnished as above and tested as per the specifications fail to meet the requirement specified.
- 6.15.3 All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing as per approved QAP. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector.
- 6.15.4 Testing performed in the presence of the purchaser's representatives shall not relieve the supplier of their own responsibilities and guarantees and any other contractual obligations.



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6.15.5 Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA)/ Owner.

6.15.6 Scope of Inspection by TPIA:

Review (R) of Chemical composition report, Heat treatment chart, Intergranular corrosion (IGC) test and Non Destructive Examination (RT/UT Report).

Witness (W) of Mechanical Testing: Tensile test, bend test, hardness test, transverse tension test, Impact test, flattening test etc (as applicable).

Random witness (10% RW): Hydrostatic test, Positive Material Identification (PMI) for Alloy/Stainless steels, Dye Penetration (DP) / Magnetic Particle (MP) Test, Galvanizing, Dimensional check, Marking, Visual check.

## 7. THERMAL INSULATION OF PIPING

7.1 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.

7.2 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.

7.3 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.

7.4 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 leachable chloride to 10ppm (max) shall be demonstrated as per the test method ASTM C-871.

7.5 For detailed specification of insulation refer Design Philosophy-Construction/Erection, Pre-Commissioning, Commissioning and Start-Up.

### 7.6 Extent of Insulation

7.6.1 Extent of insulation shall be as per final approved P&ID/ Line list /General Arrangement drawing/Isometrics and vessel and equipment data sheets.

7.6.2 Insulated piping system shall have straight pipe, bends, tees and pipe fittings completely insulated.

7.6.3 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.

7.6.4 For bucket and float type traps the inlet piping and trap shall be insulated.

7.6.5 For thermostatic and thermodynamic traps insulation shall terminate at approx 500mm before trap.

7.6.6 Instrumentation such as level gauges, level controllers, level switches, dp cells, etc., shall have their fluid containing sections and associated piping completely insulated.

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## 8. Painting

### 8.1 Scope of Painting

#### 8.1.1 The following surfaces and materials shall require painting.

- 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.
- Identification colour bands on all piping as required including insulated aluminium clad, galvanized, SS and non ferrous piping.
- Pipes, fittings & valve surfaces under insulation of carbon steel and alloy steel insulated piping system.
- Pipes, fittings, valves surfaces under insulation of stainless steel insulated piping system.
- All structural steel works, supports, walkways, handrails and platforms etc.

#### 8.1.2 The following surfaces and materials shall not require painting:

- Un-insulated austenitic stainless steel and higher alloy piping.
- Plastic and plastic coated materials.
- Non ferrous material like aluminum, galvanized, brass, bronze piping etc.

### 8.2 Colour 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/Construction Section of Document)

## 9.0 WELDING

### 9.1 Applicable Codes & Standards

All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures.

- Process Piping : ASME B31.3
- The Indian Boiler Regulations : IBR

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In addition, the following codes and specifications referred in the code of fabrication shall be followed for the welding specifications, consumable qualifications and non destructive test procedures.

- i) Welding and Brazing Qualifications ASME BPV- Sec IX.
- ii) Non destructive examination ASME BPV Sec V.
- iii) Material specifications: Welding rods, electrodes and filler metals ASME BPV Sec II Part C.

The additional requirements mentioned in this specification, over and above those obligatory as per codes, shall be followed wherever specified.

## 9.2 Welding Processes

9.2.1 Welding of various materials shall be carried out using one or more of the following processes with the approval of the Engineer-in-charge.

- Shielded Metal Arc Welding process (SMAW)
- Gas Tungsten Arc Welding process (GTAW).

9.2.2 Automatic and semi-automatic welding processes shall be employed only with the express approval of the OWNER / PMC. The welding procedure adopted and consumables used shall be specifically approved.

9.2.3 A combination of different welding processes could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of OWNER/ PMC.

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## **ANNEXURE – 1**

**TABLE OF BASIC SPAN**

Pipe Size In.	SCH/Thickness (in)	PIPE- VAPOR INSULATION			PIPE- LIQUID INSULATION			BARE PIPE EMPTY		BARE PIPE WATER FILLED		Pipe size in.
		BASIC SPAN (L)M			BASIC SPAN (L)M							
		UPTO 175° C	176° C TO 315°C	316°C TO 400°C	UPTO 175° C	176° C TO 315°C	316°C TO 400°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"
2-1/2"	SCH 40	6.5	6.0	5.0	6.0	5.5	4.5	7.5	8.7	6.5	11.79	2-1/2"
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"	3/8" w	15.0-	14.5	13.5	12.0	12.0	11.5	16.0	82.5	12.5	172.05	14"
16"	3/8" 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"	3/8" 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"
1-1/2"	SCH 80	5.0	5.0	4.5	5.0	4.5	4.0	6.0	5.45	5.0	6.60	1-1/2"
2"	SCH 80	6.0	5.0	4.5	5.5	5.0	4.0	6.5	7.53	6.0	9.45	2"
2-1/2"	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"

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112"												
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	13.0	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"	10S	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"
18"	10S	16.5	15.5	14.5	12.5	12.5	11.5	17.5	53.18	13.0	212.1	18"
20"	10S	17.5	16.5	15.5	13.0	13.0	12.0	18.5	68.50	13.0	264.5	20"
24"	10S	19.0	18.0	17.0	14.0	13.5	12.5	20.5	94.37	14.0	376.8	24"

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## **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

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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.

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### ANNEXURE-3

#### MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES

NOM PIPE SIZE IN INCHES	VERTICAL SPACING 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:-

- 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.
- The guide spacings given in the above table are indicative only.





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## 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
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

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Item	Description	
	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
	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

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Item	Description	
** Verify conformance with local regulations. * With full consideration of thermal movements		

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## **ANNEXURE-5**

### **JOB SPECIFIC REQUIREMENTS**

Sl No	ITEM	Job Requirement	Remarks
1	Equipment spacing (ISBL)	As per Piping Design basis.	
2	Minimum pipe rack width 4m/6m/8m/10m/12m in single bay	10 M for Main Rack 4M/ 6M/ 8M for Sub Racks.	
3	Spare capacity on Rack	Provision of 20% on each tier for future modifications.	
4	Cooling Water Lines	Generally on rack up to 16" Underground above 16"(in specific cases, lower sizes may also go Underground depending on layout)	
5	Minimum height of sleeper due to maintenance requirement	300 mm for pavement area 500 mm for unpaved area	
6	Fin-fan cooler location	On pipe rack and/or technological structure access to be provided	As per Equipment Layout.
7	Location of pumps: In units	- Inside pipe rack as far as possible with concrete slab below Air cooler. - For, smaller width (4M, 6M & 8M) rack, pumps shall be outside or on one side of rack portal.	Refer cl. 5.2.11.2
8	Requirements of monorail on Pumps: under pipe rack/shed- Open area-	Required for motor rating 45 KW and above for all pumps. None	
9	Requirement for exchanger bundle removal a) Hydro extractor  b) Monorail & chain pulley block	Monorail & chain pulley block required at Technical Structures.  Where Hydro extractor mobility is difficult in running plant.	However, required head Room for installing monorail shall also be kept in Technical Structures.
10	Battery limit valves operation a) At grade.	Elevated platform provided at Battery limit.	

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	b) At elevated Platform.		
11	Pipe way road crossing	Overhead pipe bridges	At B/L with access.
12	Electrical cable routing underground I Above ground: - ISBL - OSBL	Refer Electrical Design Basis.	
13	Any requirement of statutory approval.	All statutory requirements e.g. IBR/PCB/CCE and others	
14	Instrument cable routing ISBL & OSBL	Refer Instrumentation Design Basis.	
15	Safety shower / eye wash. (in case of chemical/catalyst handling system)	Required. As Per PID	
16	Requirement of elevators.	Yes.	
17	Connectivity of all platforms at higher elevations for tall columns (ie. between columns & technological structure and between columns & rack).	Yes.	Adjacent columns/ technological Structures/ rack must be connected at minimum two locations.
18	Compressor/blower house for ISBL as well as OSBL a) location b) Maintenance requirement	a) Under Shed b) E.O.T.	With additional auxiliary hook for light wt handling maintain ace platt shall be provided across full width with cat ladder at each end
19	Instrument Air Drier Shed	Yes	
20	Insulation material a) Hot /Tracing/safety b) Electrical tracing c) Cold	As per process design basis.	
21	Painting System	Refer Std Specification (Civil)	
22	Method of surface preparation a) Mechanical tools	Blast Cleaning	

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	b) Blast cleaning		
23	Sand blasting/Grit blasting	Grit Blasting	
24	Painting of SS pipes below insulation	****As Per Specification	Wherever painting is not specified, Aluminum/ SS foil as per piping design basis shall be used.
25	Specific colour coding requirements.	Client agreed	
26	Usage of IS grade material.	No	
27	Usage of asbestos gasket.	No	
28	Provision for high settlement in tank farm: a) Usage of dresser coupling in tank farms. b) Flexibility of piping.	Flexibility of Piping.	
29	Steam tracing type	Standard module for steam distribution and condensate collection manifolds with integral glandless piston valve & trap and carbon steel tracer pipe.	
30	Bulk Material	Client agreed vendor list.	
31	Engineering Drawing Mode	Electronic & Hard Copies also required	
32	Specific software package for engineering drawings -AutoCAD and AP-ISO -PDS/SP 3D with Isogen -Auto Plant Designer with Isogen or AP-ISO -PDMS with Isogen -AutoCAD	3-D Models, capable of model review and walk through.	
33	Material Control System		
34	Item Coding system		

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35	Stress Analysis Package	CEASER II (Latest Version)	
36	Access to Nozzles of columns	Platforms for all Nozzles.	
37	Staircase / Ladders for tall column/reactors.	Ladders for columns/staircases for reactors	
38	Provision of breakup flanges for removal of tube bundles of heat exchangers.	Wherever necessary.	
39	Height of pipe support pedestals	150 mm from FGL	
40	Mandatory Bulk Material Escalation	As per mandatory spares.	
41	Cathodic Protection of Tankage and U/G Piping	Required (Refer Electrical Design Basis)	
42	Cast iron valves	Cast Iron Valves not to be used.	
43	Pump Suction strainers	As per Cl. 5.3.6.6 & 5.3.6.7	However, licensor's requirements, if any, may be considered with approval from owner / PMC.
44	Two phase flow line analysis	Both static and dynamic analysis required.	
45	Connectivity of the technological structure	Technological structure to be Interconnected.	
46	Usage of check valves.	Wafer dual plate and swing check valves	Unless specifically required by process
47	Traps on steam lines.	Thermodynamic for line traps and Thermostatic for steam	

NOTE:- THE JOB SPECIFIC REQUIREMENTS GIVEN ABOVE SHALL BE CONSIDERED FINAL IN CASE OF ANY CONFLICT WITH THE MAIN BODY OF DESIGN BASIS.

## ANNEXURE – 6

### DESIGN PHILOSOPHY FOR STRESS ANALYSIS

#### 1.0 PURPOSE

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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.

## 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 B31.3.

### 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 21°C the assumed piping installation temperature. The displacement stress range from this installation temperature to the minimum recorded ambient temperature of 00 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



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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-7A 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-7B 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

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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.

#### 4.6 SPECIAL PIPING

Special piping forming part of heater internal piping, etc. are treated as proprietary piping and nozzle loading at the Interface connections are to be co-ordinated with vendor.

### 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).

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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.

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	

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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

W- Dead Weight

T1- Maximum Operating Temperature

WW- Water Weight

P2- Design Pressure

WIN- Wind Load

T2- Design Temperature

U- Uniform Load

HP- Hydro test Pressure

L2- Load case

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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.

## 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

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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-6-A

### CRITERIA FOR IDENTIFYING EXTREMELY CRITICAL LINES (LEVEL I)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
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All	All	All	Piping which will undergo hydraulic shock, auto-ignition or is in service.
All	DN $\geq$ 80	All	Category M (Lethal) fluid service per ASME B31.3 (No cyclic service).
All	DN $\geq$ 80	All	Piping which is openly exposed to winds > 75 mph.
T < -29	DN $\geq$ 80	Carbon Steel	All Services.
T < -45	DN $\geq$ 80	All	All Services
T $\geq$ 65	DN $\geq$ 80	Non-Metallic	All Services
T $\geq$ 65	DN $\geq$ 80	All	Lines with pressure $\geq$ 900 psig.
T $\geq$ 150	DN $\geq$ 80	All	All Services
ALL	DN $\geq$ 400	All	All Services.
T $\geq$ 260	ALL	ALL	ALL Services.
-29 $\geq$ T $\geq$ 65 OR -7 $\geq$ T $\geq$ 50	DN $\geq$ 80 DN $\geq$ 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 $\geq$ 27 (NOTE 2)	DN $\geq$ 80	All	Jacketed piping.
-29 $\geq$ T $\geq$ 65	DN $\geq$ 100	All	Internally lined pipe (except glass).
All	ALL	All	Glass lined piping.
All	DN $\geq$ 80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
-40 $\geq$ T $\geq$ 80 -29 $\geq$ T $\geq$ 70	DN $\geq$ 100 DN $\geq$ 200	Metallic Metallic	Underground Piping

#### NOTES:

Load sensitive equipment include fired heaters, lined vessels with lining of brittle material, non-ferrous equipments, graphite heat exchangers, plate & frame heat exchangers, etc.

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-6-B

#### CRITERIA FOR IDENTIFYING MODERATELY CRITICAL LINES (LEVEL II)

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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 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-7

### 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.



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## 2.0 SOFTWARE

Anyone of the following two software with Oracle database shall be used by the LSTK Contractor.

- i) PDS/SP3D 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.

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- 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.
- All spring hangers, roller supports to be modelled with all details.
  - Pipe supports along with concrete pedestals, Type of support
  - Details of the spring hanger's i.e. operating load, travel, spring constant should be keyed in as user-defined attributes.
  - Details of expansion bellows i.e. type, axial/lateral deflections, stiffness etc to be keyed in as user defined attributes.
  - 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, fired heaters, burners and peep holes, air coolers with motors and fans, filters, blow down drums, all equipment within packages and heat exchangers etc.
- 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.
  - Equipment supports: skirts, support legs/lugs, saddles to be modelled along with the equipment
  - Insulation type (hot, cold, tracing, jacketed, etc), Insulation thickness, operating/design Pressure /temperature, hydro test medium/pressure to be given.
  - 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.
- Skid to be tagged as main equipment.
  - All sub-equipment of all skids to have skid tag as a prefix.
  - All sub-equipment to be modelled with exact geometry.
  - 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
  - All pipe supports with the skids are to be modelled as per para 5.1.7

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- 5.1.9 Tagging of all line nos., Instrument nos., special items, equipment nos. shall be as marked in the P&IDs.
- 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. 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:
- Line operating/design, temperature/pressure in deg. C and kg/cm<sup>2</sup>g respectively
  - Liquid state i.e. vapour, liquid, 2-phase.
  - Insulation thickness and type i.e. IH/IC/IJ/IC etc.
  - Hydro test pressure in kg/cm<sup>2</sup>g and medium.
  - 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.
  - Hydro test loop no.
  - 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
- 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.
  - 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:

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- 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.
- iii) 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 modelled 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.

Sl.No.	Discipline	Model Identifier	Sl.No.	Discipline	Model Identifier
1	Piping above ground	P	5	Structural	S
2	Piping underground	U	6	Architectural	A
3	Equipment	E	7	Electrical	L
4	HVAC	H	8	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
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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	--	P X		XX

##### 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.		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

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► 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



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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/Licenser

LSTK Contractor shall be responsible for arranging 3D review sessions at his design center with Dynamic walkthrough with overhead projector system, for Owner/ PMC/ Licenser 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. LSTK 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

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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 reserves the right to verify the above at the premises (as applicable) including experience of personnel deployed on the project.

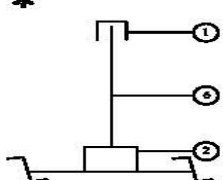
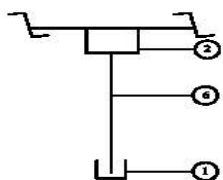
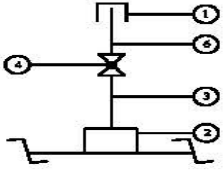
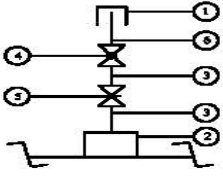
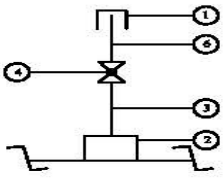
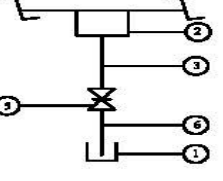
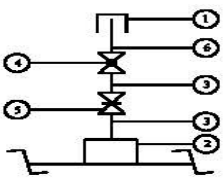
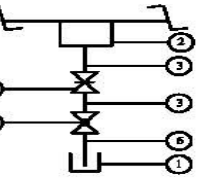
Owner/PMC decision shall be final and binding on the LSTK Contractor in this regard.



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## ANNEXURE-8

### HYDROTEST DRAIN & VENT

Fluid	Pressure rating	3/4" Vent	3/4" Drain
Gas	NP < = CLASS 2500		
Steam	NP < = CLASS 600		For steam trap installation See separate specification
	NP > = CLASS 900		
Liquid	NP < = CLASS 600		
	NP > = CLASS 900		

1. 3/4 " Thd. Cap.
2. 3/4" Branch Fitting acc. to Pipe Class.
3. 3/4" Nipple (P).
4. 3/4" Globe Valve (SW).
5. 3/4 "Gate Valve (SW).
6. 3/4" Nipple (P/T).

\* For Hydrostatic test only. For process purpose use installation as for liquid service.

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## **ANNEXURE-9**

### **Inspection & Test Plan for Piping items**

PNMP-ITP-01	INSPECTION & TEST PLAN WELDED PIPES
PNMP-ITP-02	INSPECTION & TEST PLAN SEAMLESS PIPES
PNMP-ITP-03	INSPECTION & TEST PLAN FITTINGS
PNMP-ITP-04	INSPECTION & TEST PLAN FORGED FLANGES
PNMP-ITP-05	INSPECTION & TEST PLAN STUDS & NUTS
PNMP-ITP-06	INSPECTION & TEST PLAN GASKETS
PNMP-ITP-07	INSPECTION & TEST PLAN VALVES


	INSPECTION & TEST PLAN FITTINGS	PNMP-ITP-03
		DOCUMENT NO
		SHEET 1 of 1

SL. NO.	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
				SUPPLIER	TPIA
1.0	Raw Material Identification	a) Raw Material Identification Report b) Mill Test Certificates	P.O. Specification / Applicable codes & standard	H	R/R
2.0	Welding(WPS/PQR/WPQ)				
2.1	Qualification of Welding Procedure	ASME SEC.IX Approved WPS/PQR	ASME SEC.IX	H	R
2.2	Qualification of Welding Personnel	ASME SEC.IX	ASME SEC.IX	H	R
3.0	Manufacturing (Forming, machining etc.)	Supplier's Manufacturing Procedure	Applicable Material STD	H	R
4.0	Heat Treatment(Wherever Applicable)	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	R/R
5.0	Selection of Test Coupons	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
6.0	Chemical Composition	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	R
7.0	Mechanical Testing: Tensile strength, Yield strength, Elongation, Hardness Test, Impact test (as applicable) etc.	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
8.0	Non Destructive Testing				
8.1	100% Radiography test on welds	ASTM E94	ASME SEC VIII Div.1, Para. UW-51	H	RT Film review
8.2	Ultrasonic testing(as applicable)	ASME SEC V / ASTM E213	ASME SEC VIII Div.1/P.O.	H	R
8.3	Dye Penetration (DP) / Magnetic Particle (MP)Test of Bevel Ends	ASTM E 165 for DP Test / ASTM E 709 for MP Test	ASME Sec. VIII	H	RW
8.4	Positive Material Identification (PMI) for AS/SS materials	ASTM E1476 / P.O.	ASME Sec. VIII Div.1	H	10%RW
8.5	Intergranular corrosion (IGC) test (as applicable)	ASTM A262 Practice B	P.O.	H	R
9.0	Galvanizing (as applicable)	Applicable STD/ P.O.	Applicable STD/ P.O.	H	RW
10.0	Visual examination, Overall Dimensional check, Product Marking & Packing	Applicable STD/ P.O.	Applicable STD/ P.O.	H	RW
11.0	Documentation & Certification	Applicable STD/ P.O.	Applicable STD/ P.O.	H	R

**Abbreviation:** DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPIA- Third Party Inspection Agency, W-Witness / Inspection

Note: This plan covers the minimum requirements for Inspection & Test of Forged, Seamless & Welded Fittings.


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REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

	INSPECTION & TEST PLAN FORGED FLANGES	PNMP-ITP-04
		DOCUMENT NO
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SL. NO.	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
				SUPPLIER	TPIA
1.0	Raw Material Identification	a) Raw Material Identification Report b) Mill Test Certificates	P.O. Specification / Applicable codes & standard	H	R/R
2.0	Manufacturing (Forging, machining etc.)	Supplier's Manufacturing Procedure	Applicable Material STD	H	R
3.0	Selection of Test Coupons	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
4.0	Chemical Composition	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	R/R
5.0	Heat Treatment, as applicable	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	R/R
6.0	Mechanical Testing				
6.1	Tensile Test	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
6.2	Hardness Test	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
6.3	Impact Test, as applicable	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
7.0	Non Destructive Testing				
7.1	Dye Penetration Test/ Magnetic Particle Test	ASTM E 165 for DP Test/ ASTM E 709 for MP Test	ASME Sec. VIII	H	W
8.0	Final Inspection				
8.1	Visual Examination	Applicable STD/ P.O.	Applicable STD/ P.O.	H	RW
8.2	Flange Facing Finish	ASME B46.1	ASME B46.1 / P.O.	H	RW
8.3	Overall Dimensional check	Applicable STD/ P.O.	Applicable STD/ P.O.	H	RW
9.0	Marking	MSS-SP25 / P.O.	MSS-SP25 / P.O.	H	RW
10.0	Certification	AS PER P.O.	AS PER P.O.	H	R
<b>Abbreviation:</b> DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPJA- Third Party Inspection Agency, W-Witness / Inspection					

Note: This plan covers the minimum requirements for Inspection & Test of Forged Flanges.


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	INSPECTION & TEST PLAN GASKETS	PNMP-ITP-06
		DOCUMENT NO
		SHEET 1 of 1

SL. NO.	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
				SUPPLIER	TPIA
1.0	Raw Material Identification (Chemical & Mechanical properties)	a) Raw Material Identification Report b) Mill Test Certificates	ASME B16.20 / P.O.	H	R
2.0	Compression & Recovery Test (SPW)	ASME B16.20	ASME B16.20	H	W
3.0	Hardness test (RTJ)	ASME B16.20	ASME B16.20	H	RW
4.0	Final Inspection				
4.1	Visual & Dimensional Examination	ASME B16.20 / P.O.	ASME B16.20 / P.O.	H	RW
4.2	Surface Finish	ASME B16.20	ASME B16.20 / P.O.	H	RW
4.3	PMI for AS & SS	ASTM E1476 / P.O.	ASME Sec. VIII Div.1	H	RW
5.0	Marking	ASME B16.20 / P.O.	ASME B16.20 / P.O.	H	RW
6.0	Certification	ASME B16.20 / P.O.	ASME B16.20 / P.O.		IRN
<b>Abbreviation:</b> DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPJA- Third Party Inspection Agency, W-Witness / Inspection					

Note: This plan covers the minimum requirements for Inspection & Test of Gaskets.


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	INSPECTION & TEST PLAN SEAMLESS PIPES	PNMP-ITP-02
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SL. NO.	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
				SUPPLIER	TPIA
1.0	Raw Material Identification/ Chemical composition	a) Raw Material Identification Report b) Mill Test Certificates	P.O. Specification / Applicable codes & standard	R	R
2.0	Forming	Supplier's Manufacturing Procedure	Applicable Material STD	H	R
3.0	Heat Treatment (as applicable)	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	R/R
4.0	Selection of Test Coupons	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
5.0	Mechanical Testing: Tensile, bend, hardness, transverse tension, Impact test (as applicable) etc.	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
6.0	Non Destructive Testing (as applicable)				
6.1	Ultrasonic Testing	ASME SEC V / ASTM E213	ASME SEC VIII DIV.1/ P.O.	H	R
6.2	Radiography Testing	ASME SEC V / ASTM E94	ASME SEC VIII DIV.1/ P.O.	H	RT Film Review
7.0	Hydrostatic Testing	ASTM A530/A999/API 5L	ASTM A530/A999/API 5L	H	10% RW
8.0	Galvanizing (as applicable)	Applicable STD/ P.O.	Applicable STD/ P.O.	H	RW
9.0	Intergranular corrosion (IGC) test (as applicable)	ASTM A262 Practice B	P.O.	H	R
10.0	Positive Material Identification (For AS & SS pipes)	ASTM E1476/ PMI procedure	Applicable Material STD	H	10% RW
11.0	Visual examination, Overall Dimensional check, Product Marking & Packing	Applicable STD/ P.O.	Applicable STD/ P.O.	H	10% RW
12.0	Documentation & Certification	Applicable STD/ P.O.	Applicable STD/ P.O.	H	R
<b>Abbreviation:</b> DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPJA- Third Party Inspection Agency, W-Witness / Inspection					

Note: This plan covers the minimum requirements for Inspection & Test of Seamless Pipes.

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	INSPECTION & TEST PLAN WELDED PIPES	PNMP-ITP-01
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SL. NO.	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
				SUPPLIER	TPIA
1.0	Raw Material Identification/ Chemical composition	a) Raw Material Identification Report b) Mill Test Certificates	P.O. Specification / Applicable codes & standard	R	R
2.0	Welding(WPS/PQR/WPQ)				
2.1	Qualification of Welding Procedure	ASME SEC.IX Approved WPS/PQR	ASME SEC.IX	R	R
2.2	Qualification of Welding Personnel	ASME SEC.IX	ASME SEC.IX	R	R
3.0	Manufacturing (Rolling, machining etc.)	Supplier's Manufacturing Procedure	Applicable Material STD	H	R
4.0	Heat Treatment (as applicable)	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	R/R
5.0	Selection of Test Coupons	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
6.0	Mechanical Testing: Tensile, bend, hardness, transverse tension, Impact test (as applicable) etc.	Applicable Material STD /P.O.	Applicable Material STD /P.O.	H	W
7.0	Non Destructive Testing (as applicable)				
7.1	Ultrasonic Testing	ASME SEC V / ASTM E213	ASME SEC VIII DIV.1/ P.O.	H	R
7.2	Radiography Testing	ASME SEC V / ASTM E94	ASME SEC VIII DIV.1/ P.O.	H	RT Film Review
8.0	Hydrostatic Testing	ASTM A530/A999/API 5L	ASTM A530/A999/API 5L	H	10% RW
9.0	Galvanizing (as applicable)	Applicable STD/ P.O.	Applicable STD/ P.O.	H	RW
10.0	Intergranular corrosion (IGC) test (as applicable)	ASTM A262 Practice B	P.O.	H	R
11.0	Positive Material Identification (For AS & SS pipes)	ASTM E1476/ PMI procedure	Applicable Material STD	H	10% RW
12.0	Visual examination, Overall Dimensional check, Product Marking & Packing	Applicable STD/ P.O.	Applicable STD/ P.O.	H	10% RW
13.0	Documentation & Certification	Applicable STD/ P.O.	Applicable STD/ P.O.	H	R

**Abbreviation:** DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPIA- Third Party Inspection Agency, W-Witness / Inspection

Note: This plan covers the minimum requirements for Inspection & Test of Welded Pipes.

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	INSPECTION & TEST PLAN STUDS & NUTS	PNMP-ITP-05
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SL. NO.	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
				SUPPLIER	TPIA
1.0	Raw Material Identification (Chemical Composition)	a) Raw Material Identification Report b) Mill Test Certificates	ASTM A193/ A194	H	R/R
2.0	Heat Treatment	ASTM A193/ A194	ASTM A193/ A194	H	R/R
3.0	Selection of Test Coupons	ASTM A193/ A194	ASTM A193/ A194	H	W
4.0	Chemical Composition	ASTM A193/ A194	ASTM A193/ A194	H	R
5.0	Mechanical Testing (Tensile strength, Yield strength, Elongation, Hardness Test, Proof Load test for nuts, etc.)	ASTM A193/ A194	ASTM A193/ A194	H	W
6.0	Machining of Studs & Nuts	ASTM A193/ A194	ASTM A193/ A194	H	R
7.0	Final Inspection				
7.1	Visual Examination	ASTM A193/ A194 & P.O	ASTM A193/ A194 & P.O	H	RW
7.2	Surface Finish	ASTM A193/ A194	ASTM A193/ A194	H	RW
7.3	Overall Dimensional check	ASTM A193/ A194	ASTM A193/ A194	H	RW
8.0	Marking	ASTM A193/ A194 & P.O	ASTM A193/ A194 & P.O	H	RW
9.0	Certification	ASTM A193/ A194 & P.O	ASTM A193/ A194 & P.O	H	R

**Abbreviation:** DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPJA- Third Party Inspection Agency, W-Witness / Inspection

Note: This plan covers the minimum requirements for Inspection & Test of Stud & Nuts.

0	20.01.2023		ISSUED FOR IMPLEMENTATION	HK	JKS/AK	DM
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	INSPECTION & TEST PLAN VALVES	PNMP-ITP-07
		DOCUMENT NO
		SHEET 1 of 1

SL. NO.	COMPONENTS	ACTIVITY	REF. DOCUMENTS	ACCEPTANCE NORMS	SCOPE OF INSPECTION	
					SUPPLIER	TPIA
1.0	Raw Materials					
1.1	Forging /Casting: Body, Bonnet, Cover, Disc, Wedge, Stem, Seat ring	Chemical & Physical Properties	Applicable Material STD /P.O.	Applicable Material STD /P.O.	R	R
		Heat Treatment	Applicable Material STD /P.O.	Applicable Material STD /P.O.	R	R
		Dimensions	Supplier's Drawing	Supplier's Drawing	R	R
		Surface Finish	MSS-SP-55	MSS-SP-55	R	R
		Intergranular corrosion test (IGC) (as applicable)	ASTM A262 Practice B	P.O.	R	R
		Radiography of Castings/ BW Ends	P.O./ASTM E94	ASME SEC VIII	R	RT Film Review
2.0	Hard facing / Overlay (Disc/Seat ring)	Dye Penetrant Test	ASTM E 165 for DP Test	ASME SEC VIII	P	R
		Hardness Test	Applicable STD/ P.O.	Applicable STD/ P.O.	P	W*
3.0	Final Inspection					
3.1	Assembled valves	Hydrostatic Shell & Seat Test	Applicable STD/ P.O.	Applicable STD/ P.O.	P	10%RW
		Pneumatic Seat Test	Applicable STD/ P.O.	Applicable STD/ P.O.	P	10%RW
		Operation check(Open/Close)	Applicable STD/ P.O.	Applicable STD/ P.O.	P	10%RW
		Fire safe test (as applicable)	API 607/ API 6FA	API 607/ API 6FA	P	R
		Positive Material Identification (PMI) for AS/SS Valves	ASTM E1476 / P.O.	ASME Sec. VIII Div.1	P	10%RW
		Visual & Dimensional	Applicable STD/ P.O.	Applicable STD/ P.O.	P	10%RW
		Surface preparation & Painting	P.O.	P.O.	P	W
		Marking	Applicable STD./ MSS-SP25 & P.O.	Applicable STD./ MSS-SP25 & P.O.	P	RW
4.0	Certification		Applicable STD/ P.O.	Applicable STD/ P.O.	H	R
<b>Abbreviation:</b> DT- Destructive Testing, H- Hold (Do not proceed without approval), HT- Heat treatment, R-Review, R/R- Report Review, ITP-Inspection and Test Plan, P- Performed, PO- Purchase Order, PQR- Procedure Qualification Record, PR-Purchase Requisition, RW- Random Witness, TC-Test Certificate, TPI or TPIA- Third Party Inspection Agency, W-Witness / Inspection						

\*Hardness test witness may be performed on test coupon at the time of final inspection.

Note: This plan covers the minimum requirements for Inspection & Test of Valves.

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## SECTION –5.3.2

### DESIGN PHILOSOPHY-STATIC EQUIPMENT

**PLANT : COAL GASIFICATION PLANT FOR GENERATING SYN  
GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC  
NATURAL GAS (SNG)**

**OWNER: COAL GAS INDIA LIMITED**



 <div>पी डी आई एल PDIL</div>	<div>COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)</div> <div>OWNER: COAL GAS INDIA LIMITED</div> <div>DESIGN PHILOSOPHY-STATIC EQUIPMENT</div>	PC217/E/001/P-II/5.3.2	1	
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1.0	DESIGN CRITERIA
2.0	MATERIAL OF CONSTRUCTION
3.0	TECHNICAL REQUIREMENT
4.0	FABRICATION
5.0	INSPECTION & TESTING
6.0	PICKLING AND PASSIVATION
7.0	PAINTING
8.0	INSULATION & FIRE PROOFING
9.0	SPARE PARTS (ERECTION & COMMISSIONING SPARES, MANDATORY SPARES)
10.0	DOCUMENTATION SCHEDULE
11.0	PACKAGING, IDENTIFICATION AND STORAGE INSTRUCTIONS
12.0	DISPATCH
13.0	VENDOR LIST
14.0	GUARANTEES
15	AS BUILT DOCUMANTATION

## LIST OF ATTACHMENTS

S.NO.	DESCRIPTION	ATTACHMENT NUMBER
1.	GUIDELINES FOR DYNAMIC WIND ANALYSIS	ANNEXURE - 1
2.	INSPECTION (GUIDELINES)	ANNEXURE - 2
3.	INDICATIVE ITP FOR EXCHANGER (ITP-01), PRESSURE VESSELS (ITP-02),	ANNEXURE - 3

 पी डी आई एल <b>PDIL</b>	<b>COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)</b>  <b>OWNER: COAL GAS INDIA LIMITED</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PC217/E/001/P-II/5.3.2	1	
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## 1.0 Design Criteria

- 1.1.1 This document defines the design philosophy to be applied for 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, Towers/Column, Storage Tanks, vessel Internals, reactors and all other items as applicable for coal gasification plant for generating Syn Gas For Production of synthetic natural gas (SNG) at Bardhaman, West Bengal, (INDIA) in accordance with this specification, standards specification, codes and other attachment etc. listed in NIT document. In addition, all statutory rules & regulations shall also be complied with.
- 1.2 The equipment shall be designed & constructed as per the latest edition (at the time of contract signing) of the following codes and standards:

Code**	Description
ASME Section VIII Div 1	Rules for construction of Unfired Pressure Vessels
ASME Section VIII Div 2	Rules for construction of Unfired Pressure Vessels (Alternative rules)
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 RP 2000	Venting Atmosphere And Low Pressure Storage Tank
API 2550	Method For Measuring and calibration of upright cylindrical Tanks
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 934 - E	Materials and Fabrication of 11/4CR-1/2Mo Steel Pressure Vessels for Service Above 825 °F (440 °C)
API 605	Metallic gaskets for raised face pipe flanges & flanged Connection (Double jacketed corrugated & Spiral wound)
EJMA *	Standard of Expansion Joint Manufacturers Association
ASME SEC -I	Rules for construction of power boilers
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	Fibre-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	metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral Wound, an Jacketed



ANSI	Pipes, Flanges, Fittings and Valves
IS: 875 / SITE DATA	Wind loads design consideration
IS: 1893 (Part 4) & IS: 1893 (Part 1) / SITE DATA	Seismic design consideration
BS 4994	Design & Construction of vessel & Tanks in Reinforced Plastics
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.
IBR	Indian Boiler Regulation
NACE	National Association Of Corrosion Engineers
PESO	Petroleum and explosive 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:

- a) 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.
  - b) 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.
  - c) Specifications of all critical & proprietary equipments including those specified by the process licensor shall be furnished in the technical bid. List of such critical & proprietary equipment to be submitted along with bid.
  - d) List of codes and standard as mentioned are not exhaustive. LSTK Bidder shall be responsible for addition of code and standards (with approval of Owner) as applicable to the scope. Bidder shall ensure use of latest version of applicable codes and standards at the time of design.
- 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 (IBR, PESO e.t.c) shall also be complied with.
  - 1.4 Design conditions for all equipment shall be as per Process Licensor data sheet / Specification. Minimum required thickness to be 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.  
Wind speed along with other applicable requirement mentioned in IS-875 (Latest Edition) to be followed w.r.t project site.  
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**.

 पी डी आई एल <b>PDIL</b>	<b>COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)</b>  <b>OWNER: COAL GAS INDIA LIMITED</b>  <b>DESIGN PHILOSOPHY-STATIC EQUIPMENT</b>	PC217/E/001/P-II/5.3.2	1	
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- 1.7 Seismic analysis shall be performed by Response spectrum method (RSM) coefficient method considering seismic Zone & other factors as per IS-1893 part-1 & IS-1893 Part 4 (Latest edition) w.r.t project site. I/R for static equipment shall be kept as 1.
- 1.8 Local load analysis, WRC 107/537 shall be used for nozzle on dish end, WRC 297 to be used for nozzles on shell. FEA analysis to be carried out for nozzles beyond scope of WRC.
- 1.9 All vessels/columns subject to internal pressure shall be designed to withstand a minimum external pressure of 0.175 kg/cm<sup>2</sup> abs.
- 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. Anchor bolts shall be hot dip galvanized.
- 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).  
Min duration of Hydro test shall be 60 min.  
Design pressure for each nozzle shall be sum of maximum allowable working pressure and static head of corresponding nozzles. Nozzle also to be checked in deaerated condition as per UG-44 of ASME Sec VIII div-1.
- 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 M48 and above shall be designed and spaced so as to permit tightening with a hydraulic stud-tensioner with standard socket. 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 LSTK Contractor 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 nitrogen after testing at site. Nitrogen shall be filled at a pressure of 0.5 Kg/cm<sup>2</sup>g and equipment shall be fitted with a pressure gauge and valve along with nitrogen cylinder.
- 1.17 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.
- 1.18 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).
- 1.19 All blind flanges and man way covers weighing 35kgs or more shall be fitted with handling Facilities such as davits.
- 1.20 As a General rule all nozzle attachment to shell/head shall be set in type.
- 1.21 As a minimum requirement, all vessels, Exchanger, Tanks e.t.c shall be spot radiographed.
- 1.22 Forces and moments acting on nozzles shall be considered in the equipment design.

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- 1.23 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.
- 1.24 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.
- 1.25 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.
- 1.26 Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible
- 1.27 Gas or Carbon arc welding shall not be used.
- 1.28 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 MoI	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

- 1.29 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.
- 1.30 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.
- 1.31 Gaskets used during testing shall be same as specified for operating conditions. Gaskets shall be replaced only where flanges need to be opened after hydro test.

Further, Welded, lip seal type, double conical gaskets, RTJ and Lens gasket will not be replaced after hydro test as the same are reusable. These gaskets to be replaced, if they are found damaged during or post hydro test.

Gasket selection for all equipment shall be as per Process Licensor recommendation/ standard.



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- 1.32 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.

#### 1.4 REGULATIONS

Besides codes & standards, LSTK Contractor shall follow National Laws and Regulations, Indian Boiler Regulation, PESO, 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.

All local regulations related to India and the project site is applicable, even if they are not referred in this document or in the specifications.



#### 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 H <sub>2</sub> S 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 H <sub>2</sub> S 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
NACE RP0590	Recommended practice for Deaerator
WRC Bulletin # 107/537	Local Stresses in Spherical 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 review at 30%, 60% and 90% stages.
  - 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



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- Process Design Criteria
- Electrical and Instrumentation Design Criteria

## 1.42 SITE CONDITIONS

Climatic and other site conditions as defined elsewhere in NIT.

## 1.43 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 25 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.

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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.
- 2.2 All materials, whatsoever, required to complete the supplies shall be procured by LSTK Contractor and all such materials shall be covered with due identifiable material test certificate.

Material test certificates shall comply with EN10204 Type 3.2 for high pressure equipment and EN10204 Type 3.1 for other than high pressure equipments for pressure parts and EN10204 Type 2.2 for Non-pressure parts.

LSTK Contractor to consider equipment having design pressure equal or more than 100 kg/cm<sup>2</sup> G or thickness greater than 50 mm as high pressure equipment or specified by process Licensor as high pressure equipment.



- 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/mm<sup>2</sup>) 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 & normalized 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. All LAS materials including forging used for pressure parts shall be procured as permitted in ASME sec. II part A.

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- 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 3.3.4 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 and joints.
- 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:**

- Cold formed dished ends or knuckles up to 16 mm nominal thickness shall be stress relieved.
  - Cold formed dished ends or knuckles above 16 mm nominal thickness shall be normalised.
  - For Low alloy Steel: - Cold Formed Dish ends and Knuckles shall be stress relieved.
  - 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.
  - When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.
  - Vessels in caustic service, Amine or Sour gas service shall be stress relieved.
  - 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 shall be 1/8 inch (3 mm-undiluted) 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 Gasket with flange rating  $\geq 900\#$  shall be octagonal ring joint gasket. Hardness of the gasket shall be 50BHN lesser than that of the mating flange gasket groove.

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- 2.2.18 Tube sheets shall have a nominal clad or weld overlay thickness of 3/8 inch (10 mm) but not less than 5/16 inches (8 mm) 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.
- 2.2.19 Tube sheet and Girth flanges must be made in one piece. Segmental butt-weld construction shall not be accepted.
- 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. 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 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.
- 2.2.23 When design pressure is  $\geq 600$  # class or shell thickness is 50 mm and above, Hydrogen service, cyclic service e.t.c self reinforced forged nozzle shall be provided. Shell to SR nozzle welding shall be set-in type welding.
- 2.2.24 Weld overlayed nozzle and girth flange gasket faces shall have a minimum thickness of 3/16 inch i.e. 4.8 mm (min. undiluted thickness of 3 mm) 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 degree Celsius, 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 Steel for Hydrogen service at elevated Temperature & pressure shall be selected as per API 941 & API 934 along with full compliance of other requirements. The following special requirements shall be met with for Hydrogen/Sour gas.
- All pressure parts shall be post weld heat treated.
  - All pressure retaining butt welds shall be 100% radio graphed. (Root run & Final Weld radiography is must)
  - Self reinforced forged nozzle with LIP. Joint shall be 100% radiographed
  - Tube sheet with Lip type construction, Tube sheet to shell/channel joint shall be 100% radiographed.
- 2.2.27 Gaskets for all medium with flange rating < 600 # (including girth flange) shall be SS spiral wound type with External & internal guide rings unless otherwise specified by process Licensor.

Gaskets used for high pressure equipment shall be of the following type unless otherwise specified by Process Licensor:

- Ring Joint
- Double conical with graphite tape
- Diaphragm gasket
- Lip seal Gasket

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2.2.28 Positive Material Identification (PMI) is required to verify that the elemental composition of Alloy Materials is as specified at receipt of raw material, during manufacturing and after completion of fabrication.

#### 2.2.29 CLADDING AND LINING

- a) Cladding & lining is allowed only if specified in Process data sheet of Process licensor for equipment /equipment parts subjected to Prior approval of owner. Integrally clad metal and weld overlays shall not be considered as contributing to the strength of the vessel wall thickness of the Equipment. It should not be considered in the minimum thickness calculation.
- b) Strip liners shall not be used in vessel shell for hydrogen service.
- c) Cladded plates shall be supplied as per ASTM A 264 material specification. All clad plate shall be UT examined at the steel works in accordance with ASTM A 578 level S8.

### 3.0 TECHNICAL REQUIREMENTS

#### PART A - DESIGN PHILOSOPHY FOR PRESSURE VESSEL

##### 3.1 Vessel/Column/Reactor/Filter e.t.c

3.1.1 Unless otherwise specified, Design, materials, fabrication and inspection of welded pressure vessels shall comply with ASME Code Section VIII, Division 1 (latest edition) and code and standard specified in the NIT.

ASME Sect. VIII Div. 2 shall be used for pressure above 3000 psi or if specified by Process Licensor in equipment Process data sheet.

ASME Sect. VIII Div. 2 equipment shall be ASME U stamped.

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 by Process Licensor, ASME Code stamp is not required except ASME Sec. VIII Div. 2 equipment.



Vessels/Column 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.

- 3.1.2 Design of equipment skirt shall be based on seismic/wind/thermal considerations and fire proofing/insulation requirements.
- 3.1.3 All nozzles above 24" NB shall comply with ASME B16.47 Series B (API 605).
- 3.1.4 Minimum nozzle thicknesses shall be Schedule Extra Strong above 2" NPS, and Schedule 160 for 2" NPS and below.
- 3.1.5 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.
- 3.1.6 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
<b>CS = Carbon Steel, LAS = Low-Alloy Steel, HAS = High-Alloy Steel</b>			

- 3.1.7 Equipment skirts for carbon steel vessels shall be designed from the same material (Grade) as the shell or the head. Equipment skirts for other than carbon steel shall be the same material (Grade) as the shell or the head for the top 500 mm.
- 3.1.8 Equipment with skirt support having eight or more anchor bolts shall be required to be supplied with an anchor bolt template. The template shall be of box type (no annulus type) to avoid problem during final erection and installation. The template shall have adequate strength against deformation
- 3.1.9 Maximum permissible deflection for vessel when subjected to design wind loadings shall not exceed 0.005 x Vessel/Column height. For guidelines of Dynamic Wind Analysis refer **Annexure-I**.
- 3.1.10 Minimum man way size shall be equal to 24" nominal pipe size.
- 3.1.11 Manhole/hand hole/blind holes covers shall be equipped with davits or hinges for ease of opening to facilitate handling.
- 3.1.12 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.
- 3.1.13 Use of structural steel shall be limited to non-pressure parts only.
- 3.1.14 Local stress calculations for external structural attachments, such as platform clips, pipe support clips and lifting lugs shall be performed.
- 3.1.15 Dimensional tolerances shall be in accordance with the design codes or standards, whichever is more stringent.
- 3.1.16 For Equipment 24" manhole shall be used for all equipment with internal diameter more than 900 mm. Equipment of internal diameter below 900 mm shall be flanged at one head for access with a 12 "hand hole on the other end. Larger size manhole will be specified when required to accommodate internals or critical for equipment entry.
- 3.1.17 In vertical vessels with demister, manholes shall be provided on to access both sides of the demister. Demisters shall be securely fastened to support ring by bolting or clamping.
- 3.1.18 In horizontal vessels, the manhole shall be located on one of the heads, which is away from internals such as displacers, baffles etc. The vent connection on the horizontal vessels shall be on the opposite end of the manhole. Large vessels with diameter of more than 3000 mm TI- TI, an additional 4" vent nozzle with blind shall be provided.
- 3.1.19 The extent of radiographic examination of the shell and head seams shall be spot examination, as minimum.
- 3.1.20 Vessels/Column 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.



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3.1.21 Vessels/Column 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.

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

3.1.23 All manhole/hand hole/blind holes/LG/LT/Valves e.t.c shall be accessible by suitable platform.

### 3.1.24 CORROSION ALLOWANCE

- For an intermediate head, corrosion allowances shall be added to both sides.
- For the inside of shells, heads, nozzles and manholes, the specified corrosion allowances shall be added.
- For non removable internal parts, the specified corrosion allowances shall be added to both sides.
- For removable internal parts, Corrosion allowance of 0.75mm shall be applied for removable internals on each side in contact with operating fluid.

### 3.1.25 HEAD / DISHED ENDS

- A formed head shall generally be made of single plate. The use of multiple piece head shall be subjected to Owner approval only in specific cases where availability of single piece is an issue.
- Whenever a dished end is made of more than two plates, it must have a crown and petal construction. 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. For heads which are not one-piece construction all head welds shall be subject to 100% radiography.
- 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 %.
- 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.

## 3.2 INTERNALS

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

- For tray design minimum loads of 100 kg/m<sup>2</sup> in active areas and 320 kg/m<sup>2</sup> in down comer area shall be considered.
- For atmospheric, pre flash & vacuum distillation columns for trays under flash area uniform load of 500 kg/m<sup>2</sup> shall be considered. This loading shall be applicable to first three trays above flash section.
- A concentrated live load of 150 kg at any point on the installed assembly independent of other design live loads.
- Maximum horizontal deflection at effective tray loading shall not exceed 1/900 of the span or 7 mm. Whichever is less.
- Corrosion allowance shall be added to both sides of trays, support rings and other fixed internal non pressure parts.

3.2.2 All internal bolting shall be of corrosion resistant material.

3.2.3 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.

3.2.4 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.

3.2.4.1 Trays will be numbered from the bottom.

**3.2.5. 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.

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

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

3.2.8 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.

3.2.9 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.

3.2.10 Internals (trays, distributors, support beams) shall be so designed that any expansion of it wouldn't affect Shell deformation.

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

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



3.2.13 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.

3.2.14 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.

3.2.15 Demisters shall be securely fastened to support ring by bolting or clamping. all demisters to be in double density configuration

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



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3.2.17 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.

### 3.3. ACCESSORIES

3.3.1 Clips for platforms, ladders and piping supports shall be furnished and attached to the vessel by the Vessel manufacturer.

3.3.2 Top davits of vertical vessels shall be so designed and fabricated so that heavy valves around the vessels and internal parts of vessels can be removed and grounded without being interrupted by piping and steel structures. Minimum load bearing capacity of Top davit shall be 1 Ton.

#### 3.3.3 INSULATION SUPPORT RINGS:

- 1) Insulation support rings shall be suitable provided as per the specified insulation thickness.
- 2) Maximum longitudinal interval of insulation support rings shall be 3600 mm when preformed Insulating Materials are used.
- 3) Stiffening rings may be used as insulation support rings.

3.3.3.1 Lifting lugs of appropriate size shall be provided to ensure complete safety during erection of the Vessel.

3.3.3.2 Grounding lugs shall be attached to the vessel support for the ground connection.

#### 3.3.4 TEMPLATES

- 1) Templates for vertical vessels with skirts shall be provided for lying out of anchor bolts at site. The template shall have adequate strength against deformation. Template shall be identical to the Vessel Base Frame having double ring.
- 2) It shall be confirmed that markings of the bolt hole orientation on the templates coincides With those shown on the approved drawings.



#### 3.3.5 PLATE LAYOUT

- a) Shell plate shall be laid out so that there will be minimum of welded seams.
- b) Longitudinal and circumferential welded seams shall not interfere with nozzle openings, reinforcement plates, saddle pads, and other attachments as far as possible
- c) Longitudinal welded seams on adjacent shell segments shall be separated by at least 4 times the wall thickness of the thicker plate but not less than 100 mm.

#### 3.3.6 CONNECTIONS

3.3.6.1 Unless shown in data sheets, nozzles, manholes, and hand holes shall be ground flush and smooth inside the vessel. The edges of internal projections for both nozzles and manholes shall be rounded to a radius of 3 mm minimum. Reinforcement pads shall be external.

3.3.6.2 Main vessel seams shall not pass through openings for connections as far as possible. When unavoidable, the portion of the weld seam covered by a reinforcing pad shall be ground flush with the parent metal and 100% radio graphed prior to attachment of the pad.

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3.3.6.3 All reinforcing pads shall be provided with at least one telltale hole of NPT 1/8".

### 3.3.7 FABRICATION TOLERANCE

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

### 3.3.8 HEAT TREATMENT

3.3.8.1 Fabricated vessels shall be post weld heat treated in accordance with ASME Code Section VIII, Division 1, and requirements specified in the data sheets.

3.3.8.2 The complete post weld heat treatment procedure including temperature and holding time shall be submitted to the purchaser for review. All machined surfaces shall be protected against scaling during post weld heat treatment.

3.3.8.3 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.

3.3.8.4 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.

3.3.8.5 Simulation Heat Treatment for the Alloy Steel Material shall be carried out as per the CODE Requirement.

### 3.3.9 PICKLING

When specified, all internal / external surfaces of stainless steel shall be cleaned by pickling before hydrostatic test.

- 1) Care shall be taken so that stainless steel surfaces shall not be subject to any scratch or damage during pickling.
- 2) Weld scale and other foreign material deposited on the surfaces shall be removed.
- 3) Pickled surfaces shall be completely neutralized, and washed by freshwater

### 3.3.10 PREPARATION FOR SHIPMENT

3.3.10.1 All vessels shall be drained, clean, and free of grease, oil, scale, weld spatter, and any other foreign substance.

3.3.10.2 All flange faces and other exposed machined surfaces shall be properly protected with substantial metal shields or covering against damage during shipment.

3.3.10.3 All inside surfaces and internal parts of carbon steel shall be coated with suitable rust preventive before shipment.

3.3.10.4 All openings shall be provided with metal closures.

3.3.10.5 Test holes of reinforcing pads for nozzles and manholes shall be plugged with steel or plastic plugs.

3.3.10.6 Vent holes of saddle pads shall be plugged with plastic sealant or hard grease prior to shipment.



3.3.10.7 All threaded connections shall be plugged with threaded round bars or covered with standard pipe caps of the same material as the equipment. Covers, flanges, gaskets, bolts, and nuts furnished by the fabricator shall be shipped in place.

Internals shall be tied or braced as necessary to avoid damage or dislodgment during Shipping and installation.

Baselines indicating four directions with figures of 0°, 90°, 180° and 270° shall be marked by paint on the shell. The paint colour shall be white for carbon steel and black for stainless Steel.

## PART B - DESIGN PHILOSOPHY FOR HEAT EXCHANGERS

### 3.4 SHELL AND TUBE HEAT EXCHANGERS

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## General

### a) SCOPE

This specification covers the minimum requirements for the design, materials, fabrication and Inspection of shell and tube type heat exchangers.

- b) The Design Philosophy for the Shell & Tube Heat Exchangers shall be read in conjunction with the Design Philosophy for Pressure Vessels, as per Part – A above.

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.)

3.4.1.1 Gaskets shall be used for Synthesis Gas, Hydrogen & other lethal services only after recommendation by Process licensor.

3.4.1.2 Tubular heat exchangers of auxiliary component for machine units such as lube oil coolers is to be designed, fabricated, inspected and tested in accordance with the manufacturer's standards and ASME Code Section VIII, Division 1, provided written approval is obtained from the purchaser.

3.4.2 Heat exchangers tubes thickness shall be minimum (and not average).

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 consider 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. Necessary arrangements for pulling/handling the tube bundle during maintenance at plant to be provided by contractor.

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.

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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/cm<sup>2</sup> g wherever specified by Licensor leak testing with helium 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 Flow induced vibration analysis shall be carried out for all process heat exchangers.

3.4.21 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.

3.4.22 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 extend 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.

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

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



3.4.25 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/cm<sup>2</sup>
- b) Shell / Channel design temperature < 350 °C
- 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).

3.4.26 Mock-up test for tube to tube sheet shall be carried out for high pressure heat exchangers, Hydrogen service, Temperature above +400°C e.tc to establish all the requirements.

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

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.

- 3.4.27 Removable tube bundle shall be provided with pulling York and suitable sliding arrangement.
- 3.4.28 Tube sheets shall have the corrosion allowance on each side. Tube Sheets from Plates shall not be used.
- 3.4.29 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
- 3.4.30 In horizontal exchanger cross baffles and support plates shall be provided with notches for draining and venting.
- 3.4.31 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.
- 3.4.32 Expansion bellows shall be designed for min. 5000 cycle, as per TEMA
- 3.4.33 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.
- 3.4.34 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.
- 3.4.35 The shell side test shall be performed in such a manner that the Tube-to- tube sheet joints can be adequately inspected during testing.
- 3.4.36 For stacked heat exchangers, maximum two shells shall be stacked.
- 3.4.37 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.
- 3.4.38 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).
- 3.4.39 The lower fixed support of stacked exchangers shall be designed for bundle pulling loads for removal of the upper bundle.
- 3.4.40 When two or more exchangers are stacked, the entire stack shall be shop-assembled and checked for accuracy of saddle and nozzle fit-up.
- 3.4.41 Bolts for connecting nozzles of stacked exchangers shall be removable without moving exchangers.

#### 3.4.42 PASS PARTITIONS

- 3.4.42.1 All pass partitions shall have a gasket contact surface of 9 mm width minimum, and shall be machined to a common plane at the gasket face.
- 3.4.42.2 The depth of pass partition grooves in tube sheets and flat cover plates shall be a minimum of 5 mm. For alloy cladding or facing, there shall be at least 3 mm of alloy after machining beneath the pass partition groove or gasket face.
- 3.4.42.3 When space permits, pass partitions shall be continuously welded from both sides. In cases where space is too small for both side welding, weld shall be continuous on one side in so far as possible.
- 3.4.42.4 Pass partitions shall be provided with a weep hole of about 6 to 12 mm in diameter at low points of pass partitions.

#### 3.4.43 TEST RINGS

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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.



### 3.4.44 HYDRO TESTING

- 3.4.44.1 Each heat exchanger shall be hydro tested in accordance with applicable codes and standards. Min duration of Hydro test shall be 60 min.
- 3.4.44.2 The shell side test shall be performed in such a manner that the Tube-to- tube sheet joints can be adequately inspected during testing.
- 3.4.44.3 Hydro Testing sequence & procedure for testing Exchangers having Lip Seal Gasket shall be approved by the Purchaser.
- 3.4.44.4 Stacked units shall be hydraulically tested in the fully assembled condition.
- 3.4.44.5 Air leak test shall be performed for tube to tube sheet joint for all exchangers. However Helium leak test shall be performed for critical heat exchangers/ wherever specified by Process licensor..
- 3.4.44.6 After testing, all exchangers shall be completely dried.
- 3.4.44.7 Service bolts shall be used in all shop hydrostatic tests.
- 3.4.44.8 Gaskets used during testing shall be same as specified for operating conditions. However all joint Gaskets shall be replaced by new gasket which will be opened after Hydro testing.

### 3.5 PLATE TYPE HEAT EXCHANGER

- 3.5.1 The plate type exchanger shall be designed in accordance with "API 662"
- 3.5.2 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
- 3.5.3 Nozzle neck attachments shall be with full penetration weld. Set on nozzles are not permitted.
- 3.5.4 Lock washers shall be provided for all rotated nuts.
- 3.5.5 SS plate shall be of SA 240 specification.
- 3.4.6 For gasket type PHE, vendor shall be responsible for the compatibility of gasket material & Glue, selected for specified fluids and design conditions.
- 3.5.7 All components in contact with process fluids shall be as per Process data sheets (PDS).
- 3.5.8 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.
- 3.5.9 All nozzles of Heat exchanger shall be of extended type.
- 3.5.10 The plate shall be fully supported by carrying bar and only guided by the guide bar.
- 3.5.11 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.



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

3.5.13 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.

### 3.6 Storage Tanks

3.6.1 The following design codes shall be adopted for tank design as applicable:

API 650 Welded Steel Storage Tanks for Oil Storage

3.6.1.1 For fixing the nominal capacity of the cone roof tank, allowance for free board (minimum 500 mm), vapour space and dead liquid space at the bottom shall be taken in to account. Tank diameter and height shall be firmed up based on nominal capacity (Cylinder volume).

3.6.2 For Carbon Steel storage tanks the minimum thickness shall be based on stability considerations. Minimum thickness for roof & shell shall be 5 mm, and bottom plate 6 mm.

3.6.3 Storage tanks up to 4meter in diameter shall be shop fabricated items. Tanks with diameters greater than 4 meter shall be field erected.

3.6.4 Tanks constructed of stainless steel shall comply with API 650, Appendix S.

3.6.5 Shell seams shall be located to clear openings to the maximum extent possible in accordance with API 650.

3.6.6 Bottom plates may be lap-welded with the lap toward the direction of drainage. Butt welded bottom plates shall be furnished when specified on the tank drawings or data sheets or when tanks are specified to have rubber lining.

3.6.7 For each surface in contact with product/vapour, the specified corrosion allowance shall be added to the required thickness of all load-carrying components including shell, roof, bottom and roof supports. & One-half the specified corrosion allowance shall be added to each surface of no-load-carrying internal components.

3.6.8 All walkways, stairways, and platforms shall be furnished with handrails on open or exposed sides. All the nozzles/manholes on roof shall be accessible through platform.

3.6.9 Anchor bolts shall be provided based on design considering wind/seismic loads, uplift due to internal pressure etc. However, tanks having diameter  $\leq 10$  meter shall be provided with anchor Bolts and shall be spaced at approximately 1.8M of circumference.

3.6.10 Maximum height of unstiffened shell shall be calculated based on the corroded thickness of shell courses. Section modulus of wind girders shall also based on corroded thickness of shell courses.



3.6.11 All storage tanks shall be designed considering liquid height up to top curb angle of shell Using one foot method for tanks less than and equal to 60 meter. However for seismic design, operating liquid level may be considered. All design calculation shall be carried out in corroded condition.

3.6.12 Unless otherwise specified bottom plate slope shall be 1:100 from the centre of the tank towards shell.

3.6.13 Butt welded annular ring below shell (minimum 8 mm thick excluding corrosion allowance) shall be provided for all tanks of diameter 12 m and above.

3.6.14 Fabrication tolerance on shell, bottom, and foundation e.t.c. shall be as per applicable code.

3.6.15 Anchor bolt shall be provided if required by calculation for uplift or stability for wind and Seismic load. Minimum anchor bolt size shall be M24. Tanks with diameter  $\leq 10$  m shall be provided with anchor bolt at spacing of maximum 1.8 m, however minimum 4 nos of M24 shall be provided for all tanks with diameter  $\leq 10$  m.

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3.6.16 The roof plates shall be self supported or supported by structure. Column supported roof shall not be acceptable. The roof and its supporting structure shall be designed to carry the dead Load, internal and external pressure as specified in process data sheet and live load as per design code.

3.6.17 Inside/outside painting of tanks shall be carried out based on product stored and as per Process data sheet enclosed elsewhere in NIT package.

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

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 not be 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 3 mm.

4.9 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.

4.10 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.

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

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



4.13 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.

4.14 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.

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

4.16 All Equipment shall preferably be supplied in single piece. However, in exceptional cases, Site fabrication / Field assembly may be permitted. Prior written approval from Owner/PMC shall be obtained by the Contractor for the same.



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**Additional requirements For Site fabricated Equipment:** Transportation, Loading/Unloading, handling of pre-fabricated/ pre- rolled components/ petals / subassemblies, fabrication, assembly, inspection (including inspection by approved TPIA per approved QAP (as applicable)), all NDT, PWHT as applicable, hydro testing, pickling & Passivation of SS internals, application of primer/finish paint on completed equipment to be carried out by equipment manufacturer.

{As far as possible, maximum fabrication activities shall be completed at shop including mock up assembly, rolling of plates, nozzles to flange connection, strip cladding (if applicable), Weld overlay/cladding of Nozzles etc.}

- 4.17 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.

#### 4.18 Safety

- 4.18.1 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 shall be complied.

- 4.18.2 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

#### 4.19 OPERABILITY AND MAINTENANCE

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

#### 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). Cost of TPIA shall be under LSTK Contractor scope. 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.

- 5.1.1 The final Inspection & Test Plans (ITPs) based on the indicative ITP (**Annexure-3**) shall be developed by the contractor as per contract specifications & codes and shall be submitted to PMC/Owner for approval. Inspection and Test Plan shall include detailed manufacturing/inspection activities including those of sub-supplied/ bought out items. The indicative ITPs enclosed in the NIT are for guidance to the LSTK Contractor and may not cover some of the activities to be performed during execution of works under the scope of this contract.

- 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,

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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 Vessel containing lethal, toxic and highly inflammable substance shall be fully radio graphed and stress relieved
- 5.2.5 The temperature of test water shall comply with requirement of Fabrication code..
- 5.2.6 All nozzle reinforcing pads shall be tested pneumatically at 0.5 Kg/cm<sup>2</sup>g 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 Unless otherwise stated gaskets used during testing shall be same as specified for operating conditions.
- 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 radio graphed.
- 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
- v) RT-1/ 100% radiographed equipment, Welds including nozzle -to-shell joints that cannot be radiographed, shall be 100% UT examined.
- vi) All butt welds after hydro test (for CS and LAS).

**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.

**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 & minimum 10% of total weld length excluding T joints shall be radio graphed.

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- iii) All nozzles fabricated from plates shall be 100% radio graphed.
- iv) Radiography of welds in C - 1/2 Mo & Cr - Mo - Steel shall be carried out after heat treatment.
- v) Vessel containing lethal, toxic and highly inflammable substance shall be full radio graphed.

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

- i) 225 HB for steel having Cr content less than 2%
- ii) 240 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.

## 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 KMnO<sub>4</sub> 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 external surfaces of shop/site fabricated equipment shall be primer and final painted as per painting philosophy Listed elsewhere in NIT document.

## 8.0 Insulation & Fire Proofing

8.1 The equipment shall be insulated as Listed in NIT document.

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

## 9.0 Spares Parts (Erection & commissioning, Mandatory spares)

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## 9.1 Erection & 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 Mandatory spares

9.2.1 Mandatory spares shall be supplied by the LSTK contractor as per Section-10 of ITB.

## 10.0 Documentation Schedule

Documents shall be submitted as per “Documentation schedule” in Section-9 of ITB

## 11.0 PACKAGING, IDENTIFICATION AND STORAGE INSTRUCTIONS

11.1 All equipments shall be properly packed/ crated to provide adequate protection during shipment to site.

11.2 Detailed packing list in waterproof envelope shall be inserted in the package together with the equipment.

11.3 The equipment shall have an identification plate giving salient equipment features such as make, year of manufacture, equipment no., name of manufacturer etc.

11.4 Packaging shall be, unless otherwise stated suitable for prolong storage at site to prevent undue corrosion and damage before erection and commissioning of the equipment. Bidder shall also furnish the procedures/instructions for long time storage of the equipment.

11.5 All equipment, internals shall be properly stored at site within temporary shed by LSTK Contractor.

## 12.0 DISPATCH

12.1 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.

12.2 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.

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

12.4 Equipment shall be despatched with High purity nitrogen (HPN) filling. Dry nitrogen shall be filled at a pressure of 0.5 kg/cm<sup>2</sup>g and equipment shall be filled with a pressure gauge and a valve along with nitrogen cylinder.



## 13.0 Vendor List

All equipment shall be procured/ fabricated as per approved vendor list (Section -15). 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. However all the additional proposed vendors shall have well proven track record and shall be subjected to owner's / consultant approval during detail engg as per NIT requirement.

## 14 GUARANTEES

### 14.1 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.



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#### 14.2 Performance Guarantee

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

#### 15.0 AS BUILT DOCUMENTATION

Shop changes made by LSTK Contractor/ fabricator after approval of drawings under Code-1 by PMC/ Owner and deviations granted in deviation permits, if any, shall be marked in hard copy of drawings which shall then be stamped 'As-built' by the LSTK Contractor. These 'As built' drawings shall be reviewed and stamped by Authorized Inspector also. LSTK Contractor shall prepare scanned image files of all marked-up 'As-built' drawings. LSTK Contractor shall also incorporate the above changes in the native soft files of the drawings. Authorized Inspector shall ensure/certify completeness of Final/As-built documents before equipment dispatch. In addition, LSTK Contractor shall also incorporate site changes, if any, based on mismatch observed at site and resubmit the 'As-built' documents.

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**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:

$$V_{cr} = f * D / St$$

$V_{cr}$  = Critical wind velocity  
 $D$  = Outside diameter of tower  
 $f$  = First natural frequency of tower considering foundation complete rigid (s-1)  
 $St$  = Strouhal number, may be taken as 0.15 for  $Re > 106$  and 0.2 for  $Re < 106$   
 $Re$  = Reynolds number at critical wind velocity

For  $V_{cr} < 30$  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:

$$M_d = P_d * C_k * S * \pi / d * H$$

$P_d$  = Wind pressure at critical velocity =  $0.5 * \rho * (V_{cr})^2$   
 $C_k$  = Crosswind oscillatory force coefficient may be taken as **0.5 + (4 - Log<sub>10</sub> 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  
 $\rho$  = Density

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



Moments to be considered for dynamic wind:

$$M_{res} = \sqrt{(M_d)^2 + (M_{st})^2}$$

$M_{st}$  = Static wind moment at critical wind velocity

Only if  $M_{res}$  exceeds moments due to static wind or earthquake moments, it shall be considered for equipment design.

**ANNEXURE-2**

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## 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 Licensor/Inspection agency and/or OWNER.

Note (1): X or Gamma rays



### 1.2 VESSEL INTERNALS

- a) Leak testing & final inspection is required.
- b) Check one tray of each diameter and type, mock assembled in the tray vendor 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.

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- 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

### 1.4 STORAGE TANKS

- a) Shell plates to be dimensionally checked (including diagonals for square-ness) before rolling to curvature.
- b) All shell plates to be inspected and dimensionally checked after rolling to curvature.
- c) Check material test certificates and ensure that all shell plates are clearly stamped with the cast and plate number, so that they can be identified against the relevant test Certificates.
- d) Check material test certificates for roof and bottom plates.
- e) Select the spot radiographs, D.P & M.P test as per codes.
- f) Review the radiographs. (1)
- g) On completion of inspection of shell plates ensure that vendor provides a chart giving all plate numbers, tier by tier.
- h) Inspect fabrication of all fabricated fittings. This is to include checking of material test Certificates also.
- i) Inspect tank gauging equipment.
- j) For shop fabricated tanks, witness hydrostatic tests to applicable standards.
- k) Check welding material electrodes.

Note (1): X or Gamma rays



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## ANNEXURE-3

### INDICATIVE ITP

### FOR

### SHELL AND TUBE HEAT EXCHANGER (ITP-01)



### PRESSURE VESSELS (ITP-02)

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**INDICATIVE QAP/ITP –**

**SHELL AND TUBE HEAT EXCHANGER**

**(ITP-01)**

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INDICATIVE 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 by LSTK contractor (including for bought out items)	P	R	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	A		I/R	X
03	Pre inspection meeting	P	H	H		I/H	X
04	Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	A	A		I	X
05	Welders Qualification Record	P	R	R		I	X
06	Welding Consumable Batch Certificate	P	R	R			X
07	Mock up test for tube to tube sheet joint	P	W	W/R		I	X
08	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
09	Material for Pressure Parts after receipt – Inspection, Identification 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 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	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



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	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 (if applicable)	P	RW	R			X
13		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
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	Dimensional check before PWHT	P	W	R			X
	d	Clearance for PWHT	P	H	R			X
	e	PWHT	P	R	R			X
	f	NDE after PWHT as applicable	P	W/R	R			X
	g	Hardness check after PWHT (as applicable)	P	RW	R			X
	h	Testing of Production Test coupon as applicable	P	W	W/R			X
17		NDE of Non pressure weld joints	P	R	R			X
18		Pull through test of shell	P	H	W/R			X
18.1		Tube Bundle Assembly						
	a	Tube to Tube sheet joint 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
19		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
20		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc.	P	H	H			X
21		Trial assembly of internals if any	P	W	W/R			X
22		Pneumatic test of pads and Tube to Tube sheet joint and Helium leak test (as applicable)	P	W	R			X
23		Hydrostatic test – Shell side, Tube side outside shell, Shell & Tube side after assembly, in condition (if applicable)	P	H	H			X
24		Check Chloride content of Hydro test water	P	R	R			X
25		NDE after Hydro test as applicable	P	RW	R			X
26		Vacuum Drying of equipment	P	W	R			X

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



27		Pickling and Passivation (Inside & Outside surface) for SS Equipment	P	W	R			X
28		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		I	X
31		Final stamping & issue of Inspection release certificate	P	W	R		I	X
32		Rust Prevention (N <sub>2</sub> 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 10) I-INFORMATION
NOTE	1)	CROSS (X) INDICATES REQUIREMENT OF RECORD
	2)	This is only an indicative ITP and covers major inspection stages only. LSTK Contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and specific technical requirements of NIT/design code.
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with 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/Licenser 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/Owner/PMC.
	7)	LSTK Contractor/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 TPIA.
	8)	For ‘R’ No Issue Of Inspection Call Is Required
	9)	For “W” & “H” Points – Inspection Call To Be Issued By Vendor/LSTK contractor.
	10)	Approved Third Party Inspection Agencies as per NIT.
	11)	Wherever “W/R” Is Mentioned for TPIA, It Is At The Sole Discretion Of Owner To Decide “W” Or “R” While Approval of ITP During Order Execution
	12)	Heat exchanger Tubes shall be hydro tested and eddy current tested at manufacturer’s works.

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

**INDICATIVE QAP/ ITP**  
  
**PRESSURE VESSEL**  
  
**(VESSELS, REACTORS, COLUMNS, FILTER, etc)**  
  
**(ITP-02)**

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**INDICATIVE QAP/ INSPECTION AND TEST PLAN- PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc**


<b>PRESSURE VESSELS, REACTORS, COLUMNS, FILTER, etc</b>							
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 by LSTK contractor (including for bought out items)	P	R	A		R	X
02		Design & Drawing Approval	P	I	A		R	X
03		Inspection & Test Procedures such as NDT, PWHT, Pressure test, Hardness, Painting, etc.	P	A	A		I	X
04		Pre inspection meeting	P	H	H		I/H	X
05		Welding Procedure Specification (WPS) & Procedure Qualification Record (PQR) with weld map	P	A	A			X
06		Welders Qualification Record	P	R	R			X
07		Welding Consumable Batch Certificate	P	R	R			X
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.	P	R	R			X
09		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
10		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
11		Material for Non Pressure Parts / Structural – Inspection, Identification with Test certificate & Review of certificate.	P	R	R			X
12		Formed Components such as Dished ends, Cones etc.						
	a	Visual, Dimensional, (Profile, Thickness, ovality, diameter etc.)	P	W	R			X
	b	NDE of weld joint	P	W/R	R			X

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	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	P	W/R	R			X
	f	UT for lack of bond in formed shall, cone etc. for Cladded equipment	P	W/R	R			X
13		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	Visual & Dimensional	P	RW	R			X
14		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
15		ISR, DHT for LAS as applicable during welding	P	W/R	R			X
16		PT of root run for single side weld / back chipped surface of weld for pressure retaining weld joints	P	R	R			X
17		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	P	W	W/R			X
18		NDE of Non pressure weld joints	P	R	R			X
19		PMI of all pressure parts and welds for AS/SS material	P	RW	R			X
20		Final visual & Dimensional check, including internal, external & alignment, match markings for site joints etc. (before PWHT as applicable)	P	H	H			X
21		Trial assembly of internals / trays and column/vessel section etc. as applicable.	P	W	W/R			X
22		Pneumatic test of pads	P	W/R	R			X
23		Hydrostatic test	P	H	H			X
24		Check Chloride content of Hydro test water	P	R	R			X
25		NDE after Hydro test as	P	RW	R			X



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		applicable						
26		Vacuum Drying of equipment	P	W/R	R			X
27		Pickling and Passivation (Inside & Outside surface) for SS Equipment						
	a	Visual check	P	W	R			X
28		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
29		Visual/Dimension of Foundation Template, Gage plat for base ring & foundation bolt as applicable	P	W/R	R			X
30		Review of final documents including MDR of AI (as applicable)	H	R	R		I	X
31		Final stamping & issue of Inspection release certificate	P	H	H		I	X
32		Rust Prevention (N <sub>2</sub> purge, VCI)	P	W/R	R			X
33		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 10) I-INFORMATION						
NOTE		1) CROSS (X) INDICATES REQUIREMENT OF RECORD						
	2)	This is only an indicative ITP and covers major inspection stages only. LSTK Contractor shall submit detailed ITP for all manufacturing/inspection activities including bought out items in line with above and NIT/ design code e.t.c						
	3)	Responsibility Of Performing/ Coordinating All Inspection Activities As Per ITP is with 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/Owner/PMC.						
	7)	LSTK Contractor/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 TPIA.						
	8)	For ‘R’ No Issue Of Inspection Call Is Required						
	9)	For “W” & “H” Points – Inspection Call To Be Issued By Vendor.						
	10)	Approved Third Party Inspection Agencies as per NIT.						
	11)	Wherever “W/R” Is Mentioned for TPIA, It Is At The Sole Discretion Of Owner To Decide “W” Or “R” While Approval Of ITP During Order Execution.						

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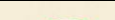
## PART II: TECHNICAL

### SECTION – 5.3.3

#### DESIGN PHILOSOPHY – ROTATING EQUIPMENTS

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS  
(SNG) PROJECT AT BARDHAMAN,  
WEST BENGAL, INDIA**

**PLANT : COAL GASIFICATION PLANT FOR  
GENERATING SYN GAS (CO+H<sub>2</sub>) FOR  
PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)**




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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

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## 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 coal gasification plant for generating syn gas (CO+H<sub>2</sub>) for production of synthetic natural gas (SNG) at Bardhaman Distt. West Bengal for CGIL.
- 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

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	Petroleum, Chemical and Gas Industry Services
API 616	Gas Turbine 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 677	General Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
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
<b><u>Performance Testing (ASME Codes)</u></b>	
PTC 8.2	Centrifugal Pump
PTC 6	Steam Turbines
PTC 9	Displacement Compressors
PTC 10	Centrifugal Compressors
PTC 11	Centrifugal Fans
PTC 22	Gas Turbines

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

## 2.2 Design Life

All equipment shall be designed for a minimum service life of 25 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 adapted to the extent applicable.

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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. Gears/any other forms of 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 to be avoided for any components in Ammonia Plant & in other plant for ammonia services.
- 3.1.3 All 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

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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 / higher 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 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.





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- 3.2.7 Diaphragm type coupling of proven make, Shim pack dry flexible coupling from reputed coupling manufactures like M/s Turboflex, Euroflex & KOP Flex or equivalent reputed proven make shall be used. Reference list / proven track record shall be submitted , if owner's demanded .The couplings shall be designed as per API-671.
- 3.2.8 Dry Gas seals shall be provided for centrifugal compressor
- 3.2.9 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.
- 3.2.10 Twin oil cooler and twin oil filter shall be provided.
- 3.2.11 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.
- 3.2.12 Complete Anti-Surge control system with computerised calculations with compressor characteristics shall be provided for each machine.
- 3.2.13 Shaft vibration monitoring instruments (both radial and axial) shall be provided to trip the machine in case of high radial vibration or axial movement.
- 3.2.14 All the trip interlock shall be two out of three voting logic. Instrumentation design philosophy of NIT to also to be referred.
- 3.2.15 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 Machine shall be balanced to minimise lateral loads.
- 3.3.2 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.
- 3.3.3 Distance piece of non-lubricated compressor shall of sufficient length to ensure that no oil is in contact with gland packing.
- 3.3.4 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.
- 3.3.5 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.
- 3.3.6 Cylinders shall be water cooled.

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- 3.3.7 The maximum piston rod loading shall be calculated considering safety valve set pressure.
- 3.3.8 Non-lubricated compressors shall be provided with piston rings, packing made of carbon filled PTFE or equivalent.
- 3.3.9 The packing boxes shall be provided with atmospheric vents to minimize gas leakage.
- 3.3.10 Pulsation dampeners shall be provided for meeting the residual pulsation requirements as per API.
- 3.3.11 For API compressors the requirements for acoustic study shall be in accordance with the API recommendation.
- 3.3.12 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.
- 3.3.13 Frame lubrication system shall be provided with auxiliary pump driven by electric motor for initial lubrication.
- 3.3.14 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 Full flow twin oil filter shall be provided.

### 3.4 Screw Compressor


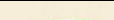
The screw compressors shall conform to API-619, latest edition. If not, specifically mentioned the screw compressor may be manufacturer standard. In addition to the above, the following shall be applicable.

- 3.4.1 Each compressor together with its driver, oil system, inter-connecting piping, all auxiliary items, such as heat exchangers, separators, pumps, valves, etc., and instrumentation, shall be one integrated unit
- 3.4.2 All drains on the process side shall have double block valves
- 3.4.3 Manufacturer shall provide adequate relief and venting at suction and discharge

### 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.

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

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- 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°C.
- 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 Flexible coupling 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 or equivalent reputed proven make shall be used. 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 Cooling water pumps shall be horizontal split casing type with mechanical seals.
- 3.5.12 Pump, including all auxiliaries, shall be designed for outdoor installation and continuous operation



### **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 Pressure relief valve should have perfect seating and there should not be any leakage when operating pressure is under set pressure.
- 3.6.3 Pump, including all auxiliaries, shall be designed for outdoor installation and continuous operation

### **Rotary pumps**

- 3.7.1 Rotary pump shall be designed as per API 676 latest edition .



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- 3.7.2 The equipment (including auxiliaries) shall be suitable for unsheltered outdoor operation. The anticipated weather and environmental conditions.
- 3.7.3 This standard shall be followed in establishing the minimum engineering requirements for positive displacement pump (rotary type) for service within the limits of similar plants applications
- 3.7.4 Pumps shall be designed and selected to ensure that suction pressure casing zones can be subjected to discharge pressure side hydrostatic test pressure

### 3.8 Steam Turbine

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

- 3.8.1 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.
- 3.8.2 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.
- 3.8.3 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.
- 3.8.4 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.
- 3.8.5 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.
- 3.8.6 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.

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- 3.8.7 Local control panel shall be adjacent to turbine for easy operation.
- 3.8.8 All valves and controlling devices shall be within easy reach for convenient and quick attention by operators.
- 3.8.9 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.



### 3.9 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.

- 3.9.1 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.
- 3.9.2 First critical speed of the rotor shall be higher than 120% of rated speed.
- 3.9.3 Capacity control shall be achieved by means of dampers (Preferably on suction side) specially for constant speed fans.
- 3.9.4 The fan casing shall be suitably split such that impeller assembly can be removed for maintenance without disturbing inlet and outlet ducting.
- 3.9.5 SS bolts and nuts shall be provided for the split casing joints of fans for corrosive service.
- 3.9.6 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.
- 3.9.7 Bearing shall be preferably oil lubricated.

### 3.10 Agitator

- 3.10.1 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.
- 3.10.2 First critical speed of the rotor shall not be less than 140% of rated speed.
- 3.10.3 Adequate space shall be provided for packing replacement without removing or dismantling of any part other than the gland and the seal cage.
- 3.10.4 Motor rating shall be minimum 125% of shaft power.



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- 3.10.5 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.
- 3.10.6 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.
- 3.10.7 Gear unit shall be provided in accordance with AGMA standard. Gear box rating shall be selected based on minimum service factor of 1.5.

### 3.11 HVAC System

- 3.11.1 LSTK to assure that HVAC system and auxiliaries shall be complete in all aspect complying to national / international / statutory requirement
- 3.11.2 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.
- 3.11.3 Complete design of air-conditioning system (heat load calculations for all three seasons, i.e. summer, monsoon & winter with psychometric plots specifying the design TR capacity, dehumidified air quantity and monsoon/winter heating capacity).
- 3.11.4 R-134a / equivalent and Eco-friendly refrigerant to be supplied & filled in the chiller units by bidder
- 3.11.5 LSTK Contractor shall provide suitable HVAC system for all process / non-process buildings/ facilities as well as for other buildings /structures . All civil buildings / facility, Control room, substation, labs etc to be equipped with suitable HVAC system with 100 % redundancy. For chiller base central air-conditioning system preferably water cooled. Complete HVAC system shall be designed for providing optimum cooling & heating during summer & winter season vice versa.
- 3.11.6 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 °C	55 ± 5%
Sub Stations (Switchgear rooms)	22 ±2 °C	55 ± 5%
Rack rooms	22 ±2 °C	Rack room equipment OEM requirement to be followed.

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PLC room	22 ±2 °C	PLC OEM requirement to be followed.
UPS room	22 ±2 °C	UPS OEM requirement to be followed.
Computer room	22 ±2 °C	OEM requirement to be followed.
Any other 'plant equipment' building / room	22 ±2 °C	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 °C	-

Other plant building/ facilities shall also be equipped with adequate HVAC system by Bidder / contractor.

- 3.11.7 Central AC system with complete auxiliaries with 100% stand-by chillers & AHUs are required with chemical filters.
- 3.11.8 Chiller's unit shall have proven track record of satisfactory operation for a minimum period of 8000 hours for similar application
- 3.11.9 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.
- 3.11.10 In case of package / portable AC such as split / window type, 1 no. Stand-by AC unit/system shall be considered / installed for working AC system/units up to 3 nos. However, 2 nos stand by AC system/units shall be considered between for 4 to 6 working AC units/systems.
- 3.11.11 Ventilation system with adequate stand-by equipment to be provided for AHU room, Pantry room, All Toilets, Locker rooms, Store rooms, cable cellar room, change rooms etc.
- 3.11.12 Site related temperature, humidity shall be considered for adequate design & selection of HVAC system along with compliance to National / international codes and standards viz. ISHRAE/ ASHRAE.
- 3.11.13 Following type of HVAC system shall be considered by bidder after calculating various loads derived based on final layouts / rooms dimensions:

S.N.	Estimated Tonnage of building	Type of HVAC system
1	Up to 10 TR	Hi Wall Energy Efficient Split AC units



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2	10 TR to 45 TR	Water Cooled Package AC system
3	45 TR onwards	Air Handling Unit + water cooled chiller with all associated equipments

3.11.14 One full charge of refrigerant for each air condition system to be provided as a spare.

### 3.12 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


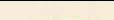
Machines shall be inspected by Third Party Inspection Agency. The Inspection and testing shall be in accordance with the all relevant codes, standards, specifications, including the minimum guide line given in Annexure – 1 (attached).

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

4.2 In general, following tests shall be conducted for all rotating equipments:

- Material test
- Non-destructive test
- 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



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The tests required to be conducted and witnessed shall be specified in the equipment data sheet.

## 5.0 SPARES

5.1 Spare philosophy shall be as per section 10 attached with 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 NIT.

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## **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.

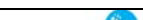

All rotating Equipments shall be inspected by Third Party Inspection Agency .The Inspection and testing shall be in accordance with the all relevant codes, standards, and specifications as specified in Specification sheet.

#### **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..
- 2.7 Final inspection and dimensional check of pump (including driver, when mounted on base plate).
- 2.8 Final inspection and dimensional check to be carried out on motor drivers.
- 2.9 Running test to be witness for spare / standby equipment also
- 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.

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- 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 Running test to be witness for spare / standby equipment also
- 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.

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## PART II: TECHNICAL



### SECTION – 5.3.4

#### DESIGN PHILOSOPHY- SOLID MATERIAL HANDLING COAL AND ASH HANDLING SYSTEM

**PLANT: COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT AT BARDHAMAN, WEST BENGAL, INDIA.**

0	25.09.2025	25.09.2025	Revised Tender	AS	AM	PK
P	14.02.2025	14.02.2025	Issued for Tender Purpose	AS	AM	PK
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



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1.0	PURPOSE
2.0	SCOPE OF WORK
3.0	CODES AND STANDARD
4.0	BRIEF SYSTEM DESCRIPTION FOR COAL & FLUXANT/LIMESTONE HANDLING
5.0	TECHNICAL SPECIFICATION OF EQUIPMENTS
6.0	DUST EXTRACTION SYSTEM
7.0	ASH HANDLING SYSTEM
8.0	ACCESS TO MACHINERY
9.0	ELECTRICAL SYSTEM
10.0	INSTRUMENTATION SYSTEM

## LIST OF ATTACHMENTS

Attachment Number	Description	Sheet No.
	NIL	

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	<b>DESIGN PHILOSOPHY – SOLID MATERIAL HANDLING SYSTEM</b>		SHEET 3 OF 23		

## 1.0 PURPOSE

This document lays down the guidelines for design, engineering, manufacturing, erection, inspection, testing etc. requirements required for & applicable to Solid (Coal, fluxant, Ash etc.) Handling System for COAL GASIFICATION PLANT/ISLAND to produce COAL to SYNTHETIC NATURAL GAS.



## 2.0 SCOPE OF WORK

The following plants & facilities shall be under the scope of the LSTK contractor depending up-on the Coal Gasification Technology opted by the LSTK contractor. The scope of work of Solid handling system shall consists of, but not limited to the following :-

- a. Coal and Fluxant/Limestone – Coal from mines shall be received at designated transfer tower within plant (battery limit & scope under LSTK contractor) through conveyor system or at surface truck/dumper unloading station/system (battery limit & scope under LSTK contractor) through truck/dumper. Fluxant/Limestone from mines shall be received at surface truck/dumper unloading station/system (battery limit & scope under LSTK contractor) through truck/dumper. Coal & fluxant/Limestone conveying/handling from mines upto designated transfer tower & surface unloading station/system (battery limit) within plant are excluded from scope of LSTK contractor. Scope of LSTK contractor shall start from & including the designated transfer tower & surface unloading station/system at battery limit within plant boundary.

Coal & fluxant/limestone received from mines shall be transferred to storage area. Closed (full side covering with full top/roof cover) storage with RCC flooring equivalent to seven (07) days consumption of each of raw materials- coal (-100 mm) & fluxant/limestone (-200 mm) required for Coal gasification Plant plus 5000MT of coal for Steam Generation Plant(SGP) [other's scope] shall be considered with one stacker & one reclaimer system. Single storage for coal & fluxant/limestone shall be considered with demarked section for coal & fluxant/limestone storage.

Coal & fluxant/limestone from storage area shall be transferred to crusher house for crushing and then transfer to bunkers of CMD system. LSTK contractor to consider provision at crusher house or at a designated transfer tower to transfer coal to Steam Generation Plant (SGP) [other's scope] after coal crushing (-100mm to -30mm).

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System to be designed for optimum and efficient operation.

- b. Blended Coal milling, drying and feeding to burners of the gasifier via the “Coal Pressurisation and Feeding” system.
- c. Conveying Ash / slag produced from gasifier to overhead bunkers. Provision shall be made in bunker discharge so that ash/slag can be handled with the help of dumper or conveyor.

### 3.0 CODES AND STANDARDS

The design, manufacture, inspection and testing of required & applicable solid (Coal, fluxant, Ash etc.) Handling System for Coal gasification Plant shall comply with all the currently applicable statues, regulations and safety codes in the locality where the equipment is to be installed. The equipment shall confirm to the latest edition of the following standards & codes. Other internationally acceptable standards/codes, which ensure equal or higher performance, shall also be accepted.

Conveyor System	“Conveyor Equipment Manufacturer’s Association” (CEMA) or IS : 11592 latest edition
Conveyor Belting	IS : 1891 latest edition or equivalent / ISO
Flat Belt/Slat Conveyors	IS : 8597 latest edition or equivalent / ISO
Conveyor Pulleys	IS : 8531 latest edition or equivalent / ISO
Conveyor Idlers	IS : 8598 latest edition or equivalent / ISO
Conveyor safety	IS : 7155 latest edition or equivalent / ISO
Troughed Belt Conveyors	IS : 4776 latest edition or equivalent / ISO
Use & Selection of Bucket Elevator	IS : 7167 latest edition or equivalent / ISO
Code of practices for selection of belt feeder	IS : 12215 latest edition or equivalent / ISO
Design criteria for pneumatic conveying systems	IS : 8647 latest edition or equivalent / ISO
Vibrating Screen	IS : 12213 latest edition or equivalent / ISO
Dust Extraction system	ACGIH latest edition or equivalent /ISO

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Mobile Continuous Bulk Handling Equipment	ISO : 5049/1 latest edition or equivalent / IS
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#### 4.0 BRIEF SYSTEM DESCRIPTION FOR COAL & FLUXANT/LIMESTONE HANDLING (Applicable solid material/system to be considered as per Licensor)

##### 4.1 COAL & FLUXANT/LIMESTONE HANDLING

Coal (-100 mm) and Fluxant (-200 mm) received at battery limit shall be transferred to fully closed storage of Coal and Fluxant with the help of belt conveyors, stacker, reclaimer, rack & pinion gate / rod gate, vibrating feeder etc. Coal & fluxant storage shall be equivalent to seven (07) days consumption of each of raw materials- coal & fluxant/limestone required for Coal gasification Plant plus 5000MT of coal for Steam Generation Plant (SGP) [other's scope].



One (1) no. stacker & One (1) no. reclaimer shall be used inside storage area of coal & fluxant handling (stacking & reclaiming).

Suspended magnets shall be provided above head pulleys of conveyors at transfer points/towers for removal of tramp Iron pieces. Metal detectors shall also be provided to detect non-ferrous materials present in the coal before crusher.

Two nos. of conveyors (1 working + 1 stand-by) shall be considered after storage from a suitable transfer tower to transfer coal & fluxant/limestone to crusher house. The received coal shall be sized in crusher house from (-100) mm to (-30) mm. Screen to be provided upstream of the crusher to screen out (-30) mm coal from feed. (-30) mm coal shall be directly transferred to the downstream conveyors & (+30) mm coal shall be fed to the crushers. Similarly, the received fluxant/limestone (-200) mm shall be sized in separate dedicated crusher from (-200) mm to (-30) mm. Screen to be provided upstream of the crusher to screen out (-30) mm fluxant/limestone from feed. (-30) mm fluxant/limestone shall be directly transferred to the downstream conveyors & (+) 30 mm fluxant/limestone shall be fed to the crushers.

One emergency reclaim hopper (ERH) shall be provided to reclaim coal/fluxant by dozers when stacker & reclaimer are not in operation. Emergency reclaim hopper shall also be



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used for coal/fluxant feeding by dozers / pay loader etc. Suitable conveyor system shall be provided to transfer material from emergency reclaim hopper to subsequent conveyors (those are coming from storage area) at nearest transfer tower.

In Crusher house, 1 working (W) + 1 standby (S) crusher & screen set for coal and 1 working (W) + 1 standby (S) crusher & screen set for fluxant/limestone shall be considered for coal gasification plant/island. Thus, total 2 nos. crushers & 2 nos. screen for coal and total 2 nos. crushers & 2 nos. screen for fluxant/limestone shall be under contractor's scope.

#### **4.2 COAL & FLUXANT/LIMESTONE STORAGE/STACKING & RECLAIMING**



Coal & fluxant/limestone shall be transferred to closed (full side covering with full top/roof cover) storage with RCC flooring for stacking. Coal & fluxant storage shall be equivalent to seven (07) days consumption for Coal gasification Plant plus 5000MT of coal for Steam generation Plant(SGP) [other's scope].

Stacker shall be used for stacking of coal / fluxant/limestone. For reclaiming, separate reclaimers shall be used to reclaim the coal / fluxant/limestone and to feed to crusher house for screening and crushing and then transfer to respective bunkers of Coal Milling and Drying System (CMD System).

#### **4.3 COAL MILLING AND DRYING (CMD)**

Coal milling & drying system shall be considered as per Licensor recommendation. Each vertical roller mill shall be fed by two (2) nos. of bunkers (1 each for coal and fluxant/limestone). The capacity of each bunker for coal shall be minimum 12 hours of operation and the capacity of each bunker for fluxant/limestone shall be minimum 24 hours of operation. Rack & pinion gate/Rod gate and Belt weigh feeder shall be installed at bottom of each bunker for measurement of flow rate of coal / fluxant/limestone. For design of system regarding PDC, EDC case, bidder to refer Process design specification/philosophy.

Coal Milling and Drying system shall feed pneumatically under pressure to the coal burners of the gasifier via the "Coal Pressurisation and Feeding" (lock-hopper) system.

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Blended coal shall be milled to meet the gasifier specifications for particle size distribution and moisture content. The moisture content in combination with the particle size ensures proper flow properties of the pulverized feed in downstream equipment.

System to be designed for optimum and efficient operation.

#### 4.4 COAL PRESSURIZATION AND FEEDING

Lock hoppers shall be used in coal pressurization system for Coal Gasifier. Please refer licensor data for more information.

The Project shall be so designed and the equipment shall be so sized that the specified material through-put is achieved without equipment overloading, material degradation or spillage.



**For the complete Material Handling system, bidder to supply all commissioning spares and mandatory spares parts (2 yrs) for all necessary equipment's for smooth & trouble free operation of complete system.**

**Bidder to also furnish list of 2 years recommended spares parts (along-with optional price) of all necessary equipment's for smooth & trouble free operation of the complete Material handling system after commission/PGTR (Performance Guarantee Test Run) & 6 month's supervision operation.**



#### 5.0 TECHNICAL SPECIFICATION OF EQUIPMENTS

##### 5.1 BELT CONVEYORS

1. Conveyor capacity shall be such that it shall be adequate to handle Coal Gasification Plant capacity. Design capacity shall be considered as min. 20% more than the rated capacity.
2. All conveyors shall include adequate structural supports, transfer towers, all drives, pulleys, idlers, chutes, belting, skirt boards, belt cleaners, hold backs(for inclined conveyors), emergency/safety switches, protective devices etc.



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3. All conveyors outside buildings shall be in enclosed gantry/galleries having main walk-way of min.1100 mm clear width on one side and min. 750 mm clear width on other side(maintenance way) of conveyors
4. All belt conveyors shall have suitable gravity take-up unit, except material weigh feeder which have short length and wherever agreed by owner/ consultant.
5. The belt speed shall be optimum so as to minimise material degradation, spillage and generation of dust. Belt speed shall not exceed 2.5 m / sec.
6. Continuous belt weigher shall be installed on conveyor at suitable locations. Display of this weigher would be connected through control panel.
7. Magnetic separator arrangement of adequate capacity to be provided at suitable location to separate any unwanted particle from the feed coal to Coal Gasifier.
8. All the conveyors shall be provided with identical designed frame size, roller size, pulley size etc. as far as possible to have better interchangeability and reducing the inventory.
9. The belting shall be of either synthetic fabric such as Nylon-Nylon / Polyester Polyamide, Steel Cord etc. with rubber covers of adequate flexibility to give a troughing angle of 35 deg. For all the conveyors the number of plies, cover thickness, factor of safety etc. shall be as per the recommendation of belt manufacturer of adequate strength.
10. Conveyor drive shall be directly coupled through suitable helical gear box.
11. Metallic flexible grid coupling shall be used for all conveyors.
12. Minimum service factor for coupling shall be taken as 2.0 on the absorbed power.
13. Minimum service factor on gear boxes shall be taken as 1.5 over the absorbed power.
14. All conveyor belts shall be fitted with belt cleaners/scrapers which will be located between the head and snub drums, on the return belt side. All conveyors' belts shall be fitted with multi-blade sprung type external belt scraper below head pulley and V-

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type internal belt scraper. All cleaned material from the belt shall fall within the head chute.

15. The skirt boards and sealing with overlapping block design shall be provided with labyrinth seals.
16. All equipment's / assemblies shall use bearing fitted in Plummer block.
17. Self-aligning training idler spacing to be considered as maximum 15m for carrying side & maximum 30m for return side.
18. Impact idlers (minimum 5 nos.) shall be provided at loading points at spacing of 300 mm. Impact idlers shall be of rubber lagged type.
19. All pulleys shall be lagged in herring-bone pattern. Head/Drive pulleys shall be lagged with min. 12 mm thickness Neoprene and Tail & Snub pulleys shall be lagged with min. 10 mm thickness Neoprene.
20. All diverter & gate shall be electrically operated.
21. For safety of conveyors and personnel, all conveyors shall be provided with safety switches like zero speed switch, belt sway switch and pull cord. In addition to these there shall be provision of audible warning (Hooter) of starting of conveyor.
22. Suitable hold back devices in case of inclined conveyors for preventing running back of the conveyor belt in case of conveyor being stopped in loaded conditions due to power failure or during normal operational delays shall be provided to give positive protection. The hold back shall instantaneously engage without shock and be capable of protecting equipment and personnel. It shall be released instantly when 'power' resumes or the 'delay' is removed. The holdback devices shall be integral with gearbox.
23. Solid material handling system operation/design shall be two shift operations i.e. 14 hours to fill both two materials (coal & fluxant/limestone) to gasification plant. Capacity of belt conveying system for gasification plant shall be considered as min. 500TPH (Rated)/ 600 TPH (Design)

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24. Minimum capacity of the ground hopper/ emergency hoppers shall be considered 2 x 45T. Covered shed shall be considered for Hoppers. Paved surface shall be provided for proper unloading of truck all around the hoppers area. MOC of the unloading hoppers shall be RCC with lining.
25. In Belt conveyor, Deck Plate shall be provided 4m length (min.) at receiving end and 2m length (min.) at discharge end.
26. In Transfer Tower at battery limit, bidder to consider space provision & civil load for conveyor (head end i.e. pulley, head frame, motor, gearbox, etc.) coming from mines and two way chute etc.
27. At Crusher House or at a designated transfer tower, bidder to consider space provision & civil load for belt conveyor (1W+1S) to SGP (tail end of conveyor i.e. pulley, tail frame, etc.) and two way chute etc.
28. For double stream conveyors in common gantry/gallery, central walk way clear width shall be minimum 1100mm.
29. Bidder to consider redundancy / stand-by for belt conveying system (1W+1S) after coal storage yard conveyor to bunkers of CMD unit for transfer the raw materials (Coal & Fluxant/limestone).
30. Elevator in crusher house shall be considered.
31. Online Coal sampling system shall be considered.
32. The specification (boom length, luffing range and slewing range etc.) of both the stacker & reclaimer shall be same/synchronizing to each other.
33. In crusher House, bidder to consider space provision for feeding (-) 30mm coal/Fluxant to belt conveyor (1W+1S) of Steam Generation Plant (other's scope).
34. Crusher (Coal/Fluxant) of Coal gasification plant shall work as primary crusher of SGP plant.



## 5.2 STACKING OF COAL, FLUXANT/LIMESTONE IN STORAGE SHED AND RECLAIMING FACILITY

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1. Coal & fluxant/limestone shall be stored in fully closed bulk storage. Stacker shall be used for stacking of coal & fluxant/limestone. For reclaiming, reclaimer shall be used to reclaim coal & fluxant/limestone and to feed to crusher house for screening and crushing and then transfer to respective bunkers of Coal Milling and Drying System (CMD System)
2. Bulk raw material storage shall be fed by storing conveyor with stacker unit of adequate capacity.
3. The stacking of the raw material in the bulk store shall be carried out in such a way that the creation of dust is minimized.
4. Adequate reclaiming of raw material from the raw material storage shed shall be done with the help of suitable reclaimer system, series of conveyors and to feed to bunkers of coal milling and drying system.
5. The stacker & reclaimer shall be provided with an enclosed cabin with fresh air supply, to ensure proper working conditions to the personnel.
6. Stacker & reclaimer system shall be designed in such a manner that utmost space within the storage can be utilized for stacking as well as reclaiming of material.



### **5.3 TRAVELLING TRIPPER UNIT / SHUTTLE CONVEYOR & BUNKER SEALING ARRANGEMENT**

1. Rail mounted movable travelling Tripper / shuttle conveyor shall be provided to feed coal & fluxant/limestone to overhead bunkers of CMD system.
2. Mobile Trippers on bunker conveyors along with belt sealing arrangement shall be furnished and erected complete with rails, including necessary supporting structures, approach/maintenance platforms with ladders and hand railings, trailing cables, all electrical including machine mounted local control panel & control panel on one end of Bunker, location of which shall be decided during detail engineering.
3. The Mobile tripper conveyors shall be motor driven type. It shall consist of structures, supports, walkways, rails, belt scrapper with adjustable rubber strip, rubber lagged

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head and bend pulleys complete with shaft bearings, chutes, stops, limit switches, brakes etc. The rating of tripper travel motor shall be adequate to move the tripper smoothly either in same or opposite direction to belt direction under fully loaded conditions. Minimum two drive axles shall be provided for tripper travel. Arrangement shall be provided at the starting point of the tripper to avoid folding of belt.

4. Supply of adequate length of rails to cover the runway length for the motor driven tripper shall be included. Suitable belt hold down guide pulley shall be provided over the concave curve of belt over tripper.
5. The travelling trippers shall be provided with fail safe A.C. thruster operated brake of totally enclosed type which shall engage as soon as tripper travel motor stops. A.C. thruster operated rail clamps along with manual Rail clamps on both side of the tripper shall also be provided.
6. Monorail & electric hoist shall be provided for lifting conveyor drum to floors. Monorail all along the tripper travel length to facilitate maintenance of tripper shall be provided.
7. Suitable dust cover shall be provided over tripper head pulley. Serrated rubber seal shall be provided at open side to prevent dust nuisance. Suitable dust tight access doors shall be provided. Spring loaded scraper type belt cleaner shall be provided below the tripper head pulley for cleaning the carrying side of the belt.
8. The tripper shall run on rails with double flanged wheels. Rails for tripper travel shall be mounted on supporting structure of respective conveyors.
9. Suitable system having encoders for monitoring position of tripper in DCS shall be provided. In addition, travel end limit switches and end stops shall also be provided.
10. Suitable access platform of chequered plate with ladders, hand railing and walkways on both sides shall be provided for access/maintenance of equipment on tripper. In addition, crossover platform shall be provided with tripper so that operator can cross the belt through the same.
11. Suitable rail cleaners shall be provided on leading and trailing edge of tripper for either track.

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12. In case of bunker feeding, the tripper shall have provision for dropping coal from conveyor onto one side of tripper to the bunker or back to the conveyor for the purpose of skipping intermediate bunkers. Complete Bunker Sealing arrangement shall be provided over the bunkers to prevent dust emission into tripper bay.



#### 5.4 HOPPERS

The hoppers shall be fabricated from Carbon steel plates (min. 10 mm thickness.) conforming to IS : 2062 or equivalent / ISO and to lined with Tiscral / Sailhard / equivalent material of min. 12 mm thickness from inside not only on bottom portion but also on vertical portion for free flow of material.

#### 5.5 FEEDERS

1. The design of the feeder shall be sturdy and robust in construction to withstand worst duty conditions and given uninterrupted flow of material. The unit shall have unbalanced motors with vibration control and variable control mechanism for controlling the rate of flow. The design shall be such that it consumes less power per ton of material handled, with less maintenance.
2. The feeder shall be able to start at full load quickly, stop smoothly and shall operate at an extremely low noise level. With the empty tray the noise level shall be less than 85db within one meter radius of the unit.
3. Whenever the feeder shall be suspended from the top, the design of the suspension gear shall be such as to provide maximum isolation of vibrations and ensure very little transmission of spurious vibrations into surrounding structures. Turn buckles shall be provided in the suspension gear for adjusting the heights.
4. The width of the deck and height of skirts shall be sufficient to suit the duty conditions. The length of the deck shall be suitable for arresting the flow from hopper efficiently when the feeder is stopped or not in working condition.
5. The deck and skirts shall be provided with abrasion resistant liners. The through shall be suitably stiffened to avoid bending.
6. The mounting springs shall be made of high quality chrome steel.





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7. No portion of the driving mechanism shall be lower than tip of the discharge point, so that sufficient clearance is available between the feeder and the belt conveyor.
8. The trough shall be inclined to give maximum output and this shall not be more than 5 degrees.
9. The feeder shall be able to deliver the coal at varying capacities (continuous variability) by varying amplitude and frequency. This variation shall be able to be controlled from the central control room with the help of a rheostat or any other contrivance.
10. All the parts of the equipment which need regular check-up / maintenance lying very close to the moving / rotating parts shall be provided with guards made of expanded metal.
11. The vibrating mechanism shall be of electro-mechanical.  
The feeder shall be able to operate round the clock and able to start in full load conditions. The feeder shall be able to operate at ambient temperatures from 4 to 50 degrees Celsius & relative humidity of 100% and in dusty atmosphere.
12. Adequate capacity feeder shall be selected by bidder at all locations. Design capacity shall be considered as min. 20% more than the rated capacity.

## 5.6 BUCKET ELEVATORS

1. Chain type Bucket elevator to be used wherever required.
2. The bucket elevator shall be designed for continuous duty at full load as specified under operating conditions and the various components shall conform to relevant codes.
3. Top cover shall be in pieces for easy to disassemble for the maintenance and inspection of complete drive assembly. The housing shall be provided with inspection opening at appropriate location.
4. Dust proof labyrinth metallic seal for the drive & return shaft shall be provided.
5. Bucket chain shall be of heavy duty and the chain specification with manufactures



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designated type/ number shall be specified.

6. Elevator shall be provided with Heavy duty positive holdback in order to prevent it from rotating backwards.
7. Hoods & safety guard shall be provided for the coupling and any other exposed rotating components. All safety switches shall be provided.
8. Adequate capacity bucket elevator shall be selected by bidder at all locations. Design capacity shall be considered as min. 20% more than the rated capacity.

## 5.7 VIBRATING SCREENS



1. The Vibrating Screens shall be electro-mechanical type. Bidder to consider adequate capacity vibrating screen. Adequate capacity screens shall be selected by bidder. Design capacity shall be considered as minimum 20% more than the rated capacity.
2. The deck of vibrating screening feeder shall have continuous solid deck section in the impact zone under direct coal fall and remaining deck shall be fitted with perforated deck assembly.
3. The solid deck section shall be provided with replaceable tiscral or equivalent liner plate of adequate thickness. The perforated deck shall be wear resistant and shall be rigidly fixed with main frame along the length of grizzly deck.
4. The vibrating screening feeders shall be mounted on the floor with the help of helical springs made of alloy steel. No rubber/synthetic material for the support shall be acceptable.
5. Vibrator bearings shall be grease lubricated, double spherical roller type suitable for vibrating equipment. The bearings shall be sized for minimum 8,000 hours of operation.
6. Suitable sealing arrangement shall be provided between the vibrating structure and chute work to avoid dust nuisance in the surrounding area.
7. Proper arrangement to avoid dust ingress into lubricant of eccentric shafts shall be provided.

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8. Necessary arrangements shall be provided for maintaining / replacing the complete vibrator assembly.
9. In case of V- belt drive, suitable arrangement like taper bush or coupling shall be provided, to avoid loosening of sheave mounted on eccentric shaft.
10. Dust hood shall be provided over the deck of screening feeder to avoid dust nuisance.

## 5.8 CRUSHER AND VMS

1. Crusher shall be provided for sizing the input coal (-100) mm to (-30) mm and sizing the input fluxant/limestone (-200) mm to (-30) mm. Crusher shall be supplied complete with accessories and subsystems.
2. Oversize raw material coming from the screen shall be transferred to the crusher. Bidder to consider adequate capacity crusher. Design capacity shall be considered as min. 10% more than the rated capacity.
3. The crusher design should be such that the crushing action is accompanied by the minimum of attrition.
4. Uniform crushing impact shall be assured.
5. The crusher shall be capable of delivering the normal rated output even when handling damp sticky coal having maximum moisture content. No clogging or building up of material on the crushing element shall develop.
6. Temperature sensing devices shall be installed on both bearings of each of the crusher to trip the crusher in case temperature goes beyond limit.
7. The entire inside surface of crusher coming in contact with coal shall be provided with abrasion resistant steel liners.
8. The Plummer block shall be of 'Split Type' design and shall be fixed with minimum four numbers of high tensile steel bolt studs of adequate size complete with adequate locking device and locating arrangement. In addition, the jacking screw shall be provided for easy lifting of top part of the plummer block. The same shall be of solid

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base with flat machined bottom surface all around having maximum contact on the foundation plate.



- Maximum accessibility shall be provided for routine inspection and replacement of parts. For these purposes, the doors shall be of hinge connection with effective dust sealing arrangement. Hydraulically operated top cover of crushers shall be provided for quick inspection.

## 5.9 VERTICAL ROLLER MILL

- Vertical Roller mills shall be supplied complete with accessories and subsystems.
- Design capacity shall be considered as min. 10% more than the rated capacity. The vertical roller mill shall be used for grinding, drying, separation and transportation.
- Vertical roller mill shall have following features like better utilisation of grinding area, even distribution of load on the table, comparative less dynamic forces on table due to lesser mass of single moving part, variable speed mill drives and “hydraulic loading system” for maximum flexibility to vary grinding pressure.
- Roller swing-out device for quick and easy changing of grinding components shall be provided or other facilities shall be used for quick and easy maintenance.
- Bevel Planetary gearbox with full lubrication and gear system shall be used.
- High efficiency dynamic classifier shall be used.
- There shall be no metallic contact between the grinding rollers and grinding tracks.
- Mill feed shall be sealed through rotary air lock.

## 5.10 TRANSFER CHUTES

- Chutes transferring Coal & fluxant/Limestone from one conveyor to another shall be designed in such a way that material fall height is minimum and the change in direction is achieved as smoothly as possible.
- All the chutes shall be provided with Tiscral/Sailhard material of min. 20 mm thickness at the striking & sliding zone and of MS material of min. 10 mm thickness at non striking & sliding zone.

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3. Inspection holes / window with covers shall be provided at all convenient locations.
4. Speed of the material falling on conveyor belt in the direction of belt travel should be almost the same as that of the conveyor.
5. The angle of chutes shall be 55<sup>0</sup> as far as possible but in no case less than 50<sup>0</sup> for proper flow of material.

#### 5.11 BUNKERS

1. The bunkers shall be of round shape and fabricated from Carbon steel plates (min. 10 mm thickness) conforming to IS : 2062 or equivalent / ISO and to lined with Tiscral / Sailhard or equivalent material of min. 12 mm thickness from inside not only on bottom conical portion but also on vertical portion for free flow of material.
2. Bunkers shall be provided with load cells, vibrators/poking hole, ultrasonic level indicator etc. The angle of conical portion of bunkers shall be kept as min. 55° with the horizontal.
3. Feeding to bunkers shall be automatic with the help of series of conveyors system.

#### 5.12 FLAP GATES

1. The motor operated 2 position flap gates shall be provided in transfer chutes as specified and shall be complete with electrically operated actuators. The gates shall be of robust construction and suitable for trouble free operation. The face of the flap gate shall be made out of 20 mm thick TISCRA/ SAILHARD or equivalent material.
2. The motor rating for the actuator shall be so selected as to provide sufficient thrust for operation of the flap gates against the moving weight of coal and/or flap gate. The flap gate travel shall be 60 deg. in general. The motor shall be completely dust tight.
3. Lever arm shall be provided between actuator and flap gate shaft for obtaining required thrust.
4. The actuators shall be capable of preventing any over travel. These shall be placed internal to the drive unit and shall be completely dust-proof. The limit switches shall be capable of adjustments to vary the total length of travel of the gates.

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- Provision for alternative manual operation shall also be made using declutch able hand wheel. The diameter of hand wheel shall be selected considering convenient force to be applied by a single operator. However, minimum diameter of hand wheel shall be 500 mm. Limit switch for safety of person operating the hand wheel shall be provided. Manual effort required to operation the flap gate shall not exceed 25 kg.

### 5.13 RACK & PINION GATES / ROD GATE

- Rotary actuator operated rack and pinion gates shall be provided at various locations as required. The gate shall be mounted such that coal load does not act vertically on gate.
- Suitable manually operated rod gates shall be provided over rack and pinion gates for their easy operation and maintenance. The rack and pinion gate shall be guided properly and suitable rollers with bearings sealed for life and dust proof shall be provided.
- The rack and pinion gates shall be of carbon steel construction with liner plate of 10 mm thick TISCRA/SAILHARD or equivalent material. The gates shall be operated by means of double rack and pinion. The material for rack & pinion wheel shall be cast steel and shaft shall be EN.-8.
- Provision for alternative manual operation of motorized rack and pinion gates shall also be made. Limit switch for safety of person operating the hand wheel shall be provided.
- Manual effort required to operate the rack and pinion gate shall not exceed 25 kg.

### 5.14 BELT SCALE

- Belt weigh scale for measurement of coal & fluxant/limestone flow rate and quantity shall be provided at specified locations. System shall be complete with flow rate indicator, totaliser, control panel etc.
- The weigh scale shall be automatic and electronic type. It should be designed for continuous automatic weighing, metering and printing of coal flow.

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3. Each belt weigh scale shall comprise of a belt weigh scale platform with minimum 4 nos. weighing idlers. It shall have unitized construction for ease of installation and shall be fully floating type (without pivot points). Minimum 4 nos. hermetically sealed load cells of precision strain gauge type shall be applied in tension to support the weigh bridge. The load cells shall have 100% overload protection and shall be structurally safe upto to 250% of rated belt scale capacity.
4. Belt scale shall be electronic microprocessor based with its program stored in non-volatile memory.
5. It shall be provided with self-diagnostic features for trouble shooting of the entire belt scale system. Fully automatic zero and span calibration facility shall be provided.
6. The electronic systems offered by the Contractor shall include all signal conditioning, power amplifiers and printed circuits etc. The printed circuits shall be encapsulated against dust and moisture.
7. The flow rate indicator shall have minimum 4 digits. The flow totalizer should have 8 digits display scale with reset facility.
8. Complete belt scale system shall be suitable for 50°C ambient temperature and 100% relative humidity. It shall be suitable for outdoor installation in a dusty area. The electronic circuit enclosure, sensors housing shall be dust and watertight.

#### **5.15 INLINE MAGNETIC SEPARATOR / SUSPENDED MAGNET**

Inline Magnetic Separators shall be provided for continuous and automatic extraction and discharge of tramp magnetic pieces from coal being discharged from conveyors as specified. The sets shall be complete in all respects with drives, magnets, inline belts, hoppers, chutes, tramp-iron boxes and all electrical ancillaries like control panels etc. Suspended Magnetic Separator shall be provided for picking up tramp magnetic pieces buried under coal from moving coal over Conveyor as specified.

#### **6.0 DUST EXTRACTION SYSTEM**

1. Dust control system shall be of dry / wet / extraction type and as well as dust suppression type to suit at the application point.

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2. The Contractor shall require providing suitable dust control system at suitable location for coal screening, crushing, coal storage, coal milling and drying system etc.
3. The dust control system to be furnished under this specification is required for control of fugitive dust emissions from dust generation points such as transfer points, feeders, crushers etc. Dust control is achieved by dust suppression/extraction system.
4. Dust control system which shall not allow a dust concentration in the ambient air inside the buildings more than acceptable limits as per the approved guidelines or any internationally recognized hygienic Standards/Codes.
5. Dust extraction system shall include but not limited to following- hoods, duct/ pipes (duct thickness shall be considered as per calculation but min. 5mm thickness), centrifugal fans/blowers, motors, rotary valve etc.

## **7.0 ASH HANDLING SYSTEM**



### **7.1 SLAG (BOTTOM SLAG) REMOVAL**

Slag (Dry basis), Slagfines (Dry basis) and Flyash are produced in coal gasification plant.

The majority of slag leaves the gasifier via the bottom as molten slag and is quenched. As the molten slag contacts the water bath at the bottom of the gasifier, the slag solidifies into dense, glassy granules. The slag granules falls into a collecting vessel located beneath the slag bath and are transferred to a lock-hopper. Between the slag bath and collecting vessel, a slag crusher is installed to crush big slag lumps. After the lock-hopper is filled, the slag is washed with clean make-up water to remove entrained gas and any surface impurities. After washing, the lock-hopper is depressurized and the slag is fed to a de-watering tank. The heat from the molten slag is removed in the slag bath and transferred to the water in the slag bath via a slag bath water circulation loop with an external water-cooled cooler.

Slag is depressurized in a lock-hopper system. The lock-hopper system operation is controlled with a sequence program. This de-watering tank is equipped with a mechanical conveyor (drag chain) to lift the settled solids off the bottom of the vessel and transport them on a conveyor belt. Finally, bottom slag received from conveyor shall be transferred



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to hopper at gasification area or to hopper at ash/slag pond area for dispatch outside by dumper/truck. Ash/slag pond is not under LSTK contractor's scope.

Dedicated bottom slag handling system shall be considered for each gasifier. Each bottom slag hopper with discharge gate, flap gate and conveyor (from hopper at gasifier area to hopper at ash/slag pond) shall be considered.

Hopper (one dedicated to one conveyor stream) near the ash/slag pond area shall have provision to load the bottom ash into truck as well as into Ash/Slag pond.

Capacity of each Bottom slag hopper shall be minimum one (1) hour of bottom slag production of each gasifier.

## 7.2 SLAG FINES REMOVAL



The bleed streams from the wet scrubber and from the slag bath are fed to sour slurry stripper for the removal of hydrogen sulphide and other gases to an environmentally acceptable level. The effluent stream from the stripper is then cooled and sent to a clarifier, where the solids are separated from the water. The wet cake solids are known as slag fines. Slag fines shall be transported to storage hopper at gasification area or to ash/slag pond with help of Dumper/truck. Slag fines may be recycled to CMD.

Capacity of each slag fines hopper shall be equivalent to one day peak production of each gasifier.

## 7.3 FLYASH REMOVAL (DRY SOLID REMOVAL)

Flyash carried with the syngas is removed in the "Dry Solids Removal" (DSR) section, via a high-pressure high temperature filter. After depressurization via a lock hopper system, stripping and cooling with nitrogen, the flyash is transferred to overhead storage silo for dispatch outside by dumpers or to ash/slag pond with help of belt conveyor. Flyash storage silo capacity shall be considered as minimum one day's ash generation. Fly ash shall be received from fly ash silo & shall be loaded to closed truck (minimum one loading arrangement).

7.4 Four (4) nos. dumpers of 40 Ton capacity each and two (2) nos. of Payloaders/Wheel loaders of 5 Ton capacity each shall be in scope of supply of LSTK contractor.

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## 8.0 ACCESS TO MACHINERY

1. Special attention shall be given in providing adequate access to all machinery for safe operation / maintenance and cleaning purpose.
2. Gravity take-up of conveyor shall be provided with the platform and access ladder for maintenance.
3. Provision shall be made for lifting out and replacing equipment's such as motors, gearboxes, conveyor pulleys, idlers parts and other heavy machinery in each Transfer Towers with the help of electric hoist. Capacity of the hoist would be based on the weight of the heaviest part to be lifted.

## 9.0 ELECTRICAL SYSTEM

LSTK contractor to consider all Electrical systems and items for Material Handling section/portion as per Electrical Design Philosophy/specification.

## 10.0 INSTRUMENTATION SYSTEM

LSTK contractor to consider all Instrumentation systems and items for Material Handling portion as per Instrumentation Design Philosophy/specification.

**NOTE: - Bidder to strictly follow licensor's specification for the mentioned items of Coal Gasification Plant. In case of conflicts between this design philosophy & licensor's specification; licensor's specification shall prevail.**

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## **PART - II: TECHNICAL**

### **SECTION – 5.3.5**

#### **DESIGN SPECIFICATION – FIRE FIGHTING SYSTEM**

**PLANT: - COAL GASIFICATION PLANT  
FOR  
GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC  
NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT AT  
BARDHAMAN, WEST BENGAL, INDIA**



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7.0	Safety equipments/ Personnel protective equipments
8.0	Emergency escape route
9.0	Execution, Inspection & Testing
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## LIST OF ATTACHMENTS

ATTACHMENT NUMBER	DESCRIPTION	NUMBER OF SHEETS
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PC217-921-P-II-5.3.5-TS	Technical specification of Clean agent fire extinguishing system	15

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## 1.0 PURPOSE

The purpose of this document is to establish the requirements of the fire fighting system for applicable facilities of the package plant.

This document is a general specification providing typical requirements of layout, material, testing, etc. for various fire fighting systems.

This specification covers design basis and execution requirements for fire protection system for Coal gasification plant. The provisions shall be made, in order of precedence, as per statutory regulations, TAC guidelines, job specifications and safe engineering practices.

## 2.0 SCOPE

Contractor shall provide fire fighting system as mentioned in this document in accordance with IS/NBC 2016 (and/or Latest Edition) for applicable facilities of the package plant.

## 3.0 DESIGN CRITERIA

The Fire Protection Philosophy is based on Loss Preventive and Control. The adequacy of fire protection facilities for fertilizer plant is very important because of the inherent hazard it carries. A fire in one part/section of the plant can endanger other sections of plant as well. If fire breaks out, it must be controlled / extinguished as quickly as possible to minimise the loss to life and property and to prevent further spread of fire.

Unless otherwise specified in the NIT the design shall meet requirement of applicable standard over and above the standards mentioned below:

IS 3034: 1993 - Fire Safety of Industrial Buildings: Electrical Generating and Distributing Stations - Code of Practice [CED 36: Fire Safety]

IS 12459: 1988 Code of Practice for Fire Safety in Cable Runs [CED 36: Fire Safety]

IS 1646: 1997 Code of Practice for Fire Safety of Buildings (General): Electrical Installations CEA (Measures relating to Electrical Safety) Regulations 2010

IS 15394: 2003 - Fire Safety in Petroleum Refineries and Fertilizer plants



IS 3844: Installation and maintenance of internal fire hydrants and hose reels on premises

National Building Code 2016 (and/or Latest).

Fire Fighting System design and layout is subject to review and approval by Local Statutory Authorities. Documentation & obtaining approval of the fire fighting system from local fire service authority shall be in scope of LSTK contractor.

LSTK contractor shall calculate the fire water requirement for their scope and tie-in for LSTK scope shall be taken from the LSTK-2 and OSBL fire water network. LSTK-2 & offsite fire water network (OSBL scope) shall be available around the unit. Contractor shall take the required tapings from this LSTK-2 & offsite header with an isolation valve for each tapings.

Fire Protection system's detailed location map to be displayed at Fire Station & Plant Control Rooms.

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#### 4.0 FIRE PROTECTION SYSTEMS

The following fire protection facilities shall be provided depending upon the nature or the installation and risk involved wherever applicable.

- a) Fire hydrant system
- b) Water spray/sprinkler system
- c) Gas flooding system
- d) Fire detection, alarm & communication system
- e) First aid fire fighting equipments including Portable fire extinguishers
- f) Personnel protective equipments (PPE)

#### 4.1 Fire Hydrant System

The engineering (sizing, material thickness, supports, etc..) of fire fighting network for the above mentioned fire protection systems / fire protection facilities, shall be provided by bidder, on the basis of codes, standards, specifications, drawings of this document.

Fire water network shall consist of mostly aboveground and/or underground, if required, piping systems.

Around units the fire water mains shall be laid aboveground and directly buried and/or in trenches, if it is laid underground. The underground ring main network system shall be laid at minimum one meter earth cushion. Top of casing pipe (RCC Hume pipe) of underground piping crossing roads (peripheral road, package unit road, access road/ways) shall be at min. 1.5 metre depth.

All underground fire water piping shall be externally protected from corrosion by wrapping and coating of cold tape as per attached specification, for underground CS pipe which shall extend up to min. 500 mm, above / beyond grade wherever applicable.

Above ground fire water piping shall be painted as per painting specification and the paint shall be conforming to shade as per IS 5.



Wherever fire water line will cross the roads, same shall be put under a suitable Hume pipe or culvert, with proper wrapping, coating as an anticorrosive treatment (Cold Tape Type, as per detailed specification provided elsewhere in NIT).

Flushing point with isolation gate valve and pressure gauge points (approx at the rate 300mtr. and at all battery limit tie in points) with isolation gate valve shall be provided on all headers.

Network shall be laid in closed loops to ensure multidirectional flow. Isolation valve to be provided at every 300m (max) and at crossings (Junctions) to ensure easy maintenance and uninterrupted water supply in case of break down and shall be planned in such a way that outage of any section of fire water line should not affect other section.

Hydrant posts shall be installed with a branch "L" shape piping to avoid directly fall of leaking water on main header.

RCC slabs (Minimum 1500mmX1500mmX100mm thk.) shall be provided at the grade level beneath of each Hydrant/Monitor/HVLR// 3way- 4 way fire brigade connection post and respective hose box.

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Up to 2.0 m portions of the headers (if above ground) on both sides of hydrant branching and the entire branch piping near of hydrants shall be epoxy painted.

Isolation valves (gate valves, rising spindle) shall be provided below monitors and at all hydrants. Suitable restriction orifice shall be provided at downstream of isolation valve of hydrant post to maintain the pressure requirements as per TAC / IS15394.

Fire water pressure at the farthest point shall be a minimum of 7 kg/cm<sup>2</sup> after installation of headers and sub headers.

All fire water piping shall be tested to hydraulic test pressure of 18 kg/ cm<sup>2</sup> (g) and/or as calculated considering pump shut-off pressure.

Radiography requirements shall be as per TAC (minimum 10%).

For process units, external ring header with hydrants and an internal distribution with monitors and hose reels shall be installed. Hydrant heads shall be placed at a minimum distance of 15m from process equipment.

Monitors around heater areas, if any, shall be necessarily provided and located in such a manner that the heater can be isolated from the plant.

Monitors shall be provided to cover the high rise columns, equipments etc. of height 15 mtr. and above, unless otherwise specified in layout drawing.

There may be cases where due to horizontal obstruction, a particular vessel/ process column may not be approachable by ordinary monitor or hydrant, elevated monitors shall be provided to take care of such conditions.

Tall columns, structure, towers and equipment where it may not be possible to provide access staircases with hydrants on landing, will be considered as protected by hydrants at ground level, provided they are less than 15 m in height. When the height exceeds 15 m, the concerned hydrants shall be replaced by monitors.

Alternate hydrants for protection of loading unloading bays, rail/truck gantries shall be replaced by water/foam monitors.

Number of hydrants shall be based on one hydrant post with two hydrant valves for every 30m (max.) of external perimeter of process units and storage tank area. For utility and other building areas, this distance shall be a maximum of 45m.



Hydrants and/or water monitors shall be located keeping in view the different risks within the premises which are to be protected and ensuring effective coverage.

Double hydrants (IS: 5290 type A, hydrant valve with single outlet) on each hydrant post (i.e. two hydrant valves mounted on each stand post) and at every 30m centre to centre, along the hydrant mains, shall be provided.

Extension of hydrants/monitors for spill fire (as required by TAC/ IS15394) shall also to be provided.

Indoors hydrants with hydrant valves (landing valves), hose reels and hose box containing accessories, for plant buildings and non-plant buildings, shall be provided as per IS-3844. In case



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of buildings, hydrants shall be located at not be less than 2 m and not more than 15 m from the face of building.

Double headed landing valves (two numbers, type-A, Landing valves on single stand post), shall be provided on the landing of first floor and above on all the buildings/Tech structure/platforms etc. with isolation valve at each tapping for landing valve assembly.

The monitors shall have isolation valve. Monitor location shall be given special consideration for protection of cluster of towers, heaters and other high structures, where it may not be possible to approach the higher levels. Minimum of two monitors shall be provided for each such area.

Field adjustable variables flow type remote operated monitors shall be provided for the protection of inaccessible equipment.

Contractor to finalise hydrant layout on plot plan, with all the requirements such as number of Hydrants, Monitors, Foam system, sprinkler system etc., based on all statutory requirements & Code Guidelines, considering ease of maintenance and safe approach for fire fighting. Due consideration is to be given for providing Emergency escape routes also. Hydrants are to be strategically located to obtain maximum advantage of layout.

Fire brigade connection (3 way & 4 way) points with Isolation gate valve as per TAC/ IS shall be provided at strategic locations

Above ground pipe shall be supported on RCC pedestals (refer attached drawing). wrapper plate (thickness same as pipe & covering approx. 120 degree at bottom portion of pipe) shall be provided at each support for above ground pipe (6" NB and above). Supports for piping system and structures shall be provided as per support specifications of NIT. If support specification not provided in NIT, safe adequacy calculations shall be submitted by bidder for review/approval by PMC/owner.

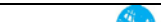

#### 4.1.1 Buried Pipes

The following points to be considered in designing of buried pipes

- i) All underground buried metallic piping shall be coated and wrapped with cold tape and laid at minimum one meter earth cushion.
- ii) Underground pipe at crossing roads, access ways shall have RCC casing pipe (Culvert or Hume pipe). Underground piping at rail crossing shall be as per Indian railways.
- iii) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/maintenance.
- iv) All U.G. headers shall clear equipment foundations.
- v) Provide break flange at + 500 MM from floor level to isolate underground pipe from above ground piping with insulating gasket kit.
- vi) Pipes shall be laid below electrical cables, if any.
- vii) Buried Pipes shall be laid in trenches after excavation, covered with 150mm sand bed all around them, backfilled and properly rammed.
- viii) RCC thrust blocks shall be provided as per engineering requirement.
- ix ) Cathodic protection shall be provided for buried pipes.

#### 4.1.2 Piping in Trenches



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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.
- vi) Valves in trenches shall be provided with extended stems. If hand wheels of the valves are located more than 300 mm below the cover plate, the valves shall be provided with extended stems extending to within 100 mm below the cover plate.
- vii) The trenches shall be lined with RCC, then provided with 150mm sand bed and also shall be covered with RCC cover after laying of wrapped and coated pipes in them. Top of pipe shall be at min one meter depth.
- viii) RCC thrust blocks shall be provided as per engineering requirement.

## 4.2 Water Spray System, water sprinkler system and water curtain system

Water spray systems shall be provided as per TAC / job specifications.

Water spray, water curtain systems, permanently connected to fire water network, shall be provided with piping system, detectors, spray nozzles (chrome plated brass), deluge valves (dry type, pneumatically & hydraulically operated (only use where air is not available) with manual by pass valve, remote automatic and local manual operation), isolation valves, strainer, low point drain with valve and suitable restriction orifice to maintain the pressure requirements as per TAC/ IS.

Instrument air service Piping/ Tubing shall be SS304.

Downstream of deluge valve shall be provided with galvanized carbon steel piping system.

Water spray application rates shall be as per TAC/IS/NFPA.



### 4.2.1 Medium velocity Water Spray (MVWS) System

- To be provided for the followings locations, but not limited to.
- Compressor seals
- Lube oil consoles
- Knock out drums (with hydrocarbon bearing service)
- Cable cellars
- Diesel/Petrol/Kerosene oil or any hydrocarbon liquid / oil tank
- Coal/ Pet coke/ solid hydrocarbon material handling plant area
- Pumps under racks.
- Empty bag storage area

### 4.2.2 High velocity Water Spray (HVWS) System

To be provided for the followings locations, but not limited to.

- Transformers of minimum 10MVA rating or with oil content of minimum 2000 litres.

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#### 4.2.3 Water curtain system

Provided as per code requirement.

#### 4.2.4 Sprinkler System

The sprinkler system, with galvanized carbon steel piping, shall be designed and installed at the following locations, but not limited.

Sprinkler system with deluge valves (dry type), shall be installed at the following location/ buildings, if applicable.

- Laboratory
- Chemical room/storage area.

Sprinkler system (wet type with QBD), shall be installed at the following location/ buildings, if applicable.

- All buildings as per NBC 2016 (and/or latest edition)
- Admin Building
- Workshop building
- Technical Building
- Meeting Room/Hall
- Canteen

#### 4.3 Foam System

Foam system shall be provided for transformer area and hydrocarbon oil tank area.

The transformer area shall be surrounded by at least 2 foam monitors strategically installed.



Hydrocarbon oil tank area and LPG/NG gas skid area shall be surrounded by at least 3 foam monitors strategically installed, so that each tank or each gas skid is fully covered within the monitors throw range.

Water cum foam monitors (SS304 body & nozzle, fixed stand post type, manual operation, 500-750 USGPM variable type flow, self inducing foam induction mechanism) along with portable type foam cans (each 200 Litres capacity) with 3% AFFF Foam, shall be provided for above areas.

The foam system shall be considered for protecting tanks and other applicable equipments for hydrocarbon services as per NFPA requirements. The foam system shall comprise of foam concentrate proportioning equipment, foam makers, piping system and foam discharge devices, as applicable, as per NFPA. The system shall automatically actuate foam on detection of fire.

#### 4.4 Clean agent flooding system

Gas flooding system with clean agent, diverter valve (if feasible), detectors & accessories for Control Room, Computer room, Computer console room, UPS room, Battery room, server/database rack room etc. shall be protected by clean agent system as per NFPA-2001(Inergen/ Argonite).

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## 5.0 MATERIAL SPECIFICATION

- Materials & equipments used for fire protection system shall be in accordance with NFPA/TAC requirements and/or attached specifications of NIT.
- Pipes(API 5L Gr. B, SMLS upto 6"NPS and welded ERW for higher sizes) fittings(ANSI/ASME), Valves(API), flanges(ANSI/ASME), Spray nozzles and deluge valves, quartzoid bulb detectors(QBD), Detector piping, Hydrant, Monitors, Hose Boxes, Hoses shall be as per piping material specifications (PMS), and/or attached specifications of NIT.
- Cast Iron valves or any cast iron piping component like pipes, fittings, flanges, valves, fasteners, gaskets, etc. shall not be used for firefighting system or for any service.
- Spiral welded pipes shall not be used.
- Seamless pipes/fittings are acceptable in lieu of welded pipes/fittings, but welded pipes/fittings are not acceptable in lieu of seamless pipes/fittings.
- LSAW pipes are acceptable in place of ERW pipes, for same thickness.
- Double seam, 180 degree apart, is allowed for pipe sizes 36" and larger only.
- Circumferential seams (minimum 2 meter apart) is allowed for pipe sizes 36" and larger only.
- Flanges shall be in one piece material, without any joints.
- All flanged valves (except forged) shall have flanges integral with the valve body.
- Forgings are acceptable in place of castings but not vice-versa.
- Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.
- Generic material of valves body, required as per process/service conditions but not specifically mentioned, shall not be lower in chemical composition than the connecting pipe material.
- PN equivalent rating for Class150# valves shall be minimum PN16.

### 5.1 Hydrant Valve shall be BIS approved (IS-5290) with following detail:



Inlet	: 3"-ANSI 150 # RF
Outlet	: 63mm
Pipe Size & material	: 4" CS
Capacity	: 36 cum/hr
Type	: Oblique angle type as per TAC requirement
Material	: SS304

### 5.2 Water Monitor

Nozzle bore size	: 38mm (Aqua fog /foam with arrangement of jet and spray).
End connection	: 4"- 150 # RF
Run Pipe Size	: Min. 6", CS
Capacity	: 2580 LPM
Material	: SS304
Approval	: IS-8442

### 5.3 Water cum Foam Monitor:

Nozzle bore size	: 38mm (Non aspirating type-Aqua fog / foam with
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	Arrangement of jet and spray)
Run Pipe Size	: Min. 6", CS
Capacity	: 750 GPM
Material	: SS304
Approval	: UL

#### 5.4 High Volume Long Range Water Monitor (HVLR)

Capacity	: 2000/1000/750/500 GPM (as required)
Horizontal Range	: 75 m approx.
Material	: SS304
Approval	: UL

#### 5.5 Hose Reel

Fire hose reels (IS-444) shall be considered at strategic locations around block as first aid fire contingency. These shall be indoor wall mounted and outdoor floor mounted type on structure and shall have water connection from hydrant network. Each hose reel shall have 30 metre long hose with nozzle. Hose reel shall be minimum 30m long x 20mm bore.

Hose reel shall cover all process areas in ground floor. Indoor wall mounted Hose reel shall be provided with each landing valve. Outdoor floor mounted type on structure at strategic locations @ 01 no(minimum) for each package area.

#### 5.6 Hose Box

Hose boxes shall be made of M.S. material and painted red with dimensions 18 SWG thick M.S. sheet, size 900 mm x 600 mm x 250 mm. Each box shall contain 2 nos.x 15 m of 2 1/2" fire hose (IS-636 Type-B) with gun metal nozzle, coupling, universal branch pipe (IS-903), MS spanner. 1no. Hose Box with accessories shall be provided for each hydrant post and each fire brigade connection (3 Way, 4 Way with isolation gate valve).

#### 5.7 Portable Fire Extinguishers

Portable fire extinguishers (IS-2190, BIS marked / BIS approved) as per TAC shall be provided for plant & non plant buildings & areas, at strategic locations. Portable extinguishers of 9 kg (wheeled) & 50kg (wheeled) DCP (ABC type), 4.5kg (mounted), 6 kg (mounted) & 22.5kg and above (wheeled) CO2 type shall be provided. Contractor shall specify the numbers and location for Owner's review and approval.

#### 5.8 Deluge valve



Deluge valve shall have flanged body/housing & cover (Cast Steel ASTM 216 Gr. WCB), Internal Metallic parts SS304, Diaphragm Rubber/ Non metallic) UL listed, Red Painted, pneumatically actuated.

### 6.0 FIRST AID FIRE FIGHTING EQUIPMENTS

The selection of safety equipment should be such that it is correctly related to the type of fire expected in the area.

The general guideline for selection and use shall be as per TAC/IS requirements. Fire extinguishers shall be provided as per TAC/IS.

Contractor shall provide the Fire extinguishers items (BIS approved) as specified in tender.

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## 6.1 Fire extinguisher

Fire extinguishers as per TAC shall be provided for process risk and at each landing of operating platform of technological structures, for the protection of equipment as a means to cope up with fire at incipient stage. Supply of all Fire Extinguishers shall be with BIS Mark.

Powder used in DCP type fire extinguishers shall be MAP 90% ABC powder, UL listed & BIS approved.

The number should be determined based on the max. travelling distance of 15 M. At least one fire extinguisher shall be provided for every 250 m2 of hazardous operating area.

Chemicals/ Consumables used in the fire extinguisher shall UL listed.

Following Fire Extinguisher types shall be provided, as applicable :

- 1) 6 Kgs., 9 Kgs. Capacity DCP Extinguishers (ABC type) shall be provided on Technological platforms/process ground floor and Control rooms.
- 2) 4.5 Kgs. Capacity Co2 Extinguishers shall be provided for buildings, sub stations & control rooms.
- 3) 22.5 Kgs Capacity Co2 Extinguisher shall be provided near transformer bay.
- 4) 50 Kgs capacity DCP Extinguishers (ABC type) shall be provided at critical operating area in plant.
- 5) 2 Kgs, 4 Kgs capacity clean agent Extinguishers shall be provided for Control Room, Computer room, Computer console room, UPS room, Battery room, server/database rack room etc.

## 6.2 Sand Bucket

Sand buckets filled with sand along with scoops, mounted on structural support stand each with at least 3 sand buckets), shall be provided in Transformer bay, Sub Station, buildings, Technical structure, platforms, Pump house, etc.

The sand buckets shall have round bottom with bottom handle having 9 liter water capacity conforming to IS: 2546. The sand stored in bucket shall be fine and free from oil, water or rubbish. Rain protection of suitable design shall be provided for all sand buckets.



## 6.3 SAFETY SIGNAGES

Contractor shall provide the safety signage's (in English & Hindi language) as per NBC/TAC , at strategic locations, for plant/ non plant areas buildings, technological structure, areas. Safety signage's must be visible under both lighted & darkness conditions.

## 7.0 SAFETY EQUIPMENTS/PERSONNEL PROTECTIVE EQUIPMENTS (PPE)

Contractor shall provide the following safety items with quantity specified for their scope of work:

- a) Safety helmets – 10 nos.
- b) Stretcher – 1 no.
- c) Fiber glass First Aid Box with all necessary items/kit & anti snake serum -01 set.

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- d) Rubber hand gloves for electrical jobs– 05 pairs per type for each substation and each control room. (min. 05 pairs per type irrespective of facility requirement).
- e) Hand operated siren - 1 no.
- f) Hand held battery loaded Emergency light, each with 1 set spare battery- 02 nos.
- g) Sand Bucket & accessories - 02 sets.
- h) Fire Proximity suit (specifications European Standard (EN) Listed by Underwriters Laboratory
- i) Resuscitator (WHO specifications or UL listed)
- j) Red/Green flag for fire drill

## 8.0 EMERGENCY ESCAPE ROUTE

Escape route shall be marked with signage, exit point. Escape route shall not be obstructed in any way. No single accident should be capable of blocking both alternatives. Escape route should take shortest route to assembly point defined within plant.

In case of process structure, satisfactory access shall be provided to all parts of each floor by means of incombustible internal or external staircases.

Exact numbers, width, location, etc. of such staircases and ramps for basements shall depend on travel distance requirements given under National Building code of India.

## 9.0 EXECUTION, INSPECTION AND TESTING

All execution, inspection and testing for completion of fire protection system shall be carried out based on codes, standards and specifications. Contractor shall develop detail inspection and testing procedures for review by owner. Contractor shall carryout demonstration test for each installed system as per scope of work.

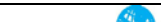

The Contractor shall meet all requirements for inspection and testing of the systems.

## 10.0 QUALITY ASSURANCE SYSTEM

All work/services to be performed by the Contractor under this contract shall be of specified/approved quality and Contractor shall have a quality assurance/quality control (QA/QC) system during the performance of various activities such as engineering, procurement, tendering, construction etc. Review/approval of activities by Owner/PMC shall not however dilute the responsibility of Contractor for maintaining quality.

The objective of the quality assurance scheme of the Contractor shall be to ensure the conformity of equipment, material, site construction (if any) to various standards, specifications, drawings and technical requirements that are being mutually agreed between the Contractor and Owner/PMC/TPI. Quality Assurance System should clearly indicate the organizational approach for quality control and quality assurance of the various equipment/construction activities (if any) and also provide a verifiable evidence of the Contractor having carried out all the activities laid down in the bid document and the procedure. Such conformity to quality level shall be ensured by controlling the quality level of purchased items at vendor's/sub-vendor's shop/site and shall cover from source surveillance to final inspection. The Contractor to submit a detailed inspection and testing plan for various shop/site activities for review by Owner/PMC/TPIA.



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## 11.0 INSPECTION

The Contractor is required to organize a proper inspection and expediting system so as to ensure timely delivery of all the items/equipment meeting the specified quality criteria. This function has to be carried out by appropriate deployment of qualified personnel who have wide experience in their respective fields. Inspection of all items supplied under this contract shall be carried out by independent third party inspection agencies like Lloyds/ BV/ TUV/DNV. Third party inspection charges for foreign origin items shall be quoted by bidder. Third Party Inspection shall be done by owner approved third party inspection agencies.

Inspection authority means the Third Party Inspection Agencies (TPIA) approved by the Owner to carryout inspection of materials.

The inspecting authority shall have the right to select random samples for check test and reject materials, if samples furnished as above and tested as per the specifications fail to meet the requirement specified.

All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector. Testing performed in the presence of the purchaser's representatives shall not relieve the supplier of their own responsibilities and guarantees and any other contractual obligations.

Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA).

The Contractor shall make arrangement for inspection and testing by statutory authorities, if applicable, at various stages of the work.

### 11.1 Scope of Inspection by TPIA:



- i) Review of Material test certificate (all batches).
- ii) Visual check for surfaces, external appearance (10% random witness).
- iii) Dimensional check (10% random witness).
- iv) Positive Material Identification (PMI) for alloy steels/austenitic steels (10% random witness).
- v) Hydrostatic test (10% random witness for pipes, fittings, valves, strainers, traps, collecting heads, draw off connection, hoses, hose reels, extinguishers, bellows, personnel protective equipments (if applicable for any item), fire fighting/protection equipments. Hydrostatic test shall be 10% random review for other items.
- vi) Any testing/demonstration required as per relevant code/standard/specification: 10% random review.
- vii) Packing: Report review.
- viii) Documentation (MTC, Inspection Release Note): 100% Review.

## 12.0 TESTING

All testing shall be done, as per relevant specifications and/or NIT specifications.

### 12.1 Non Destructive Testing

10% radiography of butt welds and 10% DP/ MP test of fillet welds shall be done for pipe classes in 150# & 300#.

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100% radiography on butt weld joints and 100% DP/MP for fillet welds test shall be done for pipe classes in 600# & above.

Radiography procedure, areas of casting to be radiographed, and the acceptance criteria of valves shall be as per ASME B16.34.



The minimum requirement of radiography shall be as under :

Pipe Class	Size (NPS)	Qty
150	Up to 24"	5%
150	26" & above	100%
300	Up to 16"	10%
300	18" & above	100%
600 & above	All	100%

### 13.0 DOCUMENTATION

Drawings and documents (4 hard copies, 1 electronic copy & 1 as-built copy of each drawing/document), for firefighting/fire protection system, design basis, general arrangement/layout drawings of fire water/ spray system/ sprinkler system/fire extinguishers/fire fighting equipments, design adequacy calculations, material specifications, material take-offs (line wise/consolidated), supplier drawings/specifications, inspection test plans, test certificates, spares list, etc. Shall be submitted by the Contractor for review/approval/information of Owner/PMC/ Statutory authorities.



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## **PART - II: TECHNICAL**

### **SECTION – 5.3.5**

#### **TECHNICAL SPECIFICATION OF PERSONAL PROTECTIVE EQUIPMENT**

**PLANT: - COAL GASIFICATION PLANT  
FOR  
GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC  
NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT AT  
BARDHAMAN, WEST BENGAL, INDIA**

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## 1.0 Safety Helmet

Safety helmets are made of fibre glass shall be supplied and shall confirm to IS:2925 (Latest amendment) & EN-397. These shall be moulded seamless in one piece from natural reinforced fibre glass/polyester resin, which can withstand heavy impact. The helmet shall be made of material highly impact, heat & chemical resistant, high dielectric strength and shall also have better quality abrasion resistance and higher softening temperature. The shell structure of the helmet shall be designed to provide extra strength and toughness. The helmet shall have sweat band and adjustable head band and shall bear IS approval. The colour of the helmets shall be decided at the time of placement of order.

## 2.0 Safety Goggles

A device worn over the eyes & held in place by a headband used for protecting the eyes & eye sockets from flying particles & injurious radiations, chemical & heat resistant and shall conform to IS-5983.

## 3.0 Stretcher with Blanket



Stretcher (size 6 feet X 3 feet with tying belts & blanket) shall be supplied and shall conform to IS:4037. Material of the stretcher and other related accessories should be as per the IS standard of practice.

Heavy duty aluminium poles for easy handling and heavy duty, vinyl-coated nylon covers that resist stains and will not absorb body or bodily fluids

## 4.0 Fiber glass First Aid Box with Medicines

Fiber glass First Aid Box portable type with locking arrangement and compartmentalised storage facility and containing the required first aids as below:

- First aid for cuts, burns, sprains (instant relief sprays) - 1 each.
- Antiseptic lotion, liquids (Dettol / Savlon tincture iodine) - 1 bottle
- Pain relieving medicines, anti vomiting medicines etc. - 2 stripes of 10 each.
- 500 mg Paracetamol I.P - 100 tablets.
- Anti snake serum bottle - 1 No.
- Band-Aids - 20 pcs.
- 25 gms of Soda Bi-Carb. I.P. - 1 pkt.
- Wound dressing small (for fingers) - 12 pcs.
- Wound dressing medium (for hands and feet) - 6 pcs.
- Wound dressing large (for body) - 6 pcs.
- Burn dressing large (for body) - 6 pcs.

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- Absorbent cotton wool 13 gms each - 6 pcs.
- Dressing arrangements (scissors / blade etc.) - 1 set.
- Eye pad with bandage in separate pkt. - 08 pcs.
- Tourniquet cotton with belt & buckles. - 1 No.
- Polythene wash bottle 500 c.c. - 1 No.
- Book of instruction on first aid to injured - 1 No.
- Copy of First Aid Leaflet issued by DG FASLI – 1 No.

## 5.0 PVC Hand Gloves



Acid alkali proof PVC hand gloves made of superior quality PVC in yellow colour. The fingers and palm should be embossed/ ribbed for better grip. Palm size should be 9" and overall length 14". The gloves should be confirming to IS: 6994/1973(part-ii).

### 5.1 Nitrile Hand Gloves

BIS Marked fully Nitrile rubber hand gloves (In pair) shall have inside soft cotton flocked lining. It shall be able to resist Acid, alkali & solvent while providing solid protection against snags, abrasion, puncture & cuts. Nitrile Rubber hand glove should meet requirement of EN-388 & EN-374. The overall length of the Gloves shall not be less than 12 Inches (from middle finger to end of the sleeve).

### 5.2 Electrical resistance, Insulating Rubber Hand Gloves in pair (one for Right Hand, one for Left Hand.)- 1100 Volts

1. Four Fingers and One Thumb
2. MAKE: CATU / Honeywell / Oberon / SICAME
3. Maximum voltage of use A.C volts: 1000 Volts (rms)
4. Class - 0
5. Size: 9
6. Type: Gauntlet type
7. Max thickness (approx.): 1.6 mm
8. Construction: Seamless
9. Standard: IEC 60903
10. Category: RC
11. Tested by authorized Government Test houses / NABL accredited LAB and relevant test certificate / Batch certificate with hand gloves serial number to be furnished with the material.
12. Made from specially compounded latex or equivalent for complete insulation & totally shock proof.
13. Test certificate of the supplied item to be furnished along with the supply.
14. Packed in sealed plastic bag.
15. The gloves shall be marked indelibly at the back-

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- A) Size, class & category of gloves
- B) Month and year of manufacturing
- 16. Following tests will be conducted under inspection of TPIA :
  - A) Leakage current Test
  - B) Tensile strength and elongation at break
  - C) Resistance to mechanical puncture
  - D) AC Proof Test
  - E) Flame retardancy Test

### 5.2.1 Electrical resistance RUBBER INSULATING HAND GLOVES in pair (one for Right Hand, one for Left Hand.)- 36 KV (rms)



1. Four Fingers and One Thumb
2. MAKE: CATU / Honeywell / Oberon / SICAME or equivalent
3. Class - 4
4. Max. Voltage of use A.C volts: 36 KV (rms)
5. Size: 10
6. Type: Gauntlet type
7. Max thickness (Approx.): 4.2 mm
8. Construction: Seamless
9. Confirming to IEC 60903
10. Category: RC
11. Tested by authorized Government Test LAB / NABL Accredited LAB and relevant test certificate / Batch certificate with hand gloves serial number to be furnished with the material.
12. Made from specially compounded latex or equivalent for complete insulation & totally shock proof.
13. Technical catalogue and test certificate of the offered item to be furnished along with the offer.
14. Packed in sealed plastic bag.
15. The gloves shall be marked indelibly at the back-
  - A) Size, class & category of gloves
  - B) Month and year of manufacturing
16. Following tests will be conducted at ERDA
  - A) Leakage current Test
  - B) Tensile strength and elongation at break
  - C) Resistance to mechanical puncture
  - D) AC Proof Test
  - E) Flame retardancy Test

### 6.0 Portable Explosive Meter cum Oxygen Meter (Explosimeter)



S.N	Particulars	Specification
1.	Use	Able to measure LEL (In Inert atmosphere) and oxygen in zone 0 area.

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2.	Type	The metering unit shall be microprocessor based. It shall be suitable for use in open as well as confined space for one hand operation and rugged with casing of protective rubberized over-mold.
3.	Sensor	Combustible (LEL) sensor- IR type Oxygen sensor: Electro-chemical type. Sensors shall be replaceable type.
4.	Ambient Condition	0°C to 50°C & humidity: up to 90% RH(non-condensing). (Locations e.g Leh/ Ladakh etc. with extreme weather conditions may decide ambient conditions as per site requirement)
5.	Housing	Minimum IP65 or Better. IP rating should also be tested & certified by accredited agencies like FM/UL/CENELEC/BASSEFA/ATEX/CIMFR/IEC etc.
6.	Area Of Use	The detector shall be intrinsically safe for use in hazardous area classification conforming to Class I, Division I, Group A, B, C & D or Zone - 0, Group-IIA, IIB & IIC, having certified for use by accredited agencies like FM/UL/CENELEC/BASSEFA/ ATEX/CIMFR/IEC etc. and PESO approval at the time of supply of material.
7.	Range	Combustible Gases: 0-100% LEL O <sub>2</sub> : 0 – 25% by Vol. (Min.)
8.	Sampling Pump	Each instrument shall be fitted with motorized pump with audio and visual low flow alarm.
9.	Remote Sampling Accessories	Minimum 10 feet long sampling hose and sampling probe equipped with quick connect device shall be supplied along with instrument with suitable filter.
10.	Alarm	Minimum 85 Decibel audible alarm at 30 cm & bright red LED flashing visible alarm with vibration. Two levels of alarms for each gas sensed and low battery as minimum. Set points shall be adjustable over entire range.
11.	Battery	Rechargeable Battery (NiMH / Li-ion) shall be suitable for minimum 8 hrs. duration (with pump). Charger operable with 230V+ 5%, 50 Hz, AC supply shall be supplied with each instrument.
12.	Size & Weight	Weight shall not exceed 1Kg. (Including Battery & Sampling pump).
13.	Calibration	Frequency Shall be as per OEM recommendation or once in six month whichever is earlier. Calibration shall be easily performed using instrument's pushbuttons no other special tools will be required. Instrument should show calibration due date. Minimum 4 No calibrations within warranty period to be carried out by OEM or its authorized representative.

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14.	Accessories	The instrument shall be supplied with necessary calibration cup/adaptor and calibration tubing to facilitate calibration locally.
15.	Display	Self-illuminating back-light digital display.
16.	Fast Response	Maximum 30 Sec. to reach to 90% of measured value The above response time shall be with 10 feet long sampling hose.
17.	Hands Free Operation	The unit shall also have a suitable arrangement for hands free operation.
18.	Rf Protection	Shall be compliant with EMC directive against EMI/RF interferences.
19.	Accuracy	+/- 2% of measured value
20.	Maximum Resolution	Combustible gas: 1.0% LEL O <sub>2</sub> : 0.1 % by Vol
21.	Performance Guarantee	Minimum 2 years including sensors. The vendor shall guarantee the design, material, workmanship and the performance of the unit for a period of 24 months from the date of supply. Any defect, faulty workmanship or operational defects found during this period shall be rectified by the vendor without any extra cost of Owner/ PMC. Suitable instrument like BG etc shall be furnished by the vendor in line with tender conditions against performance guarantee.
22.	Documentation	Vendor shall be OEM or its authorized supplier having valid authorization from OEM. All other details shall be as per ANSI/ISA 12.03.01(Combustible gases) and ANSI/ISA 92.0.01 to 92.06.01 or equivalent IEC standards.



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23.	Inspection, Testing And Performance Parameter	<p>Owner/ PMC reserve its right to get material tested at a lab of repute or vendor to submit third party inspection certificate along with all accessories by Owner/ PMC approved third party inspection agency as per the requirement of Technical Specification. In the event of non-conformity with specifications, Owner/ PMC shall be at liberty to take action as deemed appropriate at its sole discretion.</p> <p>Prior to dispatch of the material from vendor's / manufacture's place the following inspection and tests shall be carried at the vendor place to complete satisfaction of Owner/ PMC representative or his authorized third-party agency without any extra cost to Owner/ PMC for:</p> <ul style="list-style-type: none"> <li>• Visual inspection of Explosi &amp; Oxygen Meter (Explosimeter) to ensure no apparent damage or deficiency.</li> <li>• Examination of documents / certificates / test reports/ instructions/ Guidelines.</li> <li>• All consumable required for inspection and testing work shall be arranged by vendor at his own cost.</li> <li>• Vendor shall arrange all facilities to carry out inspection and testing.</li> </ul> <p>Details of field demonstration: Owner/ PMC at its discretion may ask the vendor for field demonstration/ Training for end users at a location specified by Owner/ PMC.</p>
24.	Packing	Material should be packed in OEM packing.
25.	Damage Of Material	Any damage and / or manufacturing defects to the supplied material will not be accepted.

**NOTE:**

- The default measurement of LEL shall be for Methane. The detector is calibrated to Methane.
- During supply, vendor shall submit operational & maintenance manual, warranty certificate and TPI report along with each instrument.
- Vendor shall supply calibration certificate by OEM for all the sensors. The calibration certificate should contain identification numbers of the sensors & instruments supplied by the OEM.
- Vendor shall clearly indicate the point-wise acceptance/deviation against the above specification in the offer.
- Vendor shall arrange to rectify the defects within two weeks from reporting of the defect at site/owner's premises specified by the owner without any extra cost to owner during warranty period.
- Vendor shall submit the declaration on the cross-sensitivity of sensors with other gasses of concern.
- Owner/ PMC authorized Inspection Agency shall inspect the material before dispatch of the material for quality assurance, testing & performance evaluation as per technical specification.



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## 7.0 Aluminised Fire Proximity Suit.

### 7.1 General

The suit shall be made up of aluminised glass fabric. It shall be stitched with fire retardant Kevlar yarn or equivalent threads. The material used for the suit, shall not chemically react with water and shall not show any tendency to absorb oil, grease, petrol etc.

The suit shall include hood, coat, pants, boots, mitts and pouch suitable for accommodating BA set. Shoes shall be of standard size with proper insulation and leather lining with non-skid type sole. Metal zip fasteners shall be provided for easy donning and removal of the suit.

No discomfort shall be experienced while climbing a ladder, in running while carrying a pressurised hose pipe or first aid box. The suit shall get dried easily. The complete set with maintenance manual shall be packed in a strong case / box.

7.2 Shelf life : Minimum 10 years.

7.3 Donning time : 1.5 minutes.

7.4 Protection Level : Outer shell fabric shall withstand a radiant temperature of 2000 deg.F approx.

7.5 Size : Regular size suitable for a fireman of height 5'6" to 6'2" approx.

7.6 Certification : The fabric of the fire proximity suit shall confirm to the any one of the following standards / specifications  
European Standard (EN)  
Listed by Underwriters  
Laboratories UL 214.



## 8.0 Resuscitator

The Resuscitator should be as per WHO specifications or UL listed. The resuscitator shall be an intermittent positive pressure respirator type for artificial respiration with a human non-return, non-rebreathing valve. The resuscitator shall be of bag type, manually operated and shall be packed in a transparent bag along with a first aid chart displaying its operation. The resuscitator shall be suitable to be used by an adult person.

## 9.0 Electrically Operated Siren (Range - 3 Kms)

The general requirements, 3 phase electric motor, siren, heads, starter for on/off operations, without warbling relay, acoustic power shall comply with IS:1941 (Part I)/1976. The Siren shall be approx. range of 3 KMS. It shall be suitable anywhere in the country. Siren shall be horizontal complete with mounting. The electric motor shall be totally enclosed with greased sealed ball bearing and shall conform to IS:325.



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#### 10.0 Hand Operated Siren (Range - 1.6 Kms)



The shape, components, material, design and construction shall comply with IS:6026-1970. It shall have portable stand as per IS:6026. The Siren shall be approx. range of 1.6 KMS.

#### 11.0 Low Temperature Gas Protective Suit Suitable for Handling LPG, Liquid ammonia, Propane and Other Toxic Hazardous Gases.

1.	MATERIAL OF CONSTRUCTION	:	Polyamide fabric coated with viton / silicon
2.	SEAMS	:	Sewn with chemical resistance special thread to ensure leak proof design.
3.	SEALANT	:	Shall be used for the suit for achieving chemical resistance.
4.	GLOVES	:	Shall be made up of the same material used for the suit, and they shall be covered with neoprene as an extra protection. Gloves shall be fixed with the wrist.
5.	COLOUR	:	Cherry / Brownish Red / Yellow
6.	LOW TEMPERATURE WITHSTANDING CAPABILITY	:	The suit shall be able to withstand a low temperature of minus 45 deg. centigrade without any physical damages whatsoever
7.	APPROVAL	:	<p>The Vendor shall enclose latest Test Certificates duly approved by DIFR / GIRDA, clearly indicating the followings:</p> <ul style="list-style-type: none"> <li>- That the gloves can withstand a temperature of minus 45 deg C for a period of 30 minutes.</li> <li>- No cracking, blistering was noticed on the suit after the low temperature test.</li> </ul>

#### 12.0 Water Jel Blanket

Water jel blanket (Hydro jel blanket) to be used in case of fire burns shall be supplied the minimum size should be 2.5mX1.5m. It should have necessary approval from any of these agencies (UL of USA, FM of USA, LPCB of UK, and VDS of Germany). Blanket shall be woven out of new wool, impregnated with sterile water based gel. Blanket shall be capable to protect the user from heat, smoke and to

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provide to the burn victim. The water gel blanket shall bear approvals of IS/DGMS/DIFR or equivalent.

The wool carried is capable of absorbing upto 13 times its own weight. The Water Jel Blanket shall be packed in good quality poly-jar / canister. Water Jel Blanket shall be having 5 years usable life.

### 13.0 Fire escape mask / filter type emergency respirators

Emergency respirator is a self rescue hood, ideal for escape from room and buildings contaminated with toxic fumes and gases created by fire or accidental pollution. It should be as per IS: 8523.

### 14.0 Self Contained Breathing Apparatus (45 Minutes)

Self-contained breathing apparatus (SCBA) suitable for fire fighting, rescue operation in toxic and oxygen deficient atmospheres. The equipment consists of compressed air cylinder, full face wide vision mask (with inner mask), pressure reducer, pressure gauge, low pressure warning whistle, exhalation valve, speech diaphragm, comfortable shoulder harness and light weight back plate, straps, buckles and easy to wear.

The Cylinder shall be capable to operate for 30 minutes. The Cylinder and Valve shall have CCOE approval. BA Set shall be confirming to IS: 10245 (Part-2). One number of spare cylinder shall also be supplied

### 15.0 PVC suit

It shall be used in handling acid and alkali. Chemical protection clothing can be manufactured from a special grade heavy duty high visibility yellow PVC. The material shall have excellent chemical resistance, high tensile, tear & elongation strength, abrasion, ozone as well as heat resistance. The clothing seam shall be welded by high frequency electrical heating.

### 16.0 Red and Green Flag



Red and green flag suitable for the fire drill operation shall be supplied. Handle should be made of aluminium. The flag should have minimum of 0.5m x0.30m dimensions.

### 17.0 Fireman Axe

Forged Axe head, Insulated Handle, IS-926.

### 18.0 Flame Proof Search Light (Rechargeable safety hand held torch)



S.N	Particulars	Specification
1.	Description	Rechargeable Hand-Held Torch
2.	Power	Rechargeable without removing batteries & Charging in Safe area.
3.	Battery Run Hours	Not less than 3 hours after complete one cycle charge. (To be certified by OEM)

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S.N	Particulars	Specification
4.	Lumens	Not less than 130 lmn. When measured at a distance of 1-2 Metres for major light (Lumens of the torch to be certified by OEM and NABL/ Govt. accredited Lab.)
5.	Clip/Strap	Strap/ clip
6.	Weight with battery & fittings.	Max. 400 Grms.
7.	Certification	Intrinsically safe for use in hazardous area classification conforming to Zone '0' of Gas Group IIC hazardous area Certified by PESO.
8.	IP	Ingress Protection- Min. IP65 or better (To be certified by OEM along with relevant test certificate)
9.	Housing/ Body	Housing body should be made of material of Anti-static, high impact properties
10.	Lens	Polycarbonate
11.	DROP Test	2 Meter to be certified by OEM and NABL accredited Lab./ Govt. approved Lab.
12.	Battery with Compatible Charger	Rechargeable, Li-ion / NiMH. Charger operable with 230V $\pm$ 5%, 50 Hz $\pm$ 3% AC supply and compatible charger shall be supplied with each torch.
13.	Light Source	LED only
14.	Marking	As a minimum the product shall have following markings <ul style="list-style-type: none"> <li>Marking towards intrinsically safety of the product.</li> <li>Name of the Manufacturer</li> </ul>
15.	Warranty	Minimum one year including battery and battery charger. The vendor shall guarantee the design, material, workmanship and the performance of the unit for a period of 12 months from the date of acceptance at site..
16.	Certification	<ul style="list-style-type: none"> <li>A copy of relevant approval including PESO and other documentation along with the offer.</li> <li>During supply, vendor shall submit operational &amp; maintenance manual, warranty certificate along with each instrument.</li> </ul>
17.	Packing	Material should be packed in OEM packing
18.	Damage of Material	Any damage and / or manufacturing defects to the supplied material will not be accepted.

## 19. WINDSOCKS

LED Illuminated Windsock with heavy duty stainless steel SS-304 Stand.



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Made of Stainless Steel SS-304, 360-degree rotating system to rotate the sock to wind

- i) LED light of 20 watt of above suitable for outdoor installation, Cable of size 2C, 1 Sq./mm copper of 10 mtr with LED light.
- ii) Wind Sock made of parachute polyester double lining 2-layer Combination of fluorescent colour red & white or Fluorescent Orange & Lime green with 25 mm wide reflective tape four rows for night reflection of windsock.
- iii) The LED illuminated wind socks frame shall be made of heavy duty SS-304 rod and SS-304 strips with Extended Spokes cage two feet long as per design shown in the photos.
- iv) The frame shall be fixed on rotatable pipe stand 32mm height 5 Feet long with pedestal flange.
- v) Windsock Size: Dia 2 feet x 6 Feet Long made of parachute polyester double lining 2-layer fluorescent colour red & white Combination or Fluorescent Orange & Lime green Combination with 25 mm reflective tape four rows for night reflection.
- vi) Windsock shall be fixed with the frame along with red coloured industrial type weather proof Led lights of 20 watt and above 1 Sq./mm cable fitted with light of 10mtr per with each set.
- vii) The two bearing to be used must be maintenance free and weather proof



## 20.0 Sand Drum with Scoop

Metal sand scoops with handle of large size manufactured from best quality steel duly painted.



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Bidder shall provide the following items complying specifications of tender & as mentioned below:

S.No.	Item	Specification	Quantity	Remarks
1	Cold/low temperature protective suit.	Design leak proof with material to withstand minus 45 degC for 30 minutes minimum, without crack/damage. Colour shall be cherry/brownish red/yellow suitable for use in LPG, liquid ammonia.	10 sets	
2	Fire Proximity Suit	UL listed	10 sets	
3	PVC suit		15 sets	
4	Leak Control Kit : Consisting of 1 no each of leak arresting pad, leakage control of external pipes, internal pipes, large external pipes up to 8 inch, drums / containers leakages, general purpose leakages, large hole leakages in storage tanks.		10 sets	
5	Oil Product Clean up Chemical : - Boom(5 inch dia , 3 mtr. Long) : 6 nos. - Boom(3 inch dia , 3 mtr. Long) : 6 nos. - Granular particles to absorb Oil : 20 Kg		10 sets	
6	Oil Spill Dispersant (Water Based) along with hand held spray nozzle. Dispersant : 40 litre Spray Gun with back pack		10 sets	

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S.No.	Item	Specification	Quantity	Remarks
7	Non Sparking Tools One set consisting of : - Shoe handle brush -01 no - 9" Crate opener -01 no - 16oz Claw hammer with Fiberglass handle -01no. -Common knife 5 <sup>3</sup> / <sub>4</sub> " Blade : 1 no 10 <sup>3</sup> / <sub>4</sub> " OAL, -12" Groove joint plier, -7" Long nose pliers with cutters, -8" Combination Pliers, -Deck scraper, -1 1/2" Blade X 15"Long, -Spray booth scraper, -3" blade X 9 1/4" Long, -Std Screwdriver – 5/16" Tip, -6" Blade, - 3" Phillips Screwdriver, -12" Tin Snips, -8" Adjustable Wrench, -12" Adjustable wrench, -14" pipe Wrench (Aluminium), -12" Bung Wrench (Fits 3/4" X 2")		10 sets	
8	Self-contained Breathing Appartus Set (30 minute duration) with a spare cylinder (filled-up) & accessories	IS: 10245 (Part-2).& CCOE approved	6 sets	
9	Fire escape mask / filter type emergency respirators	IS: 8523	10 sets	
10	Flame Proof Search Light (Rechargeable safety hand held torch): Rechargeable type suitable for Explosive Environment.	PESO Certified	10 no	
11	Mega Phone Explosion Proof Portable battery operated Public Address System with 1 loud speaker with a range of 1 KM in still air and 500 M in noisy areas		6 set	.
12	Hand Siren With Stand : Approx. range of 1.6 KMS	IS:6026	1 no	
13	Electrically Operated Siren (Range - 3.0 Kms)	IS:1941	1 no	
14	Fireman Axe	Forged Axe head, Insulated Handle, IS-926	10 no	
15	Fibre Glass First Aid Box (with Medicines & other Items)		10 set	

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S.No.	Item	Specification	Quantity	Remarks
16	Resuscitator : Manually operated for artificial respirators consisting of adult size nose, mouth, face plate, air bulb with oxygen inlet connection, non- return, non- breathing human valves and first aid charge packed in a plastic bag	UL listed	6 no	
17	Water jel blanket	UL/FM listed	10 no	
18	Folding Stretcher : Size 6 feet X 3 feet with tying belts & blanket.	Heavy duty Aluminium, vinyl coated nylon, BIS mark, Load 160kg min.	10 no	
19	Safety Helmet	IS-2925(Latest amendment) & EN-397 Certified, water proof, high impact, heat & chemical resistant, HDPE, ratchet fit, size 51-62 cm. with Inner head band LDPE, ventilated sweatband absorber, coloured "company name" logo.	60 no	
20	Safety Shoes	Leather upper with rubber /synthetic sole & steel cap, thermal resistant, skid resistant	60 pairs	
21	Safety Goggles	IS-5983, chemical & heat resistant	60 no	
22	PVC Hand Gloves	IS: 6994	60 pairs	
23	Nitrile Hand Gloves	CE/EN	60 pairs	
24	Electrical resistance, Insulating Rubber Hand Gloves		15 pairs	
25	Explosimeter	UL/FM listed & PESO approved	6 no	
26	Wind socks		6 no	
27	Sand buckets (9 Ltr. capacities) filled with sand along with scoops, rain protection and mounted on structural support stand (each with at least 3 sand buckets).	IS: 2546	6 set	
28	Red/Green flag each colours		30 no. each colours	

**Note:**

1. Above mentioned quantity are minimum.

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## SECTION – 5.3.5



### TECHNICAL SPECIFICATION OF CLEAN AGENT FIRE EXTINGUISHING SYSTEM

**PLANT: - COAL GASIFICATION PLANT  
FOR  
GENERATING SYN GAS ( $\text{CO}+\text{H}_2$ ) FOR PRODUCTION OF SYNTHETIC  
NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT  
AT BARDHAMAN, WEST BENGAL, INDIA**





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## 1.0 General

The intent of this specification is complete design, engineering, supply, installation interconnection with existing Fire Detection and Alarm system as per tender condition and Inspection, puff testing, Door integration test, discharge test, pre Commissioning testing to assess the actual performance of the complete Clean Agent Fire extinguishing system (hereunder called CAFES ) shall include but not limited to the following activities:

- i. Design, Engineering, manufacture, fabrication, assembly, shop testing and shop painting, sequential packing, delivery FOR site, comprehensive insurance, unloading, unpacking, storage at site, site handling, preparation of erection drawings, fabrication and erection as per approved drawings, site testing, painting, commissioning and performance guarantee of Clean Agent Total Flooding System in integration with complete fire detection and alarm system as per NFPA 2001 (Latest Edition).
- ii. The fire detection system and alarm system, if already existing and in working condition, it should be checked and confirmed by the party for compatibility with the proposed CAFES. If found computable, the proposed CAFES to be integrated with the same.
- iii. The complete system along with all major components, Design Software including Filling stations should be UL approved. Cylinders and Valves should be UL & PESO approved.
- iv. The Cylinder should be filled only at PESO & UL Listed filling station. The OEM to provide the system approval for the approved filling station location in India.
- v. Supply of all items (including those required to complete the system for successful commissioning) covered under this specification, shall be under the scope of vendor, unless otherwise specifically excluded from the scope of supply. Vendor has to furnish along with their offer, the Bill of Material indicating all items required to complete the system. Responsibility of the Vendor includes supply, execution and installation of any items/material not indicated in the Bill of material / Schedule of rates, but required to complete the system in all respects without any extra price implication to Client. Supply of mandatory spares and initial fill and consumables.
- vi. Vendor, prior to submitting his offer, should take a site visit to study the location of installation, the existing fire detection and alarm system of the proposed area to which the Fire extinguishing System shall be hooked up for automatic actuation.
- vii. It shall be noted that clean agent system to be provided shall meet the requirements of NFPA-2001 (Latest). Hence anything specified as 'Mandatory' in NFPA-2001, although not specifically mentioned in this specification, shall

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form part of this specification.



## 2.0 System and site specific requirement

The Clean Agent total gas flooding system shall be an engineered system consisting of a fixed nozzle and gas distributing network. The system shall be designed and installed in accordance with the NFPA 2001 (Latest Edition).

- i. Selection of the clean agent & design of fire protection system shall follow the standard on "Clean Agent extinguishing System NFPA Standards 2001 ( latest edition- amendment) including its safety guideline with respect to "Hazards to the personnel, Electrical clearances & environmental factors in line with the environment consideration as per Ozone Depleting Substances (Regulation & Control) Rule-2000; MoEF; GOI along with amendments published vide latest MoEF Gazette notifications on the subject.
- ii. The offered clean agent shall comply with the requirement of the Ozone Depleting Substances (Regulation & Control) Rule-2000; MoEF; GOI alongwith amendments published vide latest MoEF Gazette notifications on the subject.
- iii. If the cylinder battery bank to be provided outside the area to be protected, a suitable cylinder bank storage area to be constructed by the Vendor. The location and type of construction of storage area shall be mutually decided during site visit.
- iv. The cylinders shall be refilled at PESO approved refilling sites only.
- v. All major components excluding Piping, Fittings, Bracket Supports, Cylinder Rack & Hangers should be UL Listed/FM approved. Cylinder Manifold should be UL Listed/FM approved.
- vi. The concentration level shall not exceed the NOAEL and LOAEL level as per NFPA guidelines. Pneumatic Horns along with time delay device should be provided in the areas where concentration exceeds the NOAEL Limit.
- vii. All work related to mechanical, electrical, Instruments and civil including chipping of existing RCC/brick walls/cutting of steel plates etc. or removal & re-fixing of false ceiling and floor of risk areas, fixing fasteners and other activities required for the execution and commissioning of clean agent system at site.

## 3.0 Scope

- i. This Specification covers the design, engineering, procurement, material supply including all hardware & software, fabrication, installation, inter-connection with Existing / New (as the case may be) fire detection & alarm system, power supply & back-up arrangement, execution, performance testing, commissioning, operation & maintenance training and performance guarantee of Clean Agent Fire Extinguishing System [CAFES] for volume to be protected complying the minimum requirements of "Standard on Clean Agent Fire Extinguishing System", NFPA 2001, 2015, latest Edition" and the Ozone Depletion Substance Regulation & Control

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Rule-2000; MoEF; GOI along with amendments published vide latest MoEF Gazette notifications on the subject.

- ii. System design, comprising of specifications, working plans, flow calculations, design concentration requirement, total flooding quantity, system, design factors, duration of protection, rate of application, discharge time, nozzle selection & location, etc. shall comply the relevant criteria mentioned in NFPA-2001(latest edition). All the relevant calculations shall be done by FM/UL/LPCB/Vds approved software and submit the copy of certificate.
- iii. The system components shall be listed / approved by FM/ UL/Vds/LPCB and cylinders shall be seamless & shall be **PESO** approved.
- iv. The system shall be designed based on the largest volume to be protected. However, the grouping of cylinders shall be made in such a way that discharge of cylinders takes place corresponding to the volume of the risk under fire.
- v. The system shall also comprise of the different modes of operation and electrical manual actuation etc. with necessary control panel as per specification. Operating devices and local control panel shall be provided as per specification.
- vi. The vendor shall have to offer 100% clean agent filled standby cylinders. The vendor shall very clearly mention in their offer that they have considered total flooding centralized system and have also offered 100% standby connected cylinders.

#### 4.0 Codes and standards

The latest editions of the following codes, specification and regulations have to be used for the detailed design and specification of clean agent system.



- i. NFPA: 2001 (Edition 2015- latest amendments) (Standard for clean agent fire extinguishing system).
- ii. IS 15493-2004 latest edition.
- iii. SMPV Rules, PESO Nagpur (For storage cylinders)
- iv. OISD-STD-116 / 117/ 163 -Latest Edition
- v. Ozone Depletion Substance Regulation & Control Rule-2000; Ministry of Environment & Forests of, Govt. of India alongwith amendments published vide latest MoEF Gazette notifications on the subject.

#### 5.0 System Description

The Clean Agent total gas flooding system shall be an engineered system consisting of a fixed nozzle and gas distributing network. The system shall be designed and installed in accordance with the NFPA 2001 (Latest Edition).

The system shall consist of following major components but not limited:

- i. Bank of Clean agent cylinders with Gas each fixed with cylinder head valve and non-return valve.
- ii. Bank of standby cylinders with Gas fitted with - cylinder head valves and non-return valves.
- iii. Gas manifold and high-pressure hoses.

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- iv. Cylinder rack.
- v. Constant Flow Valve
- vi. Pressure reducing devices.
- vii. Pressure switches.
- viii. Pilot cylinders if required.
- ix. Electric Actuator
- x. Manual push buttons
- xi. Inhibitors
- xii. Directional valves & Directional Valve Control system
- xiii. Flexible Hoses
- xiv. Discharge Nozzles
- xv. Safety relief valves
- xvi. Pipe and Fittings
- xvii. Bracket Supports and Hangers
- xviii. Caution hooters Caution boards & evacuation alarm
- xix. Fire detection and alarm system including Gas release panel/ local control panels and interface unit/ monitor control module etc.
- xx. Cylinder bank room (brick construction with RCC roof)

The clean agent gas shall be stored in a metallic seamless cylinder in a pressurized condition at 200 Bar/300 Bar.

The quantity of gas required for the system shall be based on the gas required to blanket the volume of area protected including leakages as per latest NFPA 2001 standard.



The system shall be designed based on the largest volume to be protected. However, the grouping of cylinders shall be made in such a way that discharge of cylinders takes place corresponding to the volume of the risk under fire.

Pipe network shall be designed to achieve the design concentration of gas required for extinguishing the fire in the premises.

The contractor shall include provision for automatic actuation of the system in integration of FDA system in the premises concerned. Annunciation signals related to system operation shall be provided in MFAP as well as locally on panel. Provision for time delays and an evacuation alarm shall also be provided. Contractor shall note that release of gas shall be possible directly from FDA panel as well as local GRP/ local Panel to operate the system from FDA panel and obtain signal/ control. The contractor shall also include all interface units viz: control and monitor module.

Contractor to include power supplies and control interlocking. All wiring - junction boxes, push button station, indication lamps, hooters etc. shall be included in the scope of Contractor. All areas shall have illuminated board "FIRE - EVACUATE INERT GAS SHALL BE FLOODED". Each area shall have hooter adjacent to illuminated sign.

The manual pushbutton of each area shall be located near entry/ exit.

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Contractor to develop logic for above and submit working scheme along with the tender. Any interface devices required to hook up this system with the Main Fire Alarm Panel shall be included by the Contractor as part of the scope as a whole.

One no. wall mounted annunciation panel/ gas release panel near cylinder bank shall be provided for (duplicate) annunciation as well as operation of gas release system

The room volume, volume above false ceiling and the volume below false floor of each premises/room shall be considered for Fighting and detection and for calculation of Gas quantity and other components of the system

Each zone shall be equipped with fire detection system. On receiving the fire signal from the detection system agent gas shall be released automatically after a set time delay and gas shall be discharged into the enclosed space.

The system shall comprise of the following mode of operation and actuation and cancellation facility etc. with necessary control panel.

System operation shall be possible by the following means:



- Automatically due to fire detection in the protected area from main fire alarm panel.
- Operation of manual release push button located adjacent to protected area.
- By operating manual lever provided on electrical / manual control head on cylinder.
- By push button actuation at Clean Agent control panel in manual mode.

The clean agent gas shall be discharged / actuated automatically after an adjustable time delay based on the detection signal received. Pre-discharge alarm (audio + visual) shall be initiated before discharge of gas in main fire alarm panel & local control panel. Hooter shall follow the alarm once the gas is discharged.

The release of gas shall be preceded by an audio-visual alarm in the affected area for alerting and evacuating the personal and for this purpose, during time delay of about 60 seconds (which is settable from the panel) between the initiation of release and actual release of gas. The exact time delay to be incorporated in the system shall be decided during detailed engineering

To avoid an inadvertent mal operation and release of gas, on either of the mode of gas release operation (auto or manual), provision of manual interruption (i.e.) gas discharge inhibition facility through a suitable device on local control panel, main fire alarm panel as well as each protected premises shall be provided so that the agent release can be stopped within the time delay.

Multi sensor type detectors (addressable type) shall be provided below false ceiling, above false ceiling and false floor. Cross zoning of detectors shall be incorporated in such a way that the fire is detected by at least one detector of each type to activate automatic inert gas release system. However, audio visual alarm shall be annunciated even if any one of the type of detector has detected the fire. Refer electrical chapter of this technical specification for details of detection system

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Necessary provision shall be made in the fire alarm panel for switching off the air-conditioning and ventilation system automatically as soon as the fire is detected.

The Filling station should be PESO approved and UL listed. The manufacturer of the clean agent system should be approved by UL for filling at proposed filling station /facility. The Certificate of the same should be provided by Manufacturer of system during Bidding .

## 6.0 Design Criteria

- i. Complete design, software used, and all the system components/equipment shall be approved and listed by UL / FM
- ii. Design, manufacture and installation of inert gas fire extinguishing system shall be strictly as per NFPA 2001 (latest edition)
- iii. 200 bar/300 bar clean agent extinguishing system shall be designed and installed for below false floor, main room and above false ceiling of various risk areas.
- iv. The Physical properties and its discharge characteristic of clean agent shall meet the requirements of NFPA-2001 (Latest edition).
- v. The concentration level shall not exceed the NOAEL and LOAEL level as per NFPA guidelines.
- vi. The design calculation shall be supported by UL listed software.
- vii. The system shall be designed for total flooding based on the single largest risk area of the control room to be protected. However, grouping of cylinders shall be made in such a way that discharge takes place corresponding to the volume of the risk under fire. However, Contractor shall check the suitability of common cylinder bank to cover all the rooms/areas as per norms.
- viii. The system shall have 100 % Clean Agent gas filled standby cylinders along with manifold and automatic change over for each risk area from the fire alarm panel itself.
- ix. The complete volume of the single largest room including the above false ceiling and below false floor shall be considered for estimation of quantity of gas and containers.
- x. When determining the gas quantity, the leakage losses from the enclosure shall be considered by the Manufacturer by performing FAN DOOR test /Room Integrity test by approved agency. The exact amount of gas to compensate for leakage compensation shall be designed by the Contractor taking into consideration the type and features of enclosure, un-closable openings if any and other considerations so that design concentration is achieved after discharge.
- xi. The discharge time period shall be such that the design concentration can be achieved within 60 -120 seconds. The flow calculations shall establish this criterion.
- xii. The quality of gas shall conform to relevant design standard such as NFPA - 2001 or as specified by listing authorities:
- xiii. 200/300 Bar Clean agent gas Cylinder Assembly with Gas and cylinder valve



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(Main + 100%standby) to be provided.

- xiv. Manufacturer /Contractor must ascertain that Pressure in Manifold should not exceed more than 60 Bar using Contract Flow Valve. CF Valve should be mounted with every cylinder to assure pressure in manifold less than 60 Bar. CF valve should be UL Listed/FM approved.

This system shall function in automatic mode by actuation from Fire detection & alarm system in the respective premises. There shall be provision for manual operation also with a selector toggle. When detectors detect fire, the signal shall be communicated to the main control panel, which shows the address (along with location) of the actuated detector. On confirmation of fire by next detector falling in different software zone in the same premises, the respective Air-conditioning & Ventilation system will first trip and evacuation alarm signal will appear in the premises provided with this system followed by actual discharge of the gas (after time lag).

100% reserved cylinders filled with gas and accessories shall be provided for all systems. There shall be provision for switch over from main to reserve cylinders automatically from the panel as well as through toggle button.

The complete system along with all major components including Cylinder Manifolds, Design Software including Filling stations should be UL approved. Cylinders and Valves should be UL & PESO approved.

The Filling station should be PESO approved and UL listed. The manufacturer of the clean agent system should be approved by UL for filling at proposed filling station /facility. The Certificate of the same should be provided by Manufacturer of system during Bidding

### 6.1 Major Design Parameter of Clean Agent suppression system

The Applicable Design code: NFPA 2001, Latest

Version Type of system: Automatically operated, Fixed

piped system Design Pressure: 200 /300 bars.

Cylinder size: 80 ltrs /140 Ltrs. water capacity,



Gas/cylinder Design Concentration: 38.5%

Flooding Factor: 0.47 m3/m3

Discharge time: 95% of design to achieve within 60-120secs.

Cylinder storage temperature: 0° C to 54°C

Flooding Gas Nozzle Type: 360° / 180°

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## 7.0 System Requirements

### 1) Clean Agent Gas

The quantity of clean agent gas provided shall be sufficient to protect the single largest risk area with 100 % standby. Every individual risk shall have its own distributing pipe, nozzles, alarm and actuation system etc.

Both the main and standby cylinders shall be permanently connected to the distribution piping through manifold and auto change over. The clean agent discharge shall be substantially completed in a normal 60-120 seconds.

### 2) Flow Calculation

System flow calculations shall be performed using software listed or approved by UL/FM/LPCB/VDS. The system designed shall be within the manufacturers listed limitations. The contractor shall provide sufficient measure facilities in the risk areas to overcome the situation of over pressurization due to release of clean agent and provide calculation in support of same for each protected area.

The Contractor shall submit the approval certificate/ listing document from UL/FM for the software used for flow calculation.

### 3) Clean Agent Quantity

Minimum design concentration of Clean Agent gas shall be as per NFPA-2001 (Latest Edition)



norms and specified by the approving authority. Quantity of Clean Agent Gas shall be calculated for the total volume of the largest room to be protected.

### 4) Clean Agent Storage Cylinders

- i. All the storage containers shall be kept in an enclosed room.
- ii. Cylinders shall also have approval from CCE, Nagpur and UL listed/FM approved.
- iii. The cylinders shall be charged to a fill density or super pressurization within the range specified in the manufacturers listed manual.
- iv. The contractor shall select the capacity of cylinder based on the total quantity of gas required, storage space available and for better replacement and interchangeability.

The cylinder shall be seamless, brand new never retested with month & year of manufacture shall be marked on the cylinders.

- v. Each cylinder shall have a permanent name plate, specifying the agent, tare and gross weight in addition to the pressurization level, nominal agent volume.
- vi. The cylinder shall bear the mark of manufacturer, serial number, single test certificate issued by manufacturer and shall be duly approved by UL/FM.
- vii. Cylinder shall conform to the requirement of NFPA 2001 (Latest Edition) and shall be compatible with the engineered system.

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- viii. Each cylinder shall have a pressure relief valve to protect the cylinders against excess pressure conditions. Pressure gauges and pressure switches with isolation valves on manifold shall be provided.
- ix. Automatic means such as check valve shall be provided to prevent agent loss if the system is operated when any of the cylinders is removed for maintenance.
- x. The cylinder storage racks shall be provided for main as well as for reserve cylinders.
- xi. The manifold and cylinders shall be securely mounted on the floor and suitably supported in a rack with provision for convenient taking out individual cylinder for servicing, according to the manufacturer's installation manual. Such a service shall be possible without shutting down the system.
- xii. The Contractor shall indicate the space provision for room required for the storage of Gas Cylinders and Manifold Piping along with technical offer.
- xiii. The gas cylinders shall be provided with Base Plate, foundation bolts & nuts etc. so that, the entire load is evenly spread out over the entire plan area. No concentrated load shall result from the mounting arrangement of the cylinder/containers.
- xiv. All the pressure, gauges/switches, manifold connections etc shall be easily removable for servicing / maintenance without any loss of gas.

### Discharge Nozzles

Discharge nozzles shall be UL/FM approved /listed. The material of construction shall be of Brass. The selection of nozzle orifice shall be such that 95% of the minimum design concentration of gas is discharged within 60-120seconds, through the nozzles of the system.



Each nozzle shall be permanently marked to identify the manufacturer as well as type and size of the orifice along with tag / part number, orifice code, or other suitable marking as specified in relevant norms / codes.

### Piping, Fittings

Pipes shall be of ASTM A-53 or A-106 type (Seamless Carbon Steel High Pressure Sch. 80 pipe) and pipe fittings shall be provided as per the requirements specified in NFPA-2001 (Latest Edition). Pipe thickness calculation shall be as per ASME B31.1 and fittings conforming to ANSI B1.20.1. All CS Studs, Bolts and Nuts shall be Hot Dip Galvanized as per ANSI A153 for corrosion resistance. The Pressure Reduction device shall be easily identifiable. All Valves shall be approved for intended use. The Gaskets, O-Rings and other Valve material shall be compatible to the Clean Agent.

The Clean Agent piping and nozzles shall be planned avoiding fouling with the following facilities, in the areas where Fighting is being envisaged:

- AC ducts.
- Cabling in false flooring.

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- Light fittings, detectors etc.
- Other miscellaneous equipment/ fittings

### Operating Devices

- Operating devices shall include Clean Agent releasing devices or valves, discharge controls and shut down equipment necessary for successful performance of the system.
- The automatic Clean Agent system shall be of robust design and shall not be readily rendered inoperative. The Clean Agent system shall be designed to function properly for the temperature range specified in NFPA-2001.
- The Clean Agent cylinders shall be mounted on front and firmly supported in brackets in a manner that they shall not be easily subjected to mechanical, chemical or other damage, which would render the system inoperative.
- In addition to Automatic actuation, there shall be a normal manual control for actuation, which shall be located so as to be conveniently and easily accessible at all times. This control shall cause the complete system to operate in its normal fashion.
- Manual controls shall not require a pull of more than 40 lb nor a movement of more than 14 inches to secure operation. Each remote manual control for activation shall be located not more than 4 feet above the floor.

### Local Control Panel

- Local control panel shall be free standing, floor mounted type and shall be suitable for both auto and manual operation. The panel shall be naturally ventilated, totally enclosed, dust and vermin proof, with IP-55 enclosure as a minimum. The Clean Agent system shall be actuated automatically from the fire alarm and detection panel. Fire alarm and detection panel, after detecting the fire in the protected area / zone, shall energise the solenoid valve/ electrically operated valve of cylinder to trigger the gas release operation in the respective protected area / zone. In addition to direct actuation of the cylinder valve from main fire alarm panel, those cylinders shall also get actuated through local control panel/ gas release panel. Necessary control / interlock cabling between Fire Alarm and Detection Panel and Clean Agent system panel, using multi-core 2.5mm<sup>2</sup>, Cu conductor PVC insulated flame-retardant cable, shall be provided by the Clean Agent Vendor. The main fire alarm and detection panel shall be located in pump house Control Room. The location of local control panel shall be decided during the detailed engineering.
- The local control panel shall be equipped with adequate capacity of battery charger and Ni-Cd. Battery with 48 hour back up, for efficient operation of the system during mains power failure.
- Local control panel shall be provided with all alarms, indicators, caution/sign board and relays/ control switches meeting all the requirements of NFPA-2001 and shall include but not be limited to the following:
  - Two alarms and one fault indicator lamp for each zone to be protected.



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- b. Combination of alarm silence and alarm off switch.
- c. Combination of fault silence and trouble lamp switches.
- d. Alarm test switch
- e. Alarm re-set switch.
- f. The system shall have a positive warning device by sounding alarm to alert personnel of the gas discharge and also a positive indication to show that the system has actuated.
- g. Alarm indicating failure of supervised devices of equipment shall give prompt and positive indication of any failure and shall be distinctive from alarm indicating operation of hazardous conditions.
- h. All indication lamps shall be LED type with minimum size of 10 mm.
- iv. Warning and instruction signs at entrance to and inside Fighting areas shall be provided.
- v. Potential free contacts shall be provided to shut off the fire dampers / louvers and Air Conditioning System.
- vi. Operating instructions shall be displayed on a name plate fitted permanently on the Clean Agent skid.
- vii. Clean Agent extinguishing system shall incorporate a pre-discharge alarm with a time delay, sufficient to allow personnel evacuation prior to discharge. The delay shall be minimum 30 seconds. However, it shall be adjustable from 30 to 120 seconds.
- viii. Operating devices shall be by mechanical, electrical and pneumatic means conforming to NFPA2001. The power supply to electrical actuators shall be backed up with reliable battery supply. Such batteries shall be charged automatically by battery chargers. Power supply is taken from the Fire detection alarm system panels of the respective units. Required annunciations such as "Gas released", "Failure of automatic actuation", "Gas release aborted" etc shall be exhibited in the fire alarm panel.
- ix. Where pilot cylinders are employed for actuation of the cylinder banks, the number of pilot cylinders shall be as per the listed design manual.
- x. All manual operating devices shall be identified to the hazard they protect.
- xi. Manual abort switches for each of the area / zone shall be as per NFPA2001 or as specified by listing authorities.
- xii. The gas releasing devices at cylinder outlets shall be of reusable type after discharge at any instant.
- xiii. Supervision of automatic actuation devices, power supply, manual actuation circuits, and complete wiring shall be provided through control system I panel and the healthiness shall be reported or indicated in the panel automatically.

## 8.0 Inspection and Testing

The complete system shall be tested to meet the requirement of NFPA 2001 norms. All equipment

/ Devices shall be approved and listed by UL/FM/Vds/LPCB except pipes, fittings & structural support.



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Tests not limited to the following shall be performed:

- i. A thorough visual inspection of the installed system and hazard area. The piping, operational equipment and discharge nozzles shall be inspected for proper size and location. The locations of alarms and manual emergency releases shall be confirmed. The hazard area shall be inspected closely for un-closable openings and sources of agent loss.
- ii. The Contractor shall furnish the composition certificate of Clean Agent from the manufacturer satisfying the requirements of the NFPA-2001.
- iii. Gas filling certificate shall be submitted from the manufacturer/ gas filling agency
- iv. A check of labelling of devices for proper designations and instructions. Name plate data on the storage cylinders shall be as per specifications.
- v. A test for mechanical tightness of the piping shall be conducted as per NFPA-2001.
- vi. Storage containers shall meet the statutory requirement of approval / acceptance by CCE, Nagpur.
- vii. Design calculation shall be provided by the designer to prove that the area is not over pressurized and extinguishing capability is not affected due to existing ventilation of that area.
- viii. Complete system shall be installed, inspected, tested and commissioned as per recommendations of NFPA 2001. Contractor shall also consider Gas for one smallest room for system testing.
- ix. Prior to handing over of the system, the Manufacturer shall provide operational training to Employer's operating personnel which shall consist of control system operation, trouble procedures, emergency procedures, safety requirements etc.
- x. The performance test of the system shall be carried out by releasing the agent gas in a selected area and all the design parameters shall be measured. All equipment, refilling of gas after test, instruments etc shall be provided by the Contractor for the same.

## 9.0 Safety

- i. All the safety requirements recommended in NFPA2001 or as specified by listing authorities shall be incorporated in the installation by the Contractor.
- ii. Appropriate warning signs shall be fixed outside of those areas protected by the system and also in areas where the gas may spread indicating clearly the hazard associated with the system such as Noise, turbulence, cold temperature, physiological effects on personnel etc.
- iii. Apart from written warning signs, audio visual type warning signs (i.e.) hooters & strobe lights shall be provided; for pre-discharge and post-discharge activity. The sounder shall have selectable tone options.
- iv. The gas shall be discharged after a set time delay on receiving signal from the fire detection system. The duration of the timer shall be set at site after conducting test to find out the duration for evacuation of the personnel from the area.
- v. To prevent the loss/release of gas automatically or manually during maintenance, the system shall have the facility of "LOCKOUT". The status of the system lockout

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condition shall be annunciated audio visually in the panel.

## 10.0 Spares required for commissioning and Mandatory Spares

Spares required for commissioning - Any spares/components required for successful commissioning of the supplied system shall be in the scope of the vendor at no extra cost to client. Vendor to provide a list indicating quantities. Any item remaining from this category after successful commissioning shall be the property of client. However, any spares/components required for successful commissioning over and above those supplied under this category, shall be in the scope of the vendor at no extra cost to client.

Mandatory Spares: Mandatory spares/components and also the spares required during warranty period for the supplied system shall be in the scope of the vendor at no extra cost to Client. Vendor to provide a list indicating quantities of the Mandatory spares/components and spares required during warranty period.



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## SECTION:-5.4

### DESIGN PHILOSOPHY- ELECTRICAL

**PLANT : COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>)  
FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)**

**PROJECT: COAL BASED SYNTHETIC NATURAL GAS (SNG) PROJECT AT  
BARDHAMAN, WEST BENGAL, INDIA**


0	30.09.25	30.09.25	Issued for NIT	SS	RKV	RKV
P	16.05.25	16.05.25	Issued for Client's comments	RKP	RKV	RKV
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD



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PC217-TS-0802	Uninterrupted Power Supply System
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PC217-TS-0804	Neutral Earthing Resistor
PC217-TS-0805	Medium Voltage Switch Boards
PC217-TS-0806	High Voltage Switch Boards
PC217-TS-0807	Bus Duct
PC217-TS-0808	Sheet Steel Distribution Boards
PC217-TS-0809	Lighting Sub Distribution Boards
PC217-TS-0810	Induction Motors
PC217-TS-0811	Interlocking Switch Socket and Plug
PC217-TS-0813	Battery Charger
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PC217-TS-0819	Electricals for Over Head Cranes and Hoists
PC217-TS-0820A	Variable Frequency AC Drives (High Voltage)
PC217-TS-0820B	Variable Frequency AC Drives (Medium Voltage)
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PC217-PDS:E 115	Typical Details of Transformer Room Door
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## 1.0 SCOPE

The scope includes work/service for the complete design, engineering, manufacture, testing at works, Third Party Inspection, supply of all electrical equipment, dispatch, storage, handling, erection, testing at site and commissioning of complete electrical system required for **‘COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG).**

- 1.1 Although every item of supply and/ or installation might not have been described, the LSTK Contractor shall supply anything and everything to complete the project.
- 1.2 This specification shall be read in conjunction with all drawing and documents attached and other relevant reference as specified therein.
- 1.3 The scope of work/ services of LSTK Contractor shall comprise complete electrics of the **COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG).** The scope of work/ services shall broadly comprise but not limited to the following:
  - 1.4 Design & detailed engineering, Coordination, General Services etc.
    - a. Basic as well as detailed engineering.
    - b. Preparation of drawings/ document/ to suit Project implementation schedule. Preparation of drawings/ documents/ calculations/ formats/ test reports/ test certificates; Erection, Testing & Commission Manuals/ Operations & maintenance Manuals/ Reports/ QAP etc for approval/ Review/ reference/ record and/ or for any other requirement; submission to Owner/ Consultant in requisite sets, getting approval from Owner/ Consultant, making approved copies available to manufacturers, inspectors, erection & commissioning engineers, supervisors, owner/ Consultant etc. as required in requisite sets well before those are actually required by them to fulfil their obligations.
    - c. Design, manufacture, testing of equipment/ cables/ cable trays/ earthing and other erection materials etc. at manufacturer's works, submission of documents with manufacturer's test reports/ type test reports to Owner/ Consultant prior to inspection call.
    - d. Quality Assurance at each stage of manufacture including procurement of raw materials/ bought out items and arranging inspections by Owner/ Consultant/ Third Party.
    - e. Obtaining dispatch clearance from Owner in writing.
    - f. Packing, loading, forwarding, delivery at site/ store, loading/ unloading, storage as per manufacturer's recommendation; shifting from stores and handling in store as well as at site for erection.
    - g. Arrangement of testing/ checking instruments/ kits/ sets/ apparatus with valid calibration certificates issued by duly accredited laboratories/ institutions, to carry out tests stipulated in specification and documents referred therein/ other applicable standards.
    - h. Deputing electrical contractors, supervisors, electricians, cable jointers etc. on full time basis for carrying out electrical work.
    - i. Installations of equipment/ cables/ materials.
    - j. Conducting pre-energisation tests to ensure that installation is fit to be energized.
    - k. Erection shall not be considered complete unless pre-energisation tests are carried out, results are tabulated & submitted to owner/ consultant and results are found satisfactory.
    - l. Conducting functional/ pre-commissioning checks/ Cold trial runs; no-load & load tests.
    - m. Commissioning the installation.

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- n. Conducting Performance Guarantee tests and taking corrective steps (inclusive of replacement of equipment/ materials if required) till results are satisfactory/ acceptable.
- o. Conducting Pre-Acceptance Tests/ checks and tabulating the results/ observations.
- p. Liquidations of defects/ discrepancies/ observations noted during erection, pre-energisation tests, commissioning, trial runs, performance guarantee tests, Pre-acceptance tests/ checks etc.
- q. Submissions of all final/ 'As built' drawings/ documents after incorporation of changes made in soft as well as hard copies, duly certified by LSTK Contractor to the effect that those are 'Final' and/ or 'As built'.
- r. Conducting Final Acceptance Tests/ Checks.
- s. Co-ordinate with the Owner/ Consultant, other contractors/ agencies working at site as required for proper, smooth and timely execution of work/ implementation of the project.
- t. Preparation of drawings/ documents, applications for getting the installation inspected and approved by Electrical Inspectorate of state and/ or Central Electricity Authority and all coordination for getting the installation approved for energisation & use. Carrying out all modifications/ alterations required by statutory authorities. All expenses on these activities shall be carried out and borne by LSTK Contractor. The obligation of owner shall be limited to
  - Signing of application as Owner of installation and
  - Payment of fee for inspection of installation.

Approved drawings and certificates shall be submitted to the Owner/Consultants well ahead of schedule so that the actual commissioning of equipment does not get delayed for want of inspection and approval by the Electrical Inspectorate and other statutory bodies. The actual inspection work by the Electrical Inspector shall be arranged by the LSTK Contractor and necessary coordination and liaison work in this regard shall be the responsibility of the LSTK Contractor.

- u. Bidder to supply, install, testing & commissioning of Motor/motors as per Pump/pumps capacity near mining area as per IS, IE rule & CEA regulation.
- v. Power supply to motor/motors at mining side shall be in Bidder's scope.

1.4.1 Manufacture, testing at works, getting inspected by Owner and/ or their consultant/ Third Party, packing, transportation and delivery to site in well packed condition, insurance during transit and till commissioning & handing over, storing at site as per recommendation of manufacturer/ supplier/ direction of supervising engineer of Owner/ Consultant until required for erection, transportation to work place. Erection, testing & commissioning, handing over of complete electrical system of '**COAL GASIFICATION PLANT FOR GENERATING SYN GAS (CO+H<sub>2</sub>) FOR PRODUCTION OF SYNTHETIC NATURAL GAS (SNG)**'(hereinafter referred as Plant in short) but not limited to:

- a. Bus Ducts
- b. Transformers viz.
  - 33 kV/11kV, 11/3.45 , 11/0.433 kV Transformers, as required
  - Lighting Transformers
- c. Switchgears:
  - 33 kV GIS Switchgear / 33 kV GIS ICOG, as required. (Refer Note below)
  - 11 kV AIS Switchgears/ switchboards, as required.
  - 3.3 kV Switchgears/ switchboards, as required.



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- 415 Volt Switchgears/ switchboards including PMCCs, MCCs, EPMCCs MLDBs, ASPBs (welding receptacle & other non-plant / non-critical loads are generally feed through ASPBs), LSDB, PDB, Junction boxes etc as required.
- Local control Panels, Local Control stations, Switch Sockets.
- Variable Frequency Drive Panels / Soft starters, as required.

Note: - It shall be the responsibility of the LSTK Contractor to verify and ascertain during detailed engineering whether 33 kV GIS Switchgear or 33 kV GIS ICOG is technically suitable, adequate and applicable for meeting the electrical load requirements of their respective LSTK package. LSTK Contractor shall provide only Gas Insulated Switchgear (GIS) / GIS ICOG at 33 kV voltage level. Air Insulated Switchgear (AIS) / AIS ICOG at 33 kV voltage level shall not be acceptable.

- d. 11kV, 3.3kV, 415V Motors and other special application/ voltage motors as required.
- e. All Cables viz:
  - Power Cables (33kV, 11kV, 3.3kV and 1.1kV)
  - Control Cables,
  - Earthing Cable
  - Signal cables,
  - Optical fibre cables
  - Data Cables
  - Communication cables
  - Special application cables
- f. Erection/ installation & all sundry materials for installation, testing & commissioning of equipment/ panels/ fittings/ cables (including jointing & termination of cables) comprising (but not limited to) following:
  - Foundations,
  - Brackets, support structures, erection materials & accessories, as required
  - Cable trays, racks, pipes, ducts, cable channels etc as required.
  - Testing checking kits/ instruments
- g. Illumination system -Normal, Emergency(if required) and Evacuation Lighting(110V DC)
- h. Area Lighting.
- i. Aviation lighting, as required.
- j. Neutral Grounding, NER.
- k. Earthing of equipment & structures.
- l. Protection against lightning.
- m. 110VDC Batteries, Battery Charger and DC Distribution Boards.
- n. 110V & 240V AC UPS Panels with batteries & UPS & UPS Power Distribution Boards for Instrument.
- o. 240V AC UPS with batteries & UPS & UPS Power Distribution Boards for Electrical.
- p. Complete Electrics for Air Conditioning and Ventilation systems.
- q. Complete Electrics for Chemical Dosing System,
- r. Complete Electrics for fire fighting system,





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- s. Complete Electrics for EOT Crane, Hoists,
- t. Fire Detection & Alarm System for Plant and Interface & Integration of same with Centralized Fire Detection & Alarm System.
- u. Cable trench/Cable tray with supporting structure.
- v. Substation along with Transformer Rooms.
- w. The scope shall also include the erection, testing, commissioning of above equipments.

The contractor shall clear the site after commissioning of the equipments / system and obtain the Site Clearance Certificate from Owner's Engineer-in-charge.

- x. Any and all other Materials, Equipment and Services so as to make a totally integrated and functional system together with all accessories and associated equipment, ensuring safety, maintainability and reliability in compliance with all applicable codes, standards, guidelines, statutory regulations and safety requirements in force.
- y. Any other equipment, not specified, but required for safe, proper, trouble free and efficient operation of the system.
- z. Temporary/Sacrificial and Permanent (ICCP) Cathodic Protection shall be provided to all underground piping and underground Tankage. Bidder to provide isolating joints for complete isolation of their CP System from other CP System. Else, Bidder to do all necessary arrangement for interface with the centralized CP system if required. Design details shall be submitted by the bidder & shall be reviewed by the Owner.
- aa. LSTK Contractor shall consider any other requirement which is not covered in this NIT, but required for successful operation of the plant.
- bb. Spares & consumables for complete Contractor shall electrics as follows:
  - Commissioning Spares (as per Clause No. 17.0 of Design Philosophy-Electrical) and Spares for 2 Years operation (Mandatory) for all equipments (as per Section 10: Spare Parts) shall be supplied by the Contractor as part of LSTK contract.
- cc. Recommended spares (other than mandatory spare) for all the equipment (item-wise) with recommended quantity.
  - 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 shall be supplied by the Contractor as part of LSTK contract.
- dd. Tools & Tackles.
- ee. Testing Equipments/ instruments
- ff. Arranging services of major equipment suppliers during installation and commissioning.
- gg. Training of Owner's Personnel for Operation & Maintenance of the Plant.
- hh. Any and all other items/ facilities/ services not specifically mentioned but essential/ required for completeness of the systems/ equipments/ facilities.

- 1.5 Two (2) nos. 33 kV feeders, as normal power supply, each rated for 100% load, shall be provided by Owner at 33 kV Gas Insulated Switchgear (GIS) located in Main Receiving Sub-Station (MRSS). In addition to that, One (1) no. 11 kV feeder, as emergency power supply, shall be provided by Owner at 11 kV Emergency Switchboard located in Main Receiving Sub-Station (MRSS). Supply, laying & installation of 33 kV cables, 11 kV cables and associated control cables from above mentioned Main Receiving Sub-Station (MRSS) up to LSTK Contractor's Substation and termination at both the ends are in LSTK Contractor's scope. Further, downstream distribution shall be in LSTK Contractor's scope.

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Bidder shall indicate the details of Normal Loads and Emergency Loads in the bid. 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 quality electrical system of superior quality, even if the specifications of certain items are not given. The items for which technical specifications are not indicated herein shall be of IS/IEC standard and specifications of these shall be subject to owner's approval in case of order.

- 1.6 The bidder shall offer the best and proven most suitable type of energy efficient equipments manufactured by well known reputed manufacturers having proven performance track record of minimum 2 years, as per vendor list appended in this bid package. However for the sake of standardization of the electrical equipment and material used for the electrical installation, the LSTK Contractor shall supply all items of a particular type or make for whole plant of the same manufacturing company for ease of maintenance and less spares inventory.
- 1.7 Construction Power shall be made available by Owner at 11 kV Switchboard at Construction Power Substation / Compact Sub Station. Tapping of Construction Power (on chargeable basis) 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.

In construction Power, LSTK Contractor shall ensure that the minimum power factor of 0.9 shall be maintained at their end by providing suitable power factor improvement devices.

LSTK contractor shall have to distribute construction power with 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 at his own cost.

Bidder shall indicate details of construction power in the bid with month-wise breakup for the entire duration of project.

However, during non availability of construction power, LSTK contractor shall have to arrange emergency power, if required, through DG set at their own cost.

Non availability of construction power by owner shall not impose any constraints for site construction activities, contractor to arrange required power by their own through DG set at his own cost for smooth running of site construction activities.



- 1.8 Contractor shall provide adequate area lighting at site of construction, fabrication yards, storage yard 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.
- 1.9 Load Flow, Short Circuit Study, Harmonic Study, Voltage Drop / Voltage Dip calculations during motor start-up, Motor Re-acceleration studies, etc. including any special study for selection of electrical equipment & Relay setting calculations, protection coordination charts and overall relay coordination within their respective LSTK package shall be conducted by the LSTK Contractor using latest version (24.0.2) of ETAP software at appropriate stage of design-engineering.

All the Electrical equipments shall be designed and selected according to the Short Circuit Study Report.

In case equipment is ordered before studies are completed and revision of rating or design is required as a result of Electrical System Study then inclusion of such revisions shall be in LSTK Contractor's scope without any cost and time implication.

The ETAP OTI, MDB and library files shall be submitted to owner as and when required during detailed engineering.



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- 1.10 LSTK Contractor has to provide the required multifunctional dual channel transducers, Digital Multi-function Meters, latest version numerical and communicable type protective relays with non-volatile memory, comprehensive unit providing protection, metering, control & communication with communication port & interlinked with Online Energy/Load Management System and required microprocessor based devices if any in panels, communicable door mounted Motor Protection Relays in all motor feeders of PMCC & MCC, proper communication facility in supplied UPS, Battery Chargers, VFD, Soft starter, MOV and other critical equipment for proper communication with ECMS and DCS& ESD system. The interface of electrical equipments with ECMS and DCS, ESD system shall be through IEC 61850 communication protocol for Numerical relays and IEC 61850/Modbus for Multifunction Digital Meters and MODBUS TCP/IP for battery Charger, UPS, VFD, Motor Protection Relay (MPR) etc., Ethernet communication module shall also be used. 100% redundancy shall be provided for communication i.e. the relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port.

All connection of numerical relays to Ethernet / Network Switch and looping of MFMs to Network / Ethernet Switches inside the switchboards and Network / Ethernet Switches, as required, for interfacing shall be in LSTK Contractor's scope.

All communication cables and all hardwiring cables (for DI, DO, AI, AO etc.) from Switchboards Ethernet/Network Switches to respective Substation ECMS cabinets, DCS, ESD I/O Racks shall be in LSTK Contractor's scope.

- 1.11 All cables(FO/Multipair control/any other cable),termination, all accessories etc. from Ethernet switches to LMS/ECMS, DCS, ESD I/O rack shall be in LSTK bidder's scope.
- 1.12 LSTK Contractor shall provide separate room for local ECMS, DCS, ESD equipments in substations. Provision of future expansion of one Data Concentrator Panels, I/O Rack/RTU panel /Interface panel shall also be considered while designing separate room. Details shall be provided during detail engineering to successful bidder.
- 1.13 The scope shall also include obtaining all required statutory approvals from all statutory bodies. Contractor shall carry out all modifications/alterations required by statutory bodies.
- All approvals for permanent installations shall be obtained in the name of Owner. Approval for equipment & installation for Construction Power shall be in LSTK Contractor's name.
- 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.
- 1.15 Final location of equipments as well as route of cable trays shall be finalised during detailed engineering.
- 1.16 All electrical works associated with the followings but not limited to, shall be considered
- Air conditioning and Ventilation systems
  - Fire fighting system,
  - Fire protection system
  - Cranes, Hoist, elevators
  - Pollution control and monitoring equipment
  - All auxiliary building & associated electrical building/rooms.

- 1.17 Following Interface & Integrations are envisaged presently of LSTK Contractor ;
- Control & Protection for outgoing feeders of 11 kV Switchboard at Owner substation to LSTK Contractor Switchboard (Intertripping, Cable Protection etc.)
  - Interface and Integration with Centralized Fire Detection & Alarm System.
- However, any other interface and integration requirement or any other unforeseen which may arise during detailed engineering/ execution stage, same shall also be in the LSTK Contractor's scope without any cost and time implication.

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1.18 All the substations shall be provided with following equipment :

- HT Voltage detectors
- CO<sub>2</sub> fire extinguishers (4.5 litre capacity) as per applicable NFPA.
- DCP fire extinguishers as per applicable NFPA
- Synthetic insulating mats on front and back side of all the switchboards 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, wherever cable is in underground.
- Sets of Sand buckets with stand (each with at least 3 sand buckets) for substations and transformer yards.
- HT and LT hand Gloves (3 Sets each for each substation).
- A Type FRP ladder 3 feet & 8 feet – 2 nos. each type for each substation.
- First Aid Box

Other requirement or any other unforeseen which may arises during detailed engineering shall also be in LSTK Contractor's scope.

LSTK Contractor shall provide a minimum of three (3) nos. separate and independent substation buildings. These substations shall be strategically located to cater to the load requirements of Coal Gasification Unit, Purification Unit and Sulphur Recovery Unit, ensuring compliance with reliability, safety, maintainability and statutory requirements. Each substation building shall be provided with independent incoming supply, switchgear, transformers and associated auxiliaries. The final number of substations may be increased by the contractor during detailed engineering subject to Owner's/PMC approval, but shall not be less than three (3) separate and independent substation buildings.

The final location of substations may be strategically decided in such a way that each substation shall be in proximity/nearby to it's load center.



If in case, a common substation building is utilized to feed more than one process unit, the LSTK contractor shall ensure that the electrical power distribution system for each process unit is designed, engineered and implemented as a separate and independent system with clear demarcation and segregation provided at all levels of distribution system. The electrical systems of individual process units shall not be interconnected. Electrical system shall be designed in such a way to ensure independent process operation of the respective unit/plant without having dependency of one unit/plant on another unit/plant.

## 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

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The design of electrical installation shall ensure provision of a safe, efficient and reliable supply of electricity at all times including adverse system conditions. 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 aspects.

- 2.1.2 The design of electrical installation shall ensure provision of a safe 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, climatic conditions like lightning and earthquake etc. The isolation of part of system of electrical equipment due to either maintenance or shut down shall not compromise safety. All electrical equipments shall be of proven design and technology.

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 minimize turnaround time.
- To provide safety, reliability and flexibility of service.
- Adequate provision for future extension and modification.
- Maximum inter-changeability 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 of the system.



- 2.1.3 All the electrical consumers within the battery limit shall be 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 motors. At the same time, the short circuit current shall be kept within limits keeping in view of the market availability of switchgears rating. For this purpose current limiting reactors/unit ratio transformers if required may be used.

- 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.

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- 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 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 Liaison and in all interface coordination with contractors of other units of project at construction, erection, testing & commissioning phase for any common facility and for smooth execution.
- g) Equipment specification sheet/data sheets for all equipment shall be prepared by the LSTK Contractor based on relevant codes and Technical specifications/ Data sheets attached as reference. 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) LSTK Contractor shall clearly specify in their purchase specifications the requirement of conducting special tests/type tests, which are envisaged for various electrical equipment which shall have no impact on cost and time.
- i) Bidder shall must visit the site and collect all relevant information required for designing of complete system before quoting. Bidder shall make themselves familiar with the work actually involved and actual site conditions. Failure to do so shall not absolve the Bidder of their responsibilities based on adverse site conditions.
- j) All the electrical equipments shall be of proven design and technology.
- k) Normal & Emergency Load details (rating of all motor, Lighting, Switch socket etc.) load shall be submitted.
- l) Load Summary shall be prepared by LSTK contractor to determine ratings of electrical equipments (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).

Peak 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).



Electrical System shall be designed for continuous Peak Load operation.

All the electrical equipments shall be designed / sized considering motor input power (i.e. BkW divided by motor efficiency).

Margin for future requirement shall be as per clause 2.1.6 m over the above.

Minimum P.F. shall be maintained as 0.95 at every voltage level.

All the electrical equipments like Transformers, Switchboards etc. shall be suitable for starting of the largest motor, while other loads are running, considering peak load condition.

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- m) Electrical equipments to be designed by LSTK Contractor i.e. Transformers, Switchgears, MCCs, PCCs etc. shall have capacity for future requirements. The Margin shall be as follows:
- i) HV Transformer: 25% is added to the Continuous Peak Load.  
LV Transformer: 30% is added to the Continuous Peak Load.
  - ii) Switchgear: Switchgear bus bar current rating as well as breaker shall be equivalent (nearer or higher standard rating size) to full load current of upstream Transformer.
  - iii) Switchboards and MCCs fed from other switchboards: shall be rated for 125% of peak load.
- n) The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc.
- o) Prospective touch and step voltages shall not be adverse to the stipulations of relevant publications of Bureau of Indian Standards / IEC/IEEE-80.
- p) Sizing calculations for all the electrical equipments shall be submitted for review/approval, in case of award of order. Owner/Consultant's Comments, if any on the same shall also be considered and modification in any equipment shall be done accordingly, without any time and price implication.
- q) Seismic zone as applicable shall be considered for design of all electrical equipment.

## 2.2 Load Grouping

Electrical consumers shall be classified as 'normal / non-essential, emergency / essential or vital / critical loads as per the concepts defined below:

- 2.2.1 'Emergency' or 'essential' loads shall be identified on the criteria that, when failing in operation or when failing if called upon, will affect the continuity of operation, the quality or the quantity of product. For such loads, reliable source shall be ensured. Such feeders shall be grouped on a separate bus section in the respective Switchboards/ MCCs / PCCs.
- 2.2.2 Some of the loads which can be identified as emergency / essential load but not essentially limited to following:
- Electrical loads required for continuous operation of process plants utility in case of normal supply failure.
  - Electrical loads required for safe shut down of facilities in case of normal supply failure.
  - Emergency/Normal lighting & communication facilities.
  - Fire Detection and Alarm System.
  - AC & DC UPS / Battery charging equipment.
  - Control room AC equipment -Essential ventilation system for offices / Manned areas of other buildings.
  - Motorised valves as per process requirement
  - PA & Paging system (Load Details by Owner during detailed engineering).
  - AC Emergency Lube Oil Pump
  - Any other load (To be indicated by LSTK Contractor )
- 2.2.3 Critical' or 'vital' loads shall be identified on the criteria that, when failing in operation or when called upon, can cause an unsafe condition of the installation, jeopardize life or cause a major damage to the installation. For critical loads if any, UPS shall be provided to facilitate uninterrupted supply. The loads on UPS are AVR / PLC / DCS / Auxiliary supply for drives etc. Critical drives if any shall be provided with DC motors.
- 2.2.4 Some of the load which can be identified as critical / vital load but not essentially limited to following:
- Loads providing control and protection to plant equipment.
  - Loads serving critical equipment for safety of plant, equipment and / or personnel



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2.2.5 Non-essential service is a service, which is neither 'essential' nor 'vital'. Hence the non-essential load does not require any special measure such as standby feeder or standby source to safeguard the continuity of service.

### 2.3 Statutory requirement Codes and Standards

2.3.1 The design, installation, testing & commissioning shall conform to compliance of following statutory requirements :

- Indian Electricity Act
- Indian Electricity Rules
- The Indian Factories Act
- The Indian Explosives Act.
- Statutory requirement of Govt of West Bengal and Govt. of India.
- Guidelines, instructions, directions issued by Pollution control Boards of state as well as central government. Guidelines, instructions, directions issued by Chief Controller of Explosives (CCoE), CPCB, CMRI, DGMS, CEA etc.
- Guidelines of Tariff Advisory Committee
- Guidelines of Insurance Companies Association.
- Any other applicable Rules/Acts/Regulations.

The design, installation, testing & commissioning shall be in accordance with established codes, good engineering practices and latest versions of following documents valid/applicable on the date of acceptance of bid. The stipulations in these documents shall be considered as minimum requirements:



- Indian Standard Specification or equivalent IEC Standards
- Publications of IEEE
- API Standards
- National Electrical safety Code(NESC)
- Standards of Underwrites laboratory(UL)
- American Society for Testing Material (ASTM)
- American National Standards Institute (ANSI)
- Other International Standards

LSTK contractor shall be responsible for obtaining necessary statutory approvals from all the statutory bodies/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.



LSTK Contractor shall carry out all modifications / alterations required by all statutory bodies. However, necessary statutory fee shall be deposited by the Owner.

2.4 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: 325, IEC:60034	Three phase induction motors
IS: 335	New insulating oil for transformers and switchgears
IS: 722	AC electricity meters
IS: 732	Code of practice for electrical wiring installations system voltages not exceeding 650V
IS: 737	Specification for wrought aluminium and aluminium alloys, sheet and strip (for engineering purpose)
IS: 996, IEC:60034	Single phase AC motors



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IS:1248	Direct acting analogue electrical measuring instruments and their accessories:
IS: 1367 Part-13	Hot dip galvanised coatings on threaded fasteners.
IS: 1646	Code of practice for fire safety of buildings and electrical installations
IS: 1913	General and safety requirements for Luminaries (Tubular fluorescent Lamp)
IS: 2071	Method of high voltage testing
IS: 2099	High voltage porcelain bushings
IEC:62305	Code of practice for the protection of buildings and allied structures against lightning
IS/IEC60079	Electrical apparatus for Explosive gas atmosphere
IS: 11171	Specification for dry type transformers.
IS: 2544	Porcelain post Insulators for system with normal voltage greater than 1000 volts
IS: 2633	Methods of testing uniformity of coating on zinc coated articles
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
IEC 61869-1	Instrument transformers — General requirements
IEC 61869-2	Additional requirements for current transformers
IEC 61869-3	Additional requirements for inductive voltage transformers
IS: 3177 IEC60034	Crane duty motors
IS: 3347	Dimensions for porcelain transformer bushings
IS: 3637	Gas operated relays
IS: 3639	Fittings and accessories for power transformers
IS: 3646	Interior illumination: Part I & Part II
IS: 3716	Application guide for insulation co-ordination
IS/IEC:60529	Degree of protection provided by enclosure for rotating electrical machinery.
IS: 4722	DC motors
IS: 4759	Hot dip zinc coating on structural steel and allied products
IS: 5082	Specification for wrought Aluminium alloys bars, rods, tubes and sections for electrical purposes
IS: 5561	Electric power connectors
IS: 5578	Guide for marking of insulated conductors (1st rev)
IS: 6362	Designation of methods of cooling of rotating electrical machines

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IS: 6600	Guide for loading of oil immersed transformers
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: 9676	Reference ambient temperature for electrical equipment
IS: 10028	Code of practice for selection, installation and maintenance of transformers
IS: 10322-1	Specification for Luminaries,Part-1,General requirements
IS: 11353	Guide for uniform system of marking & identification of conductor & apparatus terminals
IS: 11448	Application Guide for AC electricity meters
IS: 12360	Voltage bands for electrical installations including preferred voltage and Frequency
IS: 12459	Code of practice for fire protection of cable runs
IS: 12615	Energy efficient motors
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
IEC: 60255	Electrical Relays
IS/IEC: 60947	Low voltage switchgear and control gear
IS: 60034-5	Degree of protection provided by Integral design of rotating electrical machines
IS: 60079-0	Explosive atmospheres, Equipment General Requirements
IS: 60079-1	Explosive gas atmospheres – Part-1 Equipment protection by Flame proof enclosures “d”.
IS: 60079-7	Equipment protection by increased safety “e”
SP: 30	National Electrical Codes (NEC) - BIS Publication
IS/IEC 62271	HV Switchboard.
IEC 61439-1/2	LV switchboard (PCC/PMCC/MCC) for TOTAL TYPE TESTED (TTA). Type Test Certificates for short circuit withstand of 50kA for 1 sec. along with ACB mounted in the Switchboards shall apply.
IEC 61641	Switch Board with INTERNAL ARC CONTAINMENT test.
ANSI C-37:23	Metal enclosed bus
ANSI C-37:24	Effect of Solar radiation on metal enclosed bus.
IEC 60034	Rotating Electrical Machinery
IEC 61131	Programmable controllers
IEC 60871-1	Shunt Capacitors for AC power Systems Specifications



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Any other standard may be followed provided it is equivalent or more stringent than the standards specified above.

- 2.5 If conflicting statements exist within various electrical sections/portions and other discipline sections/portions of NIT document or between this document (Design Philosophy-Electrical) and other applicable Technical Specifications, Standard Drawings, Industry Standards, codes, etc., it shall be brought to Owner's/PMC notice for clarification and proper approval shall be obtained before implementation. Decision of Owner/PMC shall be final and binding on LSTK Contractor/Vendor.

In case of contradiction between licensor specification, Design Philosophy-Electrical and Technical Specifications, it has to be brought to the notice of Owner/PMC and decision of Owner/PMC shall be final and binding on LSTK Contractor/Vendor.

The following order of precedence shall apply, unless otherwise expressly and specifically agreed in writing by the Owner/PMC.

- Local regulatory and statutory requirement
- Licensor Requirements (As applicable)
- Design Philosophy-Electrical (81 Sheets)
- Technical Specifications/Specification Sheets/Installation Standards, etc.
- Applicable IS/IEC standards

## 2.6 Site Conditions

The equipment shall be designed for the following site conditions:-

- |                                 |   |
|---------------------------------|---|
| • Minimum ambient Temperature   | Refer process Design Philosophy                               |
| • Maximum ambient Temperature   | Refer process Design Philosophy                               |
| • Design Reference Temperature  | 50 C.deg  |
| • Relative Humidity             | 100%  |
| • Altitude above mean sea level | Lower than 1000 Mtrs.   |
| • Atmospheric pollution         | Dusty due to presence of Coal Dust and other corrosive gases. |



Equipment/ cables selected shall be derated for (a) higher ambient temperature, (b) restriction in temperature rise (c) variation in voltage, (d) variation in frequency (e) installation conditions viz. proximity to heat sources, bunching, layering, separation from others/ laying in conduits etc. with respect to the conditions for which it was designed & manufactured. Various de-rating factors considered shall be informed with supporting documents.

Equipment to be installed in MCC rooms/ Electrical Rooms/ Control rooms shall be designed for + 50° C so that in case of failure of Air-conditioning/ ventilation facilities, the operation/ functioning of equipment is not be affected.

## 3.0 SYSTEM DETAILS AND UTILIZATION VOLTAGES

- 3.1 The various voltage levels for in plant power distribution shall be as follows:

A. Normal Power	33KV ± 10%, 50Hz ± 5%, 3Ph, 3 W
B. Emergency Power	11KV ± 10%, 50Hz ± 5%, 3Ph, 3 W
LSTK Contractor shall indicate Emergency Power	

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	requirement in the bid.
C. Distribution Equipment	a) 11KV $\pm$ 10%, 50 Hz $\pm$ 5%, 3 Ph, 3 W with resistance earthed neutral b) 3.3KV $\pm$ 10%, 50 Hz $\pm$ 5%, 3 Ph, 3 W with resistance earthed neutral c) 415V $\pm$ 10%, 3 Ph, 4 W/240V $\pm$ 10%, 1 Ph, 2W, 50 Hz $\pm$ 5% solidly grounded neutral.
Combined variation in voltage & frequency	$\pm$ 10%
Control Supply for: - 415V motors  - Switch Gear Breaker controlled feeders:  a. Closing, tripping& spring charging motor b. Auxiliary power	AC 240V $\pm$ 10%, 50 Hz $\pm$ 5%, 1Ph (For contactor controlled motors). DC 110V $\pm$ 5% (For breaker controlled motors) – Battery Charger  DC 110V $\pm$ 5%, 2 W - Battery Charger  AC 240V $\pm$ 10%, 50 Hz $\pm$ 5%, 1Ph, 2W
- Instrumentation and Automation, DCS & Auxiliaries	AC 110 V $\pm$ 10%, 50 Hz $\pm$ 5% 1Ph, 2W (For critical instrumentation power supply) AC 240 V $\pm$ 10%, 50 Hz $\pm$ 5% 1Ph, 2W (For normal instrumentation power supply)  Final UPS output voltage shall be as per Instrumentation Design Basis Instrumentation UPS shall be located at Control Room
Voltage Ratings- - Motors above 1000 KW - Motors above 160 KW and up to including 1000 KW. -Motors up to and including 160 KW	11 KV, 3 Ph AC  3.3 KV, 3 Ph AC  415 V, 3 Ph AC
- Space heaters - Lighting - Panic Lights - Power Sockets/Receptacle	240V, 1 Ph AC 415V/240V AC 110V DC 415V, 3 Ph AC/240V, 1 Ph AC



3.2 The actual fault levels shall be arrived at on the basis of incoming power source, transformers, contribution of motors, etc. and shall be indicated 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:

33 kV GIS Switchgear / 33 kV GIS ICOG (As applicable) – 40 kA for 3 seconds

11 kV Switchgear – 40 kA for 3 seconds.

3.3 kV Switchgear – 31.5 kA for 3 seconds.

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The fault level for all the 415V switchboards shall be 50kA for 1 sec.

Impedance of transformers shall be selected suitably (tap position at principal) without comprising voltage drop at receiving end.

11kV/0.433kV Oil type (outdoor)/ dry type (Indoor) Transformer rating shall not be more than 2000kVA.

Fault level of DC System shall be decided by the LSTK Contractor after substantiating the same by calculation.

### 3.3 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. Suitable protection system to be designed to have proper sensitive Earth fault protection.

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.

## 4.0 POWER SUPPLY AND DISTRIBUTION

- 4.1 Two (2) nos. 33 kV feeders, as normal power supply, each rated for 100% load, shall be provided by Owner at 33 kV Gas Insulated Switchgear (GIS) located in Main Receiving Sub-Station (MRSS). In addition to that, One (1) no. 11 kV feeder, as emergency power supply, shall be provided by Owner at 11 kV Emergency Switchboard located in Main Receiving Sub-Station (MRSS). Supply, laying & installation of 33 kV cables, 11 kV cables and associated control cables from above mentioned Main Receiving Sub-Station (MRSS) up to LSTK Contractor's Substation and termination at both the ends are in LSTK Contractor's scope. Further, downstream distribution shall be in LSTK Contractor's scope. Supply & installation of cable trench / cable trays and necessary cable tray vertical and horizontal supports, main structural supports (as required), etc. shall be in LSTK Contractor's scope. Further distribution to equipment at 33 kV, 11 kV, 3.3 kV, 415/240 V AC, 110V AC UPS, 240V AC UPS, 110 V DC etc. through proper type and size of cables, their supply, erection, testing and commissioning etc. shall be in LSTK Contractor's scope.



LSTK Contractor shall consider 33/11kV, 11kV/3.45 kV, 11kV/0.433 kV transformers for downstream distribution. The supply system shall be designed for maximum power requirement of the plant. Double radial system of power supply, each suitable for 125% of full load shall be followed for entire plants.

LSTK Contractor shall indicate details of power requirement and the Rating of 11kV Feeders in the Bid.

- 4.2 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.
- 4.3 The insulation system of cable 33 kV, 11 kV & 3.3 kV equipments shall be based on unearthed system only.
- 4.4 Each incoming feeder shall be sized for 125% load of the switch board. The outgoing feeders shall be sized for the nominal load. Breaker rating of all the outgoing feeders of 33 kV GIS, 11 kV switchboards & 3.3 kV switchboards shall be same considering provision of inter-changeability, except Incomer & Bus coupler Circuit Breakers.
- 4.5 Primary connections of transformers shall be provided with cables of suitable size and secondary connections shall be through cables/bus duct.
- 4.6 The entry of cables in all the switchboards shall be from bottom only.

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- 4.7 All switchboards shall be provided with minimum two incoming feeders and one bus tie having auto/manual changeover facility.
- 4.8 It shall be possible to have momentary paralleling of power sources at 33KV, 11 kV, 3.3 kV switchboards and 415V PMCC /PCC/MCC and trip the desired circuit breakers.
- 4.9 The normal operation of the 33 kV GIS, 11 kV Switchgears, 3.3 kV Switchgears, Power & Motor Control Centre (PMCC) and Motor Control Centre (MCC) shall be as under:
- Bus-coupler shall be provided between all the sources. Incomer and Bus-coupler breaker rating shall be same for all the switchboards. 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.
  - The bus tie breaker shall be provided with auto/manual/Independent selection. 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.
  - When one of the incoming feeder trips, the bus tie breaker is closed automatically based on the philosophy described 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.
  - Auto Change Over scheme shall be provided for incomer feeders and bus coupler feeder of 11kV switchboard, 3.3kV Switchboards and 415V Switchboards. Under normal operating conditions, incomer-1 and incomer-2 breakers shall be closed and bus coupler breaker shall remain open with 'Local-Remote-Off' switch in 'Remote' position. The bus coupler breaker shall close automatically under the following conditions being fulfilled:
    - Either of the incoming breaker trips due to under voltage (70% or below).
    - Voltage on the healthy bus is more than 80% for the set period.
    - Residual voltage on the bus with no power supply comes down to 30% or below.
    - Auto manual switch in set for Auto operation.
- Required nos. of bus PT, line PT and under voltage relays shall be provided to achieve the desired automatic changeover.
- Auto transfer shall take place only on sustained loss of power on either of bus sections. Auto transfer shall be blocked in case of fault on either of bus sections or no power on both incomers or in case of standby earth fault. However, tripping of Transformer due to REF operation, auto transfer should not be blocked.
  - Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply with synchro check relay in Bus Coupler panel. There shall also be provision of selective tripping of one feeder out of three feeders with a Delay (two incoming feeders and one Bus Coupler).
- 4.10 PMCC & MCC shall have 2 Nos. Normal Power Incomers feeding non-critical loads. DC Battery Charger, UPS System etc. shall be fed from PMCC. 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.
- 4.11 Auxiliary Services Power Board (ASPB) shall be provided in the plant for supplying power to welding switch sockets, EOT crane and other auxiliary loads.
- 4.12 Separate MCCs be provided for Air-conditioning and Ventilation systems.
- 4.13 For the use of the Owner during plant shut down period, 1 No. indoor type feeder pillar, which shall be located in a separate room other than substation building and away from hazardous area. The feeder pillar shall be fed from the 415 V switchboards (PMCC) of the

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nearby substation. Feeder pillar shall comprise of 1 No. 630 A 4 PMCCB incomer, 2 Nos. of 250 A TPN MCCB outgoing feeders, 2 Nos. 125 A TPN MCCB outgoing feeders and 4 Nos. 63 A TPN MCCB outgoing feeders. Other construction details shall be as per specification of sheet steel distribution board (PC217-TS-0808).

Location of feeder pillar shall be decided during detailed engineering.

## 4.2 Instrumentation Power

- 4.2.1 The power supply for critical instrumentation and normal instrumentation shall be 110V, 1Ph UPS & 240V, 1 Ph UPS supply respectively. (Instrumentation Design Basis shall also be finally referred for this purpose).
- 4.2.2 Provision for 240V, 1 Ph power for lighting of instrument panels shall be provided from LSDB.
- 4.2.3 All instrument panels shall have two UPS incomer supply (one from different bus of UPS DBs) to avoid any type of power obstruction in case of failure of one supply.
- 4.2.4 A separate and common 110V AC UPS System with associated Battery (Ni-Cd) and UPS AC Distribution Board shall be considered for telecommunication system, CCTV system, Public Address / Paging system and Fire Detection & Alarm System (FDAS) of complete LSTK package which shall be located at Control Room. The configuration of UPS shall be 2x100% parallel redundant with single bypass system with 2x100% Ni-Cd battery bank configuration. The battery back-up time for CCTV & FDAS system shall be considered as 120 minutes (2 hour) whereas for telecommunication & Public Address / Paging system shall be considered as 8 hours. (Common battery bank with suitable duty cycle to meet above criteria of back up time shall be suitably considered). (Instrumentation Design Basis shall also be finally referred for this purpose).

## 4.3 Lighting Distribution

- 4.3.1 In substation a Main Lighting Distribution Board (MLDB) shall be in provided. MLDBs shall have two incomers through 415/433 V Lighting Transformers. One Incomer of MLDB shall be feed from PCC/PMCC and One Incomer shall be fed from EPMCC. In other areas the Lighting Distribution Boards shall receive power from MLDB. One third lighting load shall be connected to the emergency bus. The MLDB Incomers shall have Metering facility with Digital communicable Multi-function Meters. MLDB shall have fault level of Min. 25 kA.

Both the lighting transformers feeding MLDB and their respective circuit breakers shall have same rating. Both the lighting transformers shall be designed for 125% load of MLDB.



Areas requiring DC critical lighting (panic lighting) shall include Control Rooms, Substations, Compressor houses, emergency escape routes and all other plant buildings applicable for this LSTK package. DC critical lighting (panic lighting) shall be provided in the pipe rack, exit/entry point only in case considered for process units. Sufficient number of panic lights shall be considered and provided in above mentioned areas in case of complete shutdown.

The both normal and emergency section (provision for emergency) of Main Lighting Distribution Board shall have separate Sections of bus bars for indoor and outdoor lighting. Indoor / Outdoor bus Sections shall be connected by means of suitably rated contactor operated through GPS enabled timer. There shall be provision to Switch ON & OFF Outdoor Type feeders from ECMS in Remote Mode.

The Lighting system shall be GPS enabled through ECMS along with the conventional timer philosophy of switching on and off the plant lighting.

- 4.3.2 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 bypass the automatic switching.

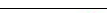



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- 4.3.3 All outdoor lighting fixtures and outside lighting of Sub-Stations, Offices, Control Rooms etc., shall receive power from outdoor lighting bus.
- 4.3.4 Demographical Electronic Timer and Contactor shall be provided for Outdoor Bus Section.
- 4.3.5 Main Lighting Distribution Board shall feed Lighting Sub Distribution board having 63A 4 Pole MCB and ELCB as incomer, 16Amp DP RCBOs as outgoing. The outgoing RCBO shall have rating of 300 /100 mA. Six, Nine or Twelve way Lighting Sub Distribution board shall be used having 30 % as spare outgoing RCBO feeder.
- 4.3.6 Welding outlets shall be fed from ASPB having 3 phase supply for welding connection. All welding outlets shall be provided with CBCT ELCBs of 100 mA.

#### **4.4 DC Power**



- 4.4.1 Separate 110 V DC system shall be provided for switchgear protection and control for each process unit and stationed in AC room of each respective substation. It shall be obtained from Ni-Cd batteries.
- 4.4.2 DC system for switchgear protection and control purpose shall be with Rectifier-cum-Battery in parallel redundant configuration with dedicated battery bank. The rectifier shall work in online float charging mode while feeding the complete DC load and off-line boost charging mode. Battery configuration shall be 2x100%. Battery backup time shall be 120 minutes. Battery bank shall be provided with isolation facility for ease of operation & maintenance.
- 4.4.3 Separate 110V DC system for critical lighting / panic lighting shall be installed in each substation (common for all process units fed from substation). Under voltage relay contacts of emergency bus section of MLDB shall be used to switch on the DC lighting circuits.
- 4.4.4 DC system for critical lighting purpose shall be with Rectifier-cum-Battery in single non-redundant configuration. The rectifier shall work in online float charging mode while feeding the complete DC load and off-line boost charging mode. Battery configuration shall be 1x100%. Battery backup time shall be 120 minutes. Battery bank shall be provided with isolation facility for ease of operation & maintenance.
- 4.4.5 Each rectifier-cum-battery charger shall have independent power supply to be fed from different bus of upstream emergency source.
- 4.4.6 Dual DCDB with a coupler switch shall be provided for both the DC systems (for switchgear control and for panic lighting). The loads shall be distributed on the two DCDBs giving redundancy in supply to DC loads. DCDB shall be single front, non draw-out type. For DCDBs, 20% spare feeders (or) minimum 1 No. of each rating on both DCDBs shall be provided.
- 4.4.7 DC Battery Charger, AC UPS and HVAC for control room shall be fed from emergency switchboard.
- 4.4.8 Ni-Cd battery end cell voltage shall be considered as 1.1V. Aging factor shall be considered as 125% and future load margin of 20% shall be considered for entire DC system (batteries, chargers and distribution)
- 4.4.9 For Temperature derating factor shall be based upon Minimum Ambient Temperature shall be decided during detailed engineering.
- 4.4.10 Each rectifier cum battery charger shall be sized to continuously supply the total connected DC load + battery charging requirement (both float and boost conditions), with a minimum of 30% spare capacity over and above the calculated requirement to account for owner's future use and reliable operation under all service conditions.
- 4.4.11 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

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- 4.4.12 Battery chargers shall be provided with tap cell connection to take care of interruption of float charger when other charger is being used to boost charge the battery bank. Meters shall be provided on battery charger for monitoring of leakage current.
- 4.4.13 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.
- 4.4.14 For all other specifications of Battery Charger, refer PC217-TS-0813.
- 4.4.15 For all other specifications of Battery Bank, refer PC217-TS-0814.

## 5.0 SUB-STATION

- 5.1 Elevated with trays in cable cellar : Yes  
Complete Substation : Air conditioned  
Roof slab for  
a. Power transformer : Yes  
b. Distribution transformer : Yes  
Batteries in substation and control Rooms : Separate room  
Switchgear room : Air conditioned  
Battery charger in substation : Air conditioned  
UPS Systems : Air conditioned  
Nickel- Cadmium Battery : Separate room (Ventilated)  
Variable speed drive panels : Air-conditioned  
Thyristor controlled panels : Air-conditioned  
Annunciation panel (HMI) : Operator Room in substation
- 5.2 The Sub-Stations shall be located near the load centres but away from hazardous areas as per IS/IEC. Actual size of substations shall be based on the final dimensions of substation equipments. Each Substation shall include Maintenance Room, Engineer Room, Shift Office (Staff Room), Gents toilet (both Indian and western WC), Ladies toilet (both Indian and western WC) etc. The toilets and maintenance room shall be outside the switchgear hall (with split AC). The maintenance room shall have facility for workmen to keep their tools. Toilet and drinking water facility shall be at ground floor and at first floor as well. The arrangement of verandah at ground floor and loading/unloading platform (provision of chajja with suitable capacity of monorail and chain pulley block arrangement) at first floor above the verandah shall also be provided at both the opposite sides of the substation for equipment hoisting and entry purpose.
- 5.3 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 Epoxy flooring. False ceiling shall be provided in Substation except Switchgear Room.
- 5.4 The main entry for operating personnel shall be provided with double door system and airlock lobby. The substation shall also have required number of emergency door opening outwards as per relevant statutory norms of industrial building code/standard complying all the safety requirements for operating personnel.
- 5.5 The cable cellar shall have a minimum clear height of 3.5 m from finished floor level to bottom of cable cellar beam and shall house all cable trays and their supports. The minimum space for man movement below bottom most tray shall be 1.3 m. Cable cellar of each substation shall be provided with required number of exhaust fans for adequate ventilation (at the two opposite ends of the cable cellar to be considered as minimum). However, fire integrity of wall between outdoor bays and cable cellar / switchgear room shall not be compromised.
- 5.6 The substation switchgear floor shall have a minimum clear height of 4.5 m. For switchgear floor provided with false ceiling, the minimum clear height below false ceiling shall be 4.5 m.

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Further, for switchgear floor without false ceiling, the clear height may be increased beyond 4.5 m, as required to accommodate bus duct, HVAC duct / air pressurization duct, etc.

- 5.7 The cable cellar finished floor level shall be 500 mm above the approach road level and shall be paved and cemented. Transformer floor shall be at least 300 mm above the finished floor level of cable cellar room.
- 5.8 In addition to the entry to substation for operating personnel, a separate entry of minimum 3.5M (H) X 3M (W) with rolling shutter shall be provided for all equipment entry. The rolling shutters should be manually operated with gear box. The Sub-station shall also have an emergency door opening outwards.
- 5.9 Sub-station wall adjacent to the transformer bays and walls separating transformers shall be 355 mm thick (inclusive of plastering) in case of brick construction or 240 mm thick in case of RCC construction up to roof slab. RCC roof slab shall be provided for Transformer, Series Reactor, capacitor etc. The gate of Transformers shall be designed to prohibit bird entry.
- 5.10 Adequate number of Portable Fire Extinguishers of Dry Chemical Powder and Carbon dioxide shall be provided in suitable location in Substation, Transformer bays, Control room building etc. in addition to sand bucket as per CEA requirement. These extinguishers will be used during the early phase of fire to prevent its spread and costly damage.

All extinguishers shall be supplied with initial charge and accessories as required.

Portable type extinguishers shall be provided with suitable clamps for mounting on walls or columns.



All extinguishers shall be painted with durable enamel paint of fire red colour conforming to relevant Indian Standards.

Dry chemical powder type extinguisher shall conform to IS: 2171.

Carbon Dioxide type extinguisher shall conform to IS: 2878.



- 5.11 Sub-station building shall be without any columns within the switchgear room to ensure optimum space utilization.
- 5.12 20A single phase DP MCB with industrial socket shall be provided at every 20 metre interval in the switchgear hall.
- 5.13 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 for 33 kV GIS/11 KV/3.3 KV/415 V Switchboards:
  - a) Front clearance of 2.0 M for HV Switchboard including HV GIS.
  - b) The clear space of 1.5M at rear side of 11kV/3.3 kV Switchboard.
  - c) A clear space of 1.5M behind the double front switchboards and 1M for single front.
  - d) A clear space of 2.5M/2.0M between the two MV/LV boards facing each other.
  - e) A clear space of 2.5M on either side at entrance/exit.
  - f) A clear space of 1.0M between two boards in same line after future panel space of switchboard.
  - g) A clear space of 1M in switch room from top of equipment.
- 5.14 Each electrical substation shall be provided with a dedicated independent local HVAC system and a dedicated pressurization system (both systems required on N+1 redundancy). Switchgear Room, UPS & Battery Charger room, ECMS room, Control Room, Maintenance Room, Engineer Room, and Shift Office of each electrical substation



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shall be fully air conditioned through HVAC system dedicated for that particular substation. (as per Design Philosophy – HVAC System) with proper ducting arrangement for uniform cooling, however all the equipment shall be suitable for operation under specified ambient condition even on failure of air conditioning system. The substation shall have HVAC system, so that, the temperature inside the substation is maintained at 25 Deg.C in all conditions. Provision for remote alarm on failure of air conditioning system shall be provided. Indication of substation and control room temperature shall be provided. Heat load to be calculated on the basis of heat generation in the substation during peak summer period. Fire damper to be provided in the ventilation duct of the HVAC. There should be a separate room for installation of the HVAC Units located at ground floor.

- 5.15 Epoxy flooring of minimum thickness of 5 mm shall be done to reduce the heat load and improve the aesthetic look.
- 5.16 The battery room shall form a part of the sub-station. Battery room shall be provided with minimum n+1 flameproof exhaust fans and louvered opening in opposite wall/door. A sink with water tap shall be provided with water connection. Eye wash shower shall also be provided. Floor of the battery room and walls up to 2 M height shall have acid/alkali resistant protective epoxy coating. Light fittings, exhaust fan, on/off switches etc. in this room shall be chemical resistant type and flame proof type.
- 5.17 Location of battery charger shall be nearer to battery room.
- 5.18 To the extent possible Bus duct shall be in straight position. Bending of bus duct shall be avoided.
- 5.19 Staircases (with SS Handrail) and other rooms shall be paved with Kota stone.
- 5.20 Fixed type glass ventilators on all sides shall be provided near the ceiling height for natural lighting.
- 5.21 Arrangement shall be provided for lifting heavy equipment to be brought into the sub-station.
- 5.22 Sufficient nos. of entrances in line with National Building Code (min. 2) shall be provided for each floor.
  - a. All doors of sub-station shall be air-tight fire proof steel doors except doors of control rooms/ PLC rooms which may have anodised aluminium frame with toughened glass panel. All doors shall open towards exit.
  - b. Windows shall have anodised aluminium frame and provided with toughened glass.
  - c. In case height is more than 10 meters, elevators (of capacity for 10 persons) shall be provided. Elevator shall be suitable for the area of installation.
  - d. 1000 mm wide insulating mat as per latest IS standard of appropriate voltage grade shall be provided in front as well as rear of each panel.
- 5.23 The Sub-stations shall also have an emergency door opening outwards as per latest edition of National Building Code.
- 5.24 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: -
  - Transformers located in separate Bay/Room.
  - High Voltage Switch Boards
  - Power Control Centres
  - Power & Motor control centres
  - Emergency Power & Motor control centres
  - Motor Control Centres
  - Auxiliary Service Panel Boards

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- Lighting Transformer (Indoor / Outdoor as per requirement)
- Main Light Distribution Board
- Lighting Distribution Boards
- Lighting Sub-Distribution Boards
- Battery Sets
- Rectifier-Cum-Battery Charger
- Cell Booster
- DC Distribution Boards
- Rectifier-inverter Sets
- 240 V AC UPS System along with UPS distribution board.
- Neutral Earthling Resistors (Indoor / Outdoor as per requirement)
- Input / Output Panels
- VFD System
- PA System (Provision of space for PA system equipments in respective control room and other areas)
- HVAC System
- Any other equipment required

5.25 All static devices such as Rectifier-Cum-Battery Chargers, Variable Speed Drive Panels, Soft Starter etc., shall be housed in a separate room. Heat load for panel to be taken by panel manufacturer.

5.26 Separation walls between transformers in all substations and safe inter transformer distances for switchyard transformers shall be provided.

5.27 Transformers shall be located in bays adjacent to the sub-station building. All bays shall have oil drained floor, surfaced with gravel or other suitable material.

5.28 In order to prevent leaking oil from reaching and polluting the water bearing stratum, transformers shall have the following provisions, depending on the oil capacity of the transformer.

Oil Capacity up to 2,000 litres:

Transformers installed adjacent to sub-station shall be provided with oil soak pit with a layer of pebbles of about 40 mm granulation.

Oil Capacity exceeding 2,000 litres:

Transformers installed adjacent to sub-station shall be provided with oil collection pit and sump pit as per Drg. No. PC217-PDS: E 114 for draining away of any oil, which may escape or leak from the tanks, to a waste oil tank.

5.29 A clear space of at least 1.5 meter shall be maintained all around the transformers after installation of HVWS System.

High Velocity Water Spray (HVWS) System shall be provided for transformers fire protection having oil capacity more than 2000 Litres.

5.30 Separate common oil pits are required for Transformers.


The volume of common oil pit will be 125% of the volume of oil of the transformer, which contains the largest volume of oil in transformers.

The oil pit will be closed type of water-proof concrete construction.

The oil pit will be connected to individual pit under each transformer and drain line of each transformer will be at least 150 mm dia. pipe with a minimum slope of 1:96 as per TAC Regulation.

Transformer fire/drainage of oil will be considered for only one transformer at a time.

Level of pit will be so selected that there would not be accumulation of oil/water/oil-water mixture in the pit under each transformer.

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Pit shall be provided with 2 x 100% sump pump for common oil sump. 1 No. Portable sump pump shall also be provided.

Oil Pit under Transformer and its Cooler Bank: Gravel filled open oil pit will be provided under each transformer and its cooler bank. The pit shall be such that it can take oil/water surge of 20% of the volume of the transformer oil. Level of pit shall be such that there will not be accumulation of oil/water in the pit. The gravel size will be 60 mm. Each pit will be connected to the drain line leading to new common oil pit.

- 5.31 In all substations/MCC rooms, space for future extension of switchboards shall be provided. Two panel extension space on each side (for each bus section) shall be provided for all HV Switchboards, PCCs. 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 PMCCs, MCCs and ASPBs.

The HV switch boards and power control centres shall have sufficient number of spare feeders to the extent of 20% or 1 No., whichever is higher for each type & rating.

For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of 20% or 1 No., whichever is higher, for each type & rating shall be provided.

- 5.32 Fire protection for substations shall be provided to comply with requirements of 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 contradiction / conflict, most stringent specification shall be followed.

Substations shall be provided with smoke detectors and fire alarm system as specified elsewhere in the NIT and as per relevant Indian Standard.



- 5.33 Fire barriers shall be provided at cable/bus-duct entry/exit point. Cable shall have fire protection paint for 1 m length at building entry points and Panel entry points for above ground cables.
- 5.34 Air Pressurisation system for electrical substations shall be of dry type.
- 5.35 The ventilation equipment shall be designed to effect the required number of air changes per hour and supply fresh air (minimum 15 no air change/hour)
- 5.36 Two numbers (1+1) of blowers 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.
- 5.37 A positive pressure of 5 mm of water gauge shall be maintained within the area to be Ventilated.
- 5.38 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.
- 5.39 Refer our specification for ventilation (ES: 8205) attached.

## 6.0 PROTECTION & METERING

- 6.1 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.

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- 6.2 Protective relays shall be of latest version, numerical and communicable type with non-volatile memory, comprehensive unit providing protection, metering, control and communicable with communication port for interlinking with online energy/Load Management System. 100% redundancy shall be provided for communication i.e. the Relay should have minimum 2 Nos. IEC-61850 communication port in addition to Front Port. Numerical Relay shall have communication on IEC-61850 protocol in redundant mode and meters shall have communication on MODBUS protocol. Relay shall have 4 CT input for O/C and E/F protection. There should be option for derivation of E/F internally.
- Relay shall meet the requirement for withstanding electromagnetic interference according to relevant parts of IEC 60255 / IEC 61850. Failure of single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.
- The relay should support (tested for) IEC 61850 Edition 2 with parallel redundancy protocol as per IEC 62439-3 with two nos. of port and one additional port at front for local communication. Use of any type of converter is not acceptable.
- 6.3 The Numerical relay shall be provided with integral (no separate unit) arc flash protection system based on both current & light detection method. Relay should have provision of 3 nos. arc sensor, each for cable chamber, busbar chamber & circuit breaker chamber. Sensor shall cover any flash over occurring in the respective chambers. Facility should be there to adapt selective logic schemes for tripping only respective breaker or Incomer breaker.
- 6.4 The relay should support (tested for) IEC 61850 Edition 2 with parallel redundancy protocol as per IEC 62439-3 with two nos. of port and one additional port at front for local communication. Use of any type of converter is not acceptable.
- 6.5 Numerical relay shall indicate MWH, MVAR, MVA, V, A, Hz, PF. It shall have future provision for connecting with substation HMI. Separate multifunction meter with communication (for centralized energy monitoring) shall be used and shall not be part of protective device.
- 6.6 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.
- 6.7 LSTK Contractor shall supply licensed (lifetime) software along with required communication cables for Parameterization and viewing of disturbances, events, etc. through Laptop for all Make and models of Numerical relays. 1 No. Laptop complete (Minimum 8GB RAM, Minimum 1 TB hard Disk, latest processor) with all required software and accessories complete in all respect shall also be provided.
- 6.8 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.
- 6.9 In general all protection shall be through microprocessor based numerical. However high speed tripping relay shall be separate.
- 6.10 All Auto-changeover logic to be built in Numerical Relay. Numerical Relays shall have sufficient I/O to cater the same and there should be minimum 10 % spare I/O for future use. External I/O Card/ Module are not acceptable.
- 6.11 All Process Stop and other important Parameters shall be routed through Numerical relays for recording and Time-stamping. Hardware Annunciator is not required. Common Audio Visual Alarm for each Bus section of Switchboard shall be provided through Numerical relays.

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6.12 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:.



Protection devices for power distribution system shall be as indicated below (Figure inside bracket refers to note below) (YES – Applicable)

Sl. No.	Relay Description	Relay No.	HV Tr. Fdr. Sec Wdg. Volt=> 3.3 KV	HV Tr. Fdr. Sec Wdg. Volt< 3.3 KV	HV /LV Motor Fdr., HV Breaker controlled contactor controlled	O/G Bkr. HV Plant Fdr.	O/G Bkr. MV PMCC	I/C HV	I/C MV PMCC
1.	IDMTL Over-Current Relay	51	YES	YES	-----	YES	YES	YES (2)	YES
2.	IDMTL Earth-Fault Relay	51N	YES (4)	YES	-----	YES	YES	YES (2)	YES
3.	Standby / Backup Earth Fault Relay (earthed neutral)	51G (10)	YES (22)	YES (22)	-----	-----	-----	-----	-----
4.	Motor Protection Relay with (50, 50N, 46, 49, 50L/R, 95)	99	-----	-----	YES	-----	YES	-----	-----
5.	Instantaneous Restricted Earth Fault Relay (Earthed side)	64R (10)	-----	-----	-----	-----	-----	YES (22)	YES
6.	Instantaneous Over current Relay	50	YES	YES	-----	-----	-----	-----	-----
7.	Instantaneous Earth Fault Relay	50N	YES (5)	YES	-----	-----	-----	-----	-----
8.	Differential Protection Relay	87	YES (6)	-----	YES (7)	YES	-----	YES	-----
9.	High speed tripping relay	86 (18)	YES	YES	YES	YES	YES	YES	YES
10.	Trip Circuit Supervision Relay	95	YES	YES	YES	YES	YES	YES	YES
11.	Transformer Auxiliary Relay	63	YES	YES	-----	-----	-----	-----	-----
12.	Under Voltage Relay with timer	27 / 2	-----	-----	YES	-----	-----	YES (16)	YES (16)
13.	Check Synchronisation Relay	25	-----	-----	-----	-----	-----	YES (8)	YES (8)
14.									



#### Notes for Relay Protection Philosophy

- All the numerical relays shall be of communicable type and connected to ECMS on IEC 61850 (Ethernet based) communication protocol with time stamping and time synchronization.
- In case of HV switchboards with continuous parallel operation of incomers, following additional relays shall be provided:
  - One set of 87B (Bus differential) and 95 B (Bus wire supervision) for each bus section.
  - 32 (Directional IDMTL over current and earth fault) relays for the incomers.
- In case of grid power supply EHV incomer following additional relays shall also be provided:
  - Relay 21 for distance protection, Relay 59 for overvoltage protection with timer, Relay 67 for directional over current protection, Relay 67N for directional earth fault protection, Relay 81 for under frequency / df/dt protection and Relay 98 as dead bus charging relay.
  - Minimum protection relays for EHV Transformer shall be 50, 50N, 51, 51G, 51N, 63TX, 64R, 86, 87T, 87F & 95.



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4. Instantaneous earth fault (50N) shall be provided only for transformer with delta primary.
5. Directional IDMTL earth fault (67N) shall be provided for transformer with star primary.
6. For transformers rated 5 MVA and above.
7. For motors rated 1000 kW and above, excluding VFD fed motors.
8. Wherever auto-transfer feature is provided.
9. For switchgears where continuous or momentary paralleling of Incomers is envisaged, check synchronizing relay shall be provided.
10. 51G and 64R relays for input transformer of VFD system shall be decided by VFD Manufacturer.
11. The bus tie feeders in HV switchboards shall be provided with 51, 51N, 86 and 95 relays.
12. HV capacitor bank feeders shall be provided with 51, 51N, 59 (over voltage), 60 (Neutral displacement), 86 and 95 relays.
13. The following feeders shall be provided with timers for delayed tripping on bus under voltage while the under voltage relay shall be common for the bus
  - a. HV and MV capacitor feeders.
  - b. HV and MV breaker controlled motor feeders.
  - c. Contactor controlled motor feeders with DC control supply.
 Numerical relays where ever provided for motor and capacitor feeders shall use in built under voltage relay and timer for delayed tripping on bus under voltage.
14. One no. DC supply supervision relay (80) shall be provided for each incoming DC supply to the switchboard.
15. In case of numerical relays, all relays shall be comprehensive units including all protection, metering and control.
16. Under voltage and over voltage function along with associated timer shall be part of the numerical relays.
17. Auto changeover scheme control & logic between Incomers and bus coupler shall be built in the numerical relay.
18. Tripping relays (86) shall be separate relay. There shall be two nos. high speed tripping relay for motor feeder. One for electrical fault and one for process fault. Electrical fault relay shall be hand reset type and process fault relay shall be self reset.
19. Breaker control switch shall be hardwired type.
20. Stand by earth fault relay 51G shall be provided in the incomer of switchboard fed from transformers where transformer & switchboard both are located remotely from HV substation as well as in same HV substation.
21. For transformers located remotely away from HV Substation, a local power isolating device in the form of breaker panel without any protection relay shall be provided before transformer. A local emergency stop push button (Lockable) shall also be provided in transformer bay for tripping remote breaker.
22. Restricted earth fault relay 64R shall be provided for transformer rating  $\geq 1$  MVA in the incomer of switchboard fed from transformers having secondary winding star connected. This shall trip the HV side breaker.
23. Relay 87 and 64R shall be separate numerical relay. Hence shall not be part of main comprehensive numerical relay. CT for 87 and 64R can be clubbed, as two core of single CT.
24. Accuracy class of the current transformers shall be
  - Class PS for differential and special requirements.
  - Class 0.5 / 0.2 S for metering purpose.
  - Class 5P20 for protection purpose
 All the CTs shall have rated burden of minimum 15 VA and secondary rated current of 1 A.
25. Accuracy class of the potential / voltage transformers shall be
  - Class 5P for protection purpose.
  - Class 0.5 / 0.2 S for metering purpose.

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All the PTs shall have secondary voltage 110 V or 110 V / sqrt.3 and rated burden of minimum 50 VA per phase for both metering and protection core.



26. All the incoming, outgoing and tie breaker feeders of any HV & MV Switchboard shall be provided with numerical relays only with communication facility as protection devices. Releases shall not be acceptable in any case.
27. Numerical relays in all HV motor feeders shall be suitable for RTD / BTD inputs.
28. Each bus section shall be provided with separate under voltage relays.
29. Multifunction meter shall be provided to keep a record of power consumption and supervision of all concerned parameters like current, voltage, power, frequency, power factor etc. as specified. All the metering instruments shall be flush mounted.
30. Separate Communicable Digital Multifunctional meters shall be provided in all feeders with Numerical Relays for communication with ECMS system.
31. Motors shall also be provided with Unbalanced (-Ve) Sequence Protection Relay (46), as required.
32. Numerical under voltage relays (27) with time delay relay including VT fuse failure relay shall be provided for Bus VTs.
33. All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with display.
34. No Meters, transducers or measuring equipments to be installed in the Protection CT circuit.
35. Cable Differential relays for both the end to be supplied by Downstream user contractor i.e. LSTK Contractor. Cable Differential relay will be of Fiber Optic Cable based communication only.
36. All required Alarms and Trips shall be incorporated in the Numerical relays. Sufficient LED shall be available in the Relays.
37. Trip Circuit Supervision relay shall be part of Numerical relay.
38. All Motors above 55KW and Outgoing Feeders above 100A shall Earth Fault protection with CBCT and Digital Earth Fault Relay with display.
39. Capacitor Feeder: 59, 27, 50, 51, 50N, 51N, 60, CBFP etc.
40. Main HV (33KV/11KV/ 3.3KV) Incoming Panel in each substation shall be provided with line differential protection between sending end and receiving end.
41. All accessories and connecting equipment required for FO cable connection shall be provided in switch board.
42. Ethernet Switch in cubicle of both bus shall be provided and all relays shall be connected to Ethernet Switch.

- 6.13 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 for Load management at remote location. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated below :

The metering devices in HV and MV switchboards shall be as below:

- Type of metering: Analogue/As part of the Numerical relay  
(Figure inside bracket refers to note below) (YES - Applicable)

Sl. No.	Feeder type	A	V	Hz	PF	MW	MWH	HM	MVAR	MVAH	MVA
1.	HV Incomer	YES	YES	YES	YES	YES	YES	----	YES	YES	YES (1)
2.	HV Bus Tie	YES	----	----	----	----	----	----	----	----	----
3.	HV Transformer	YES	----	----	----	YES	YES	----	----	----	----
4.	HV Bus PT	----	YES	----	----	----	----	----	----	----	----
5.	HV Plant Feeder	YES	----	----	----	----	YES	----	----	----	----
6.	HV Motor	YES	----	----	----	----	YES (kWh)	YES	----	----	----

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7.	HV Capacitor	YES	YES	----	----	----	----	----	YES	----	----
8.	PMCC Incomer	YES	YES	----	YES	----	YES (kWh)	----	----	----	----
9.	PMCC Bus Tie	YES	----	----	----	----	----	----	----	----	----
10.	PMCC Bus PT	----	YES	----	----	----	----	----	----	----	----
11.	ACB Outgoing (Non Motor)	YES	----	----	----	----	YES (kWh)	----	----	----	----
12.	MV Motor (>55 KW)	YES	----	----	----	----	----	----	----	----	----
13.	MCC / ASB Incomer	YES	YES	----	----	----	----	----	----	----	----
14.	MCCB O/G (250A and above)	YES	----	----	----	----	YES (kWh)	----	----	----	----
15.	MLDB Incomer	YES	YES	----	----	----	YES (kWh)	----	----	----	----

**Notes for Metering:-**

1. MVA meter in external power supply incomers shall include maximum demand indication also.
2. Separate analogue type voltmeters with voltmeter selector switch and analogue type ammeters with ammeter selector switch shall be provided for incomers of all switchboards.
3. Ammeter (size 48mm x 48mm) shall be provided in space heater circuit of breaker fed HV & MV motors.
4. Apart from metering which shall be part of the numerical relays, Communicable digital multi-function meters of Accuracy Class 0.5/ 0.2( for Incomers only with suitable Metering CT shall be provided in all the breaker feeders of HV & MV Switchboard i.e. in incomers, bus coupler, outgoing plant feeders, transformer feeders, motor feeders, capacitor bank feeders, etc.
5. Multi function meters with serial communication over RS-485 or fiber optic cable, preferably with IEC protocol shall be provided in all the breaker feeders.
6. Power factor meter shall be provided for synchronous motors in addition to the metering provided for induction motors.
7. For current feedback to DCS/PLC and VFD feeders motor current transducers shall be provided and mounted in switchgear panel.
8. CT operated Ammeter for all motor feeders above 5.5 KW, all MOV and LOPs shall be provided at both LCS and feeder end of switchboard.
9. All ammeters for LV motors shall be connected through CT. Only HV motors shall have 3 ammeters or ammeter selector switch or Voltmeter and Voltmeter Selector Switch.
10. Hour run meter shall be provided in all breaker controlled motor feeders.



## 7.0 CONTROL AND MONITORING

The following provision shall be made for control and monitoring of following electrical equipments.

### 7.1 Transformers

- TNC switch in primary & secondary side of switchgear.
- Emergency trip from secondary side for tripping primary side of transformer.
- VCB with all required protection to be considered in all the 11kV & 3.3kV switchboards..
- Lockable 'OFF' push button in transformer room to trip sending end switchgear.



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- Indication lamp for 'ON' 'OFF' 'Auto-trip', 'Non-trip' and 'Trip Circuit Healthy', 'Ready to Close', 'Ready for Service', 'Test', 'Service', 'Space Heater ON'.
- Ammeter and voltmeter on both primary and secondary side.
- Load break switch with Earthing Switch on transformer primary side (only where primary side circuit breaker is not located in the same sub-station).

## 7.2 Motors Controlled Through Circuit Breakers

- TNC switch, L/R Switch with Ammeter on LCS
- Current monitoring at DCS/PLC through Dual Channel Current Transducer with Display facility installed at switchgear end, where required from process point of view.
- Indication Lamps in switchgear for 'ON', 'OFF', 'Auto-trip' and 'Trip Circuit Healthy', 'Ready to Start', 'Ready for Service', 'Test', 'Service', 'Space Heater ON', 'Space Heater ON for Motors'
- Emergency trip in switchgear.
- Winding and bearing temperatures of motors shall be available at DCS in control room.
- Process interlock in CCR, where required.
- Control and Feedback for Motor Start & Stop command, Trip Indication, ON Indication, OFF Indication, Local / Remote Indication and Ready to Start Indication in remote (DCS/PLC etc.)
- Motors controlled through Circuit breakers should also be provided with ammeter, KVAh, KWH and running hour counter. These shall be incorporated in Numerical relay or Multi-function Meter.

## 7.3 Medium Voltage Motors Controlled Through Contactors



- Start & Stop Push Button (Mushroom Stay Put Type) with Ammeter, Local/Remote switch on LCS.
- Current monitoring in DCS, where required from process point of view.
- Emergency Trip in PMCC/MCC.
- Process interlock in CCR, where required shall be wired through separate auxiliary relay.
- Indication lamp for 'ON', 'OFF', 'Ready to Start' and 'Fault' in switchgear.
- Control and Feedback for Motor Start & Stop command, Trip Indication, ON Indication, OFF Indication, Local / Remote Indication and Ready to Start Indication in remote (DCS/PLC etc.)
- Motor space heater & Panel board space heater shall be provided with Ammeter & LED in Switchgear.
- All Motor feeders of PMCC & MCC (irrespective of Rating) shall have door mounted communicable (Modbus / Profibus) type Motor Protection relay (MPR) with Earth fault protection and display.

## 8.0 EQUIPMENT SPECIFICATION

### 8.1 General Features

- #### 8.1.1
- The equipment shall be suitable for tropical climate conditions and corrosive and saline atmosphere.

All electrical equipment accessories and wiring shall have fungus protection involving special treatment of insulation and metal against fungus, insects and corrosion.



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Fine mesh screen of corrosion resistant material, preferably SS shall be furnish on all ventilating openings to prevent entry of insects.

- 8.1.2 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.
- 8.1.3 The equipment including motors to be installed in outdoor plant area shall have IP 55 enclosure.
- 8.1.4 4 mm FRP (fire retardant and UV stabilized) canopies shall be provided for all outdoor equipments like motors, starters, LCS, SDBs, sw. sockets etc.
- 8.1.5 All the water plants being highly corrosive - Cable tray ,LCS, Junction boxes, Lighting JB and Lighting poles in plant area shall be strictly of FRP with SS fasteners only to avoid corrosion
- 8.1.6 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.
- 8.1.7 Creepage distance shall be 31mm/kV (for highest system voltage) for all equipment.
- 8.1.8 Cable glands shall be used for termination of cables in all equipment. Single compression glands and double compression glands shall be used for indoor & outdoor use respectively. The material of glands shall be nickel plated brass and aluminium for multi core and single core cables respectively. The lugs shall be of tinned copper type. Lugs shall be of the same type as that of cables and bus bars. If cables & bus bars are of different metals, then bimetallic lugs have to be used to avoid junction heating.
- 8.1.9 Clamp type terminals shall be acceptable for wires up to 10 mm<sup>2</sup> size, for conductors larger than 10 mm<sup>2</sup>, bolt type terminals with tinned copper compression type crimping lugs shall be provided for all power and control cables termination purpose.
- 8.1.10 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.
- 8.1.11 All similar equipment ( viz. HV Switchboard, LV Switchboard – PCC, PMCC, MCC, EPMCC, ASB, LDB, DCDB, Transformers, Numerical relays, UPS, Battery Chargers, Motors, etc.) supplied against a package should be of single Make only – for ease of O&M and spare management.

## 8.2 Power Transformers

- 8.2.1 The transformers shall be double wound, copper conductor, and Dyn11 type. Transformers shall rated for 33KV/11KV, 11/3.45 kV, 11/0.433 kV, as required. Transformer with 3.45 KV Secondary winding shall be considered for the substation only, where 3.3 KV switchboards is to be installed for feeding 3.3 KV motors.
- 8.2.2 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 above continuous peak load.
  - 30% spare capacity in LV transformers above continuous peak load.
- 8.2.3 The rating of power transformers shall be selected keeping following into considerations:
  - (a) Duty : Continuous
  - (b) Outdoor type : ONAN/ONAF (ONAN rating shall have 25% spare capacity above continuous peak load. ONAF rating shall be minimum 15% above ONAN rating).
  - (c) Indoor type : Dry Type

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Epoxy cast resin/ resin encapsulated type

- (d) Maximum loading : 80% when one of the transformers is out of service
- (e) Peak efficiency at : 35% - 40% of load
- (f) Class of Insulation : B or better for oil filled  
: F limited to b or better for dry type

8.2.4 Maximum temperature rise over ambient of 50 Degree Celsius shall be limited to:

- (a) Outdoor transformers:
  - Top oil (measured by thermometer) : 50 ° C
  - Winding (measured by resistance) : 55 ° C
- (b) Indoor transformers:
  - Winding (by resistance method) : 90 ° C or lower as permissible for class of insulation offered

8.2.5 Special consideration shall be given in specifying the percentage impedance of the transformers to suit the switchgear short-circuit capacity available.

8.2.6 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, Standby Earth Fault, Restricted Earth Fault ,Differential (for sizes of 5 MVA and above), \*Buchholz Alarm and Trip,\*Winding Temperature Alarm,\* Trip, \*Oil Temperature Alarm, \*Oil Level Alarm& Trip, \*Trip for Winding Temperature and Oil Temperature. All protection except REF shall be provided on secondary side, if the primary side circuit breaker is located in other sub-station. REF protection shall trip the primary Inter-tripping of primary and secondary circuit breaker of transformer shall be provided for all faults through lockout relays.

CT for Restricted Earth Fault protection shall be provided inside the transformer.

8.2.7 High Velocity Water Spray (HVWS) System shall be provided for transformers fire protection having oil capacity more than 2000 Litres and rating up to 20MVA.

8.2.8 Following Push buttons shall be provided for transformers :


- Lockable 'OFF' push button in transformer room to trip the breakers on primary side.
- Push button shall be provided on breaker on secondary side for permission to close breaker on primary side
- Emergency trip PB on breaker on secondary side for tripping breaker on primary side of transformer.

8.2.9 The instruments such as OTI/WTI, Buchholz relay and MOG shall have Magnetic Reed Switches. The mercury switch contacts are not acceptable.

8.2.10 For all transformers, conservators shall be provided with Magnetic Oil Gauge (MOG) having 1NO contact activated on Low oil level. For transformers above 2000KVA , Air cell shall be provided in the conservator.

8.2.11 Transformer rooms shall have roof slab.

8.2.12 Routine test on all transformers and heat run test on one transformer of each rating shall be performed in presence of Owner/Consultant.

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8.2.13 All Routine, Heat Run Tests shall be performed in compliance with B.S.171, IEC publication No.60076, IS 2026 (parts I to V), CBIP and IS: 2026 (Part III) including SFRA Test before dispatch from Manufacturer's works and at erection site during commissioning or latest editions or any other authoritative standard. Certificates for Type Tests on similar type Transformers shall be submitted.

8.2.14 All Power transformers above 5 MVA shall have facility for Remote display (in ECMS) of Oil Temperature, Winding temperature, Conservator Oil Level and moisture ppm of Oil through 4-20 mA signal / Modbus communication.

8.2.15 Transformers shall be Energy Efficiency Level 2.

8.2.16 For all other specification refer PC217-TS-0803.

### 8.3 Neutral Earthing Resistor (NER)

8.3.1 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.

8.3.2 Neutral earthing resistor shall be outdoor type made of AISI 304/406 punched stainless steel grid element. 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.

8.3.3 All NER not requiring operation shall be provided with isolator.

8.3.4 For all other specification refer PC217-TS-0804.

### 8.4 Switchboards

#### 8.4.1 General

8.4.1.1 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.

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.

Breaker duty cycle shall be O-0.3sec-CO-3min-CO.

Separate CT shall be provided for differential/REF protection.

LV circuit breaker shall be 4 Pole type except for outgoing motor feeders which shall be 3 Pole type.

8.4.1.2 Suitable shutter arrangement shall be provided to protect the person from accidental contact with live bus in trolley chamber.

8.4.1.3 Switchgear structures shall be self-ventilating and shall be designed and constructed to facilitate inspection, cleaning, repair and maintenance and to ensure absolute safety during operation, inspection and maintenance.



8.4.1.4 Unless otherwise specified, switchgear line up shall be front and rear accessible with hinged doors suitable for padlocking on both front and rear. Access to breakers, control compartments and control cable terminations shall be from the front, while rear access is required for power cable terminations.

8.4.1.5 All protection and metering CTs, PTs shall be easily accessible for testing, maintenance and replacement.

8.4.1.6 Ethernet switch with 10% spare ports on each bus of each switch board & all internal wiring up to Ethernet switch shall be provided in each switch board.



8.4.1.7 It shall be compatible with connection to Plant LMS/ECMS system.

8.4.1.8 The degree of protection shall be IP 4X for HV switchboards and IP 52 for LV Switchboard up to 1600A rating and IP-4X for LV switchboards above 1600A rating.



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- 8.4.1.9 All HV, MV & LV Switchboards/GIS shall be LOTO compliant.
- 8.4.1.10 33 kV GIS, 11 kV & 3.3 kV Switchboard shall conform to IS/IEC 62271-200, IAC-A FLR-50KA/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. LV switchboard shall conform to IEC 60947. All 3 compartments (Busbars, Circuit breaker & Cable compartment) shall be tested for Internal arc for the said rating.
- 8.4.1.11 The observation window on the CB compartment door shall be made of special toughened/ laminated glass substantiated in type test reports as proving it arc proof. Observation window shall be of same material and construction as the type tested design/construction as specified in IEC.
- 8.4.1.12 Each cubicle shall be equipped with anti-condensation heater controlled by thermostat.
- 8.4.1.13 Each HV compartment should have individual exhaust channel / pressure relief flaps to let out over-pressurized hot gases at the top of the switchboard in case of an internal fault. Suitable factory fitted arc duct arrangement shall be provided for venting out the arc out of the switchgear room.
- 8.4.1.14 Front access doors with single action operator will be provided to the HV circuit breaker compartment and LT Relay compartment. Bolted type CB door locking arrangement shall not be accepted.
- 8.4.1.15 For one no. complete switch gear, separate one no. Earthing truck with breaker each for bus and feeder earthing to be provided for one no. complete switch gear.
- 8.4.1.16 An electro-mechanical device shall be provided to ensure the auxiliary circuits have been securely connected between the fixed and moving portions of the switchgear, before allowing closing operation of the circuit breaker. The voltage rating of the device shall be the same as the voltage used for the closing circuit.
- 8.4.1.17 Tripping and closing coils shall be of continuous rated type to ensure longer life. All Feeders of 11 KV shall have Double Trip coil for safety.
- 8.4.1.18 Circuit breakers shall be provided with a mechanically operated visual indicating device to display the circuit breaker switching state and a mechanical operation counter.
- 8.4.1.19 The circuit breaker operations of closing and opening shall be possible with the circuit breaker compartment door closed.
- 8.4.1.20 It shall be possible to trip the circuit breaker locally by mechanical means. Voltage Transformer (VT) shall be cast-resin with built-in primary fuses, VT's shall be draw out type.
- 8.4.1.21 Voltage transformer shall be independent of circuit breaker carriage
- 8.4.1.22 Electrical interlocks and castle key interlocks shall be provided between Bus-bar Earthing Switches and all Bus-bar Isolators of each Bus-bar Section in such a way that Bus-bar Earthing Switches cannot be closed when the Bus-bar Isolator of any circuit in the section is closed.
- 8.4.1.23 Bus VT Miniature Circuit Breaker (MCB) ON auxiliary contacts and under voltage relay contacts shall be monitored in the interlocking scheme to confirm the dead bus condition.
- 8.4.1.24 All CT & PT must be suitable for continuous operation of min. 20 % overload and for service under all rated and fault conditions.
- 8.4.1.25 Only ring type lugs shall be used in CT secondary connections at the CT end and the relay end.
- 8.4.1.26 Current transformers shall be in accordance with IEC 61869-1 & 61869-2. The rated output shall match the requirements of the equipment connected. The secondary current rating shall be 1 A, Unless otherwise specified, cores for measuring instruments shall have accuracy classes of not more than 0.5 % and saturation factors less than 5.





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- 8.4.1.27 Secondary terminals of current transformers shall be wired up to a terminal block with short-circuiting links, located at an accessible place. At this terminal block one side of each transformer shall be connected to earth.
- 8.4.1.28 The CT rating plate and the terminals must be accessible after the Power cables have been installed.
- 8.4.1.29 LV switchboard (EPMCC/PMCC/MCC) 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.
- 8.4.1.30 LV switchboard (PMCC/EPMCC/MCC) shall comply with Internal Arc Containment test as per IEC 61641.
- 8.4.1.31 The bus bars and connection shall be made of electrolytic grade copper only. Aluminium bus bars are not acceptable. All bus bars of 11kV & 3.3kV switchgear including bus duct shall have Raychem sleeving suitable for Line to line voltage . Proper shroud to be provided in the joints.
- 8.4.1.32 Tripping and closing coils shall be of continuous rating type.
- 8.4.1.33 Clearance between gland plate to cable termination point in all switchboards shall be adequate but not less than 300mm to ensure proper cable termination.
- 8.4.1.34 FRP supports shall be used for bus bars with adequate clearances and creepage distance to prevent flash over due to effect of dust moisture.
- 8.4.1.35 Protective relays shall be mounted on the front of the switchgear panel.
- 8.4.1.36 All logic like, Auto/Manual changeover etc. shall be built-in the Numerical relay. Adequate number of I/Os shall be provided to meet the requirement. 10% spare I/Os shall also be provided. External I/O Card/ Module are not acceptable.
- 8.4.1.37 All relays used for protection shall be microprocessor based numerical type only with latest communication protocol IEC-61850 and shall have large graphical display. All relays shall have coating for protection against harsh environment conditions. All numerical relays shall be of one make only. Selected models of numerical relays shall have metering, control, status and protective functions. It shall be possible to save minimum 5 records of each event. Important functions and features, in addition to the fault measuring capabilities, shall include:
- Programmable scheme logic,
  - Remote communication interface for setting / interrogation from ECMS,
  - Local communication interface (HMI-keypad and / or serial PC communication),
  - Time-tagged events, fault and disturbance records,
  - Display of measured/processed quantities,
  - Self-monitoring (Hardware / Software),
  - Inter-protection communication,
  - Electronic transducer communication
- 8.4.1.38 All protection relays shall be provided with test plugs and all CT, VT wiring shall be wired through the test plugs in HV, MV & LV Switchboards.
- 8.4.1.39 The protection scheme(s) shall include all hardware and software to permit remote setting / interrogation / fault evaluation from the ECMS (engineering) workstation or from the computer monitoring system.
- 8.4.1.40 All protection relays shall be equipped with communication port using IEC protocols to work as an integrated part of the ECMS hierarchy. Should the relay schemes be offered

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from multiple Bidders / Contractors, all third party user interface software products shall be supplied to the ECMS platform to bring together all types of protective relaying into a unified control system hierarchy.

- 8.4.1.41 Completely separate and isolated circuits shall be used for Switchgear control, tripping / protection, alarms, and auxiliary devices. These circuits shall have separate control power buses and feeders, suitably protected, for each power bus section.
- 8.4.1.42 Each control circuit shall be protected by a two-pole miniature circuit breaker with auxiliary N/C contact. The auxiliary contacts of all MCB's of the same circuit type, e.g. circuit breaker motor control, disconnect switch motor control, alarm, space heater, trip, etc., shall be wired in series to a group / common alarm terminal.
- 8.4.1.43 Each 11kV & 3.3kV outgoing/incoming and transformer feeder control panel shall include voltage detectors to indicate phases "ALIVE". The voltage detectors shall be connected to each phase on the cable side.
- 8.4.1.44 LSTK contractor shall supply minimum 1No. laptops with licensed software for communication & configuration of all make& Type of Numerical Relays.
- 8.4.1.45 GPS system and associated hardware & software shall be provided for synchronisation of clocks of numerical relay and metering LA&ECMS
- 8.4.1.46 All meters shall be digital multifunctional meters with backlight LCD display and communication port. Additionally digital type ammeter, voltmeter and Hour Meter shall be provided separately for various feeders as indicated above.
- 8.4.1.47 All the motor / capacitor feeders controlled through vacuum circuit breakers shall be provided with surge arrestors. Lightning Arrestor (LA) shall be provided on each bus of 11KV Switchboard.
- 8.4.1.48 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.
- 8.4.1.49 Control supply bus and space heater supply bus-bars (Copper) of adequate rating shall be provided throughout the length of switchboards with as many sections as sections in power bus-bars.
- 8.4.1.50 Control supply shall be tapped from control bus in each cubicle/ panel itself through DP MCB of suitable rating.
- 8.4.1.51 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
- 8.4.1.52 A bottom channel of not less than 100 mm shall be provided.
- 8.4.1.53 Mounting height of components requiring operation and observations shall not be lower than 300 mm and higher than 1800 mm from FFL of substation.
- 8.4.1.54 The switchboards shall have adequate short-circuit ratings and be suitably sized for the load and spare capacity foreseen. The short time rating of bus bar shall be 3 seconds for HV switch boards and 1 second for other boards.
- 8.4.1.55 For other boards (PMCCs, MCCs, MLDBs, ASPBs, DCDBs etc.) sufficient number of spare feeders to the extent of min. 20% for each type & rating shall be provided.
- 8.4.1.56 The 415V switch boards shall have PVC insulated bus bar system suitable for rated voltage. At joints of these bus bars removable shrouds shall be provided.

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8.4.1.57 All HV & LV Switchgear, UPS, Battery Charger etc. shall have Ethernet/Network Switches and other communication equipments.

8.4.1.58 For interfacing with DCS system, separate marshalling panels (with 20% spare terminals) shall be provided on each bus section in all HV & MV switchboards in the same panel line-up. The marshalling panels shall be of full height same as that of switchboards. The horizontal bus bar chamber at the top shall be continuous through this marshalling panel also, for future extension of the MV switchboard. All critical control signals for DCS interface shall be hardwired between substations and DCS. Other non-critical data of Electrical system will be sent to DCS with redundant communication facility between DCS and ECMS.

Hardwired signals (with minimum requirement specified below) from various Motor feeders of a bus section for DCS interface shall be wired and terminated in the marshalling cabinet:

- DCS Start permissive
- Process Start command (Auto)
- Remote Start command (Manual)
- Process Stop command
- Process Trip command (for breaker controlled motor feeder)
- Breaker/Contactor 'ON' indication
- Breaker/Contactor 'OFF' indication
- Ready to Start indication
- Electrical Fault Trip indication

8.4.1.59 Following monitoring signals, as a minimum, shall be taken from substation to DCS interface, through redundant MODBUS SERIAL LINK communication from ECMS system.

- Load Data viz. KW, PF, A, etc.
- L/R indication
- Process Trip indication
- Electrical Fault Trip indication
- Trip Details

8.4.1.60 Auto changeover scheme shall be provided for incomers and bus couplers on all 11 KV switch boards, 3.3 KV switch boards and PMCCs/PCCs/ MCCs. Under normal operating conditions, incomer-1 and incomer-2 breakers would be closed and bus coupler breaker would remain open with 'auto-manual' switch in 'auto' position. The bus coupler switch would close automatically under the following condition being fulfilled:-

- i. Either of the incoming breaker trips due to under voltage (70% or below).
- ii. Voltage on the healthy bus is more than 80% for the set period.
- iii. Residual voltage on the bus with no power supply comes down to 30%.
- iv. Auto change over shall be locked on loss of power on both the incomers.
- v. Auto changeover shall not occur in case of fault on the incomer.

Auto changeover shall also be provided on switchboards catering to emergency loads.



8.4.1.61 Paralleling of two incoming feeders is not foreseen. However, facility for momentary paralleling shall be provided for intentional changeover without interruption of supply.

8.4.1.62 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.

8.4.1.63 Separate redundant AC and DC control supply shall be provided for each Switchboard.

8.4.1.64 Control supply for contactor motor starter and contactor feeders in 415V Switchboards such as PMCC/EPMCC/MCC etc. shall be feed from 240V AC supply which shall be internally tapped from 240V AC control supply bus. This control supply bus shall be fed





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from suitably rated 415/240V control transformer. Control Transformer shall be provided for each bus section of 415V Switchboard and each control transformer shall be suitable for taking the control supply load of all the buses and motor controlled with breaker shall have 110 V DC control supply irrespective of its being HV or LV.

- 8.4.1.65 Control Supply for VFD Panel / Soft Starter Panel / Thyristor Panel shall be 240V AC UPS supply.
- 8.4.1.66 For motors with auto-starting provision, trip of a running motor shall start standby motor automatically.
- 8.4.1.67 All the HV/LV 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.
- 8.4.1.68 Max. 3 runs of 400 sq.mm power HV cable shall be terminated in single panel. For more than 3 runs of cable complete dummy/adaptor panel shall be provided.
- 8.4.1.69 The CB ON and OFF lamp shall be provided at rear and front side of 11kV/3.3kV switchboards.
- 8.4.1.70 All breakers service ON/OFF contact multiplier contactors shall be mechanically latched type and independent of control supply. Loss of supply and restoring the supply shall not affect the status of the relay/ contactor.
- 8.4.1.71 All breakers shall be electrically operable and mechanical operation from the breaker shall be possible locally. Manual breakers are not acceptable.
- 8.4.1.72 Separate Ammeter shall be provided for panel and motor feeder Space heater circuit for each panel.
- 8.4.1.73 The terminal strips used shall be of stud and nut type and control wiring shall be done with ring type lugs only.
- 8.4.1.74 Dual channel output with display type current transducer for all HV and LV switchboard feeder shall be provided requiring Ammeter at control panel.
- 8.4.1.75 All motor (HV/LV) power feeders shall have separate earth fault protection through CBCT and earth fault relay. LV motor (above 55KW) and power feeder above 100A shall have CBCT and Digital earth leakage relay with display.
- 8.4.1.76 All external hardware shall be of stainless steel only.
- 8.4.1.77 The control compartment and power compartment shall be separate.
- 8.4.1.78 Following Set of accessories as detailed below shall be provided for each 11kV/3.3 kV Switchboard :
  - a) Breaker handling trolley – 2 Nos.

Following Set of accessories as listed below shall be provided for each 415 V Switchboard:

- a) Breaker lifting and handling trolley: Minimum 2 nos.
- b) Test cabinet with coupling cables for testing the breaker in draw out position: Minimum 1 No.
- c) Racking in/out handle for breakers: Minimum 4 nos.
- d) Racking in/out handle for draw out MCC modules: Minimum 2 for each MCC
- 8.4.1.79 Alarm relays with reverse flag shall be provided to annunciate failure of main incoming A.C. and D.C. power supplies and annunciation D.C. supply in each panel. Lamp indications shall be provided individually for main D.C. supply-1 fail, main D.C. supply-2 fail, and panel annunciation D.C. supply fail. A common A.C. electric bell shall be provided to give an audible alarm in case of failure of D.C. supply-1/D.C. supply-2/annunciation



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D.C. supply in any panel. A common push-button shall also be provided for cancellation of lamp indications and audible alarm.

- 8.4.1.80 Gland plate for single core cables shall be non-magnetic.
- 8.4.1.81 For all other specifications, refer PC217-TS-0805, PC217-TS-0806, PC217-TS- 0808 and PC217-TS-0809.
- 8.4.1.82 Separate panel shall be considered for incomer Line PT& Bus PT (11 kV & 3.3 kV Switchboards) and PT shall be draw out type. 4 pole MCB shall be provided on LV side of Bus &Line PT.
- 8.4.1.83 Inspection window shall be provided for HV termination in the switchboard for carrying out thermography, provided internal arc test certificates for this design is available with the bidder.
- 8.4.1.84 All Incomers and bus couplers shall be provided with synchronising facility. Synchrocheck relay shall be provided in each bus PT & contacts shall be multiplied and wired in each outgoing feeders of each bus section.
- 8.4.1.85 Supervision of installation, testing and commissioning including testing of Relays of all switchboards shall be done through OEM only.
- 8.4.1.86 All Cable Differential Relays shall be FO Cable type only. Supply & termination of the FO cable & associated HDPE duct, as required, for feeder differential protection shall be included LSTK Contractor's scope.
- 8.4.1.87 Similar make of numerical relays shall be preferably installed for a particular voltage level i.e.
- Similar make for HV-11kV & 3.3kV level
  - Similar make for LV-415Vlevel.
- 8.4.1.88 11kV & 3.3kV Circuit Breaker shall have integrated earth Switch with proper Mechanical& Electrical Interlocks& Electrical Interlocks.
- 8.4.1.89 11kV & 3.3kV Breaker rack in rack out facility should be operable only when breaker panel door is closed position.
- 8.4.1.90 LV Switchgear design shall be such that the feeder doors should not open in locked out tagged out condition.

#### **8.4.2 33 KV GIS Switchgear**

- 8.4.2.1 The 33 KV GIS switchgear shall be indoor, GIS metal enclosed.
- 8.4.2.2 The switchgear shall be an indoor gas-insulated, metal clad cubicle design with single/double bus bar system, assembled to from free standing, self supporting dead front structure. Vertical units shall be assembled to from a continuous line-up of uniform height. It shall be designed to ensure optimum continuity and reliability of supply as well as safety during operation.
- 8.4.2.3 LV compartment frame shall be fabricated using 2mm CRCA sheet steel while doors and covers shall be made from 1.6mm thick CRCA sheet steel.
- 8.4.2.4 The degree of protection shall be at least IP65 for gas compartments and IP4X for supporting frames, low voltage and other compartments as specified in IS/IEC 60529. All openings, covers and doors shall be provided with suitable Neoprene/ XLPE/ EPDM gaskets around the perimeter to make the switchgear dust and vermin proof.
- 8.4.2.5 The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Any fault shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear.

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- 8.4.2.6 The thermal design of switchgear shall be suitable for insulation of the switchgear in poorly ventilated conditions.
- 8.4.2.7 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. 33 kV GIS Switchgear shall be Internal Arc Classified (IAC) type AFLR minimum, tested as per IS/IEC 62271-200 for internal arc up to the GIS rated short circuit current (40 kA) for duration of 1 second.
- 8.4.2.8 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy, indications. Process trip lamp/annunciator window to be provided wherever applicable.
- 8.4.2.9 Control supply shall be 110 V DC.
- 8.4.2.10 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 33 kV GIS Switchgear.
- 8.4.2.11 For all other specifications, refer PC217-TS-0801.

### 8.4.3 11 KV Switchboard

- 8.4.3.1 The 11 KV switchboard shall be indoor, metal enclosed, draw out type, equipped with VCBs, stored energy mechanism working on 110 V DC and shall feed power to the various substations through transformers and other outgoing feeders.
- 8.4.3.2 Degree of protection shall be IP4X as per IS/IEC 60529, IEC 60298. Switchgear sizes and configuration shall be rationalized to minimum spare holding.
- 8.4.3.3 A study shall be conducted by LSTK Contractor to determine the rated short circuit capacity for the selection of 11 kV Switchboard. However, Rated short circuit breaking capacity of 11 kV Switchboard shall be as determined by the study or 40 KA for 3 sec, whichever is higher. 11 kV Switchboard shall be suitable for Internal Arc (AFLR) withstand current of “rated short circuit current” for 1 sec.
- 8.4.3.4 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy indications. Process trip lamp/annunciator window to be provided wherever applicable.
- 8.4.3.5 Control supply shall be 110 V DC.
- 8.4.3.6 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 11KV Switchboard.

### 8.4.4 3.3 KVS Switchboard

- 8.4.4.1 The 3.3 KV switchboard shall be indoor, metal enclosed, draw out type, equipped with Vacuum Circuit Breakers (VCBs), stored energy mechanism working on 110 V DC. for all feeders.
- 8.4.4.2 The minimum degree of protection shall be IP4X as per IS/IEC 60529, IEC 60298. Switchgear sizes and configuration shall be rationalized to minimum spare holding.
- 8.4.4.3 A study shall be conducted by LSTK Contractor to determine the rated short circuit capacity for the selection of 3.3 kV Switchboard. However, rated short circuit breaking capacity of 3.3 kV Switchboard shall be as determined by the study or 31.5 kA for 3 sec, whichever is higher. 3.3 kV Switchboard shall be suitable for Internal Arc (AFLR) withstand current of “rated short circuit current” for 1 sec.
- 8.4.4.4 Incoming, bus coupler and outgoing feeders shall be provided with ON, OFF, Trip, Trip Circuit Healthy, Spring Charged indications. Process trip lamp/annunciator window to be provided wherever applicable.
- 8.4.4.5 Control supply shall be 110 V DC.

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8.4.4.6 Extra anti-condensing space heater shall be provided in Bus –Bar and Cable chamber of 3.3KV Switchboard.

#### **8.4.5 Low Voltage Switchgears**

8.4.5.1 415 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)

8.4.5.2 Low voltage switchboards shall be metal clad, arranged with self supporting units and assembled together in a row.

8.4.5.3 Internal physical separation / segregation of 415 V Switchboards shall be 3 B for Non-ACB feeders and 4 B for ACB feeders.

8.4.5.4 The switchboards shall be suitable for extension at both the ends.

8.4.5.5 Bus bars shall be of uniform cross section and supported on non-hygroscopic FRP insulators with adequate clearances and creepage distance to prevent flash over due to effect of dust/moisture.

8.4.5.6 The horizontal bus bars as well as vertical droppers of LV switchboards shall have heat shrinkable insulated sleeves.

8.4.5.7 Sufficient bus supports shall be given to give adequate mechanical strength during short circuits.

8.4.5.8 A continuous ground bus shall be provided at the bottom in the PCC/PMCC/MCC for grounding the PCC/PMCC/MCC.

8.4.5.9 Rated short circuit breaking capacity shall be 50 KA for 1 sec.

8.4.5.10 The PCC, PMCC, EPMCC MCC, Main lighting distribution board and auxiliary services power board shall be provided with withdraw able air circuit breakers for incoming feeders and bus ties.

8.4.5.11 All feeders of 415 V switchboards shall be provided with MCCB except feeder rated more than 400A, for which ACB shall be provided. All outgoing feeders shall be draw-out type in all the switchboards.



8.4.5.12 All ACBs shall be electrically operated- EDO type only. Manual breakers are not acceptable. Each electrically operated breaker shall be provided with antidumping (94), Breaker fail (52BF) and trip free feature, trip annunciation (30) and lockout (86) relays. Lockout relay shall be hand reset type.

8.4.5.13 All ACBs shall be without any internal releases. The required protections shall be wired by means of external numerical relays.

8.4.5.14 Motor feeders below 75 KW rating shall be contactor controlled and 75 KW & above, these shall be ACB controlled with combined motor protection relay. All other feeders of 415 V switchboards shall be provided with MCCB except feeder rated more than 400A, for which ACB shall be provided. All outgoing feeders shall be draw-out type in all the switchboards.



8.4.5.15 Switchboards shall be provided with thermostatically controlled anti-condensation heaters.

8.4.5.16 All units in the MCC shall be completely accessible and removable from front. Both power and control connections shall be stab-in type.

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- 8.4.5.17 Bus bar clearances shall conform to relevant Indian Standard/IEC for equipment voltages up to and including 500 V AC.
- 8.4.5.18 The switchboards shall be compartmentalized and individual feeder modules shall be draw-out type. Fixed type modules shall not be acceptable.
- 8.4.5.19 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 MCCB, starter, 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.
- 8.4.5.20 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.
- 8.4.5.21 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.
- 8.4.5.22 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.
- 8.4.5.23 Provisions shall be made to manually close/trip circuit breakers on loss of control voltage.
- 8.4.5.24 LV motor and power feeder above 100A shall have CBCT and Digital earth leakage relay.
- 8.4.5.25 All external hardware shall be of stainless steel only.
- 8.4.5.26 The control compartment and power compartment shall be separate.
- 8.4.5.27 All low voltage switchboards shall be provided with 20% spare outgoing feeders or minimum 1 No. of each rating & type (fully wired) and with all the components.
- 8.4.5.28 The timers shall be electronic type only. Pneumatic or synchronous type timers are not acceptable.
- 8.4.5.29 Each outgoing motor feeder shall consist of a number of components mounted in a module duly wired. In general outgoing feeder rated below 75 KW shall consist of:
- MCCB.
  - Control supply On/Off switch and fuse
  - Power Contactor
  - Electronic Digital Motor Protection Relay with built-in Earth Fault, Overload, Stalling, Single phase protection, etc. Thermal Bimetallic Overload Relay is not acceptable.
  - C.T for metering
  - Overload reset button.
  - Process Trip / ON / OFF indicating lamp with separate indicator fuse.
  - Auxiliary contactors for multiplication / control.
  - Test position limit switch and test PB
  - CT operated Ammeter for all motor feeders above 5.5 KW, all MOV and LOPsat both LCS and Feeder end.
  - Selector switches as per requirement.



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8.4.5.30 Following potential free contact shall be available for each Motor feeders for indication in ECMS in addition to process requirement:

- Motor ON
- Motor OFF
- Ready to Start
- Motor Process Trip
- Motor Elect Trip

8.4.5.31 Provision for indication of minimum following electrical parameters in 415V PCC / PMCC/ MCC shall be made:

- a) ON OFF, TRIP, TRIP CIRCUIT HEALTHY, TEST, SERVICE Position, indication in ACB feeders.
- b) The KWH meters on incomers shall have provisions for sealing for tariff purpose, as required.
- c) MCC shall conform to the following as a minimum :
  - Motor starters rated for utilisation category AC3 and protection equipment with a minimum of type 2 co-ordination.
  - The number of modules per tier shall not exceed 6.
  - MCC incomer sizes and configurations rationalised to minimise spares holdings.

#### 8.4.6 Auxiliary Supply Power Board

The ASPB shall generally be single front, floor mounted draw out type having essential and non-essential bus. Non-essential bus shall be disconnected in case of failure of normal supply through a contactor. Substation station shall have ASPB. Additional 2 Nos.63A Feeders shall be provided for Owner's use.

#### 8.4.7 Lighting Sub Distribution Boards

The Distribution Boards shall be single front, non-draw out wall mounted type.

#### 8.4.8 UPS Distribution Boards

8.4.8.1 The UPS Distribution Boards shall be single front, floor mounted non-draw out type for supply of 110 V AC / 240 V AC UPS Distribution Boards shall have 20% spare outgoing feeders of each rating & Type (fully wired) and with all the components.

#### 8.4.9 Direct Current Distribution Boards

8.4.9.1 The Direct Current Distribution Boards (DCDBs) shall be single front, floor mounted non-draw out type for supply of 110 V DC control power to switchgears and panic lighting. Each Substation station shall have separate DCDB. DCDB shall have 20% spare outgoing feeders of each rating & Type (fully wired) and with all the components.



#### 8.5 Motors

8.5.1 The rating of LV and HV motors shall be selected from the sizes as recommended in relevant Indian Standard/IEC.

8.5.2 All electric motors shall meet the standard IEC 60034-30-1.

8.5.3 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%

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75 KW and above

10%

#### 8.5.4 Voltage Ratings:

Voltage rating for the motors of different ratings shall be as below:

Including & up to 160 KW: 415 V, 3-phase, 50 Hz AC

Above 160 KW & up to including 1000 KW: 3.3 KV, 3-phase, 50 Hz AC

Above 1000 KW: 11 KV, 3-phase, 50 Hz AC

All motors shall be designed for 3-Phase supply only.

8.5.5 The motors shall have maximum continuous rated duty S1 as per relevant Indian Standard/IEC. Rated duty for special duty motors wherever required e.g. cranes etc. Shall be considered as per driven equipment requirement.

8.5.6 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.

8.5.7 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.

8.5.8 All motors 30 KW and above shall have space heater provision.

8.5.9 All HV motors shall have winding, hot air and bearing RTDs. All the temperature signals shall be terminated to DCS only.

8.5.10 All LV motors shall be of efficiency class 'IE3' as per latest applicable version of IS: 12615. All HV Motors shall be of high efficient and high power factor type.

8.5.11 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.

8.5.12 The starting current of 11 KV & 3.3 KV motors shall not exceed 550% of FLC. No positive tolerance is acceptable over 550% FLC.

8.5.13 Type test certificate of similar motor for use in specified hazardous area (if applicable) shall be furnished.

8.5.14 The duty cycle of the motor shall meet the process and driven machine requirement.

8.5.15 In case of 11 KV & 3.3 KV motor, the terminal box shall be suitably designed for proper termination of XLPE insulated Aluminium cables through heat shrink termination kit.

8.5.16 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.



8.5.17 Motor rated above 30 KW shall have on line greasing provision and for motor rated above 45 KW, grease outlet feature shall be provided.

8.5.18 All HV motors shall have safety factor not less than 1.1.

8.5.19 Motors rated 1000 kW and above shall have suitable measures to prevent flow of shaft currents and shall have 2 sets (i.e. 6 nos.) of PS class CTs for differential protection.

8.5.20 The motor shall be capable of withstanding the electro dynamic stress and heating imposed if it is started along with the driven equipment at voltage of 110% of the rated value.

8.5.21 During starting of large motor, the voltage may drop to 80% of the rated voltage for a period of 60 seconds. All electrical equipment, while running, shall successfully ride over such period without affecting system performance.

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8.5.22 D.C. motor provided for emergency service shall be shunt/compound wound type. Motor shall be sized for operation with fixed resistance starter for maximum reliability.

DC starters shall be complete with MCCB, contactors, resistors, relays, meters, push-buttons, lamps, etc. DC contactor shall be Class I – Category DC3. Switch Duty shall be DC22. The resistor enclosure shall be provided with ventilating louvers and wire mesh guard and shall have a degree of protection IP-23.

8.5.23 The motor may be subjected to sudden application of 150% rated voltage during bus transfer, due to the phase difference between the incoming voltage and motor residual voltage. The motor shall be designed to withstand any torsional and/or high current stresses, which may result, without experiencing any deterioration in the normal life and performance characteristics.

8.5.24 Shaft voltage shall be limited to 200 mV.

8.5.25 For all other specifications, refer PC217-TS-0810.

## 8.6 Rectifier-cum-Battery Charger

8.6.1 The Rectifier-Cum-Battery Charger shall be fully automatic using silicon controlled rectifier and shall be of 2x100% parallel redundant configuration. It shall consist of units as described below:-

- i) Main Float cum Boost charger (FCBC-1): Operates normally, supplies DC load & charges battery
- ii) Standby Float cum Boost charger (FCBC-2): Same as FCBC-1, operates in parallel with FCBC-1, in standby mode or in load sharing mode.

8.6.2 Either charger shall be able to supply full load. Both chargers shall be hot-swappable, meaning maintenance of one charger shall not interrupt DC supply.

8.6.3 The battery and charger combinations shall be such as to ensure continuity of D.C. supply at load terminals without even momentary interruption.

8.6.4 AC Ammeter and AC Voltmeter on Charger Input; DC Ammeter, DC Voltmeter for charger output/ battery voltage and on demand type Battery Charge / Discharge Ammeter shall be provided.

8.6.5 Following analog signals through suitable transducer shall also be provided for hook-up in ECMS:

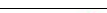

- Status of charging current (float & boost charging)
- Battery current
- Incoming voltage

8.6.6 Following potential free contacts shall also be provided for hook-up in ECMS

- DC under voltage
- DC overvoltage
- DC earth leakage
- AC incoming power supply failure
- AC input fuse blown-off
- Thyristor/ diode failure
- DC output fuse blown-off
- DC battery fuse blown-off
- Filter Capacitor fuse blown-off
- Load on Battery (using current direction sensing with time delay)
- Battery under voltage/ Disconnected during discharge (using zero current sensing)
- Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

8.6.7 For all other specifications, refer PC217-TS-0813.




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## 8.7 Battery Sets.

- 8.7.1 These shall be Ni-Cd Battery Sets shall be rated to meet the total DC power requirement for 5hour after complete power failure.
- 8.7.2 Spare capacity of 20% for future use shall be considered.
- 8.7.3 Battery shall be designed with minimum temperature as per site ambient temperature.
- 8.7.4 Load Test of all Battery to be done at site. Battery will be accepted based on load test only.
- 8.7.5 For all other specifications, refer PC217-TS-0814.

## 8.8 Uninterruptible Power Supply System (UPS)

- 8.8.1 Separate 110V AC UPS System for critical instrumentation power supply (DCS/ESD/FGD, etc.) shall be installed for each process unit in control room. UPS system shall be specific for each process unit. Two units shall not be fed from same UPS system.
- 8.8.2 Separate 240V AC UPS System for power supply to VFD Panel / Soft Starter Panel, ECMS/LMS I/O racks, Interface Panels, Marshalling Panels, RTU Panels, etc. and for other miscellaneous electrical purposes shall be installed in each respective substation.
- 8.8.3 UPS system shall be provided with ACDB with two incomers and 1 bus-coupler scheme with 100% redundancy of feeders on each section. UPS shall be of parallel redundant (2x100% capacity) configuration with single bypass system.
- 8.8.4 The UPS System shall have IGBT type with touch screen LCD display and shall be backed up by nickel cadmium (Ni-Cd) battery rated for 1 hour (60 minutes) back up time at rated capacity of the UPS. Battery configuration shall be 2x100%
- 8.8.5 UPS system construction shall be such that each charger, inverter module can be made fully isolated for maintenance. No common devices/wiring shall be installed. Further there shall be no common device between main & redundant units (e.g. master oscillators etc.) in order to ensure that the failure of the same does not cause shutdown of more than one unit.
- 8.8.6 UPS system shall have facility for built in Online battery bank monitoring & testing facility for displaying/calculating expected battery bank back-up time (during testing if battery bank does not have sufficient back up time, test shall be terminated & load shall be shifted to charger automatically).
- 8.8.7 UPS shall be suitable for 100% step load.
- 8.8.8 Battery Load cycle test shall be carried out by the vendor at site.
- 8.8.9 25% spare/future margin shall be considered in UPS rating over actual load requirement.
- 8.8.10 UPS Configuration shall be as per attached Block Diagram. The over load capacity of UPS shall be 200% for 10 cycles, 150% for 60sec & 125% for 10min.
- 8.8.11 All three sections, i.e. Rectifier-I, Rectifier-II, common Bypass shall be fed through separate feeders of emergency/ normal bus of PMCC.
- 8.8.12 UPS shall be PWM based using IGBT. Each charger and SCVS shall have isolating transformer at the input.
- 8.8.13 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

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8.8.14 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 ECMS and DCS System.

8.8.15 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 as below :

In synchronism : No break transfer i.e. within 6 milliseconds (Maximum)

In asynchronous mode : Within 16 milliseconds (Maximum).

8.8.16 The technical parameters of UPS shall be as under:

#### Input

a) Rated Voltage 415 V  $\pm$  10%

b) Rated Frequency 50 Hz  $\pm$  5%

#### Output

a) Rated Voltage 110 V AC / 240 V AC

Voltage regulation:

Static (0-100% load)  $\pm$ 1%

Dynamic for 100% load change:  $\pm$ 5%



8.8.17 Following potential free contacts shall be made available on the UPS,

- Rectifier ON
- Inverter ON
- Battery CBB ON
- Load on Inverter
- Inverter fail
- Rectifier Fail
- Inverter O/P under voltage
- Inverter Sync.
- Load on battery
- Bypass Fail
- Load on bypass
- Load transferred. etc

Note: A separate common potential free contact for all the faults/alarms (in UPS / SCVS) shall be made available

8.8.18 Operation Philosophy of UPS:

- 2 sets of rectifiers and inverter shall be provided. Under normal conditions, when AC mains power is available, both the rectifiers shall operate in parallel and supply DC power for float/rapid charging the batteries and simultaneously to inverters. In case of failure in one rectifier, the other rectifier shall feed the complete load and the batteries without any interruption.
- In case of Incoming supply failure or failure of both rectifiers the batteries shall feed the inverters without any interruption. Each rectifier shall be designed for simultaneously feeding complete inverter load and float/rapid charging of the batteries to its rapid capacity. Battery (100% Capacity) shall be separate for each Inverter. i.e. 2x100% battery configuration. Each rectifier shall be equipped with "On Line" automatic as well as manual charging facility.
- Normally both the inverters will be synchronised with each other and with stabilised bypass supply. Both inverters shall operate in parallel and share the load equally.

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- The load sharing controls shall not be subject to common mode failure and any failure of the load sharing controls shall not result in the loss of the vital power.
- When a disturbance/fault occurs in any of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter without interruption.
- In case both the inverters develop a fault, the complete load shall be transferred to stabilized bypass supply through the static switches and retransfer of the load from the stabilized bypass supply to the inverter shall be possible in auto as well as in manual mode without interruption.

8.8.19 All alarms & status of UPS shall be communicable through Modbus / Ethernet protocol to ECMS.

Following minimum shall be considered:

- Load on Inverter
- Load on Bypass
- Load on Battery
- Battery on float/ boost charging mode.
- Charger failure.
- Inverter failure
- AC mains failure
- DC under voltage
- DC Over voltage
- Automatic retransfer of load to inverter inhibited.
- Fan failure
- AC Voltage , current & frequency of each inverter
- AC incoming power supply Voltage & voltage.
- DC current at each rectifier output.

8.8.20 UPS AC Distribution Board shall be single front and non-draw out type.

8.8.21 Each branch circuit of UPS Distribution system shall have fused disconnect switch. The fuse shall be fast clearing type. The largest branch circuit load shall not exceed 25% of the UPS system rating.

8.8.22 For all other specifications, refer PC217-TS-0802.

## 8.9 Variable Speed Drives (VSD/VFD)



8.9.1 Microprocessor based variable speed drive shall be communicable type and shall be able to communicate with ECMS/DCS. It shall be possible to set speed from process DCS for optimum performance through 4-20 mA signal. Speed/current/status feedback to DCS shall be provided. Drive will run at preset speed in the event of loss of signal from DCS.

8.9.2 System shall be highly reliable, efficient and shall provide high power factor, low harmonic distortion, low noise level etc.

8.9.3 System shall be provided with complete by pass circuit to ensure the power supply reliability in case of VSD/VFD failure. It shall be possible to start the motor in DOL mode through by-pass system in case there is any problem/fault in the VFD. The Electrical system and the process should be capable to operate the Motor in fixed speed (without VFD).

8.9.4 The system shall be suitable for load characteristics, continuous speed control. Drive shall be able to accelerate the load over the full speed range (0 – 100 %) with incoming line voltage regulation of 10%.

8.9.5 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


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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.

- 8.9.6 The system shall be suitably designed with due care for long length of cables, output filters, chokes, motor insulation, cable voltage grades etc.
- 8.9.7 The VSD panel shall be located in the clean air conditioned room in the substation. 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.
- 8.9.8 The VFD shall be provided with Input and Output transformer.
- 8.9.9 "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.
- 8.9.10 Preferably screened type cables or cables as recommended by VSD/VFD vendors shall be used for VSD/VFD systems.
- 8.9.11 The VSD/VFD panels to be supplied shall be of proven model.
- 8.9.12 Training of VSD/VFD shall be provided to owner personnel.
- 8.9.13 For all other specifications, refer PC217-TS-0820A and PC217-TS-0820B.

#### 8.10 Local Control Stations

- 8.10.1 Local Control Stations shall be provided for all motors for testing and maintenance purpose when the selection is made is "LOCAL MODE" Operation. The essential features of the LCS shall be as given below:
- 8.10.2 LCS shall be pressure die cast aluminium housing (preferably), dust & vermin proof, weatherproof, suitable for wall or pedestal mounting with equipment mounted on a base plate inside and behind a front cover (bolted type).
- 8.10.3 Provision for pad locking in OFF position shall be provided.
- 8.10.4 Local control stations for breaker controlled HV and LV motors shall be provided with T-N-C switch, Ready to Start Indication, ON indication, Space Heater ON Indication, Trip Indication, Local-OFF-Remote Control switch and ammeter. Moreover, space heater ON indication lamp, trip indication lamp shall also be provided at the switchgear panel.
- 8.10.5 Local control stations for contactor controlled LV motors shall be provided with start/stop push buttons, ammeters and Space Heater ON Indication (for motor rated 30KW and above), ON indication, Local-Remote switch (as required) for the motors having rating 5.5 KW and above. If required from process point of view, ammeter shall be provided for motors below 5.5 KW also.
- 8.10.6 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.
- 8.10.7 All local control stations shall have weather proof IP-65 enclosure. Canopies of suitable size shall be provided with all local control stations.
- 8.10.8 All components shall be completely wired up to terminal block and also provided with earthing terminals.
- 8.10.9 Inscriptions on corrosion resistant metal strips giving drive description, mechanism number and functional requirement shall be provided.
- 8.10.10 Two numbers of LCS shall be provided for the motors, which are installed at elevated platforms. One shall be installed at ground level and the other near the motor.
- 8.10.11 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 × 72 mm having scale range 0-90 degree. The ammeter shall be provided with uniform scale up to CT primary

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current and compressed end scale up to the 8 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.

- 8.10.12 Complete Push Button along with its actuator mounted on the cover with wiring done through flexible cables with proper protection.
- 8.10.13 Preferably Ring Type lug and suitable TB to be used for connection, to avoid loose connection.
- 8.10.14 All spare hole to be plugged with suitable metal plugs.
- 8.10.15 For all other specifications, refer PC217-TS-0817.

#### 8.11 Switch Sockets

- 8.11.1 Sufficient number of inter-locked type 63A, 415V, 3 Ph and 20A, 240V, 1 Ph switch sockets shall be provided in various plant locations to facilitate the maintenance work. Supply to switch-sockets shall be taken from ASPB through suitably rated RCCB.
- 8.11.2 63A, 415V power sockets shall be provided so as to ensure complete coverage of the plant through 50 meter radius. 20A, 240V convenience outlets shall be provided so as to ensure complete coverage of the plant through 20 meter radius. Maximum 2 Nos. 63A switch sockets and 2 Nos. 20A switch sockets shall be connected in one circuit.
- 8.11.3 Minimum 1 No. 125A, 415V, TPN Switch Socket shall be provided near Transformer bay for use of Transformer oil filtration machine. Sufficient number of 125A power sockets shall also be provided in workshops and fabrication yards depending upon load requirement.
- 8.11.4 For all Other Specifications, Refer PC217-TS-0811.

#### 8.12 Conduits

- 8.12.1 Conduits shall be of heavy gauge with minimum wall thickness of 1.4 mm (up to 25 mm dia.) and 2 mm (above 25 mm dia.) rigid steel, hot-dip galvanized, cut square, reamed, threaded and screwed tight at all joints.
- 8.12.2 Conduits entrances to pull boxes and switches shall have double lock nuts & insulating bushings. No running thread shall be used.
- 8.12.3 Flexible metallic conduit shall be used for connection to equipment which are subject to vibration and also for connection to level /limit/pressure switches. Conduit runs shall be supported at an interval of 750 mm for vertical run and 1000 mm for horizontal run.

Conduits shall be sized so that conduit fill (ratio of total cable area to conduit area) shall not exceed the following:

One Cable: 53%

Two Cable: 31%



Three Cables & Up: 40%

Wiring installation in CCR Room, Control Room, Switchgear Rooms, Pump Houses, DG Room, Compressor House will be done by multi-stranded, PVC insulated, colour coded wires laid in GI conduits of 20 mm dia. size (minimum) conforming to IS-9537 for areas like The thickness of conduits up to & including 25 mm dia. will be 16 SWG and conduits above 25 mm will be 14SWG.

Conduits will be heavy-duty type hot dip galvanized steel conforming to IS-9537. Conduit accessories will be hot dip galvanized. In corrosive area, conduits will have suitable epoxy coating additionally.

Flexible conduits made with bright, cold rolled annealed and electro galvanized mild steel strips and coated with PVC will be used where required.



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Conduits in control room, service building, laboratory building and other air-conditioned areas will be surface mounted on the roof above false ceiling, however vertical drops of conduits will be concealed along walls and finally plastered for better aesthetics.

Filling area of wires in conduit shall not exceed 40% of the conduit area.

Wiring for AC Normal, AC Emergency, and DC Emergency services will run in separate conduits.

Lighting and receptacles will be fed from separate circuits. No two different phase circuits will be run in the same conduit. However, different circuits of same phase may be laid in the same conduit.

Wiring shall be designed for the uniformly distributed spread of luminaries on each phase i.e. R,Y,B. Distribution of luminaries on these phases shall be such so that there is generally uniform light intensity in the event of failure of one or two phases.


Following sizes of 1100 V grade, PVC insulated single core stranded copper conductor wires/

PVC insulated Stranded 2 Core copper/aluminum conductor cable will be used:

	Wire	Cable
Lighting Panel to Fixtures:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
Lighting Panel to JB's/ Switches:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)
JB's/ switches to Fixtures:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu) 2.5 sq. mm (Cu)
Panel/ JB's to flood light fixtures:	2.5 sq. mm (Cu)	3Cx 2.5 sq. mm (Cu)

### 8.13 Bus-Duct

- 8.13.1 The bus bars and connection shall be made of electrolytic grade copper only. Aluminium bus bars are not acceptable. All bus bars shall be insulated with Raychem sleeving.
- 8.13.2 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.
- 8.13.3 The bus bar insulators shall be non-hygroscopic, non-inflammable material. Earth bus shall run along the full length of bus duct without any break.
- 8.13.4 Outdoor bus-duct shall be weatherproof to IP-65 and shall be provided with canopy, silica gel breather. Construction of outdoor Bus duct shall be such that water gets drain off easily. Extra thickness shall be provided at the corners where water accumulation is likely to happen.
- 8.13.5 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.
- 8.13.6 Openings with cover at suitable locations shall be provided on bus duct for accessing the bus bars for maintenance.
- 8.13.7 Silica-gel breather shall be provided on both indoor and outdoor portions of the bus duct. (shall not be required for pressurized bus duct).
- 8.13.8 Proper sealing shall be done between Outdoor & Indoor section of the Bus Duct.
- 8.13.9 For all other specifications refer, PC217-TS-0807.

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## 8.14 **Electrical Control & Monitoring System.**

- 8.14.1 Electrical Control & Monitoring System(ECMS) shall be provided for Supervision, control, monitoring, data acquisition, data logging & printing of status of all important electrical equipments & feeders and Load Shedding Scheme as per the recommendations of the system study report as per process requirement and in consultation with Owner/Consultant for entire fertilizer complex., ECMS shall be provided by Owner.

Data concentrator Panel and other ECMS System Equipments including PC console, chairs, furniture etc. for this package shall be in Owner's scope. However, LSTK contractor has to consider space for same in separate room in Substations, as per NIT. LSTK Contractor shall provide multifunctional dual channel transducers in all the breaker feeders as well as contactor feeders of all important & critical Loads. Also, supply & installation of Ethernet, Network Switches in each bus of respective HT & LT switch board and extend all signals up to Ethernet; Network Switches shall be in the scope of LSTK Contractor. All Switches shall have 20 % spare ports. All Ethernet, Network switches shall have the same specification as per the main ECMS system requirement provided by other vendor.

All communication cables and all hardwiring cables (for DI, DO, AI, AO etc.) from Switchboards Ethernet/Network Switches to respective Substation ECMS cabinets / I/O Racks shall be in LSTK Contractor's scope.

Minimum Inputs and Outputs to be considered for ECMS for proper operation/control, effective monitoring and load management shall be inclusive of but not limited to the following:

### a. **Transformers:**

Oil Temperature, Winding temperature, Conservator Oil Level and moisture ppm of Oil through 4-20 mA signal / Modbus communication and status of Buchholz Relay.

### b. **Incomer /Bus coupler/ Feeder ( Power/Motor)**

KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT

ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER.

Remote ON & OFF Control from ECMS.

### c. **LT motor feeder of breaker controlled motors in EPMC/PMCC/MCC**

KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT

ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, READY TO START, PROCESS TRIP, EMERGENCY STOP, LOCAL/REMOTE selection on LCS, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER.

Remote ON & OFF Control from ECMS.

### d. **LT motor feeder of Contractor controlled motors in EPMC/PMCC/MCC**



ON, OFF, TRIP ON FAULT, READY TO START, PROCESS TRIP.

### e. **Breaker Controlled Power feeder in PCC/MCC/ASPB**

KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT

ON, OFF, TEST, SERVICE, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, CONTROL SUPPLY ON, RELAY WATCH DOG, FAULT DETAILS, DISTURBANCES RECORDER.

Remote ON & OFF Control from ECMS.

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#### f. UPS

Load on Inverter, Load on Bypass, Load on Battery, Battery on float/ boost charging mode , Charger failure , Inverter failure ,AC mains failure, DC under voltage, DC Over voltage ,Automatic retransfer of load to inverter inhibited,

Fan failure, AC Voltage, current & frequency of each inverter, AC incoming power supply Voltage & voltage, DC current at each rectifier output.

#### g. Battery & Battery Charger

Status of charging current (float & boost charging) , Battery current ,Incoming voltage, Load Voltage DC, Load current DC, DC under voltage

DC overvoltage , DC earth leakage ,AC incoming power supply failure ,AC input fuse blown-off ,Thyristor/ diode failure ,DC output fuse blown-off ,DC battery fuse blown-off ,Filter Capacitor fuse blown-off ,Load on Battery (using current direction sensing with time delay) ,Battery under voltage/ Disconnected during discharge (using zero current sensing) ,Cubicle fan failure/ cubicle temperature high (for chargers with forced cooling).

#### h. VFD

KW, KVA, KVAR, KWh, PF, VOLTAGE, CURRENT, SPEED, SPEED REFERENCE.

ON, OFF, TRIP ON FAULT, TRIP CIRCUIT HEALTHY, FAULT DETAILS

Remote ON & OFF Control from ECMS.

All Multi-function Meters of all HT, LT Switchboard, LDB, etc. to be connected with ECMS.

All connection/ wiring up to I/O Rack shall be in the scope of LSTK Contractor. Connection/wiring from Network Switch to Data Concentrator Panel &Centralized ECMS shall be in EDS LSTK Contractor's scope. However, cable tray, support for cable trays etc. for Cables from Network Switch to Data concentrator Panel & Centralized ECMS System (within battery limit of this package plant) shall be in LSTK Contractor's scope.

Redundant Power Supply from 240 V UPS Distribution Board to all ECMS equipment, OWSs, EWSs etc. (up to termination to I/O Racks, OWSs, EWSs etc.) shall be in LSTK Contractor's scope.

8.14.2 All relays and energy meters shall have communication facility for serial communication (Relays on IEC-61850 protocol and Meters on MODBUS protocol).

#### 8.15 Junction Boxes

8.15.1 Junction boxes shall be provided on the machine body, where the terminal block of electrical equipment is not adequate for the termination of aluminium cables or to terminate an external multi-core control cable.

8.15.2 Separate junction boxes shall be provided for power and control cables. These shall be mounted at convenient and easily accessible locations.



8.15.3 These shall be of cast aluminium enclosure having IP65 degree of protection and adequately sized, with terminal blocks, cable lugs and cable glands as required.

8.15.4 The cabling between these junction boxes and electrical equipment shall be in LSTK Contractor's scope of work.

### 9.0 CABLING


#### 9.1 Cables



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- 9.1.1 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 for HV cables shall be in contractor's scope. Supply and execution of heat shrink type straight through jointing kits for HV cables shall be in the scope of the LSTK Contractor (if required).
- 9.1.2 Cables shall be sized considering the following factors.
- Maximum continuous load current
  - Voltage drop
  - System voltage
  - Laying conditions
  - De rating 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.
- 9.1.3 All HV power cables shall be made of stranded aluminium conductor with XLPE insulation, PVC inner sheathed FRLS type, 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.
- Single core HV Power cable shall be of aluminium conductor. The construction of same shall be as per above.
- 9.1.4 All LV power cables shall be with stranded aluminium/copper conductor with XLPE insulation, PVC inner sheathed FRLS type, armoured, PVC outer sheathed FRLS type and construction as per IS: 7098 (Part 1). Power cables with conductor size up to and including 16 sq. mm shall be with copper conductor, conductor size 35 sq. mm and above shall be aluminium conductor.
- Single core LV Power cable shall be of aluminium conductor. The construction of same shall be as per above
- 9.1.5 All control cables shall be with 2.5 sq. mm, stranded copper conductor with XLPE insulation, PVC inner sheathed FRLS type, 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.
- 9.1.6 All control cables shall have 20 % spare cores. All cores shall be identified with numerical core numbers printed on core in addition to colour coding.
- 9.1.7 All cables shall be armoured and shall have extruded inner and outer sheath.
- 9.1.8 Cables connected in parallel shall be of the same type, cross section and terminations.
- 9.1.9 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.
- 9.1.10 In case of length of any control cables comes out to be more than 400 Meters, FO cable with suitable accessories for proper connectivity shall be provided.
- 9.1.11 The maximum voltage drops in various cables of the electrical system shall be within limits stated in the following table:

Sl.No.	System Element	Maximum Permissible
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		Voltage Drop
a)	High voltage cables for general distribution	1 %
b)	Bus duct / Cable between transformer secondary and Switchboards	0.5%
c)	Cable between PMCC and MCC or auxiliary switchboard i) MCC / Auxiliary Switchboard near PMCC ii) MCC / Auxiliary Switchboard situated remote from PMCC	0.5% Note-3b 2 to 2.5% Note-3a
d)	Cables between HV Switchboard and HV Motor (during running)	3%
e)	Cable between PMCC and motor (during running)	5%
f)	Cable between MCC (situated near PMCC) and motors	5%
g)	Cable between MCC (situated remote from PMCC) and motors	3%
h)	Cable between Auxiliary Switchboard / MLDB and Lighting Panel / Power Panel	1 to 1.5% (Note-2)
i)	Circuit between lighting panels and lighting points	4% (Note-2)
j)	DC Supply Circuit (electrical Controls)	5% and/or as per instrumentation requirement
k)	DCDB to Control Room	2% (Note-1)
l)	UPS outgoing circuit	5% (Note-1)

#### Note-1

Minimum voltage available across any instrument in the field / control room / satellite rack room shall be as per instrumentation design basis. Distribution system for instrumentation supplies shall be designed accordingly. In case of any conflict between electrical equipment specification sheet and instrumentation design basis report, the latter shall govern regarding instrumentation power supplies.

#### Note-2



In case of difficulty in achieving specified voltage drops in cables up to lighting panel, 5% drop from Auxiliary Switchboard / MLDB up to lighting points may be permitted.

#### Note-3

- Higher voltage drop may be permitted between PMCC and remote mounted MCC / ASB; if overall voltage drop up to motor (from PMCC) is limited within 5.5%.
- For large substations 1% drop may be permitted.

The maximum voltage drop at various buses during start-up of large motor and / or motor reacceleration conditions shall be within the limits stated below:-

Sl. No.	System Element	Operating Condition	Maximum Permissible Voltage Drop

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a)	At the bus bars of the worst affected Switchboard	Start-up of the large HV motor with other loads on the bus or reacceleration of a group of HV motors (Simultaneous start-up or group reacceleration of HV motors is not envisaged)	10%
b)	At the bus bars of the worst affected MV Switchboard (PMCC / MCC)	Start-up of large MV motor with other loads on the bus, or reacceleration of a group of MV motors.	10%
c)	Cables between HV Switchboard and motor	Motor start-up or reacceleration	5%
d)	Cable between MV Switchboard (PMCC / MCC) and motor	Motor start-up or reacceleration	10%



Notes:

- Soft Starter / VFD Starter shall be considered for starting large HV motors if essential / unavoidable as per system design requirement / equipment design limitation. For cases other than starting limitation, requirement of soft starter / VFD for any drive shall be confirmed by Process Department.
- Unless otherwise specified as in clause a), all HV motors and MV motors shall be suitable for Direct on Line (DOL) starting.

#### 9.1.12 MINIMUM CABLE SIZES FOR 415V MOTORS

Direct on line (D.O.L) start motors (2/4 pole motors)

MOTOR RATING	CABLE DETAILS			
	NUMBER OF RUNS	NO. OF CORES PER RUN	CONDUCTOR MATERIAL	CONDUCTOR SIZE ( MM <sup>2</sup> )
Below 3.7 KW	1	3	Cu	2.5
3.7 KW	1	3	Cu	4
5.5 KW	1	3	Cu	10
7.5 KW	1	3	Cu	10
9.3 KW	1	3	Cu	16
11 KW	1	3	Cu	16
15 KW	1	3	Cu	16
18.5KW	1	3	Al	35
22 KW	1	3	Al	35
30 KW	1	3	Al	50
37 KW	1	3	Al	70
45 KW	1	3	Al	95
55 KW	1	3	Al	120
75 KW	1	3	Al	185
90 KW	2	3	Al	95
110 KW	2	3	Al	120
125/132 KW	2	3	Al	150
160 KW	2	3	Al	185

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- Minimum cables sizes as indicated above are for 2/4 poles motors fed from MCCs located near PCCs and PMCCs. Actual cable sizes shall be based on actual distance of motor from switch board.
- Cable sizes for motors not confirming to above table (e.g. for 2/4 poles motors rated up to 150kw & motors with high starting pf), extended distance, reduced voltage starting, low speed motors, VFD driven etc. shall be worked out on case to case basis.
- However cable sizing calculation shall be submitted for approval.

#### 9.1.13 Design Criteria for Cables/Bus Duct & Short Circuit Withstand Time:

##### a) Design criteria for cables/bus duct

Sr. No.	Design Criteria	3.3 kV / 11 kV	415 V
1.	Loads beyond 1000A rating and located near the transformer	Bus Duct / 1-core cable	Bus Duct / 1-core cable
2.	Loads located up to 200 M	Cable	Cable
3.	Loads located 200 - 1000 M	1-core cable / 3-core cable	1-core cable / 3.5-core cable
4.	Loads located beyond 1 KM	Cable	Cable
5.	Recommended limiting size of multi-core cable (sq.mm) / Single Core (sq.mm)	3 Core x 400 / 1 Core x 630	3.5 Core x 300 / 1 Core x 630
6.	Insulation voltage grade	3.3 kV / 11 kV Unearthed	1100 V Earthed
6.	Type of cable insulation	XLPE	Power: XLPE Control: XLPE
7.	Power, Control & Earthing Cables	Armoured	Armoured

For breaker control motor circuits the selection of size will be made ensuring that the cable shall withstand a short circuit fault directly for 0.2 sec.

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 transformer	0.25 sec
Feeders from PCC/PMCC to MCC	0.6 sec
Main 11 KV primary distribution feeders	0.7 sec
11 KV cable from transformer to switch board	1 sec
Incomer from other switchboard	0.6 sec


9.1.14 The minimum size of power cables shall be 2.5 sq. mm (Cu).

9.1.15 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. All the control and power wiring shall be carried by using FRLS wires only.

9.1.16 Deration factor, group laying factor etc. as per Technical Catalogue of Cable Manufacturer (of whose cables shall be supplied) shall also be considered while sizing the cables.

9.1.17 For all other specifications, refer PC217-TS-0815.

## 9.2 Cable Laying

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9.2.1 The cables shall generally be laid on overhead racks. Pipe racks where available, shall be used to support the cable racks.

HV power cable shall be laid on cable tray in single layer having 1D spacing between the cables. LV power cables shall be laid on cable tray in touching formation in single layer. Control cables shall be laid on cable tray in touching formation in two layers.

HV Power, LV Power and Control shall be on separate trays. Instrument and electrical cable trays shall be separate.

Cables shall be clamped properly on the cable rack in such a way that position and layout of a particular cable shall not change throughout the rack so that it can be easily traced during maintenance jobs.

Walkway to be considered for access to Electrical / Instrument cables on pipe rack.

From substations to various electrical consumers, cable shall be laid overhead. However, wherever overhead cable routing is not feasible LSTK Contractor 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 and shall be in scope of LSTK Contractor.

9.2.2 The cable racks shall be ladder type, pre-fabricated from suitable hot dip galvanised steel. Maximum cable tray size shall be 600mm wide. Maximum supporting span shall be 2 Mtrs. as per PDS Doc. No. PDS: E 530. Cable trays shall be designed considering 25% margin for future use.

All cable racks must be provided with GI flat strip of size 75mm X12 mm as running earth all along the tray.

9.2.3 All FO cable shall be laid through HDPE pipe with all accessories (Connecting arrangement).

9.2.4 All cables shall be terminated using suitable cable lugs.

9.2.5 All HV terminations and joints shall be of reputed make subjected to Customer approval.

9.2.6 Bimetallic lugs shall be provided, as required.

9.2.7 In Control Room (excluding false ceiling) and Substation, lighting cable shall be laid in concealed conduit.

9.2.8 For all other specification of cable racks, refer PC217-TS-0816 & PDS attached.

## 10.0 ILLUMINATION SYSTEM


### 10.1 General

10.1.1 LED type lighting shall be provided. The average illumination levels in the various sections of the plants shall be as indicated in Annexure-I. All the plants and area lighting shall be energy efficient.

10.1.2 LED type lighting shall be provided for all areas. The minimum illumination levels in the various sections of the plants shall be as indicated in Annexure-I.

LED shall conform to the following types and standards:-

Product Type	Safety Standard	Performance Standard
Self ballasted LED lamps for general lighting services > 50 V	IEC 62560 Latest Edition	IEC 62612 / PAS Publicly available specification
Control gear for LED modules	IEC 61347-2-13 Latest	IEC 62384 Latest Edition

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	Edition	
LED modules for general lighting	IEC 62031 Latest Edition	IEC / PAS 62717 Latest Edition
LED luminaries	IEC 60598-1 Latest Edition	IEC / PAS 62722-2-1 Latest Edition Luminaries performance – Part 2-1: particular requirements for LED
LEDs and LED modules	IEC TS 62504 Terms and Definitions for LEDs and LED modules in general lighting.	

Maintenance factor for indoor lighting shall be considered as 0.7 and for Outdoor lighting 0.6.

The colour rendering index shall not be less than 90%.

The LED lights shall work satisfactorily at the design temperature of 50 Degree Celsius.

The life assessment of LEDs shall include control gears/ driver as well.

- 10.1.3 The specified illumination level shall be maintained after considering maintenance factor 0.5 for Coal Dust Area, 0.6 for plant & outdoor areas (other than Coal Dust Area) & 0.7 for indoor areas and utilisation factor as per manufacturer catalogues for size of room & type of fixture.
- 10.1.4 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.
- 10.1.5 Aviation lights shall be provided on tall structures and all isolated structures. . Aviation Lighting shall be in accordance with International Civil Aviation Organization (ICAO) Publication Annexure 14 and to Indian Standards, together with the approval of local aviation authority.



LED type Low Intensity Aviation Obstruction Light suitable for 240V, 50 Hz supply. It shall be covered under Indian patent act (Govt of India) No. 188995. Degree of protection shall be IP-65.

The illumination intensity of aviation lights and mounting height shall be considered based on vicinity of civilian air terminal within 1 KM radius. Aviation lights at each location shall be fed from two separate and distinct DBs (one fed from normal bus and another fed from emergency/normal bus of MLDB). In case aviation lights are not switched ON for any reason, whatsoever, a signal shall be sent to control room which will sound buzzer and also result in flashing of red light. On acknowledgement, buzzer shall stop but flasher will continue unless aviation lights are turned ON.

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.

- 10.1.6 Plant lighting circuits shall be single phase (Phase & Neutral) rated 240 V AC. Each circuit shall be rated to 16A but not loaded more than 8A. A minimum of 25% of MCBs of each



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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 1000W approx.

- 10.1.7 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.
- 10.1.8 In plant office rooms, wall mounting boards shall be installed to control the lighting. These boards shall include switches for lights, fans, 15A/5A plug sockets and fan regulators etc.
- 10.1.9 15A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/junction box having ELCB of 30mA.
- 10.1.10 16A plug sockets shall be fed through separate circuit of lighting sub-distribution boards/junction box.
- 10.1.11 Illuminated exit sign shall be provided in substation / Control Room.
- 10.1.12 Power factor of complete fitting shall be 0.95 min. at 230 V.
- 10.1.13 Lights from LED's shall be soothing to eye and without any bright spots on the floor/objects illuminated by the luminaries.
- 10.1.14 The driver shall be mounted internally and be replaceable with the aid of commonly available hand tools.
- 10.1.15 The LED module or array shall be designed in such a way that the failure of one LED shall not affect additional LED's.
- 10.1.16 Life expectancy of LED Luminaries shall be minimum of 50000 hrs with greater than 70% of rated lumen output.
- 10.1.17 Min. efficiency of LED driver: The minimum efficiency of LED driver shall be 85% for driver power output rating  $\leq 40W$  and 87% for driver power output rating  $> 40W$ .
- 10.1.18 Short circuit protection /Open load protection shall be required for LED fixtures.
- 10.1.19 Surge Protection for minimum 2kV for indoor and minimum 3kV for Outdoor LED systems shall be provided. However, if a site is prone to lightning and surges 10kV surge protection shall be required. In case of outdoor luminaries, the Surge Protection Device (SPD) should be series type with fail safe.
- 10.1.20 Color temperature of LED Luminaries: 5700K
- 10.1.21 Cover type for outdoor type fittings shall be Toughened glass or UV stabilized polycarbonate whereas, whereas, for indoor and non-weather proof items, UV stabilized Poly Carbonate can be used.
- 10.1.22 For more details, refer PDS attached.
- 10.1.23 For lighting fixtures and 16 Amp plug socket circuits, 3 core 2.5 sq. mm (Cu) cable shall be used.
- 10.1.24 Junction Boxes shall be provided with all type of Lighting Fixtures for looping. Connectors are not acceptable.

## 10.2 **LED Tube Lighting Fixtures (inside Substations)**

- a) High quality LED fluorescent tube twin batten type complete with 2 X 20W tube eco friendly, no UV radiation as per the specification tabulated below:

Sl. No.	Parameter	Technical Specification
1.	Degree of Protection	IP-20
2.	Lumen output per Lamp	$\geq 2000$
3.	CCT	6500K
4.	Luminous efficacy	$\geq 100$ lm/watt
5.	CRI	$>80$

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6.	Guaranteed Life	≥ 50000 burning hours
7.	PF	>0.95
8.	THD	<10%

### 10.3 Street Lighting And Security Lighting

10.3.1 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.

10.3.2 FRP poles of suitable mounting height shall be used for street light and plant lighting (platforms/ structures/ access ways/ walk ways/ pump house/ pump bay etc.), steel tubular poles of suitable mounting height shall be used

The poles shall be subjected to min. following tests:

- Thickness of galvanising
- Drop test as per IS: 2713.

Deflection test as per IS: 2713

10.3.3 Hot dip galvanized octagonal high mast lighting shall be used for yard and general area lighting. LED type fittings may be used.

#### 10.3.4 LED Street Lighting Fixtures

- LED Street Light Fitting with cool white light in Pressure Die Cast Aluminium Housing with UV Stabilized Poly Carbonate Cover with in-built power unit of 3500 lumen suitable for 240V, 50 Hz, System shall be used.
- Life of LED L70>50000 Hrs. Life Time, CRI>75, Fixtures shall be IP-65.

## 11.0 EARTHING AND LIGHTNING PROTECTION

### 11.1 Earthing

11.1.1 Complete earthing installation shall be done as per IS: 3043, IEEE-80, IE Rules and IEC recommendations. The earthing system shall be designed to:

- Provide a permanent & continuous path from equipment and conductor enclosures to earth from circuits for flow of fault current.
- Provide sufficient current carrying capacity to conduct safely any current liable to be imposed on it.
- Provide sufficient low resistance to earth to limit the potential between metalwork and earth within safe limits.
- Provide equal distribution of potential and minimum potential difference for safety of personnel.
- Ensure sufficient current in case of fault to facilitate the operation of relays, over current devices, fuses etc. provided in the circuit.

11.1.2 Common underground earthing grid shall be provided covering sub-stations and plants which is further connected to overall Earthing Grid. The overall earth resistance (dry) shall be limited to 1 ohm.



11.1.3 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 75mm×12mm.

Anti-corrosive bituminous paint shall be provided at each joint of earth flat after necessary finishing and priming treatment .

11.1.4 Earth pit shall be maintenance free type (chemical earth pit) considered.

11.1.5 Chemical earth pits shall be considered instead of conventional earth pits in view of faster dissipation of lightning surges and fault currents, easy installation and maintenance free




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feature. Enhanced high quality UL certified 17.2 mm copper bonded (250 micron) earthing electrode/ rod along with 22.6 KG graphite based (non-bentonite) as a ground enhancing material with stainless steel clamp for connecting copper bonded rod with horizontal flat strip shall be used.

- 11.1.6 Backfill shall be permanent and maintenance free. (No re- charging with salts or any other chemicals) and shall maintain its earth resistance with time. Backfill shall confirm IEEE 80-2000 Clause No.14.5 (d). Backfill in its set form shall have a resistivity of not more than 0.12 ohm-m. Backfill shall comply the requirements and all applicable tests as per part-7 of IEC 62561.
- 11.1.7 Earthing grid/ring shall comprise of buried GI earth strips and GI pipes/electrodes.
- 11.1.8 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 interconnected.
- 11.1.9 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.
- 11.1.10 As far as possible, the reinforcement rods inside concrete column shall be connected to the earthing grid/ring to reduce the overall earth resistance.
- 11.1.11 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.
- 11.1.12 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 for voltage level above 66 kV and 3 seconds for voltage up to 66 kV as per IS -3043.
- 11.1.13 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.
- 11.1.14 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.
- 11.1.15 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                  |
- 11.1.16 Wherever process equipments are mounted on steel structures, the structures shall be earthed instead of earthing the individual equipment.
- 11.1.17 The pipe structures shall be earthed at not more than 25M apart.
- 11.1.18 For all equipment in hazardous area, in addition to external earthing one internal earthing shall be provided.
- 11.1.19 Minimum sizes of earth conductors to be used shall be as given below.

Sl.No.	Equipment	GI conductor size	Al conductor Size
1.	HV/LV switch board, transformers, HV motors	50mm×8mm	150 sq. mm

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2.	Motors rated 75 KW and above	50mm×6mm	150 sq. mm
3.	Motors rated 30 KW to less than 75 KW and vessel earthing	35mm×6mm	95 sq. mm
4.	Motors rated 5.5 KW to less than 30 KW	25mm×6mm	25 sq. mm
5.	Motors less than 5.5 KW	8 SWG	6 sq. mm
6.	All minor equipment rated 250V & above.	10 SWG	6 sq. mm
7.	Earth Grid	75mm x 12 mm.	-

Vendor to calculate the actual size. However, higher size of calculated one or above-mentioned size shall be provided.

All GI conductors shall meet the galvanizing requirement as per IS.

11.1.20 The main ground grid shall be buried in earth at a minimum depth of 1000 mm below finished grade level unless stated otherwise.

## 11.2 Lightning Protection

11.2.1 All structure shall be protected against lightning strokes by suitable lightning protection system to be designed and installed as per IS/IEC-62305.

11.2.2 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.

### 11.2.3 Air Terminal

The vertical air terminal rods shall be installed at the roof of buildings to protect these objects from lightning strokes.

The vertical air terminal shall be made of 20 mm dia. galvanized steel rod. The projected length of the rod shall be as required to protect the object (on which the rod is fixed) from lightning stroke.

The air terminal rod shall be properly fixed on the top of the building/structure to withstand very high wind pressure. In case the air terminal rod is embedded at the top of roof of building: the portion embedded inside the concrete shall not touch the reinforcement bars and shall be duly insulated from them.

All the vertical air terminal rods shall be electrically connected together by means of horizontal conductors of size 50 x 6 mm galvanized steel flats.

The shielding angle for one vertical air termination shall be 45 degrees. For more than one rod, shielding angle between the rods shall be taken as 60degrees.

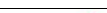

Horizontal air termination (i.e. G.S. Flat conductor) shall be so laid that no part of the rood will be more than nine (9) meters from the nearest roof conductor.

### 11.2.4 Shielding Masts

The shielding mast for lightning protection shall be installed at the top of steel columns cap plates of power house main building.

The shielding mast shall be made of galvanized steel pipe and the height of the same shall be decided considering the zones to be protected.

Each shielding mast shall be connected to grounding grid by a down conductor 50 x 6 mm. Galvanized steel flat run along the building column. In addition all power house building columns joints shall be electrically bonded.

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#### 11.2.5 Down Conductors

The down conductors shall be 50 x 6 mm galvanized steel flats. The connection between each down conductor and earth electrode shall be made via test link located at approximately 1500 mm above ground level.

### 12.0 CAPACITOR BANKS

12.1 The LSTK Contractor shall ensure that the power factor remains minimum 0.95 lag (inductive) in all the Bus of HV, MV & LV Switchboards.

Suitable capacitor bank shall be designed and installed at 415 V voltage level in the substation.

Capacitor bank at 3.3 kV or 11 kV may also be considered, if required.

The capacitor bank shall utilize the Automatic Power Factor Controllers to maintain the power factor of individual plant. Under no circumstances power factor shall become leading (capacitive) and all necessary protections to avoid this shall be used.

12.2 For all other specifications, refer PC217-TS-0822.

### 13.0 FIRE DETECTION AND ALARM SYSTEM

13.1 LSTK Contractor shall provide the Fire Detection and Alarm System which shall be an independent system comprising of individual break glass type manual call points, automatic sensors e.g. smoke and heat detectors, main panel, repeater panel, hooter, battery, battery charger and any other hardware.

13.2 The system shall be designed to provide audio-visual indication at the main panel to be located in Control Room and repeater panels shall be provided in fire station.

13.3 The manual call points shall be provided at strategic locations with access along all exit routes and roads.

13.4 Electrical sirens shall be provided to cover entire package plant. Hooters and exit lights shall be provided at required locations in the buildings.

13.5 The fire detection system shall be interfaced with fire suppression system.

13.6 Supply, installation, testing and commissioning of above mentioned components/equipment for plant area, substation & control room shall be by the Contractor along with necessary supply and laying of required signals cables.

13.7 The required nos. of MCPs and detectors in substation & control room shall be calculated as per IS norms and contractor shall get approval from client during detailed engineering stage.

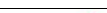

13.8 Separate Centralised Fire Alarm & Detection System of entire complex shall be provided by Owner. Fire Alarm & Detection System of this package shall be provided and hooked-up with the Centralized Fire Alarm System shall also be in LSTK Contractor's scope. All interfacing equipment as well as cabling required for hook-up shall be in LSTK Contractor's scope.

13.9 All cables (including communication cables) shall be armoured type only.

13.10 For all other specifications refer PC217-TS-0826.

### 14.0 RADIO SYSTEM

14.1 20 nos. flameproof walkie-talkie along with Base Station & License and 20 nos. flameproof hand lamps shall be provided for convenience of installation, operation and maintenance of equipment.

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- 14.2 A fully functional digital radio system which supports full-duplex voice and data services for large number of talk groups shall be provided for this Package for operating, maintenance and safety purpose.
- 14.3 The digital radio base station shall be installed in the control room and shall include the following minimum components:
- Ethernet switch
  - Digital repeater
  - Splitter
  - Combiner
  - Duplexer
  - Power supply unit
  - Installation pole
  - All other necessary accessories, including coaxial cable, cables, charge, patch cords etc.
- 14.4 The preferred location for the master antenna is on the roof of control room.
- 14.5 The system shall be flexible so that changes can be made to the configuration in the field.
- 14.6 The system shall be fully compliant with the relevant National / International cords and standards issued by statutory authority.

## 15.0 MOUNTING STRUCTURES

Switch sockets, cable trays, DBs etc shall be mounted / supported on suitable structure fabricated out of standard sections of mild steel, i.e. channels, angels, flats etc conforming to IS: 2066.

## 16.0 SPARES

### 16.1 Commissioning Spares

The commissioning spares shall form an integral part of the scope of supply. Contractor shall be responsible for the quantification of the commissioning spares for the smooth commissioning start up of the plant/ package system. Item wise list of commissioning spares with recommended quantity shall be furnished for information. The same shall be Part of LSTK price

### 16.2 2 years operational spares (Mandatory)

Contractor shall supply Mandatory spares for all equipments as per Section 10: Spare Parts list attached with NIT. The same shall be Part of LSTK Price.

### 16.3 Recommended Spares (Other than Mandatory spare) )


Contractor shall provide recommended spares (other than mandatory spare) for all the equipment (item-wise) with recommended quantity.

### 16.4 All spare parts shall be identical to the parts used in the equipments.

### 16.5 Any other spare parts or special tools not specified, but required, shall also be provided. The same shall be part of LSTK Price.

## 17.0 VENDORS' SERVICES

### 17.1 The LSTK Contractor shall consider the services of major equipment suppliers during installation, testing and commissioning in their scope as required.

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17.2 The services of engineers of following equipments' (OEM) manufacturers are envisaged and required during installation, Testing and commissioning. LSTK contractor shall arrange for the same without any additional cost implication:

- Transformers
- Battery Charger
- AC UPS
- Variable Speed Drives
- Numerical relay
- HV & LV Switchboard
- Circuit Breakers
- Fire Detection & Alarm System

17.3 Site Testing, parameterization and commissioning of the Numerical relays shall be done by OEM expert only.

## 18.0 TESTING & INSPECTION

18.1 LSTK Bidder / Equipment Vendor shall submit detailed Inspection & Test Plan (ITP) / Quality Assurance Plan (QAP) indicating all the type tests, routine tests, special tests/acceptance tests for each electrical equipment for Owner's review & approval before performing testing and inspection at OEM's factory works being witnessed by approved Third Party Inspection Agencies (TPIA).

18.2 Testing of all electrical equipments shall be done in accordance with relevant IEC/BIS codes in presence of owner's representative at manufacturer's works before despatch / at site before installation. All such tests shall be arranged by the contractor and testing charges, if any, shall be borne by the contractor.

18.3 The LSTK Contractor shall submit the certificates of type tests performed on identical equipment as evidence of the compliance of the equipment with the type tests. All Type Test Certificates shall not be older more than 5 years except GIS for which Maximum 10 years old Type test Certificates is acceptable subject to no change in Design.

18.4 The LSTK Contractor shall submit the certificates of routine and acceptance tests conducted on the purchased equipments.

18.5 All the routine/acceptance tests shall be performed at the manufacturer's works in the presence of owner's representative.

18.6 Stage Inspection of Electrical Equipment shall be considered. The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.

18.7 The equipment shall be dispatched from works only after receipt of Owner written approval of the test reports.

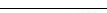

18.8 The LSTK Contractor shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.

18.9 In addition, the equipment shall be inspected at site for final acceptance.

18.10 Certified reports of all the tests carried out at the works shall be furnished in six (6) copies for approval of the Owner.

18.11 Electrical installation work shall be subjected to inspection by owner / his authorized representative, statutory bodies like Electrical Inspector, Factory Inspector and where applicable by equipment supplier's engineer. The contractor shall carry out without extra cost to owner rectifications / modifications desired by the above authorities to make the installation conforming to I.E. Rules etc.



18.12 The owner may reject any portion of the work considered defective or of poor workmanship and the contractor shall make good these defects without extra cost to owner.

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## 19.0 DOCUMENTATION

- 19.1 The LSTK Contractor shall submit the documents for electrical equipments (MS-word, MS-excel and AutoCAD) as per the drawing and documentation schedule as given in this bid package.
- 19.2 Sizing of Electrical system and Equipments shall be submitted during detailed engineering stage.
- 19.3 LSTK Contractor shall ensure that following shall be mentioned in each sheet of drawings/ documents in the order mentioned below:
- Logo and Name of the client
  - Logo and Name of the consultant
  - Logo and Name of the contractor (LSTK Contractor )
  - Logo and Name of the Manufacturer on the drawings prepared by manufacturer, if applicable
  - Name of the Project for which drawings are applicable
  - Title of the drawing (Title shall indicate the details shown in the drawing)
  - Drawing/ document number with sheet number and number of total sheets in the drawing (Drawings having different title shall be assigned different drawing number)
  - All sheets of each drawing shall bear same title, same document number and same revision number
- 19.4 At the time of handing over of the installation, LSTK Contractor shall supply as built drawings taking into consideration the actual execution carried out at site.
- 19.5 Erection, testing/ checking (inclusive of calibration check) prior to energisation/ after energisation and commissioning Manuals shall be in bound book format and shall give step by step procedure for:
- Storage, Handling and Erection
  - Checking/ testing after erection and before energisation.
  - Pre-commissioning tests/ checks and cold trials
  - Commissioning
  - Drawings relevant for erection, operation, maintenance and repair of the equipment.
  - List of instruments/ testing kits/ sets, measuring instruments etc. required for testing/ checking with specification, ratings, ranges etc.
- 19.6 Operation& Maintenance Manuals for each of the equipment/ system being shall be in bound book format and shall be supplied along with dispatch of equipment and inclusive of following:
- Log sheets indicating daily/ hourly recordings of parameters to be noted down by customer's operating personnel.
  - Procedure for shut down and energisation.
  - Preventive maintenance schedule.
  - Safety procedures for safe operation of equipment and complete system.
  - Specification of equipment installed. Manufacturer's catalogues operation and maintenance manuals for all types of relays/components used.
  - Test procedures for site tests/ checks.
  - Spares list for each equipment/ system for 2 years operation and maintenance.



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- (h) Relevant calculations and protection relay setting table for the equipment/ system being supplied by him
- (i) Instructions for Diagnostic trouble shooting / fault location charts
- (j) Tests for checking of proper functioning/ Operation.
- (k) Storage and re-conservation Manual
- (l) Safety Manual
- (m) Drawings relevant for operation, maintenance and repair of the equipment
- (n) Instructions for Maintenance and Repair
- (o) List of spare parts with ordering specifications and manufacturer's catalogues.
- (p) List of consumables with specifications, brand names and annual consumption figures.
- (q) Manufacturer's catalogues with ordering specification for all items
- (r) List of special tools and tackles
- (s) QAP, Internal Test Certificates and Inspection Certificates
- (t) Procedure for ordering spares.
- (u) All as built drawings.

**19.7 Drawings/ documents to be submitted with inspection call of equipment:**

- (a) Type test certificate for identical equipment
- (b) Sub-supplier's/ vendor's catalogue/technical literature
- (c) Test reports for internal inspection
- (d) Test certificates of components
- (e) Technical specification & data sheets of equipment
- (f) All drawings as applicable of category 'Approved', 'Approved with comments' and drawings 'For information/ Reference' including comments thereon

**19.8 The details of equipment layout and cable routing will be designed by the LSTK Contractor during detail engineering stage and these shall be subject to approval by Owner/Consultant. Changes as required to achieve a neat layout with adequate working space all around, for better aesthetics as well as to meet statutory regulation and codes shall be done without any time and cost implication.**

## **20.0 TOOLS & TACKLES**

The LSTK Contractor shall supply at least one set of all special tools for each substation required for maintenance of the equipment supplied by them and price shall be included in the offer. List of tools & tackles with quantities shall be mentioned in the offer.



## **21.0 REVIEW OF DRAWINGS & DOCUMENTS BY OWNER/ CONSULTANT**

- 21.1** The successful Bidder (herein after referred as contractor), shall submit within one month of placement of LOI; list of drawings/ documents/ Manuals that would be submitted by them. The list shall mention Serial Number, Title of the drawing/ document/ manual, Category (For Approval, For review, For Reference, etc) and tentative date of submission. The list shall be prepared taking in to account into consideration stipulations in respect of submission of drawings/ documents and scheduled date for completion.
- 21.2** Template for name plate of drawings, documents and drawing/ document numbering system shall also be submitted by contractor and approval obtained.

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- 21.3 The LSTK Contractor shall ensure that all sheets of the drawings/ documents and top sheet of manual prepared by manufacturer/ vendor/ supplier & submitted by him or by his consortium member or by manufacturer or his consultant, are checked by him/ leader of consortium and vetted by LSTK Contractor / Leader of consortium before submission with stamp ensuring correctness, completeness, suitability of document for subject work and compliance with stipulations of order
- 21.4 The responsibility for delay in approval/ review of drawings/ documents due to
- Submission of incomplete drawings/ documents not meeting the requirement of project/ stipulations of order
  - Non-compliance of comments made earlier
  - Drawings are not submitted in requisite copies;
- and consequent delay in project shall be that of contractor.
- 21.5 The contractor shall ensure that in case any model number is mentioned in the drawing, detailed technical catalogue, literature, explanatory notes to describe the model and its technical details in full are also submitted along with the drawing. Such drawings/ documents should be assigned Drawing/ Document Number, Number of sheets in the drawing, Rev number etc (Unique Identification). Reference of such drawing/ document number should be mentioned in the drawing.
- 21.6 The drawings/ documents shall be prepared in such sizes that those can be read easily. Size of font in print submitted shall not less than size10 Arial or equivalent.
- 21.7 The drawings/ documents shall be submitted in sizes in which those are prepared. Photocopies in reduced sizes shall not be accepted.
- 21.8 The contractor shall leave space on each sheet for stamping the drawing by Owner/ consultant to avoid stamping on contents of drawing making them unreadable. Submission of drawings in A4 size shall be avoided.
- 21.9 All sheets of a drawing shall be assigned same title and drawing number. Drawings having different title shall be assigned different drawing numbers.
- 21.10 GA drawings, schematic diagrams, single line diagrams, bill of material, data sheets, characteristics curves, cable schedules and cable termination diagrams shall be assigned separate drawing numbers.
- 21.11 Revision shall be clearly marked on all subsequent issue of drawings and documents.
- 21.12 Inability to incorporate some of the comments shall be clearly stated by contractor with reasons and without delay. However, to accept or reject the non-compliance based on the reasons indicated by contractor shall be discretion of Owner/ their consultant.
- 21.13 In case alterations are considered necessary by the contractor in the drawings already approved, such drawings shall be resubmitted for approval again stating the considerations necessitating changes/ alterations. In case, alterations/ changes proposed by contractor are approved by the consultant/ Owner; all other drawings and data affected by such alterations/ changes shall be duly revised and re-submitted for the approval as stated above.
- 21.14 Contractor shall depute their concerned engineers (with the engineers of suppliers, if required) shall visit consultant after submissions of drawings for discussion, modification of drawings and approval so that project is not delayed for want of approval of drawings.
- 21.15 It will be the responsibility of contractor to submit the drawings and obtain approval to meet the project schedule. Delay in approval of drawings due to following shall be the responsibility of contractor:
- non-submission of drawings/ documents/ well before those are actually required and/ or



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- b. delay in incorporation of comments and/ or
- c. non-incorporation of comments by contractor and/ or
- d. submission of drawings without checking and ensuring requirement stipulated in contract/ order

21.16 Contractor shall note that any approval and/ or clearance accorded by Owner or consultant for manufacture and/ or to proceed further given during discussions or recorded in the minutes of the meetings shall be valid only after the drawings showing relevant details are submitted by contractor and clearance/ approval is accorded by Owner/ Consultant by stamping and signing on the relevant drawings.

21.17 Approval of drawings by Owner / his consultant shall not relieve the contractor of his contractual obligations and responsibility for engineering, design, workmanship, materials and performance of the equipment

21.18 Contractor shall furnish, if requested, additional drawings, calculations, information to the Owner/ Consultant to enable him to examine/ study the drawings submitted.

21.19 Contractor shall note that work shall be carried out exactly as indicated in the approved drawings and no alterations shall be made without the written approval of the Owner/ Consultant.

## 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 engineers for one week.
- c) Numerical relay: Two engineers for one week
- d) HV & LV Switchboard : Two engineers for one week
- e) Fire Detection & Alarm System : Two engineers for one week

## 23.0 VENDOR LIST

23.1 Make of all electrical equipment shall be as per Vendor List attached with this NIT.

23.2 Any other vendor shall be subject to Owner/Consultant's approval.

23.3 Any other item for which vendors are not mentioned in NIT, LSTK Contractor shall furnish list of proven suppliers with PTR subject to Owner's/ Consultant's approval during detailed engineering. Document (PTR) shall be in English language only.



## 24.0 INSTALLATION, TESTING AND COMMISSIONING

24.1 The LSTK Contractor 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 LSTK Contractor 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 LSTK Contractor shall furnish field inspection and test data sheets for all equipments for owner's approval.

24.4 The LSTK Contractor 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.

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24.5 The erection work shall be supervised by competent supervisors holding relevant supervisory license from the Government.

#### 24.6 Installation of Equipment

- The equipment shall be installed in switchgear rooms, MCC rooms, control rooms and at shop floors.
- The scope of work of LSTK Contractor under installation shall be inclusive of but not limited to the following:
- Physical inspection and handling
- Assembly and interconnection of shipping sections, if any, as per manufacturer's instructions. Supply of materials, fabrication and installation of supporting frames/ brackets for proper support of equipment/ panels/ devices/ cable trays etc..
- Installation on foundation/ supports/ brackets.
- Alignment, levelling and clamping/ welding/ fixing/ grouting with supports/ foundation bolts as required.
- Mounting loose supplies and connection of wiring.
- Conducting pre-energisation tests/ checks to ensure that installation is carried out as per manufacturer's instructions/ direction of supervising engineer and is healthy/ fit for energisation.


#### 24.7 Cable Installation

##### 24.7.1 General

- All Cables to be laid in overhead cable tray only. Cable Tray for HV, LV and Control cable should be separate. Underground cable to be avoided, Cables to be laid on racks in underground concrete cable trenches inside the plant only where overhead structure is not possible. Cables may be laid in ground (slit with HDPE conduit) where number of cables to be laid are less and do not justify use of concrete cable trenches.
- All the cable tray structures shall be painted with two coats of primer and two coats of final paint after necessary surface preparation.
- Cable OD 40 MM and above shall be clamped individually.
- Cables shall be clamped only after the cables are neatly arranged, dressed tailored and kept in position. Support of cables on edges of cable trays/ structural steelwork shall be avoided.
- Power cables shall be laid in one layer only. Control and other cables may, however, be laid in two layers. More than two layers shall not be permitted.
- All the cable tray network shall be earthed by a continuous earth strip.

24.7.2 Cable laying in Trench/ on Racks/ Trays/ Cleated on Wall/ Structure. For proper support, access and neatness of appearance of installation; cables shall be laid on racks or cable trays or cleated on wall and/ or structure taking following into consideration:

- Cable racks/ trays shall be 250 mm apart.
- Ladder type cable trays shall be used for laying power cables.
- Perforated type cable trays shall be used for laying control, signal, and communication etc. cables.
- Coaxial cables for data transfer from/ to microprocessor based equipments shall be laid in HDPE conduits with pull boxes fixed to cable supporting racks.

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- (e) Top tray shall be used/ left vacant for communication, signalling and fire alarm cables.
- (f) Cables shall be laid in separate trays according to voltage and noise classification. Fire proof partition shall be provided between HV and LV cables.
- (g) Power, control and lighting cables shall be laid in separate cable trays.
- (h) Large size cables shall be clamped individually. Small size cables may be bunched together provided that in any bunch all cables have sheath of same material.
- (i) Cables in trays shall be clamped at not more than every 1500 mm for horizontal run and 800 mm for vertical run and near bends.
- (j) Cable racks/ trays shall be planned in such a way so that at least 20 % or one rack/ tray (whichever is more) can be added in future and at least 20 % free space shall be left in each cable tray for cable laying in future..
- (k) Support to cable trays shall be provided at intervals as required for proper support but at interval not more than 1000 mm.
- (l) Support to trays shall also be provided at each joint of tray irrespective of it's distance from adjacent support.
- (m) GI trays shall be fixed using nuts and bolts as welding will not be permitted.

#### 24.7.3 Cable laying in conduits

- (a) Cables shall be laid in GI conduits while laying on or crossing floors/ wall/ railway lines/ roads.
- (b) While laying on floor or wall or crossing roads conduits shall be embedded in concrete/wall.
- (c) When laid on floor the top cover shall be minimum 10 mm.
- (d) At rail/ road crossings, the conduits shall be laid not less than 1 meter below top surface of the road.
- (e) Mechanical protection by G.I. Pipe shall be provided to all cables up to 1200 mm from ground/ floor level.
- (f) Minimum diameter of G.I. pipes used for laying/ protection of cables shall be 1.6 times the cable diameter.
- (g) Only one cable shall be laid in one conduit.
- (h) Conduit shall be sealed after cable laying.
- (i) Standard bends or fabricated bends shall not be used. wherever required, conduits shall be bent using bending machine. Bending radius shall not be less than 10 times the diameter of conduit.
- (j) Jointing of the conduits shall be done using sockets which may be welded from top to avoid ingress of water.
- (k) Ends of conduits shall be made smooth to avoid damage to cables.

#### 24.7.4 Cable Jointing

- (a) Joints in cable length less than standard drum length shall not be allowed.
- (b) Joints, if unavoidable, shall be made at most suitable places.
- (c) Joints shall not be made at passageways or under rail/ road crossings and in hazardous area.
- (d) Joints shall be segregated by not less than 2 meters so as to reduce the possibility of one joint failure affecting the other.

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- (e) Individual cores in cables shall always be joined number to number or colour to colour of the insulation over the conductors.
- (f) Continuity and current carrying capacity for earth conductor and/ or armour shall be provided.
- (g) Cable jointing shall be done by joiners who possess certificate of competency for carrying out particular joint.
- (h) Minimum 2 meters cable loops shall be kept near each joint.

#### 24.7.5 Cable Termination

- (a) Double compression heavy type glands/ heat shrinkable termination kits and bi-metallic/ copper lugs shall be used for termination of cables.
- (b) Paint of the gland plate at the contact point of gland shall be removed for proper contact.
- (c) Cable glands/ termination kits shall be earthed.
- (d) Cables to individual cubicles shall be neatly laid out and supported.
- (e) Cables shall be clamped at a distance of 400 mm from gland/ termination.
- (f) Conductors of control cables shall be neatly arranged in compact group. The entire group shall be placed and tied with nylon straps.
- (g) Spare cores shall be terminated with sufficient length to permit future connection to the terminal block associated with control cables.

#### 24.7.6 Identification

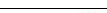

- (a) Cable tags shall be made of non- corrodible material, preferably SS.
- (b) Voltage, cable number etc shall be engraved on each tag.
- (c) Cable tags shall be tied to each cable at
  - (i) All termination (outside as well inside panel/ box.)
  - (ii) All bends.
  - (iii) All points before and after which their route cannot be easily identified.
  - (iv) Entry and exit from conduits.
  - (v) All joints.
  - (vi) Every 15 meter for straight run.

### 25.0 TESTING OF INSTALLATION AFTER ERECTION

25.1 The LSTK Contractor shall carryout tests/ checks after erection of equipment/ cables to check, ensure and demonstrate the conformity of equipment supplied and installation done with the specification and statutory requirement.



25.2 Prior to starting the test, the LSTK Contractor shall satisfy himself and ensure that

- a. The installation is strictly in accordance with the specification, drawings and statutory requirement.
- b. Any automatic controls that might vitiate the tests have been relaxed.
- c. All instruments to be used for testing are suitable for the purpose and have been calibrated by a recognised laboratory within the last 12 months and copy of the calibration certificates have been submitted to the Owner/ Consultant.

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- d. The testing, commissioning, operation and maintenance manuals are available to the testing engineer and Owner/ Consultant.
- e. Formats for recording test results have been finalised with the Owner/ Consultant and copies have been distributed to all concerned.

- 25.3 The skilled manpower to test all the equipment, cables, earthing etc deputed by LSTK Contractor is well aware of and prepared to perform checks/ tests.
- 25.4 The tests shall be witnessed by the representatives of Owner/ Consultant.
- 25.5 The LSTK Contractor shall compile and tabulate all the test results in agreed formats and submit to Owner/ Consultant for approval prior to acceptance of installation.
- 25.6 Testing and checking shall be carried out to demonstrate and record prior to completion, that supply and installation meets the requirement/ performances specified. The installation shall be tested in presence of Owner/ Consultant.
- 25.7 The LSTK Contractor shall give at least 24 hours notice to Owner/ Consultant to enable them to witness the test.
- 25.8 The LSTK Contractor shall submit to Owner/ Consultant test record sheets on daily basis.
- 25.9 Equipment or any part of the installation shall be energised only after all pre-energisation tests are completed and test results are approved by Owner/ Consultant.
- 25.10 Failure to submit test results as tests are completed may render the LSTK Contractor for carrying repeat tests.
- 25.11 The LSTK Contractor shall supply six (6) bound and indexed copies of all tests in agreed formats prior to preliminary acceptance and handing over of the equipment/ installation, duly signed by representatives of the Owner/ Consultant who have witnessed the tests.
- 25.12 It will be the responsibility of the LSTK Contractor to supply/ arrange at his own cost all necessary testing equipment and measuring equipment required for conducting the tests as per applicable standards.
- 25.13 Should any of the tests reveal any discrepancy or non-conformity, the same shall be attended to and retested before proceeding with any other tests.
- 25.14 All tests shall be conducted in accordance with this specification, standard specifications of Bureau of Indian Standards, recommendations of IEC and IE Rules.
- 25.15 Tests checks to done at site shall be inclusive of but not limited to the following:
- a. Physical Check & Verification : All Equipment/Cables etc
  - b. Tightness of connections : All Equipment/Cables etc
  - c. Checking for cleanliness : All Equipment/Cables etc
  - d. Size & No. of Earth connection : All Equipment/Cables etc
  - e. Erection, alignment, mounting height and clearances : All Equipment/Cables etc
  - f. Insulation Resistance test : All Equipment/Cables etc
  - g. Earth continuity test : All Equipment/Cables etc
  - h. Earth Resistance test : All Equipment/Cables etc
  - i. Earth loop impedance test : All Equipment/Cables etc
  - j. No load & rated load current : All Motors/ Loads
  - k. No load & rated load P.F. : All Motors/ Loads
  - l. No load & rated load Power : All Motors/ Loads


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| m.  | Functional checks                           | : | All Equipment & Controls                               |
| n.  | Primary injection test                      | : | All switchgear   |
| o.  | Secondary injection test                    |   | All protective relays/ devices                         |
| p.  | Ratio and polarity test                     |   | CTs  |
| q.  | Power frequency HV test                     |   | Power & Control circuit                                |
| r.  | Phase sequence checks                       |   | /C & bus couplers                                      |
| s.  | Winding resistance test                     |   | Motors & Transformers                                  |
| t.  | Direction of rotation                       |   | All motors   |
| u.  | Free running for 2 Hrs                      |   | All motors   |
| v.  | Under voltage tests                         |   | All U/V Devices  |
| w.  | Calibration Checks                          |   | All instruments  |
| x.  | Load and Performance tests                  |   | UPS, PLC, & Variable Frequency equipment, Battery Bank |
| y.  | Checking of Voltage, current                |   | UPS, PLC, & Variable Frequency equipment               |
| z.  | Checking of specific gravity and acid level |   | Battery  |
| aa. | Illumination levels                         |   | All areas  |

25.16 It is anticipated that following equipment will be necessary to perform testing of the installation. The LSTK Contractor shall, therefore, arrange these as well as any other equipment for testing of the installation.

- a. HV Testing Set
- b. Primary Injection Set
- c. Secondary Injection Set
- d. IR Testers
- e. Earth Continuity testers
- f. Soil resistivity Testers
- g. Earth resistance Testers
- h. Phase to earth loop impedance testers
- i. Milli volt drop testers
- j. Micro-ohm meter
- k. Phase sequence testers
- l. Clip-on ammeters
- m. Voltmeters
- n. Power factor meter
- o. Frequency meter
- p. 3 Ph 4 wire unbalance load kWh meter
- q. Cable fault location equipment
- r. Digital multi-meter suitable for testing IC voltage and current levels
- s. Analogue Multi-meters



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- t. Portable multi-range precision ammeters, voltmeters complete with CTs, PTs for AC/ DC circuits.
- u. Protection relay test plugs
- v. Portable earthing equipment
- w. Dual beam oscilloscope with storage facility.
- x. UV recorder
- y. Illumination level meter
- z. Thermometers
- aa. Power Analyser / Portable Power Meter
- bb. Rpm meter
- cc. Noise meter

25.17 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

## 26.0 QUALITY ASSURANCE

- 26.1 All equipment, components, materials proposed to be supplied by LSTK Contractor shall be procured, manufactured, erected, commissioned and tested as per a comprehensive Quality Assurance Programme (QAP) to be approved by the Owner/ Consultant.
- 26.2 The Successful Bidder shall submit within 1 Month of from order; Quality Assurance Plan (QAP) for all the equipment/ panels/ cables/ motors/ devices etc. under their scope of supply.
- 26.3 All routine and acceptance tests shall be carried out as per relevant IS / IEC/ Other Standards during inspection at manufacturer's works in presence of Owner or his representative.
- 26.4 The LSTK Contractor shall submit type test certificates for similar equipment supplied by him elsewhere. In case type test certificates (not more than 5 years old and conducted at duly accredited laboratory) for similar equipment is not available, the type test shall be conducted in presence of Owner or his representative without any financial implications to Owner.
- 26.5 The inspection procedure shall be finalized and approved by Owner and/ or their consultant/ authorized representative.
- 26.6 Inspection will be carried out as per drawings and quality assurance plan approved by the Owner/ Consultant. Inspection shall be carried out either at manufacturer's shop/ works or any other place where facilities for conducting tests/ checks are available.
- 26.7 Owner reserves the right to witness any of the tests and verify the documents of the LSTK Contractor, his supplier/ vendor/ manufacturer.
- 26.8 Manufacture test certificate for bought out components shall be submitted during inspection.
- 26.9 No equipment or part items shall be dispatched without final acceptance certificate and dispatch instructions in writing issued by Owner and/or their authorized representatives.

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- 26.10 The LSTK Contractor shall carry out an inspection and testing programme during manufacture in his works and/ or that of his vendor's works to ensure accuracy/ correctness/ completeness of components, compliance with drawings, conformance to functional and / or performance requirements, identify and acceptability of all materials, parts and equipment. The LSTK Contractor shall also carry out all tests/ inspections required to establish that the items/ equipment conform to requirements of the specification and the relevant codes/ standards specified in the specification in addition to carrying out tests as per the approved Quality Plan.
- 26.11 Quality audit/ surveillance/ approval of the results of the tests and inspection, approval of drawings will not, however, prejudice the right of the Owner to reject the equipment at any subsequent stage if it does not comply with the specification or does not give complete satisfaction in service and shall in no way limit the liabilities and responsibilities of the LSTK Contractor of ensuring complete conformance of the materials/ equipment supplied to relevant specification, standard, data sheets, drawings etc.
- 26.12 The owner or their representative shall be allowed to visit the manufacturing works for stage inspection during manufacturing stage.
- 26.13 The LSTK Contractor shall intimate the owner 4 weeks in advance of the tests and submit the detailed schedule of tests.
- 26.14 LSTK Contractor s shall supply reports of type tests, acceptance tests, all requisite factory tests and site tests in bound volumes.
- 26.15 All the equipment shall be tested at site to know their condition and to prove suitability for energisation and required performance.
- 27.0 COORDINATION WITH OTHER CONTRACTORS**
- 27.1 LSTK Contractor shall coordinate with Owner's other Contractors and shall freely exchange all technical information required for this purpose.
- 27.2 All civil works connected with electrical installation shall be under the LSTK Contractor's scope.



## **ANNEXURE-I**

### **ILLUMINATION LEVELS**


Average illumination levels (Mean Lux) for various areas shall be as follows:

Sl. No.	AREA	LUX
<b>1.0</b>	<b><u>ROADS</u></b>	
1.1	Plant roads	20
<b>2.0</b>	<b><u>YARD</u></b>	
2.1	Marshalling yard	20
2.2	Loading/unloading areas	50
2.3	Open areas	20
<b>3.0</b>	<b><u>PLANT</u></b>	
3.1	Operating platforms	100
3.2	Non-operating platform/ general process areas & walk ways	50
3.3	Pipe rack	100
3.7	Area near large rotating equipment/plant	200
3.8	Air Conditioning Plant Room	200
3.9	Elevator machine Room	200
<b>4.0</b>	<b><u>SUB-STATION</u></b>	
4.1	Switch room - Front of panel	250
	- Back of panel	150
	- Battery room	150
4.2	Transformer room, cable room.	70
4.3	Outdoor/transformer bay	70
<b>5.0</b>	<b><u>CONTROL ROOMS</u></b>	
5.1	Front of panel	500
5.2	Back of panel	200
6.0	OFFICES	300
<b>7.0</b>	<b><u>STORES, BATH ROOM</u></b>	100
<b>8.0</b>	<b><u>STAIR CASES</u></b>	
8.1	Safe areas	100
8.2	Hazardous areas	100
<b>9.0</b>	<b><u>PANIC LIGHTING</u></b>	10

Lux level for A.C. Emergency lighting in Control Room shall be 250 lux.



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## TECHNICAL SPECIFICATION 33 KV GAS INSULATED SWITCHGEAR (GIS)

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2.	CODES AND STANDARDS
3.	SERVICE CONDITIONS
4.	OPERATIONAL REQUIREMENT
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6.	GAS INSULATED SWITCHGEAR COMPONENTS
7.	NAME PLATES
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9.	SPARES
10.	DRAWINGS AND DOCUMENTS
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## 1.0 SCOPE

- 1.1 The specification covers scope of design, engineering, fabrication, manufacturing, inspection and testing before supply, transportation, delivery at destination, unloading & storage at site, site erection, site testing, commissioning and putting in to successful operation of 33 KV Gas Insulated Switchgear (GIS) / 33 KV GIS ICOG complete with all materials and accessories.
- 1.2 This specification is applicable for both 33 KV Gas Insulated Switchgear (GIS) (with 2 I/C + 1 B/C configuration) as well as for 33 KV GIS ICOG Panel.
- 1.3 This specification shall be read in conjunction with attached specification sheet /data sheet.

## 2.0 CODES AND STANDARDS



- 2.1 The GIS equipments / components used shall comply with the requirements of latest revision of the following standards and also the other Indian and International Standards as applicable, unless otherwise specified:

IEC 60071 Insulation coordination  
 IEC 60255 Electrical Relays  
 IEC 60099 – 4 Metal-oxide surge arresters without gaps for a.c. systems  
 IEC 60137 Bushings for alternating voltages above 1000 V  
 IEC 60255 Electrical Relays  
 IEC 60270 High-voltage test techniques - Partial discharge measurements  
 IEC 60376 Specification of technical grade sulphur hexafluoride (SF<sub>6</sub>) for use in electrical equipment  
 IEC 60480 Guidelines for the checking and treatment of sulphur hexafluoride (SF<sub>6</sub>) taken from electrical equipment and specification for its re-use  
 IEC 60529 Degrees of protection provided by enclosures (IP Code)  
 IEC 60694 Common specifications for high-voltage switchgear and control gear standards  
 IEC 62271-4 Use and handling of SF<sub>6</sub> Gas  
 IEC 61869-1 Instrument transformers — General requirements  
 IEC 61869-2 Additional requirements for current transformers  
 IEC 61869-3 Additional requirements for inductive voltage transformers  
 IEC 62271-4 Handling procedures for sulphur hexafluoride (SF<sub>6</sub>) and its mixtures  
 IEC 62271-100 Alternating current circuit-breakers  
 IEC 62271-102 Alternating current disconnectors (isolators) and earthing switches  
 IEC 62271-200 Gas Insulated metal-enclosed switchgear for rated Voltages upto 52kV  
 IEC 62271-201 AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV  
 IEEE 80 Standard for station grounding  
 IEEE std. C37.122.1-1993 IEEE guide for Gas Insulated substations  
 IEEE STD 693 Guidelines to ensure functional adequacy under Seismic disturbance

- 2.2 The equipment shall also conform to the provisions of CEA regulations and other statutory regulations currently in force.
- 2.3 In case of any contradiction between various referred standard/ specification/ data sheet and statutory regulation, most stringent requirements shall prevail. However, Owner's decision in this regard will be final and binding.
- 2.4 Item not covered and required shall confirm to the latest issue of IS/IEC.

## 3.0 SERVICE CONDITIONS

### 3.1 Ambient Condition

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- 3.1.1 The 33 kV GIS and the accessories to be supplied against this technical specification shall be suitable for satisfactory continuous operation under the following tropical conditions.

Max/design ambient temperature	: 50 deg C
Min. ambient temperature	: 1 deg C
Max daily average ambient temperature	: 46 deg C
Max relative Humidity (%)	: 100%
Max altitude above M.S.L (meters)	: < 1000
Condensation	: Occasional
Induced electromagnetic disturbance	: 1.6 kV
Pollution class	: IV
Creepage distance	: 31 mm/kV
Seismic Zone	: Zone IV

- 3.1.2 The 33 kV GIS shall be suitable for installation and satisfactory operation in a pressurised substation or in a substation with restricted natural air ventilation in a tropical, humid and corrosive atmosphere.

## 3.2 System Details

- 3.2.1 The required overall parameters of GIS shall be as follows:



Parameter	Unit	Value
Rated System Voltage	KV	33 $\pm$ 10%
Highest System/Equipment Voltage	KV	36
One min. Power frequency withstand Voltage	KVrms	70
Rated Lightning Impulse withstand voltage	KVp	170
Rated Frequency Hz 50	Hz	50 $\pm$ 5%
Rated Continuous busbar current at 50 deg C Design temperature	Amp	3150
Incomer/ bus coupler current rating at 50 deg C	Amp	3150
Outdoing bay (Feeder and Transformer Bay)- current rating at 50 deg C	Amp	2000
Rated Short circuit Withstand current for 3 sec	KA	40
Rated dynamic withstand current	KA	100
System Neutral earthing	-	Solidly Earthed
Maximum SF6 Gas leakage rate per year	% per year	As per IEC

- 3.2.2 Auxiliary supply voltage.

For Operation, control and signalling 110 Volts DC (+10% & -20%)  
For other loads 415 / 230 Volts (+/-10 %), AC 50 Hz (+/-5 %),

## 4.0 Operational Requirement

- 4.1 All equipments shall be suitable for continuous duty operation at the specified rating under the specified ambient conditions and system detail and operating condition

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including sudden change of load and voltage without exceeding permissible limit of temperature as per relevant standard.

- 4.2 The assembled equipment shall be capable of withstanding the electrical, mechanical and thermal ratings of the specified system. All joints and connections shall be required to withstand the forces of expansion, vibration, contraction, and specified seismic requirements without deformation or malfunction and leakage. The apparatus shall be capable of withstanding the specified environment.

## 5.0 General Requirement of Design, Construction and Performance

- 5.1 GIS shall consist of 33kV SF6 Gas-Insulated Switchgear with vacuum circuit breakers, Double bus-bars with two sections, 3-phases with all other associated equipment, complete with control and power wiring, as indicated in the Conceptual single line diagram attached. Provision shall also be made for additional bays one on each side (without equipments) over and above bays shown in SLD.

The 33kV switchgear shall be capable of withstanding the electrical and mechanical stresses as specified in the Technical Data Sheets.



A leakage rate of less than 0.1% per annum is required. The gas tanks should therefore preferably be state of the art manufactured of stainless steel and cut / welded by laser or manufactured from 6mm thick aluminum alloy.

All Circuit Breakers & Disconnectors operating mechanism to be of pure Spring-spring type ( any hydraulic or pneumatic is not acceptable).

A mechanical mimic diagram of suitable size showing incoming/outgoing 33kV feeders shall be provided on the front side of cubicles. In case of bay control units equivalent displays on the unit are acceptable.



## 5.2 Enclosures

- 5.2.1 The switchgear shall be of the free-standing, self-supporting, dead-front, double bus design with all high-voltage equipment installed inside gas-insulated metallic grounded enclosures and suitably sub-divided into individual arc and gas-proof compartments.
- 5.2.2 The SF6 GIS shall be of INDOOR type. The degree of protection shall be at least IP65 for gas compartments and IP4X for low voltage and other compartments as specified in IEC-60529.
- 5.2.3 The metal enclosures for the SF6 gas insulated equipment modules shall be made of non magnetic & arc-proof material i.e. Aluminium alloy, offering mechanical and thermal properties suitable for this application. The enclosure shall be suitable for three phases, i.e. Single enclosure. The external fixtures should be made of corrosion resistant material and should be capped where required. Suitable Bellow Compensators shall be made of Stainless steel to preserve the mechanical strength of the equipment at the connection portions under all condition.
- 5.2.4 Enclosures shall withstand the full rated fault current as specified in the Technical Data Sheets during arcing faults without puncturing.
- 5.2.5 The exterior surface finish of switchgear paint shade shall be RAL 7035. Sufficient quantities of all paints and preservatives required for touching up at sites shall be furnished
- 5.2.6 Gas section barriers including seals to the conductor and enclosure wall shall be gas-tight and shall be capable of withstanding the maximum pressure differential that could occur across the barrier,. These shall also not contain any substances which could contaminate the enclosed gas or affect its insulating properties over a period of time.

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- 5.2.7 The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electro-dynamic stresses even under short circuit conditions.
- 5.2.8 The switchgear shall have earth bus for connection to the plant earth grid.
- 5.2.9 The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its live constituent part.
- 5.2.10 Whenever possible, the complete feeders or major assembly of components should be shipped as transport units.
- 5.2.11 Bus-bar compartments and breaker compartments must have their own independent gas supervision and alarm systems with contact density gauges for alarm and indication.
- 5.2.12 The fully enclosed bus-bars shall be made from electrolytic drawn copper.
- 5.2.13 Bus-bars and their enclosures shall take thermal expansion of the entire switchboard into account.
- 5.2.14 Suitable mounts and compensators shall be provided where necessary.
- 5.2.15 Suitable clearance between phases and between live parts and enclosure shall be verified to keep it safe for the operator to approach and even to touch the enclosure in the worst case of gas leak, i.e., when the pressure inside the enclosure becomes equal to the air pressure outside the Switchgear.
- 5.2.16 Enclosures shall be free standing and self supporting. Unless indicated otherwise in the requisition these shall be supplied with a base frame. The floor shall not be considered as being part of the enclosure.
- 5.2.17 All components requiring periodic maintenance shall be easily accessible.
- 5.2.18 Cable installation work on functional units (replacements or new installations) and equipping of spare panels shall be safely possible without adjacent units having to be de-energized.
- 5.2.19 The Loss of Service Continuity category (LSC) of the switchgear shall be LSC2 according to IEC 62271-200.
- 5.2.20 For operator safety the switchgear must have protection system against internal faults in each partitioned compartment.
- 5.2.21 Unlikely in the event of internal arc the hot gases are guided via pressure relief disks from each compartment concerned. The hot gases should be guided away from the operator either by the venting direction of pressure release disc or by the pressure relief duct ends guided into open air or fitted with absorbers to cool and de-energize the hot gases. The release of gases shall be directed by the pressure relief disc so to minimize the hazards to persons or risk of fire to be reliably prevented. Evidence is to be provided for fully type tested GIS Switchgear in accordance with IEC 62271-200, IAC class AFLR at 40 kA for 1 Second.
- 5.2.22 The temperature-compensated manometer for pressure measurement must also permanently monitor the relevant gas compartment. Manometer shall have positive indication without use of any proximity switch or any auxiliary AC/DC supply. Provision must be made for action to be taken when the upper or lower threshold is exceeded, leading to a drastic reduction in damage by internal arc faults.
- 5.3 Modular Design**
- 5.3.1 The GIS design shall be modular and to be easily installed and commissioned with ability to extend on both ends in future with simplified civil engineering works and suitable for use in locations where severe environmental conditions exists.



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5.3.2 The GIS switch gear shall be of modular design offering high degree of flexibility. Each module shall be complete with SF6 gas circuit breaker, Bus Side & Line Side Disconnectors with maintenance Grounding switches, bus & elbow sections, Voltage transformers, Current transformers, L.A., local control cubicle, and cable end enclosures and all necessary components required for safe & reliable operation and maintenance.

5.3.3 The bus bars shall be sub-divided into compartments including the associated bus bar disconnecter. The busbars must be of flat copper of rectangular cross-section to DIN standards and continuous in the section concerned without any transverse barrier or Bus bars are partitioned at each bay with an objective to isolate Busbar compartment for the purpose of extension and at the same time avoid damage to adjacent bays in the event of fault. Individual bus bar pieces may be bolted together panel by panel. This is must be to ensure all live part of busbars including interpanel connections are also inside SF6 gas insulation. Plug-in type interpanel busbar connections in air shall not be permitted. Bus bar extensions shall be possible with the offered arrangement without a shutdown of the substation, for maintenance on a bus bar module minimum outage of bays shall be ensured.

5.3.4 Arc faults caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. In case of any internal arc fault in a busbar, busbar disconnecter or circuit breaker, of double bus system, repair works shall be possible without shutting down complete substation and at least one busbar and the undisturbed bays must remain in operation.

5.3.5 Each bay module should be equipped with suitable arrangement for easy dismantling and refitting during maintenance without disturbing other units.

5.3.6 There shall not be any kind of interference to the connected & nearby equipment and system, when the equipment is operated at maximum service voltage.

5.3.7 All the operating mechanisms of CB, Bus Side disconnecter with ES & Line side disconnecter with ES, shall be present on panel front and operated standing in front of panel on the individual equipment for better reliability.

#### 5.4 **Maintenance and repair of a circuit breaker:**

The positioning of the circuit breaker in the GIS shall be such that it shall be possible to access the circuit breaker of any feeder from the front/ rear bottom side for routine inspection, maintenance and repair at site without interfering with the operation of the adjacent feeders. The GIS shall be so designed that any component of the GIS can be removed easily.

Internal components shall be maintenance free for at least 10 years. Routine replacement of insulating gas shall not be required in less than ten years.



#### 5.5 **Interchangeability**

As much as possible, all the parts shall be of standard manufacture with similar parts and assemblies of same rating being interchangeable.

#### 5.6 **Future Extension**

The modular design of GIS switch gear shall be capable of extension in the future on either end by the addition of extra feeders, bus couplers, busbars, circuit breakers, Disconnectors, and other switch gear components without drilling cutting, welding or minimum dismantling any major part of the equipment.. The arrangement shall be such that expansion of the original installation can be accomplished with minimum GIS down time. In case of extension, the interface shall incorporate facilities for installation and testing of extension to limit the part of the existing GIS to be re-tested and to allow for connection to the existing GIS without further dielectric testing.



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## 5.7 Physical arrangement

- 5.7.1 The layout shall be properly designed by the bidder to completely accommodate the present & future requirements of the sub-station as per the furnished single line diagram. These may be adjusted as necessary to suit the manufacturer's standard design.
- 5.7.2 The arrangement of the switchgear offered must provide adequate access for checking and maintenance.
- 5.7.3 Optimized arrangements are required so as to reduce installation time, minimize maintenance & repair cost, provide ease of operation and facilitate future expansions.
- 5.7.4 The number of transport/shipping splits shall be minimized to keep installation time of GIS to a minimum. The arrangement shall afford maximum flexibility for routine maintenance. Equipment removal and SF6 handling should be accomplished with ease. The ease of operation shall be ensured.



## 5.8 Gas Sectionalisation

- 5.8.1 The switch-gear gas enclosures must be sectionalized, with gas tight barriers between sections or compartments.
- 5.8.2 The sections shall be so designed as to minimize the extent of plant rendered inoperative when gas pressure is reduced either by excessive leakage or for maintenance purposes and to minimize the quantity of gas that has to be evacuated and then recharged before and after maintaining any item of equipment.
- 5.8.3 The arrangement of gas sections or compartments shall be such that it is possible to extend existing bus-bars without having to take out of service another section of the bus-bar at a time.
- 5.8.4 For limitation of any internal arc to the concerned bay or bus section, the necessary gas work should be limited only to the affected gas compartment / bus section present on either side of bus sectionalizer or bus-bar sectionalized bay by bay, without disturbing adjacent bay or other live bus section.
- 5.8.5 Sectionalisation shall ensure that circuit breaker enclosure will not include any other equipment in its gas compartment.

## 5.9 Expansion Joints and Flexible Connections

- 5.9.1 The layout shall sufficiently take care to the thermal expansion / contraction of the assembly by the provision of expansion joints. Expansion joints shall be placed in between any bay section of the busbar.
- 5.9.2 The number and position of expansion joints or flexible connections shall be determined by the manufacturer to ensure that the complete installation will not be subject to any expansion stresses which could lead to distortion or premature failure of any piece of the SF6 equipment, support structures or foundations. Bracing shall be provided for all mechanical components against the effects of short circuit currents specified under system parameter. The design calculations for all the supports shall be submitted.
- 5.9.3 The continuity of service during thermal expansion / contraction and vibrations shall be ensured. Expansion joints, flexible connections and adjustable mountings shall be provided to compensate for reasonable manufacturing and construction tolerances in the associated equipment to which the GIS may be connected. Required sliding plug-in contacts for conductors shall be provided.
- 5.9.4 Metallic bellows (preferably of stainless steel) shall be provided over expansion joints.

## 5.10 Barrier and Non-Barrier Insulators

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5.10.1 Support insulators shall be used to maintain the conductors and enclosure in proper relation. These support insulators may be of two types. Barrier insulators which are employed to isolate gas compartments and non-barrier insulators which allow the gas pressure to equalize.

5.10.2 The gas barrier insulators sealing to the conductors and the enclosure wall shall be provided as per requirement.

#### 5.11 **Gas seals, Gas Density & pressure and other requirements.**

5.11.1 Double sealing of O-ring type shall be used for sealing the connections between the switch-gear modules. The leakage rates shall be kept to an absolute minimum under all normal pressure, temperature, electrical load and fault conditions.

5.11.2 Piping and fittings for gas monitoring and gas supply shall be made of copper or brass.

5.11.3 All gas compartments shall be fitted with filter material which absorbs the residual moisture and moisture entering inside the High-voltage enclosure.

5.11.4 The guaranteed leakage rate of each individual gas compartment must be less than 0.1 % p.a. over the lifetime of the Switchgear.

5.11.5 Initial Filling of the equipment must guarantee gas service periods of not less than 10 years.

5.11.6 Assembled enclosures must withstand at least twice their rated internal operating pressure. This fact must be proven on each individual section of the Switchgear.

#### 5.12 **Gas Treatment Requirements**

Under normal operating conditions it shall not be necessary to treat the insulating SF6 gas between major overhauls.

#### 5.13 **Gas Monitoring Devices**

Gas density or pressure monitoring devices (manometer) shall be provided for each gas compartment. The devices shall provide continuous and automatic monitoring of the state of the gas. The SF6 gas monitoring device shall have two supervision and alarm settings. The gas monitoring device shall monitor at least the following, locally and on remote.

i. "Gas Refill" Level- This will be used to annunciate the need for gas refilling.

ii. "Breaker Block" Level- This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the device contact shall trip the breaker and block the closing circuits.



iii. Over pressure alarm level- This alarm level shall be provided to indicate abnormal pressure rise in the gas compartment.

#### 5.14 **Conductors**

The conductors shall be made of electrolytic grade copper suitable for specified voltage and current ratings. The electrical connections between the various gas sections shall be made by means of multiple contact connectors (plug-in type / bolted) so that electrical connection is automatically achieved when bolting one section to another. Field welding of conductor is not acceptable. The surface of the connector fingers and conductor on such connections

#### 5.15 **Gas filling and Evacuating Plant/Gas reclaimer for 33 kV GIS unit.**

5.15.1 All apparatus necessary for filling, evacuating, and recycling the SF6 gas into and from the switch-gear equipment shall be supplied to enable any maintenance work to be carried out.

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5.15.2 The apparatus for filling, evacuating and recycling all gases to be used shall be provided with all necessary pipes, couplings flexible hoses, tubes and valves for coupling to the switch-gear equipment.

5.15.3 The gas compartments shall preferably be fitted with permanent vacuum couplings through which the gas is pumped into or evacuated from the compartments.

5.15.4 The initial gas filling of the entire switch-gear including the usual losses during commissioning shall be supplied over and above the 20% quantity of spare gas.

#### 5.16 Support Structures

All supporting structures necessary for the support of the GIS equipment including associated parts such as anchor bolts, beams etc. shall be supplied. Any scaffolding or a movable platform required for maintenance shall also be supplied.

All steel structure members shall be powder coated. Thickness of coating shall be 100 micron. All field assembly joints shall be bolted. Field welding shall not be acceptable.

#### 5.17 Safety Precautions

5.17.1 The switchgear must provide a maximum degree of safety for the operators and others in the vicinity of the switch gear under all normal and fault conditions. The safety clearances of all live parts of the equipment shall be as per relevant standards.

5.17.2 It must be made impossible to touch any live part of the switchgear unwillingly, i.e. without use of tools or brute force.

5.17.3 An operator standing in the normal operating position should not be endangered by any moving external part of the switchgear.

#### 5.17.4 INTERLOCKS:



Mechanical & electrical interlocks shall be provided to ensure absolute and reliable protection against potentially harmful Mal-operation of the switchgear. All interlocks that prevent potentially dangerous mal operations shall be so constructed such that These cannot be defeated easily.

1) Specifically the following conditions shall be impossible to reach:

- Electrically and manually closing or opening of the disconnector / earthing switch while the breaker is closed.
  - Electrical closing of disconnector switch, while the earthing switch at the remote end is closed.
  - Electrical closing of earthing switch while the remote end disconnector/circuit breaker is in closed position.
  - Electrical / manual closing of busbar disconnectors of any circuit while the busbar earthing switch is closed.
- Bus VT Miniature Circuit Breaker (MCB) ON auxiliary contacts and under voltage relay contacts shall be monitored in the interlocking scheme to confirm the dead bus condition.
  - Bus-bar disconnectors of any circuit shall not close electrically or manually while a Bus-bar Earthing Switch is closed.

5.17.5 If in spite of all possible safety measures if any arc occurs, the following is required.

5.17.5.1 The effects of an internal arcing fault must be limited to the related gas compartment.

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- 5.17.5.2 Each gas compartment must have its own automated external pressure relief device to provide instant and safe discharge of accidental overpressure.
- 5.17.5.3 The set points for the pressure relief device shall be lower than pressure withstanding capability of the enclosure with sufficient margin.
- 5.17.5.4 To limit the effects of an internal arc the switch gear shall be suitably subdivided into individual arc and gas-proof compartments, at least for
- Bus-bar
- 3-position disconnecter for each busbar
- Circuit breaker
- Line isolators and earthing switch, (Line, transformer)
- 5.17.6 The following requirements are to be followed.
- 5.17.6.1 The bracing/welding of all components subject to mechanical forces caused by short circuit currents shall be capable so as to withstand the effects of at least 2.5 times the rated symmetrical short time withstand current.
- 5.17.6.2 The thermal rating for all current carrying parts and insulating materials shall be a minimum of three seconds for the rated short time withstand current.
- 5.17.6.3 All components of the switch gear which are on ground potential shall be electrically interconnected and effectively earthed.

#### 5.18 **Grounding of GIS:**



- 5.18.1 All grounding connections must remain operational during and after an arc fault. Proper grounding for mitigating over voltages during disconnecter operation shall be included. Viewing windows shall be provided at the Disconnectors and earthing switches to ensure that each contact position can be inspected easily from the floor level.
- 5.18.2 GIS will be housed on GIS floor. The bidder shall provide under-ground mat below the substation. The bidder shall also provide adequate number of Galvanized steel risers to be connected to grounding mat, as per relevant standards.
- 5.18.3 The bidder shall supply entire material for ground bus of GIS such as conductor, clamps, joints, operating and safety platforms etc. to be laid / embedded in GIS floors. All required grounding connectors and associated hardware material shall be in bidder scope.
- 5.18.4 The grounding arrangement of GIS shall ensure that touch and step voltages are limited to safe values as per IEEE std. 80-2000. Calculation for sizing of grounding conductors including ground mat for step & touch potential shall be furnished.

### 6.0 **GAS INSULATED SWITCHGEAR COMPONENTS**



#### 6.1 **Circuit Breaker:**

##### 6.1.1 **General:**

- i. The GIS circuit breakers shall comply with the following general requirements for circuit breakers and the latest revisions of the relevant IEC-62271-100 specifications
- ii. Circuit – breakers shall be of with vacuum as arc quenching medium & SF6 as insulation medium and with a minimum- maintenance contact system. These shall be of single / three phase encapsulated type.
- iii. These should be shipped as a completed three-phase unit within a complete bay module.

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- iv. Each circuit-breaker shall have Spring – Spring drive mechanism ensuring proper closing and opening and shall permit checking of adjustments and opening/closing characteristic. The ON/OFF latches shall be mechanically interlocked with each other. The circuit breaker shall be completely factory assembled, adjusted and tested.
- v. The total break time from energizing the trip coil at rated control voltage to final arc extinction shall be as short as possible, but in any event not greater than 3.5 cycles i.e. 70 ms.
- vi. The breakers shall be restrike-free.
- vii. The circuit-breakers shall be capable of tripping and re-closing (Auto reclose) according to the specified duty cycle without derating: O –0.3 s – CO – 3 min. – CO. • Short line faults.  
  
The circuit breakers shall be complied to mechanical endurance class M2 & shall be capable of being operated locally or from remote. Local operation shall be by means of an open/close control switch located in the bay control cabinet. The minimum guaranteed nos. of maintenance free operations of complete GIS shall be 30000 Nos
- viii. The Drive shall have sufficient stored energy for completing 1CO with auxiliary power switched off.
- ix. Each SF6 gas compartment shall be designed for automatic pressure relief in case of pressure built-up due to arcing, at the same time, ensuring that escaping gases are clear-of the operating personal in the front of the Switchgear. Any devices for pressure relief shall be absolutely vermin, dust and damp proof under normal service conditions.
- x. The protection relays and Bay Control Units or Bay Control and Protection Units shall be installed in separate metal-enclosed LV compartments associated with each individual feeder panel.
- xi. A gas service cart with pressure-vessel, vacuum pump, and all required gauges and Fittings for servicing the Switchgear shall be included in the scope of supply.
- xii. Routine maintenance to any of its external components, including the protective relays and instrument transformers, shall not be required in less than five year intervals; internal components shall be maintenance-free for at least ten years, including the refilling of gas.
- xiii. The Switchgear shall be of the free-standing, single-front, single-tier, self-supporting, dead-front design with all high voltage equipment installed inside, SF6 gas-insulated, metallic and earthed enclosures, suitably divided into individual arc and SF6 gas-proof compartments, at least for:
  - a. Bus-bars,
  - b. Bus Side Disconnectors & earthing switches,
  - c. Circuit breakers,
  - d. Cable connections.
  - e. Line side disconnectors & earthing switches
- xiv. Each SF6 gas-filled compartment is to be equipped with suitable static filters to absorb any humidity that penetrates through the enclosure materials over long periods of time. In addition filters for removal of SF6 decomposition products shall be provided in those compartments in which arcing or corona discharges can take place.
- xv. Each compartment shall have pressure relief devices and pressure indication gauge. Gauge will have clearly visible pointer and low and high pressure alarms.
- xvi. All incomers and outgoing feeders shall be provided with surge arresters.

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xvii. LV Compartment shall be located at an accessible height.

#### 6.1.2 Closing Devices

The closing coils shall be suitable for operation at any voltage between 110% and 80% of the nominal control voltage measured at the device terminals

#### 6.1.3 Tripping Devices

- All electrical tripping coils shall be suitable for operation at any voltage between 110% and 70% of the nominal control voltage measured at the device terminals.
- Each circuit-breaker shall be equipped with two shunt trip system. The one shunt trip system shall be electrically separated from the other system.
- An emergency hand tripping (mechanical) device shall be provided in the operating mechanism.

#### 6.1.4 Anti-Pumping

The circuit-breaker mechanism shall be provided with anti pumping device.

#### 6.1.5 Operating Mechanism

The operating mechanism shall be in a dust proof (minimum IP 4X) box for this INDOOR installation of Gas Insulated Switchgear. One vermin-proof, sheet steel cabinet of adequate size shall be provided for housing the operating mechanism, aux relays, control and auxiliary equipment and for terminating all control, alarm and auxiliary circuits in suitable terminal boxes. The control cabinet shall be provided with hinged doors with provision for locking and removable cable gland plates for bottom cable entry. Viewing windows shall be provided for observation of the instruments without opening the cabinet. Suitably engraved nameplates shall be provided to identify all equipment in the control cabinet.

The breakers shall have at least 4 normally open (NO) and 4 normally closed (NC) spare auxiliary contacts for Owner's use. If these are not available, auxiliary relays shall be used to multiply the auxiliary contacts of the breakers.



#### 6.1.6 Spring operated Mechanism

- Closing action of circuit breaker shall compress the opening spring ready for tripping.
- When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the LCC.
- Provisions shall be made to prevent a closing operation of the breaker when the springs in the partial charged condition.
- A mechanical indicator shall be provided to indicate the status of the spring.
- Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in closed position.
- The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

#### 6.1.7 Auxiliary Switches

Each breaker shall have auxiliary switches with adequate number of NO and NC contacts all wired to terminals located in the local control cabinet of the circuit breaker bay. 20 % spare contacts should be provided.



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#### 6.1.8 Indicating Devices

- i. Position indicators shall be provided to clearly indicate whether a circuit-breaker is open or closed.

Status    Color

Open position                      Open    Green

Closed position                      Closed    Red

- ii. Each circuit-breaker shall be provided with an operation counter to record the number of tripping operations performed. The counter may be located at the local control cabinet.

#### 6.1.9 Gas Connections

Necessary valves and connections shall be provided to assure ease in handling the SF6 gas.



#### 6.1.10 TESTING FACILITIES:

Timing test facility shall be provided with switchgear such that it is not necessary to open up any gas section to make test connections to the circuit breaker terminals. All details of test facilities to be provided shall be submitted with technical bid.

### 6.2 Disconnecter Switches/Isolator and Maintenance Grounding switches

#### 6.2.1 General

- I. Means to safely isolate and ground any feeder breaker of the Switchgear shall be provided with disconnector / grounding switches.
- II. The GIS disconnector switches and grounding switches shall comply with the following general requirements of disconnect switches and the latest version of the relevant specifications IEC 62271-102.
- III. Motor-operated combined isolation / grounding switches, Disconnector / grounding switches shall be designed to withstand the rated and fault current of the Switchgear. Designs where the actual grounding of the feeder / bus-bar is done via the circuit breaker, i.e., where the disconnector is used only to preselect the grounding position, are preferred.
- IV. Such three-way switches must have definitive stops at their "ON", "ISOLATED" and "GROUNDED" positions, with no direct movement from the "ON" through the "ISOLATED" into the "GROUNDED" position.
- V. View-ports or mechanical indicators / mimic connected directly and permanently to the operating shaft are required to positively display the actual switch position. Indirect position indicators are not acceptable.
- VI. Power operated drives shall be provided which shall be suitable for local, remote (Substation Control and Monitoring System - SCMS) and also should be fitted with an emergency manual operation facility.
- VII. Disconnect switches shall be three / single phase encapsulated, group operated, no break, with one common motor operated mechanism for all the three poles. These shall also have facilities for emergency manual operation and necessary handles shall be provided.
- VIII. Line side disconnector with Earthing Switch shall be E1 class operated. Safety earthing switches shall be E0 class operated. The disconnector shall be M1 class operated.
- IX. Maintenance earthing switches shall be single phase encapsulated, group operated, no break, with one common motor operated mechanism for all the three poles. These shall

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also have facilities for emergency manual operation and necessary handles shall be provided.

- X. Disconnect switches and grounding switches shall have electrical and Mechanical interlocks to prevent grounding switch from closing on an energized section. Interlocks with other bays for bus transfer switching shall be done through bay control cabinets. Actuation of the emergency manual operating device shall also disable the electrical control. Disconnectors in open condition shall be secured against reclosure.
- XI. All main contacts, male and female, shall be silver plated.
- XII. Each disconnect switch and grounding switch shall open or close only due to motor driven or manual operation independently. There should also be a pre-set timer in motor circuit for protection against time over –run in case of inadvertent failure of drive mechanism in any intermediate position of the disconnector travel path.
- XIII. The disconnect switches shall be capable of interrupting the charging current of the connected GIS bus & associated components.

#### 6.2.2 Interlock System

- I. The interlock System must positively prevent an Operator from reaching or creating unintentionally a dangerous or potentially dangerous condition.
- II. Specifically the following conditions must be impossible to reach:
  - Forcing the operator into the only safe and logic sequence to actuate breakers, switches, isolators and grounding switches.
  - Checking the actual fully closed or fully open position of all switching elements before and after each move.
  - Providing the logical checks and issuing the resulting PERMISSIVE or BLOCKED signals for the switchgear.
  - Indicating positively the absolute condition/position of the supervised equipment.
  - Electrically and manually operating the breaker with the disconnector / grounding switch not fully engaged in any of its three positions.
  - Electrically and manually closing or opening of the disconnector / grounding switch while the breaker is closed.
  - Electrically and manually closing of the disconnector switch while the earthing switch at the remote end is closed.
  - Electrically and manually closing of the disconnector / grounding switch while the remote end isolator/circuit breaker is in closed position.
  - Local emergency unlocking facilities via safety-key switches under the full responsibility of the operator. Intrabay and interbay electrical interlocking shall be provided.
- III. When the manual emergency cranks are used, it shall be impossible to control the devices electrically.
- IV. Electrical interlocks shall be provided between Bus-bar Earthing Switches and all Bus-bar Isolators of each Bus-bar Section in such a way that Bus-bar Earthing Switches can not be closed when the Bus-bar Isolator of any circuit in the section is closed.
- V. Bus VT Miniature Circuit Breaker (MCB) ON auxiliary contacts and under voltage relay contacts shall be monitored in the interlocking scheme to confirm the dead bus condition.



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- VI. Moreover the Bus-bar Isolator of any circuit shall not close electrically or manually while a Bus-bar Earthing Switch is closed.
- VII. Castel key interlocks shall be provided in all incoming and outgoing feeders to provide mechanical interlocking with the upstream / downstream Feeders.
- VIII. Castel Key Interlock shall be provided between the Capacitor Bank main door to the HV VCB in the GIS.

#### 6.2.3 Duty requirements:

The disconnecting switches shall have breaking capabilities as per IEC requirements. Contact shielding shall be designed to prevent restrikes and high local stresses caused by the transient recovery voltages when currents are interrupted.

The bus disconnecting switches shall reliably handle capacitive currents due to the making and breaking of switchgear components as well as commutation currents due to bus bar reconfiguration.

The disconnecter shall be used for the safe isolation and earthing of the line side feeder/ cable. In the event of maintenance activities on CB compartment, the breaker is isolated physically from bus side as well as line side.

Cable feeders shall be capable of switching induced current as per IEC requirement.

#### Short Circuit Requirements



The rated peak short-circuit current or the rated short time current carried by an isolator or earthing switch for the rated maximum duration of short circuit shall not cause:

- a) Mechanical damage to any part of the isolator or earthing switch.
- b) Separation of the contacts or contact welding.
- c) A temperature rise likely to damage insulation.

#### 6.2.4 Operation Mechanism.

- I. Mechanism shall be arranged mechanically, electrically, so that all three phases of any particular disconnect switch or grounding switch operate simultaneously.
- II. All mechanisms shall be suitable for electrical motor operation to achieve a fully automatic operation. For emergency situations manual operation shall be possible. Handles or hand cranks shall be provided, together with all necessary operation rods and rod guides. Manual operation shall be prevented if the interlocking system does not allow the operation of the switch.
- III. The auxiliary supply shall be electrically decoupled from the motor when the switch is operated manually.
- IV. The mechanisms shall be arranged for locking in the open and in the closed position. Facility shall be available to allow the switch to be padlocked in any position.
- V. Disconnecting operating mechanism of all disconnecter/ isolator & earth switches shall be at easy operable height.
- VI. The isolator shall be provided with positive continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under most adverse conditions and when operated in tension or compression for isolator closing.

The operating mechanism design shall be such that during the operation of the isolator (especially manual operation), once the moving blades reach the sparking distance,

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springs shall take over to give a quick, snap action closing so that the isolator closing is independent of manual efforts. Similarly, the springs must assist during the opening operation to give quick breaking feature.

VII. Similarly, the springs must assist during the opening operation to give quick breaking feature.

VIII. Additional Requirements for Safety Earthing Switches

a) Earthing switch, whenever possible can form an integral part of each pole of the disconnecter. Two independent earthing pads each with flexible copper braids and suitable connectors for earth conductor lead shall be provided at the hinge end of the earthing switch.

b) Interlocks shall be provided so that manual operation of the earthing switches or insertion of the manual operating device will disable the electrical control circuits.

#### 6.2.5 Auxiliary Switches:

Each disconnect switch and grounding switch shall provided with sufficient Nos. of NO – NC as per entire scheme requirement plus two (2) NO-NC electrically independent contacts terminated up to terminal board, at user's disposal. The auxiliary switches shall indicate the position of the switch contacts, and shall be independent of the motor operation.



#### 6.2.6 Position Indicators

I. Mechanically connected position indicators shall be provided externally to permit observation of close/open position of the disconnect switch and grounding switch.

#### 6.3 Current Transformers:

##### 6.3.1 General

- I. The current transformers provided for each phase shall be supplied in accordance with the following general requirements and the latest revisions of the relevant IEC 61869 specifications.
- II. All transformers must be suitable for continuous operation of min. 20 % overload and for service under all rated and fault conditions.
- III. The current transformers must be outside SF6 gas compartment.
- IV. The current transformer shall be ring / toroidal type, multi ratio with fully distributed secondary windings with relay accuracy as per latest relevant IEC Standards incl. multi core as per requirement and shall be mounted inside the high voltage enclosure.
- V. The secondary terminals of current transformers shall be placed outside the high voltage enclosures, mounted in suitable, accessible terminal boxes and the secondary leads of all the current transformers shall be wired to shorting type terminals. At this terminal block one side of each transformer shall be connected to earth.
- VI. It shall be possible to test each current transformer without the removal of gas through the insulated grounding switches.
- VII. Unless otherwise specified, cores for measuring instruments shall have accuracy classes (0.2S) of not more than 0.5 % and saturation factors less than 5.
- VIII. Current transformers for protection purposes shall be of accuracy class 5P and a saturation factor that will ensure the proper working of the protective devices for all short-circuit currents up to the rated value of the switchgear. Maximum possible DC component of short circuit current shall be considered for CT dimensioning.

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- IX. The polarity of the primary and secondary windings of each current transformer shall clearly be indicated.
- X. The number and position of the current transformers shall be relative to the circuit-breakers, disconnecting switches and ground switches as detailed in the attached single line diagram.
- XI. The rating, No of cores, ratios, accuracy class, characteristics etc. for the individual current transformer secondary cores shall be as indicated in data sheet. The various ratios of current transformers shall be obtained by changing the effective number of turns on the secondary winding.
- XII. Each current transformer shall be provided such that the enclosure current does not affect the accuracy or the ratio of the device or the conductor current being measured. Provision shall be made to prevent arcing across the enclosure insulation.
- XIII. To guarantee the correct operation of the connected protection equipment, through faults stability calculations shall be submitted showing sufficiency of the chosen CT cores, i.e. rated output, rated accuracy, limit factor, rated primary current, knee-point e.m.f. and resistance of the secondary windings (corrected to the maximum service temperature). Maximum possible DC component of short circuit current shall be considered for CT dimensioning.

#### 6.4 **VOLTAGE TRANSFORMER:**

##### 6.4.1 General:

Each voltage transformer shall be metal enclosed, SF6 insulated in accordance with relevant IEC 61869. The location, polarity, ratios, and accuracy shall be as specified.

The rated output shall match the maximum load of the equipment connected plus min. 25 %, but with a minimum of 50VA unless specified otherwise. The ratios shall be as per the single line diagrams.

Unless otherwise specified Voltage transformers for measuring purposes shall be of accuracy class 0.2, and Voltage transformers for protection purposes shall be of accuracy class 1 (3P).

Voltage transformers must be able to withstand the full rated power frequency withstand and BIL voltages.

Voltage transformers shall be inductive direct plug-in type.

V.T. secondary MCB's shall be provided.



It shall not be possible to connect the secondary circuits of VTs in parallel. In case only one Voltmeter has been installed a selector switch shall be provided.

It shall be possible to isolate the voltage transformer without de-pressuring any gas filled compartment.

##### 6.4.2 Construction:

VTs should be mounted either in same GIS panel or in segregated compartment and not forming a part of bus bar. Transformers should be of either plug-in construction or the disconnect-link type and be attached to the gas-insulated system.

A voltage transformer designed so that it does not have to be disconnected during dielectric testing. The metal housing of the transformer should be connected to the metal enclosure of the GIS with a flanged, bolted, and gasketed joint so that the transformer housing is grounded to the GIS enclosure. Adequate measures shall be provided to prevent any unacceptable impact on the secondary control and protection circuits, which might result from fast transients (VFT) or Ferro-resonance.

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#### 6.4.3 Covers and shields:

Enclosures of voltage transformers shall be grounded and completely safe to touch during operation.

#### 6.4.4 Primary and secondary terminals:

Primary and secondary terminals should have permanent markings for identification of polarity, in accordance with IEC.

#### 6.4.5 Provision shall be made for grounding of the secondary windings inside the local control cabinet.

### 6.5 Local & Remote Control and Operation

#### 6.5.1 General

One local control cabinet (LCC) for GIS shall be supplied for the local control and operation of each bay. Each LCC shall contain the local control, interlocking, operation and indication devices for the associated GIS bay.

The LCC shall be mounted integrally within each GIS bay. The LCC's shall be located with sufficient space for access and the possibility to work at the equipment directly at the switch-gear in front of the related circuit breaker.

The LCC's shall be installed indoor type Minimum IP 4X protected. Access to the components shall be provided.. The control and operation circuits shall be well shielded and with safety measures to protect operator from touching energized parts.

The LCC should have required arrangement for control and operations of GIS from Remote.

The LCC shall include all required functions for control and supervision of a complete GIS. Necessary provision for interfacing for remote operation shall be provided.

#### 6.5.2 Required features for conventional local control cabinets

The LCC's shall be provided with the following features:

A mimic diagram showing the single line diagram. Position indicators, on/off switches for the HV devices and local / off / remote switches shall be installed on or adjacent to the various symbols of the mimic diagram.

##### 6.5.2.1 Each LCC shall be provided with space heater to prevent the internal equipment from humidity deposit. The heater shall be rated 230 V AC and fed through MCB.

#### Low Voltage Compartment:

The following devices shall be supplied as a minimum:

Circuit breaker control switch with ON – OFF indicating lamps. – Circuit breaker “local-remote” selector switch. Disconnect switch, control switch with ON – OFF indicating lamps.

Grounding switch, control switch with ON – OFF indicating lamps.



Monitoring control of all high voltage switching devices in a bay.

Digital display of current, voltage, active and reactive power, power factor etc.



##### 6.5.2.2 Any interposing relays and control switches associated with the circuit breakers disconnect switches, grounding switches etc.

##### 6.5.2.3 The alarm and indication for devices specified e.g. gas, DC & AC supervision.

##### 6.5.2.4 Fuses and links. These shall be installed in the interior of the LCC's

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- 6.5.2.5 Terminal blocks for the terminating and marshalling of auxiliary supply circuits, control, interlocking, and indication & alarm circuits from the GIS and for cable connections to the remote control room or the owner's control system.
- 6.5.2.6 A fluorescent lamp and a duplex convenience outlet rated 230 V AC, 15 amps with ground fault interrupter shall be installed in each LCC.
- 6.5.2.7 The Low voltage compartment shall be fitted with pre wired interface terminal blocks for connection to user's control & protection panels. The interface includes CT & PT inputs for protection & Measuring system, Protection trip 1 & 2 signals, Aux switch contacts etc.
- 6.5.2.8 Completely separate and isolated circuits shall be used for Switchgear control, tripping / protection, alarms, and auxiliary devices. These circuits shall have separate control power buses and feeders, suitably protected, for each power bus section.
- 6.5.2.9 Each control circuit shall be protected by a two-pole miniature circuit breaker with auxiliary N/C contact. The auxiliary contacts of all MCB's of the same circuit type, e.g. circuit breaker motor control, disconnect switch motor control, alarm, space heater, trip, etc., shall be wired in series to a group / common alarm terminal.
- 6.5.2.10 Each switchgear shall be provided with 2 (two) independent feeders from the DC distribution board of the DC system. Each feeder shall normally feed one section of the switchboard. Switching facility with autochangeover shall be provided at the switchboard such that any one feeder can feed the entire switchboard secondary load.
- 6.5.2.11 Voltages for control, trip and alarm shall be monitored by built-in normally energized auxiliary relays, separate for each bus or feeder section. These relays shall be time delayed on drop-off and their contacts shall be wired to group / common alarm terminals.
- 6.5.2.12 All breakers shall have key-operated selector switches installed in their low voltage compartment (separate from the bay control unit). The key shall be removable in the remote positions only.
- 6.5.2.13 The switch shall have following functions:
- Local position (the breaker isolator and earthing switches can only be operated locally by its push buttons).
  - Remote position (the breaker and Isolator can only be operated from ECMS).
- 6.5.2.14 Breaker / isolator / earthing switch ON / OFF control switches (separate from Bay Control Unit) shall be provided.
- 6.5.2.15 To prevent condensation, space heaters shall be installed in each LV equipment compartment. Each LV equipment compartment shall have a space heater feeder, fed from a separate external power source (from SPDB - Small Power Distribution Board) and protected by a two-pole MCB with auxiliary N/C contact wired to a group / common alarm terminal. The heater elements shall be controlled by humidity and temperature.
- 6.5.3 Wiring Requirements**
- I. Control panel shall be complete in all respects to ensure proper functioning of the control, protection, and monitoring and interlocking schemes.
  - II. Wiring shall be done with flexible 1100V grade, FRLS, PVC insulated, switchboard wires with 2.5 mm<sup>2</sup> stranded copper conductor. Wiring between equipment and control cubicle shall be routed through G.I. rigid conduits and shall be done by PVC & screened cable only, with safety measures to protect operator from touching energized parts.

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- III. Each wire shall identify at both ends with permanent markers bearing wire numbers as per Contractor's wiring diagram.
- IV. Wire termination shall be done with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.
- V. All spare contacts of relays, push buttons, auxiliary switches etc. shall be wired up to terminal blocks in the control cubicle.
- VI. Terminal blocks shall be 1100V grade, stud type with engraved numbers suitable for termination of at least two numbers of 2.5.0 mm<sup>2</sup> stranded copper conductor. Terminal blocks for CT, PT, auxiliary AC & DC supply shall be disconnecting link type.
- VII. Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished.
- VIII. Co-axial type cable glands suitable for use with shielded cables shall be used at each termination.
- IX. All control cables shall be installed and terminated in such a manner as to limit the effects of transient electromagnetic voltages on the control conductors to an acceptable level.
- X. Any cabling within GIS shall be supported on cable tray. No cable shall be in hanging position.
- XI. Insulator cones shall be embedded in full return current carrying metal fixing rings in order to avoid mechanical stresses to the cast resin part and to impart full conductivity across the flange connection. Earthing of different gas compartments/enclosures is not allowed with cross bonding with any metal strips.

#### 6.5.4 Connections within the GIS and their LCC's



All cable connections between the various GIS modules and the LCC's shall be made by multi-core cables with multipoint plug in connections on both the ends. PTs & CTs circuit shall be wired with crimped type copper lugs.

The electrical connections between the various gas sections shall preferably be made by means of multiple contact connectors so that electrical connection is automatically achieved when bolting on section to another. The surface of the connector fingers and conductor tubes on such connections shall be silver plated.

#### 6.6 Control Relay Panels

- 6.6.1 Separate Control Relay Panel (CRP) for each bay shall be supplied to facilitate control of circuit breakers, disconnectors, earth switches and metering, protection etc.
- 6.6.2 CRPs shall be free-standing floor mounted type panel to be located in separate room adjacent to GIS hall. CRP shall be in dust and vermin proof hot dipped galvanised sheet steel construction.
- 6.6.3 A mimic diagram shall be provided on the front of the panel with control switches and position indicators for CB, disconnector and earth switches. The panel shall be dead front type with front door having clear glass cut-out of adequate size so that mimic diagram, annunciator windows, indicating lamps are clearly visible from outside.
- 6.6.4 All protection relays, bay control units, DMMs and associated auxiliary equipment shall be of standard construction from experienced and reliable manufacturers. Important functions and features, in addition to the fault measuring capabilities, shall include:
  - Programmable scheme logic,
  - Remote communication interface for setting / interrogation from SCMS,



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Local communication interface (HMI-keypad and / or serial PC communication),  
Time-tagged events, fault and disturbance records,  
Display of measured/processed quantities,  
Self-monitoring (Hardware / Software),  
Inter-protection communication,  
Electronic transducer communication.

6.6.4 CRP shall house bay control units (BCUs) and protection relays. These panels shall also house the various selector switches, auxiliary relays, timers, local indications, alarms and facia annunciation window etc. to realise various interlocks as per requirement among circuit breakers, disconnectors and earth switches and for breaker pole discrepancy, anti-pumping etc. It shall include the following as minimum:

- a) Local / off / remote selection switch
- b) CNT control switch for breaker
- c) Breaker ON, OFF, Trip-1, Trip-2, Trip circuit healthy indications
- d) Disconnector & earth switches ON, OFF control switches & indications
- e) DC supply healthy indication
- f) Spring charging devices status
- g) Aux. relays / other devices as required by the design.



6.6.5 Completely separate and isolated circuits shall be used for each operating mechanism control, trip- 1, trip-2, close, alarms and auxiliary devices. Close and trip circuits shall be kept isolated to their final mechanical or electrical actuators from the CRP terminals.

6.6.6 Trip circuit-1 & trip circuit-2 shall be individually monitored for continuity under open and closed condition of breaker. Close circuit shall be monitored under open condition of breaker.

6.6.7 The contacts and signals originating from/going to the GIS, associated auxiliary and monitoring equipment shall be wired up to the CRP, for external use.

#### 6.7 **Protection Relay :**

- 6.7.1 All protection relays shall be provided with test plugs and all CT, VT wiring shall be wired through the test plugs.
- 6.7.2 The protection scheme(s) shall include all hardware and software to permit remote setting / interrogation / fault evaluation from the ECMS (engineering) workstation or from the computer monitoring system.
- 6.7.3 All protection relays shall be equipped with dual redundant communication port using IEC 61850 with site selectable Edition 1 & 2 , Dual communication (FO or RJ 45) with Parallel redundancy protocol (PRP), KEMA Level "A" certification communication protocols to work as an integrated part of the ECMS hierarchy. Should the relay schemes be offered from multiple Bidders / Contractors, all third party user interface software products shall be supplied to the ECMS platform to bring together all types of protective relaying into a unified control system hierarchy.
- 6.7.4 Protection relays and BCUs shall be supplied from 110 V DC. The relay's maximum DC auxiliary power consumption shall be less than 15 W (all inputs activated and over the full supply range) except busbar protection relay.

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- 6.7.5 Relay shall have 15 or more user programmable function LEDs and 1 fixed LED for relay healthiness.
- 6.7.6 All Numerical relays shall have features for electrical measurements including voltage, current, power, frequency, power factor etc.
- 6.7.7 All numerical relays shall have provision of both current (CT) and voltage (VT) inputs as required for protection & measurement purposes using protection cores.
- 6.7.8 The relay shall be capable of measuring and storing values of a wide range of event, faults and disturbance. The relay shall have facility to record at least 1000 Events.
- 6.7.9 The numerical relay shall provide supervisory functions such as trip circuit supervision, I2t counter for maintenance & CB wear estimation, CT supervision
- 6.7.10 All protective relays shall be fully drawn out type with automatic CT shorting.
- 6.7.11 Relay shall support complete ladder logic with various logic gate
- 6.7.12 All relays shall have connections for both CT and PT Inputs.

6.7.13 **Incomer & Bus Sectionalizer Feeder Protection** shall have following functions:

- Instantaneous Over current protection
- IDMT Over current protection
- Instantaneous Earth fault protection
- Reverse power protection
- Directional over current protection
- Under power
- Low & high impedance REF
- Voltage vector shift
- df/dt protection
- Under/Over frequency protection.
- Under/Over voltage protection.
- Circuit breaker failure with two time.
- Cable Fault locator
- Graphical display for single line diagram

6.7.14 **Outgoing feeder with cable differential relay** shall have following protection functions:



Note: Two separate relay to be provided for the Primary Protection for the as cable differential (87L) & overcurrent protection is provided as a backup to the primary protection. All protection singles in a single relay will not acceptable.

Graphical display for single line diagram (any one of the relays either main or backup)

6.7.14.1 **Primary Line Differential protection relay:**

- Differential protection for two-ending-operation & operating time must be less than 35ms



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- Protection Interfaces for optical fiber cables support distance up to 2km with multimode or 30km with single mode FO as per the requirement

#### 6.7.14.2 Backup overcurrent relay :



- Instantaneous Over current protection
- IDMT Over current protection
- Instantaneous Earth fault protection
- Low & high impedance REF
- Circuit breaker failure with two time
- Cable Fault locator

#### 6.7.14.3 Transformer Differential protection relay:

- Differential protection with operating time less than 30ms for both low & high stage
- Shall have separate REF protection relay with site selectable high & Low impedance restricted earth fault functionality. Also, shall support Over current & earth fault functionality
- Relay shall support Graphical HMI for Single line diagram

### 6.8 Busbar Differential Protection

- 6.8.1 A numerical low or high impedance bus-bar protection scheme with phase segregated measurement shall be offered (ANSI 87BB). It shall be capable of detecting all types of faults, i.e. multi-phase and single phase-to-ground faults with an overall operating time of less than 1.5 cycles. The architecture of the bus-bar protection shall be derived from using individual bay units along with a central fault-measuring unit.
- 6.8.2 In the architecture of the bus-bar protection, the central unit shall receive data from all bay units, carry out computation and comparison of the restraint and differential currents, locate the fault position, and send the trip decision to the respective bay units operating on the faulted bus-bars.
- 6.8.3 The bus-bar protection shall support automatic transfer of data to ECMS at the substation, whenever system fault-related information or data is produced. The design shall support being scanned by ECMS and FMS for both SCADA like data (protection status, protection start / trip, fault values, fault location and fault records, etc.), and historical data (waveform records). Facilities shall include user interface (both front and rear ports), serial communication and diagnostic / self-supervision, etc. Communication software for local and remote access of data from, and parameter download into, the bay units and / or central unit shall also be provided.
- 6.8.4 The protection shall use GPS time reference; however, the bus-bar protection shall be able to operate correctly independent of this time reference.
- 6.8.5 The bus-bar protection, on operation, shall trigger the breaker fail relay scheme. The breaker failure relay (BFR, ANSI 50BF) scheme shall be provided to monitor the post-trip currents on all bays following fault detection by any of the generic protection relays. The BFR shall be integrated into the bus-bar protection scheme with the supply of additional software package to perform breaker fail relaying function. It shall be sensitive enough to operate between 20 % and 200 % of nominal current, adjustable in steps of less than or equal to 10 %.
- 6.8.6 2-line Human Machine Interface (HMI) facilities shall be provided on both bay and central units.

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- 6.8.7 The DC supplies to the bay units and central unit shall be fed from the independent station batteries in a redundant configuration (from DCDB – DC Distribution Board).
- 6.8.8 The bus-bar protection shall be capable of being blocked by a lockable manual switch. Under this condition, the tripping functions shall also be blocked on all feeders (to be provided as hardwired facility). However, the measuring function of the bus-bar protection should remain in service to facilitate signal measurement checks in the restraint and operating circuits of the protection.
- 6.8.9 Extension of the bus-bar protection system shall easily be made possible. The protection cubicles shall be completely wired for the total number of feeders specified in the scope of works. However, protection cubicles shall be designed to provide at least 2 spare wired points for each bus-bar section. In wired points, terminal blocks, wiring and space are provided but hardware equipment and other slot-in modules will not be supplied.
- 6.8.10 The busbar differential protection bay units shall also provide the possibility to be used as additional back-up overcurrent protection with protection functions ANSI 50/50N and 51/51N.

**6.9 BUSHINGS:**

All the bushings shall have an impulse & power frequency withstand level that is higher or equal to the level specified under item 2.1. Only SF6 insulated Epoxy Cast Resin will be accepted.

**6.10 Metal-Enclosed Surge Arresters:**



- I. The surge arrestors shall conform in general to IEC 60099-4.
- II. The surge arrester shall be of heavy duty Distribution Class hermetically sealed, Gapless, ZnO, Surge arrester, suitable for use with GIS, for each phase, at the 33 kV line underground cable entry terminals of GIS shall be provided for Line Bays.
- III. These shall have adequate thermal discharge capacity for severe switching surges, long duration surges and multiple strokes.
- IV. Surge Arresters shall be of either the “plug-in” construction or the disconnect-link type and be attached to the gas-insulated system in such a manner that these can be readily disconnected from the system while the system is being dielectrically tested. The metal housing of the arrester shall be connected to the metal enclosure of the GIS with a flanged, bolted joint.
- V. The ground connection shall be sized for the fault level of the GIS. It shall be insulated from the GIS-enclosure and grounded externally to permit periodic maintenance and monitoring of the leakage current.
- VI. The size of the connecting conductor shall be such that all the energy is dissipated to the earth without getting overheated.

**6.11 Insulating Gas and gas leakage rate**

The GIS shall be furnished with sufficient sulfur-hexa-fluoride (SF6) gas to pressurize the complete system in a sequential approach, one zone or compartment at a time to the rated nominal density. The guaranteed leakage rate of each individual gas compartment and between compartments shall be 0.1 % p.a. over the lifetime of the Switchgear. for the service life of equipment.

The quality of new filled-in SF6 gas shall meet the following requirements in line with IEC 60376:

Reuse or recycling of removed gas:

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Clear instructions shall be provided by bidder about handling, recycling & treatment of new and used SF6 gas.

During commissioning dew point of SF6 gas shall be measured and documented.

Components may be empty or filled with N2 for transportation and refilled with SF6 at site.

## 6.12 Gas sections

The GIS enclosures (one enclosure for all the three phases or Single phase encapsulation) shall be divided into several gas sections separated by gas-tight barriers. Each section shall be provided with necessary valves to allow evacuation and refill of gas without evacuation of any other section. Location of gas barrier insulators is to be clearly discriminated outside the enclosure by a band of distinct colour normally used for safety purposes.

It should include the necessary valves, connections, density monitors, gas monitor system and controls, indication, orifices, and isolation to prevent current circulation. For the purpose of gas monitoring and maintenance, the GIS shall be divided into various individual zones in each bay. The CB gas zone shall be independent from all other gas compartments and shall meet the requirement of relevant IEC.

Each gas zone shall be furnished with a gas monitoring system i.e. manometer consisting of a gas density continuous monitoring device provided with two electrically independent contacts which operate in two stages as follows:

- a) First alarm : At a gas density normally 5 to 10% below the nominal fill density.
- b) Second alarm : Minimum gas density to achieve equipment ratings.

In special cases determined by the supplier, a third stage with a set of contacts may be necessary in certain areas. Provisions shall be made for connecting pressure gauges, service cart, and moisture test instrumentation to any one of the gas sections.



Permanent Gas Treatment Devices:

Means shall be provided inside each enclosure for treating the SF6 gas by the use of Desiccants, driers, filter, etc. to remove impurities in the gas. All gas compartments shall be fitted with static filter material containers that will absorb residual and entering moisture inside the high voltage enclosures. Filters inside the breaker compartment shall also be capable of absorbing gas decomposition products resulting from the switching arc.

## 6.13 GIS Connection /Termination:

### 6.13.1 GIS to TRANSFORMER:

- a. Transformers shall be connected to the GIS by termination of 33 kV XLPE power cable to OIP condenser bushing. The connection between GIS and high voltage cable at GIS end shall be done through cable termination / cable sealing end. The plug in cable sealing ends for XLPE cables shall consist of gas tight plug in sockets and prefabricated plugs with grading elements of silicone rubber. All high voltage cables will be connected from below through cut-outs in the floor. To maintain the totally insulated design concept of the Switchgear, only fully insulated plug-in type terminations with direct solid dielectric-to-gas insulation shall be used.
- b. Terminations (including plugs) and all accessories shall be provided for all feeders including spares.
- c. Provision for cable termination of XLPE cables, as indicated in 33kV GIS SLD, shall be considered for outgoing cable feeders and incomers, as a minimum. **The**

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**plug in cable sealing ends for XLPE cables shall consist of gas tight plug in sockets and prefabricated plugs with grading elements of silicone rubber.**

- d. Sufficient space must be provided in the Switchgear to terminate and connect required cables per phase. Suitable cable support, trays / cleats and grounding facilities must be provided in the cable basement area including all outgoing feeders.
- e. Suitable arrangements of test plug / socket shall be provided which will permit full dielectric testing for outgoing cable of all cable feeders including primary current injection test for current transformers. It shall be possible to carry out the tests without dismantling other equipment.
- f. Totally insulated panel connections, cable plug connectors featuring the inner cone bushing system are required. They must be completely safe to touch. There must be sufficient provision & space available for connection of up to four no. of cables of upto 630 sqmm sizes or as per system SLD requirement

#### 6.14 Locks and Padlocks

- a. Provisions for padlocks and padlocks shall be provided on the switchgear for locking the marshalling compartments or other live parts of the Switchgear to be opened during maintenance.
- b. Padlocks shall be provided as listed below (three ordinary keys for each lock shall be supplied):
  - Locking the Disconnecter/Earthing Switch in the isolated and earthed position,
  - Locking the C.B. control switch,
  - Locking the local/off/remote switch,
  - Locking the 3 (three) selector switches required for manual / automatic transfer operation.
- c. Six (6 Nos.) master keys to fit all types of control and lock switches shall be provided.
- d. Suitable wall mounted metal cased key cabinet shall be provided. In each key box provisions shall also be foreseen to keep permit books and danger boards.

#### 6.15 Earthing of Metallic Parts



- a. All metal parts of the Switchgear and all integral earthing features shall be connected directly to a copper earth bar, which shall run along the full length of the switchgear.
- b. The cross-sectional area of the earth bars shall be as specified and capable to carry the max. rated short time withstand current of the Switchgear for the specified time.

#### 6.16 Voltage Detectors

Each 33 kV outgoing/incoming and transformer feeder control panel shall include voltage detectors to indicate phases "ALIVE". The voltage detectors shall be connected to each phase on the cable side.

The indicators shall be located on front of the panel. It may be noted that this unit shall also be suitable to be used for interlocking of earthing switches (voltage free condition), whenever feeders are not equipped with voltage transformers.

#### 6.17 Corrosion Protection

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- a. The Switchgear shall be treated and protected to withstand at least five years of operation after energizing under the site conditions without sustaining significant corrosion or attacks from fungus or rodents, provided the surfaces remain mechanically undamaged.
- b. The manufacturer's standard corrosion protection may be acceptable subject to the approval by COMPANY.
- c. As minimum painting standard for all steel surfaces, the following is applicable:
  - Cleaning to bare metal by mechanical and / or chemical means,
  - Phosphatising or priming with at least one coat of zinc-rich primer. Paints of toxic nature such as lead or chromate are not allowed,
  - Finish painting shall be preferably consisting of powder coating method with DFT 100 micron or electro-statically applied and oven-dried epoxy powder to a thickness of at least 60 microns. Alternatively, at least two coats of epoxy-based compound lacquer may be spray-applied.
- d. All hardware used in the assembly of the Switchgear must be either of corrosion proof material, or be hot dip galvanized.
- e. Gas monitoring and service piping shall be made of copper or stainless steel.



#### 6.18 Switchgear space heater

- a. 33 kV Switchgear motor-drive compartments shall have a space heater, fed from a separate power source (regardless of the position of the 33 kV CB (ON or OFF) position, protected by a two-pole MCB in combination with an earth leakage protecting device of 30 mA, with auxiliary N/C contact wired to a group/common alarm terminal and shall be equipped with sensors for temperature and humidity control.
- b. The heater shall be located at a suitable position and its capacity shall be as required to maintain the interval temperatures above the dew point taking into consideration the specified environmental conditions.
- c. A switch for each heater shall be provided so that the heater circuit can be switched "ON" or "OFF" as required independently.
- d. When the heating system is live, this shall be indicated by means of a prominently situated red LED.

#### 6.19 Internal Fault

- a. The switchgear shall be qualified as classification IAC according to IEC 62271-200 with regard to its mechanical strength in the event of an internal arc. The test performance shall be in conformity with accessibility type AFLR.
- b. The test shall be executed for all separate compartments within the functional unit containing HV equipment, i.e. bus-bar compartment, circuit breaker / contactor compartment and cable compartment.
- c. Type test reports regarding internal arc withstand performance shall be available in the quotation stage.
- d. All assemblies shall be type-tested at the rated short circuit current with an arc duration of 3 seconds.

#### 6.20 Special tools, tackles and equipments

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Special tools, tackles and equipment that are required to perform installation, commissioning, operation & maintenance of the gas insulated switch gear shall be included in scope of supply. Minimum following tools shall be supplied.

- 1 A suitable designed mobile SF6 gas-handling unit shall be included to enable complete vacuuming and re-filling of SF6 gas. It shall contain and comprise a wheeled trolley housing, compressor, standard pressure gauges, piping and control. It may be noted that the gas handling unit shall be provided with all items and filters required to safely remove and dispose the de-composed / contaminated gasses in the GIS after any failure or flashover.
- 2 A suitable calibrated manometer shall be provided to enable calibration of gas manometers and gas pressure switches.
- 3 Precision pressure gauge
- 4 Set of equipment for pressure measurement and gas density meter.
- 5 Any other special tool/tackle required.
- 6 The ladders and walkways shall be provided wherever necessary for access to the equipment. A portable ladder with adjustable height shall also be supplied for access to the equipment.
- 7 All interlocks that prevent potentially dangerous mal-operations shall be constructed such that these can be operated only **by use of special tools**.

The tools shall be shipped in separate containers, clearly marked with the name of the equipment for which these are intended. The requirement of HV testing during commissioning or repairing or replacement shall be arranged by successful bidder at no extra cost. No delay shall be permitted on account of the non availability of the HV test equipments.

## 7.0 Name plates



- 7.1 All equipment shall be provided engraved nameplates shall preferably be of 3-ply (Black-White-Black) lamicoid sheets or anodised aluminium. Nameplates shall be fastened by screws and not by adhesives.
- 7.2 GIS rating and name plate
- 7.3 Each bay shall have a name plate showing listing of basic equipment and their relative location.
- 7.4 Each bay auxiliary control cubicle must be identified with its designation to which it is assigned.
- 7.5 Each of the equipment devices including CB, Disconnect switch, Earthing switch, CT, VT and busbars etc. mounted inside the switchgear shall be provided with proper nameplate and rating plate. as per the latest edition of relevant IEC standards.
- 7.6 Special warning labels shall be provided wherever considered necessary.
  - a) Gas Single Line Diagram showing all devices in a single line diagram with the gas sectionalizing of the GIS indicated

## 8.0 Test and inspection

### 8.1 Type Tests:

Following type test reports from NABL laboratory/ CPRI , ERDA , India /reputed international test laboratory, as specified in IEC standard 62271-200, 62271-100 (amended up to date) shall be submitted for the offered type, rating of GIS invariably with the technical bid. Bid without type test reports will not be considered for evaluation.



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The type test reports shall not be older than FIVE years and shall be valid up to expiry of validity of offer. However, if there is no change carried out by the manufacturer in the design since it was validated having carried out type tests, the Type Test Report should be not be older than 10 years and shall be valid up to expiry of validity of offer. In event of any changes in the offered design from the type tested design the bidder shall confirm to carry out the required type test/s, special tests, before commencement of supply, without affecting delivery schedule, free of cost.

- I. Tests to verify the insulation level (Lightning impulse, Switching impulse and ac withstand test with PD) test on each GIS device (CB, Disconnecter, bus, etc).
- II. Dielectric tests
- III. Partial Discharge tests
- IV. Tests to prove the temperature rise of any part of the equipment and measurement of the resistance of the main circuit.
- V. Tests to prove the ability of the main and earthing circuits to carry the rated peak and the rated short time withstand current.
- VI. Tests to verify the making and breaking capacity of the included switching devices.
- VII. Tests to prove the satisfactory operation of the included switching devices / Mechanical endurance tests
- VIII. Internal Arc Classification
- IX. Pressure test on partitions.
- X. Verification of the degree of protection of the enclosure.
- XI. Gas tightness tests
- XII. Electromagnetic compatibility tests (EMC).
- XIII. Additional tests on auxiliary and control circuits.
- XIV. Type tests on Circuit breakers, disconnectors, earth switches, surge arrestors, CT, PT etc as per the relevant standards.
- XV. Seismic test
- XVI. Gas leakage test

## 8.2 Routine Testing:

All equipment shall be subjected to the Routine tests as laid down in IEC 62271-200 in presence of Owners representative. Routine test shall include But not limited to the following:

- I. Dielectric test on the main circuit.
- II. Dielectric tests on auxiliary circuits
- III. Partial discharge measurements
- IV. Tests on auxiliary and control circuits.
- V. Measurement of the resistance of the main circuit.
- VI. Gas leakage test
- VII. Design and visual checks.
- VIII. Functional tests
- IX. Tests on auxiliary circuits, equipment and interlocks in the control mechanism.

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- X. Complete mechanical operation tests
- XI. Complete test of interlocking devices.
- XII. LCC- & Control Relay panel complete functional & interlock test as per approved drawing with LCC duly connected to respective bay GIS module in all respect.
  - IR test
  - Hv test
- XIII. Timing tests for circuit breaker
  - 15.Primary injection test for all current and voltage transformers
  - 16.Secondary injection tests for all protection relays.

### 8.3 Tests after installation of complete GIS at Site:

After installation and before being put into service, the GIS shall be tested in order to check the correct operation and dielectric integrity of the equipment as laid down in IEC 62271-200. The successful bidder shall furnish a commissioning test plan and a statement method for the tests on site. Tests shall include the following:

1. Dielectric tests on the main circuits.
2. Measurement of the resistance of the main circuit.
3. Gas tightness tests. (Gas leakage test)
4. Checks and verifications.
5. Gas quality verifications.
6. On site power frequency voltage withstand test
7. Tests as per IEEE C37.122.1 clause 4.10.5
8. Functional & interlock tests for all items
9. Demonstration of operational compatibility with SCADA
10. Visual inspection, checks & verifications.
11. Mechanical operation tests of circuit breakers, Bus Side Disconnecter switches with earthing switches and Line side disconnector switches with Earthing Switches.
12. Insulation resistance measurement



### 9.0 SPARES

- 9.1 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.
- 9.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 9.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 9.4 Any other spare parts not specified, but required, shall also be quoted along with the offer. All spare parts shall be identical to the parts used in the equipment

### 10.0 DRAWING 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.



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- Name of client
- Name of consultant
- Enquiry / Order Number with plant / project name
- Code No. and Description

#### 11.0 MAINTENANCE:

The bidder shall provide the services of experienced persons, supervisors, Engineers, experts, etc. for AMC services for satisfactory operation.



The bidder shall have dedicated localized after sales & service team which should be capable any activity to operate complete GIS satisfactorily.

#### 12.0 Training:

Training shall include the following any other specific area may be brought to notice and shall be included.

1. General Explanation for GIS
2. Layout and Architecture of GIS
3. Gas Sectionalisation of GIS
4. Construction of CB
5. Operating Mechanism of CB
6. Maintenance of CB
7. Overhaul of CB (Interrupting chamber)
8. Overhaul of CB (Operating Unit)
9. Construction of DS/ES
10. Maintenance of DS/ES
11. Overhaul of DS/ ES
12. Construction of Bus/ Cable head/ SF6 – air bushing
13. Maintenance of Bus/ Cable head/ SF6 – air bushing
14. Overhaul of Bus/ Cable head
- 15.-Cable connections
16. Operation of GIS with SCADA
17. Construction & Maintenance of Lightning Arrester
18. Construction & Maintenance of VT/CT
19. Construction & Maintenance of Local control panel
20. Erection of GIS at site.
21. Installation & Testing of GIS at site
22. Type tests of GIS
23. Routine tests of GIS.
24. Faults simulation of GIS
25. Localization of GIS fault.



#### 13.0 PACKING AND DESPATCH

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- 13.1 All equipments shall be suitably packed and protected during shipment/transportation by sea, rail and road in such a manner that it is protected against the climatic conditions and for any damage during transportation, transit and storage.
- 13.2 Each shipping unit shall be sealed in a clean dry condition with leak-tight shipping covers securely mounted for shipment. All covers to be removed during installation shall be clearly marked. Each shipping section shall be carefully sealed and filled with dry gas to a slightly positive pressure to prevent the entrance of moisture and contamination.
- 13.3 Gas insulated switchgear (GIS) shall be properly packed to protect during ocean shipment, inland transport, carriage at site and outdoor storage during transit and at the site. Completely assembled bays (subject to transport limitations) of the GIS shall be transported as one shipment unit. Packing materials shall be dust and waterproof. All packages shall be clearly, legibly and durably marked with uniform block letters on at least three sides. Fragile items like bushings, CTs, VTs, LAs and fully assembled bays shall be securely packaged and shipped in containers. Silica gel or approved equivalent moisture absorbing material in small cotton bags shall be placed and tied at various points on the equipment wherever necessary.
- 13.4 Impact recorders (Accelerometers) shall be provided on the packages to confirm that GIS has not suffered any shocks during shipment, transport, handling, etc
- 13.5 All blanking plates, caps, seals, etc., necessary for sealing the gas sections during shipment to site shall be provided. Vendor to provide quantity of components accordingly considering permanent installation.

#### **14.0 DEVIATIONS**

Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

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**ANNEXURE – I**  
**DOCUMENTATION FOR 33kV GAS INSULATED SWITCHGEAR**

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.	N	Y	Y
4	Typical general arrangement drawings of the equipments indicating space requirement, room dimensions, crane capacity Vertical load/ Live load data	N	Y	Y
5	Earthing layout	N	Y	Y
6	Sectional view of GIS	N	Y	Y
7	Gas Schematic diagram	N	Y	Y
8.	Control schematic and wiring diagrams	N	Y	Y
9	Catalogue for bought out accessories.	N	N	Y
10	Installation operation & maintenance manual	N	N	Y
11	Manufacturing Quality assurance plan with effective quality assurance system	N	Y	Y
12	Field Quality plan indicating instruction	N	Y	Y
13	Gas system installation procedures, gas handling procedures.	N	Y	Y
14	Type test certificates for GIS	N	N	Y
15	Spare parts list with identification	N	N	Y
16	Design Calculations for Bus-bar sizing, Short circuit forces and vibration on Bus-bar & each equipment, thermal stability and losses.	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 CD 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.
4. All final drawings and documents shall be submitted in CD in AutoCAD and MS office format as applicable for Owner's future reference.



Y - Yes, N - No

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**SPECIFICATION SHEET**  
**VACUUM CIRCUIT BREAKER of 33 kV GIS**

<b>PROJECT:</b> Coal Based SNG Plant		<b>PLANT:</b> LSTK-1 (CG+Purification+SRU)	
<b>ISSUED FOR :</b> PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
<b>GENERAL</b>			
Item No. :		Ref. Stds. :	
Quantity :		Encl. Docs. :	<input checked="" type="checkbox"/>
Description :		Make :	
Code No. :		Maker's Type. :	
<b>TESTS :</b> Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others : <input checked="" type="checkbox"/>			
<b>SERVICE CONDITIONS</b>			
<b>TECHNICAL DETAILS</b>		<b>AMBIENT CONDITIONS</b>	
Type :	VCB	Temp.- Max./Min./Design Ref. : 46 / 1/ 50°C	
Rated Voltage :	33 kV	Rel. Humidity : 100%	Alt. above Sea < 1000M
Max System Voltage :	36 kV	<b>Atmospheric Pollution</b>	Dusts : Coal Dust & Urea Dust
Rated current at design site ambient temp :	3150 A		Vapour : Ammonia & Highly Corrosive
Breaking capacity :	40 kA (3 Sec)	<b>Location</b>	Indoor : <input checked="" type="checkbox"/> Outdoor : <input type="checkbox"/>
Making Capacity :	100kA kA	<b>AUX. POWER SUPPLY</b>	
Short circuit current withstand :	40 kA for 3 sec	<b>System Data</b>	A.C. : 415/ 240 V $\pm$ 10 %, 50Hz $\pm$ 5 %
Voltage withstand			D.C. : 110 V $\pm$ 10 %, 2wire
1 Min power freq :	70 kV	<b>Instrument Contact Rating</b>	A.C. :
1.2/50 micro sec impulse :	170 kVp		D.C. :
Characteristic for short line fault related to rated short circuit breaking current			
Operating cycle :	0 - 0.3 s - CO - 3 Min- CO		
Auto reclosing :	Required		
Enclosure material	Aluminium alloy		
Rated break-time (ms)	65 Not more than 100		
Rated closing time(ms):	65 Not more than 200		
Mechanical Endurance class	M2		
Electrical Endurance class	E2		
Restriking probability class	C2		
Inductive current breaking capability	Switch No Load current of transformer		
First pole to clear factor	As per IEC 62271-100		
Opening time in ms	Not more than 55ms		
Closing time in ms	Not more than 100		
No of tripping coils per breaker	2		
No of closing coils per breaker	1		
TRV characteristics	As per IEC 62271-100		


Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

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**SPECIFICATION SHEET**  
**CURRENT TRANSFORMER & VOLTAGE TRANSFORMER, 33 KV GIS**

<b>PROJECT:</b> Coal Based SNG Plant		<b>PLANT:</b> LSTK-1 (CG+Purification+SRU)			
<b>ISSUED FOR :</b> PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>					
<b>GENERAL</b>					
Item No. :	Ref. Stds. :				
Quantity :	Encl. Docs. : <input checked="" type="checkbox"/>				
Description :	Make :				
Code No. :	Maker's Type. :				
<b>TESTS :</b> Routine <input checked="" type="checkbox"/> Type <input checked="" type="checkbox"/> Others : <input checked="" type="checkbox"/>					
<b>SERVICE CONDITIONS</b>					
<b>TECHNICAL DETAILS</b>			<b>AMBIENT CONDITIONS</b>		
Nominal system voltage	33 kV+10%		Temp.- Max./Min./Design Ref. : 46 / 1/ 50°C		
Maximum system voltage	36 kV		Rel. Humidity : 100% Alt. above Sea < 1000M		
Ltg Impulse withstand voltage	170kV		<b>Atmospheric Pollution</b>	Dusts : Coal Dust & Urea Dust	
1 Min. P.F. withstand voltage	70kV			Vapour : Ammonia & Highly Corrosive	
Frequency	50 Hz +5%		<b>Location</b>	Indoor : <input checked="" type="checkbox"/> Outdoor : <input type="checkbox"/>	
No. of Phases	Three			<b>AUX. POWER SUPPLY</b>	
Earthing Mode	Effectively /Solidly Earthed		<b>System Data</b>	A.C. : 415/ 240 V ± 10 %, 50Hz ± 5%	
System BIL				D.C. : 110 V ± 10 %, 2 Wire	
Rated BIL			<b>Instrument Contact Rating</b>	A.C. :	
Rated Normal Current				D.C. :	
Rated short time w.s. current	40kA ( 3 sec.)				
Rated making current	100kA				
System fault level	40 kA (3 sec.)				
Rated Voltage	33kV				
Type of Mounting					
Protected					
Type of Connection	Plug-in				
Applicable standard	-----				
<b>Current transformer</b>					
Type					
No. of cores					
<b>Core details</b>	1	2	3	4	5
Rated primary current					
Rated secondary current					
Application	Metering	Protection	Protection	Protection	Protection
Rated burden					
Knee point voltage					
Magnetising current					
Secondary resistance					
Insulation class of winding					
<b>Voltage transformer</b>					
Type	Electromagnetic/ Capacitive type				
Number of cores	3				
Rated primary voltage					
Method of pri. connection	Delta				
<b>Core details</b>	1	2	3		
Rated secondary voltage					
Application	Metering	Protection	Protection		
Method of sec. connection	Delta	Delta	Delta		
Accuracy class					
Rated burden					
Insulation class of winding					
Rated voltage factor					
Acceptable limit of variation of total capacitance over carrier freq. range					
Std reference range of freq. for which accuracy is valid					
Rated total Capacitance (pF)					



Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

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**SPECIFICATION SHEET**  
**DISCONNECTOR SWITCH OF 33KV GIS**



<b>PROJECT:</b> Coal Based SNG Plant		<b>PLANT:</b> LSTK-1 (CG+Purification+SRU)	
<b>ISSUED FOR :</b> PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
<b>GENERAL</b>			
Item No. :		Ref. Stds. :	
Quantity :		Encl. Docs. :	<input checked="" type="checkbox"/>
Description :		Make :	
Code No. :		Maker's Type. :	
<b>TESTS :</b> Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others : <input type="checkbox"/>			
<b>SERVICE CONDITIONS</b>			
<b>TECHNICAL DETAILS</b>		<b>AMBIENT CONDITIONS</b>	
Nom. Voltage with	33kV	Temp.- Max./Min./Design Ref. : 46 / 1/ 50°C	
Rated current	3150	Rel. Humidity : 100%	Alt. above Sea < 1000M
Rated voltage(rms)Un	36kV		
Number of phases		<b>Atmospheric Pollution</b>	Dusts : Coal Dust & Urea Dust
Wire			Vapour : Ammonia & Highly Corrosive
Rated Frequency with + %	50 Hz +5%	<b>Location</b>	Indoor : <input type="checkbox"/> Outdoor : <input checked="" type="checkbox"/>
Combined (V & F) Variation	+12.5%		
Rated short-time current	40kA 3 sec	<b>AUX. POWER SUPPLY</b>	
Rated peak withstand current	100kA	<b>System Data</b>	A.C. : 415/ 240 V $\pm$ 10 %, 50Hz $\pm$ 5%
Voltage withstand			D.C. : 110 V $\pm$ 10 %, 2 Wire
1 Min power freq :	70 kV	<b>Instrument Contact Rating</b>	A.C. :
1.2/50 micro sec impulse :	170 kVp		D.C. :
No. of spare auxiliary contacts on each isolator	6NO and 6NC		
No. of spare auxiliary contacts on each earthing switch	6NO and 6NC		
Enclosure material	Aluminium alloy		
Type of operating mechanism	Motor Operated		
<b>Mechanical Endurance :</b>			
Disconnecter	Class M2		
Earthing switch	Class M1		
Type Mechanical operation	Mechanically & Electrically Spring Operated Ganged		
Bus transfer switching capability (% of rated current)	80		
Rated bus charging current	0.2A		
Rated induced current switching capability	As per IEC 62271-102 Class B		

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

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### TECHNICAL PARTICULARS 33 KV GAS INSULATED SWITCHGEAR



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ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>	
<b>General</b>		<b>Service conditions</b>	
Name of manufacturer (OEM)		Ambient Air Temp. in Deg. C Min./Max.	
Type tested at Name of Laboratory		Altitude above MSL, in mtr	
<b>System Parameters</b>		Pollution Class	
Highest System voltage in kV		Creepage distance, in mm/kV	
Rated voltage of System in kV		Relative humidity	
Rated voltage of Equipment in kV		Vibration level	
<b>Rated Insulation level Phase to Earth and between Phases</b>		Noise level	
One Min Power Frequency withstand voltage kVrms		Induced Electromagnetic Disturbance, in kV	
Switching impulse withstand voltage, kVp		Seismic conditions	
Phase to Earth		<b>Auxiliary supply (AC &amp; DC Voltage, Frequency)</b>	
Between Phases		Operation-	
Lightning Impulse withstand voltage, kVp		Control	
Rated Frequency		Illumination & heater	
Rated current in Amp		<b>Support Structure</b>	
Rated current at 50 °C (equipment) in Amp		i Material	
Rated current at 50 °C (bus bar) in Amp		ii Minimum thickness of galvanizing	
Rated short circuit withstand current kArms		iii Foundation channels /Anchor bolts	
Duration in sec			
Peak, kAp			
Enclosure withstand time for an internal fault in sec.			
Estimated total energy loss at			
100 % of rated capacity			
75 % of rated capacity			
50 % of rated capacity			
25 % of rated capacity			
<b>Enclosure</b>			
Code of pressure vessel			
Design temperature in Deg.C			
Material			
Material grade & applicable standard			
Outside diameter in mm			
Minimum Wall Thickness, in mm			
Painting Shade & Thickness	External		
	Internal		
Degree of Protection			
Inductance in H/mt			
Capacitance in pF/mt			
Resistance in Ohm/mt			
Expansion Bellow	Material		
	Min allowable adjustable displacement		
	Longitudinal : Transverse :		
Sealing system			
Estimated life in years			
Barrier	Material		
	Dielectric strength		
<b>Grounding</b>			
<b>Grounding Material</b>			
Grounding of complete GIS			

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<b>PROJECT:</b> Coal Based SNG Plant		<b>PLANT:</b> LSTK-1 (CG+Purification+SRU)	
<b>ISSUED FOR :</b> PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>			
Grounding of individual compartment			
Grounding at flange joints			

<b>SF6 Gas</b>	
Quantity of SF6 Gas of complete GIS at filling pressure, in kg	
Quantity of SF6 Gas of largest compartment GIS at filling pressure, in kg	
Nos of Gas compartments	
Quantity of SF6 Gas of individual compartment GIS at filling pressure, in kg	
Maximum permissible dew point, in Deg.C	
<b>Circuit Breaker</b>	
Type	
Operating Mechanism type	
Nos. of phases	
Rated current in Amp	
Mechanical Endurance class	
Electrical Endurance class	
Restrike probability class	
Rated SC breaking current	
Rated SC breaking current - single phase test	
Rated Line charging breaking current	
Rated Cable charging breaking current	
Capacitor bank switching capability,	
Out of phase making & breaking current	
Rated short line fault current	
TRV characteristic	
First Pole to Clear factor	
Nos. of interrupters per phase	
Type of arc control device provided, if any	
Type of arcing contacts	
Material of main contact	
Material of Arcing contacts	
Filter material	
Timings of operations	
a - Opening at nominal control voltage	
b Closing time at nominal control voltage	
Tripping	
Closing	
Rated operating duty cycle	
Tripping Coils	
- No of coils	
- Rated Watts	
Closing Coil	
- Rated Watts	
Spring Charging Motor	
- Rated Voltage	
- Rated Watts	
Spring charging time at rated Aux supply	
Maintenance required after nos. of operation at	
i No load	
ii Rated current	
iii 25% of rated SC current	
iv 50% rated SC current	
Rated SC current	
Provision of anti pumping	
No of operations after switching off of motor Aux. supply	
Provision of Manual trip	
Electrical interlocking	
Padlocking	
Type of Operation counter provided	





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<b>DISCONNECTORS</b>	
Type	
Rated current in Amp for	
- Bus disconnecter	
- Line disconnecter	
- Transformer disconnecter	
- PT disconnecter	
ivMaximum Current that can be safely interrupted by the Isolator (Amp).	
- Inductive	
- Capacitive	
Rate Short time withstand Current in kA, for 3 sec	
Rated peak short time Current, kAp	
Rated bus charging current, in Amp	
Type of contacts	
Material of contacts	
Current Density at minimum cross section (A/mm2)	
Mechanical Endurance class	
Type of Operating Mechanism	
Operating Motor details	
- Rated Voltage	
- Rated Watts	
Operating Time	
- Closing	
- Opening	
Mechanical indication on drive shaft	
<b>Maintenance Grounding Switch</b>	
Type	
Rate Short time withstand Current in kA, for 3sec	
Rated peak short time Current, kAp	
Rated lightning impulse withstand voltage across the open gap, kVp	
Rated Power Freq withstand voltage across the open gap, kVrms	
Type of Operating Mechanism	
Operating Motor details	
- Rated Voltage	
- Rated Current	
- Rated Watts	
Operating Time	
- Closing	
- Opening	
Mechanical indication on drive shaft	
<b>Current transformers</b>	
i Type	
ii Material	
iii Position of Current Transformer	
iv Reference Standard	
v Rated Continuous thermal current	
vi Rated Short Time current	
vii Duration	
a Feeder Bay CT	
i Metering Core	
- Ratio	
- Output Burden	
- Accuracy Class	
ii Protection Core -1	
- Ratio	
- Output Burden	
- Accuracy Class	
iii Protection Core -2	
- Ratio	
- Output Burden	



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- Accuracy Class	
b Transformer Bay CT	
i Metering Core	
- Ratio	
- Output Burden	
- Accuracy Class	
ii Protection Core -1	
- Ratio	
- Output Burden	
- Accuracy Class	
iii Protection Core -2	
- Ratio	
- Accuracy Class	
- Minimum Knee Point Voltage at highest ratio	
- Maximum Excitation Current at Vk	
- Maximum Resistance at highest ratio	
iv Protection Core -3	
- Ratio	
- Accuracy Class	
- Minimum Knee Point Voltage at highest ratio	
- Maximum Excitation Current at Vk	
- Maximum Resistance at highest ratio	
c Bus Coupler Bay CT	
i Metering Core	
- Ratio	
- Output Burden	
- Accuracy Class	
ii Protection Core -1	
- Ratio	
- Burden	
- Accuracy Class	
iii Protection Core -2	
- Ratio	
- Burden	
- Accuracy Class	
<b>Voltage Transformer</b>	
Type	
Position of Voltage Transformer	
Reference Standard	
Rated Over Voltage Factor - Continuous	
Short Time Over Voltage Factor	
Duration	
Partial Discharge Level	
Thermal Rating of Primary Winding	
26 Line & Bus VT	
i Metering Core	
- Ratio	
- Output Burden	
- Accuracy Class	
ii Protection Core -1	
- Ratio	
- Output Burden	
- Accuracy Class	
iii Protection Core -2	
- Ratio	
- Output Burden	
- Accuracy Class	
<b>Enclosed Surge Arrester</b>	
Name of Manufacturer	
Arrester Class & Type (with mfr type design.)	
Rated system voltage (kV)	
Rated Arrester Voltage (kV)	
Max continuous operating voltage (MCOV) – (kV)	



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Nominal Discharge Current (KA) with 8/20 Micro-second wave	
Max resistive component of cont current at MCOV-mA crest	
Max capacitive component of cont current at	
MCOV -mA crest	
Long Duration Discharge Class	
Min. Energy Discharge Capability (KJ/KV rating)	
Max. switching current impulse residual voltage KVP	
1000 Amps	
250 Amps	
Pressure Relief Class KA (rms)	
High Current short duration impulse withstand	
level with 4/10 micro-second wave (KA) peak	
<b>Over –voltage withstand capability – KV</b>	
a) 100 Seconds	
b) 10 Second	
c) 1.0 Second	
d) 0.1 Second	
e) Reference Voltage (KV)	
f) Reference Current (KA)	
Surge counter	
Leakage monitor	
<b>Local Control Cubical</b>	
i Name of Manufacturer (OEM of GIS)	
ii Location in GIS	
iii Material	
iv Sheet Thickness	
v Degree of Protection	
vi Padlocking arrangement	
vii Major components of LCC	
- Bay control mimic diagram	
- Control Switches	
- Indicating lamps	
- Position indicators	
- Annunciation scheme	
- Auxiliary relays	
- Contact multiplication relays	
- System parameters display	
- Heater with thermostat	
- Interface terminal blocks for relaying & protection	
<b>GIS to Line connection</b>	
Nos of XLPE cable can be terminated	
Type of cable termination required	
<b>GIS to Transformer connection</b>	
Nos of XLPE cable can be terminated	
Type of cable termination required	

**Note:** Technical Particulars shall be filled by the bidder and submitted with the bid.

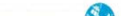

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# **TECHNICAL SPECIFICATION** **UNINTERRUPTED POWER SUPPLY**

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5.0	CONSTRUCTIONAL DETAILS
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## 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 with block diagram & UPS distribution diagram.
- 1.3 The scope shall include the following:
- Full wave controlled rectifier
  - Inverter
  - Static switches
  - Storage battery
  - Static voltage stabilizer for bypass supply
  - Manual bypass switches
  - Isolation / output transformer to achieve desired output voltage
  - UPS Distribution Boards
  - Interconnecting cabling between various units of UPS
  - 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 enclosed 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 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

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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  $\pm 1.0\%$ . 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  $\pm 1\%$  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 two hours 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 of Nickel-Cadmium type. 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 of 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.

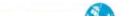

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- 4.17 All semi-conducting devices shall be protected by fast acting semi-conducting fuses. These fuses shall be co-ordinated with load side HRC fuses.
- 4.18 The battery may be taken out of service for maintenance during which period it shall be possible 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 step lessly within  $\pm 5\%$  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/IEC-60947.
- 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 cadmium plated 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.





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- 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 owner'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 65°C 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 240°. 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:

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- i) Maximum output voltage variation under steady state condition shall be  $\pm 3\%$ .
- ii) Maximum harmonic distortion shall be less than 5%.
- iii) The output voltage shall be restored within  $\pm 2\%$  of nominal value in less than 2 secs.

#### 6.9 **Battery**

Battery along with accessories shall conform to Engineering Standard ES-0814.

#### 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 **OPTIONAL ITEMS**

These shall supplied as per requirement.



#### 7.1.1 **Monitoring System** 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:

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- 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.

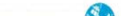

8.3 Unless otherwise specified, the finishing shade shall be light grey shade no.631 as per IS: 5.

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)

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- 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 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.

11.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.

11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

11.4 All spare parts shall be identical to the parts used in the equipment

## 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.

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### ANNEXURE - I



#### DOCUMENTATION FOR UNINTERRUPTED POWER SUPPLY

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Block Diagram	N	Y	Y
4.	General Arrangement drawings and foundation plan	N	Y	Y
5.	Calculation for battery sizing	N	N	N
6.	Feeder Details for Distribution Boards	N	Y	Y
7.	Descriptive literature and catalogues	N	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	N	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 for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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## 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

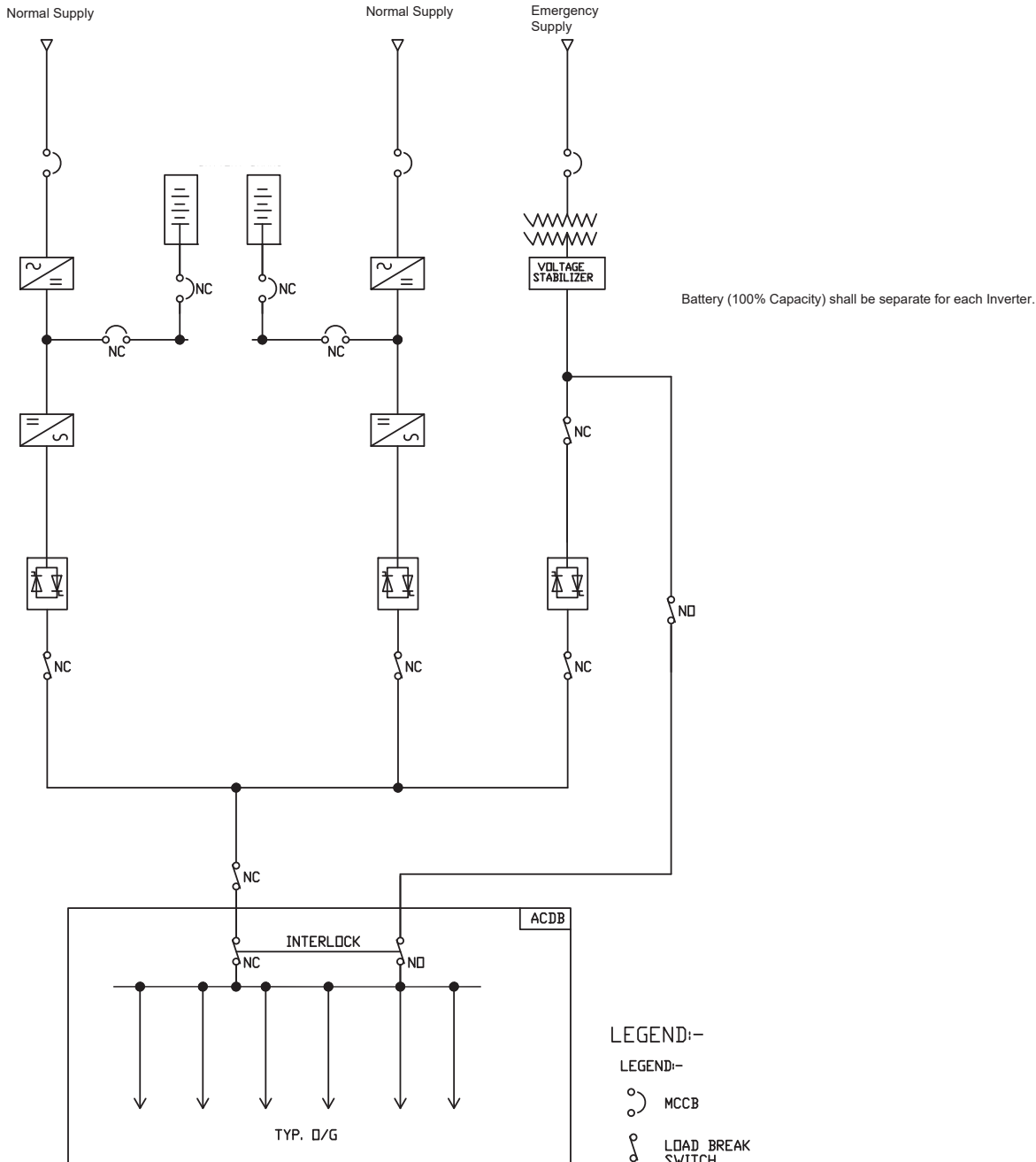
#### B. LED INDICATION

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

### TYPICAL UPS BLOCK DIAGRAM




FOR REFERENCE ONLY

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# **TECHNICAL SPECIFICATION** **POWER TRANSFORMERS**



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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	LIST OF FITTINGS
ANNEXURE - II	DOCUMENTATION FOR TRANSFORMERS

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## 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.
- 1.3 This standard shall be read in conjunction with the relevant part of Design Philosophy – Electrical.

## 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 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 maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10 per cent continuous over voltage condition it does not exceed 1.9 Tesla at any tap position.
- 4.4 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.
- 4.5 The transformer shall be designed to be loaded as per IS 6600.
- 4.6 The transformer shall be so designed as to operate in parallel satisfactorily with similar transformers.

## 5.0 GENERAL DESIGN FEATURES

- 5.1 Transformers shall be built under strict quality assurance procedures to comply with IEC 60076 and or IEC 60726 and shall have a guaranteed life time of 30 years.
- 5.2 Transformers shall be suitable for continuous operation at full load for at least 30,000 hours without maintenance requiring the transformer to be de-energized
- 5.3 The design of the transformers shall be in accordance with the latest practice.
- 5.4 **Rated Voltage, Frequency and Phase Connection**  
These shall be as indicated in Design Philosophy – Electrical.

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- 5.5 The transformer shall be so designed that it is capable of operation at 125% rated voltage for a period of one minute and 140% rated voltage for a period of five seconds due to sudden load throw off.
- 5.6 Transformer shall be capable of withstanding thermal and mechanical stresses caused by symmetrical or asymmetrical faults on any winding.
- 5.7 Transformers shall withstand, without injurious heating, combined voltage and frequency fluctuations which produce the following over fluxing conditions:
- 110% for continuous operation
  - 125% for 1 - minute
  - 140% for 5 – seconds
- 5.8 **Tap Changing Gear**
- 5.8.1 Each transformer shall be provided with on-load/ off-circuit tap changing equipment on the high voltage winding with taps. It shall be mounted on one side, in an easily accessible position.
- 5.8.2 The range of tap changer shall be as indicated and arranged in steps of 2.5%.
- 5.8.3 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.
- 5.8.4 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.
- 5.9 **On-Load Tap-Changing Mechanism (O.L.T.C.)**
- 5.9.1 For transformer specified with on-load tap changer, high speed 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. 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. The OLTC gear shall have diverter resistance and the current diverting contacts shall be housed in a separate oil chamber segregated from the main tank of the transformer.
- 5.9.2 Transformer shall be provided with an on-load tap changing mechanism, as required. This shall be designed suitable for remote control operation from switch boards in the control room in addition to being capable of local manual as well as local electrical operation.
- 5.9.3 It shall not be possible to use the electric drive when manual gear is in use and it shall be possible to use only one electrical control at a time. Operation of the local or remote control switches shall cause one tap movement only until the control switch is returned to the off position for the next operation.
- 5.9.4 The local electrical control switches shall be mounted in the outdoor cubicle.
- 5.9.5 The equipment shall be so arranged as to ensure that when a tap change operation has been commenced it shall be completed independently of the operation of the control relays and switches. If a failure of the auxiliary supply during a tap change or any other contingency result in that movement not being completed, adequate means shall be provided to safeguard the transformer and its auxiliary equipment from damage. Supervisory indication shall be provided to indicate “The change incomplete” foul.

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- 5.9.6 Limit switches may be connected in the control circuit of the operation motor provided that a mechanical de-clutching mechanism is incorporated. Otherwise it shall be directly connected to the operating motor circuit and mechanical stop provided.
- 5.9.7 Thermal devices or other means shall be provided to protect the motor and control circuits. All relays switches, fuses etc. shall be mounted in the marshalling box and shall be clearly marked to indicate their purpose.
- 5.9.8 The whole of the apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation.
- 5.9.9 A five-digit counter shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.
- 5.9.10 A permanently legible lubrication chart shall be fitted within the driving mechanism chamber.
- 5.9.11 The On-Load Tap Changer shall include the following :-
- An oil immersed tap selector and arcing switch or arc-suppressing tap selector, provided with resistor for reduction of make and break arcing voltage, overload and short circuits.
  - Motor driven mechanism.
  - Control and Protection devices.
  - Local and remote tap-changer position indicator.
  - Manual operating device.
- 5.9.12 The on-load tap changer shall be designed so that the contacts shall not interrupt arc within the main tank of the transformer. The tap selector and arcing switch or arc suppressing tap selector switch shall be located in one oil filled compartment. The compartment shall be provided with a means of releasing the gas produced by the arcing. It shall be designed so as to prevent the oil in the tap selector compartment from mixing with the oil in the transformer tank.
- 5.9.13 The oil in those compartments of the main tap-changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of an adequate diameter pipe corresponding dia of OLTC oil surge relays connection from the highest point of the chamber connection corresponding to the dia. of OLTC oil surge relay from the highest point of the chamber to the conservator. This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay.
- 5.9.14 The tap changer shall be capable of permitting parallel operation with other transformers for which necessary wiring and accessories, if any, shall be provided.
- 5.9.15 The centre of manual operating device shall be located at a height of 1500 mm from rail top so that it can be operated by a person standing at the ground level. The arrangement shall be strong and robust in construction. The transformer shall give full load output on all tap positions.
- The mechanism shall be complete with normal accessories including at least the following:-
- A mechanical tap position indicator (Rated tap voltages shall be marked on the diagram plate).
  - A mechanical operation counter.
  - Mechanical stops to prevent over cranking of the mechanism beyond extreme tap positions.
- 5.9.16 The control scheme for the tap changer shall be provided for independent control of the tap changers when the transformers are in independent service. In addition, provision shall be made to enable parallel operation control also at time so that the tap changer will be operated simultaneously when one unit is in parallel with another will not become out of step and this will eliminate circulating current.

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Additional features like Master / Follower and visual indication during the operation of motor shall also be incorporated.

Control circuit shall incorporate the following:

- a) Local/remote manual electrical operation.
- b) Device to ensure a positive and full completion of tap change once it is initiated even if there is loss of power.
- c) An interlock to cut-off electrical control automatically upon recourse being taken to manual mechanical control in emergency.
- d) Electrical interlock to cut-off a counter impulse for a reverse tap change, being initiated during a progressive tap change and until the mechanism comes to rest and resets circuits for a fresh operation.
- e) All auxiliaries and devices for electrical control of OLTC gear should be housed in a weather-proof cabinet mounted on the transformer and shall include:
  - Local tap position indicator
  - 5 digit operation counter
  - Cubicle lighting
  - Thermostatically controlled space heater.
  - Miniature circuit breaker with magnetic and thermal overload devices for controlling the incoming supply to the OLTC motor.
  - Padlocking arrangement for the hinged cabinet door.
  - Removable plate with cable glands.
  - Inside tag with control scheme indelibly marked.

5.9.17 Necessary interlock, blocking independent control when the units are in parallel, shall be provided.

5.9.18 Under abnormal conditions such as may occur if the contactor controlling one tap changer sticks, the arrangement must be such as to switch off supply to the motor so that an out of step condition is limited to one tap difference between the units. Details of out of step protection provided for the taps should be furnished in the bid.

5.9.19 The contactor and associated gear for the tap change driving motors shall be housed in a local kiosk mounted adjacent to the transformer. The motors shall be suitable for operation on 230 V single phase or 3-phase 440 V, 50 cycle external power supply. The kiosk having space heater, shall be dust and vermin proof and suitable protected against corrosion or deterioration due to condensation, fungi etc.

5.9.20 Indoor cubicle (RTCC panel) shall be provided in the control room which shall contain :

- a) Indication of the transformer ratio in use on each transformer and the number designating the tap in use by means of digital type indicators.
- b) Raise and lower push Button switch and AVR Relay.
- c) Independent/Master/Follower selector switch.
- d) Remote tap position indicator with indicating lamp.
- e) Repeater dial of winding temperature indicator for remote indication with a device for indicating hottest spot winding temperature in addition to a pointer to register the highest temperature reached.
- f) An indication lamp showing tap change in progress.
- g) Necessary audible and visual alarms.
- h) Pressure relief device operation alarm.

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- i) Out of step relay with two spare contacts (2 NC and 2 NO).
- j) The remote indoor cubicle in addition to the above indications shall also have the following trip and non-trip alarm windows facias with 5 spare windows suitable for 110V DC supply.
  - i. Oil Temperature alarm
  - ii. Winding Temperature alarm
  - iii. Winding temperature trip
  - iv. Buchholz alarm
  - v. Buchholz trip
  - vi. Sudden Pressure trip (Main tank)
  - vii. Surge Relay trip (OLTC Gear)
  - viii. Tap changer out of step alarm
  - ix. Low oil level alarm
  - x. Cooling fans working indication
  - xi. Oil pumps on and off indication
  - xii. Failure of group of fans alarm
  - xiii. Failure of group of oil pumps alarm
  - xiv. Failure of supply
  - xv. Oil flow alarm

Each relay for tripping function shall have two normally open and two normally closed contacts for connection.

#### 5.9.21 Remote Electrical Group Control

The OLTC control scheme offered shall have provision of remote electrical group control during the parallel operation of transformer. This is in addition to independent control of OLTC:

- i) A four position selector switch having Master, Follower, Independent and Off position shall be provided in the remote OLTC control panel for each transformer.

This shall be wired to enable operator to select operation of OLTC in Master, Follower or Independent mode.

- ii) Out of step relays with timer contacts shall also be provided to give alarm and indication in case tap position in all the transformers under group control are not in same position.

#### iii) **Master Position**

If the selector switch is in Master position, it shall be possible to control the OLTC units in the follower mode by operating the controls of the master unit. Independent operation of the units under Follower mode shall have to be prevented. However the units under independent mode will be controlled independently.

#### iv) **Follower Position**

If the selector switch is in Follower mode, control of OLTC shall be possible only from panel of the Master unit.


#### v) **Independent Position**

In this position of Selector Switch, Control of OLTC of individual unit shall only be possible

5.9.22 The OLTC shall be provided on the conservator side of the Power Transformer and not in front of H.V. Bushings.

5.9.23 OLTC shall be suitable for bi-directional power flow.



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#### 5.10 Impedance Voltage

The impedance voltage of the transformer at 75°C shall be as per relevant IS / IEC. This shall be guaranteed within limits specified in relevant IS / IEC at principal tap position.

#### 5.11 Losses

The losses under the full load condition, at the rated voltage and frequency shall be indicated by the vendor at 75°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.

For upto 2 MVA transformer losses shall be as per energy efficiency level-3 of latest IS 1180.

#### 5.12 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.

#### 5.13 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.

#### 5.14 Terminal Arrangements

The HV and LV side terminal arrangement shall be provided as required. 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.

5.15 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.

5.16 The short circuit test results for similar transformers shall be furnished.

5.17 The transformer shall be so designed as to minimise any undue noise and vibration.

The noise level shall be limited to the value specified by latest NEMA Standard / CBIP.

5.18 Due attention shall be given in the design for the suppression of harmonics.

#### 5.19 Cooling System


5.19.1 The cooling system shall be provided as required. 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.

5.19.2 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..

5.19.3 Transformer shall have multiple cooling units with standby cooling units.

5.19.4 Cooling fans for each radiator bank shall be housed in fan box to prevent ingress of rain water. Each fan shall be suitably protected by galvanized wire mesh guard. It shall be possible to remove the cooling fan with motors without disturbing and dismantling the cooler structural frame work.

5.19.5 Where OFAF cooling is applicable, two numbers of centrifugal oil pumps shall be used. Measures shall be taken to prevent mal-operation of Buchholz relay or sudden pressure relay when all oil pumps are simultaneously put into service. The pumps shall be so designed that

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on failure of power supply to the pump motor, the pump impeller will not limit the natural circulation of oil.

- 5.19.6 Cooling fans and oil pump motors shall be of squirrel cage, totally enclosed whether proof type suitable for operation on 400 volts, three phase, 50 Hz power supply. All motors having ball and roller bearings and grease lubricators shall be fitted with hexagonal nipples conforming to relevant Indian Standard.
- 5.19.7 An oil flow indicator with alarm contacts shall be provided for the confirmation of the oil pump operating in a normal state. An indication shall be provided on the control panel to indicate that the pump is running.
- 5.19.8 The coolers and theirs accessories shall be hot dip galvanized or corrosive resistant painted.
- 5.19.9 The supporting arrangement for the cooler units or for radiator banks shall be in such a manner that the stresses if developed, shall not be transferred to the flanges of the butterfly valves.
- 5.19.10 The shut off valves shall be provided on the tank at each point of connection of cooler units radiators to the transformer tank. Removable blanking plates shall be provided to permit blanking off the oil connection to cooler radiators.
- 5.19.11 All valves shall be of gun metal or cast steel or may have cast iron bodies with gun metal fittings. They shall be of full way type with internal screw and shall be opened by turning counter clock-wise when facing the hand wheel.
- 5.19.12 Means shall be provided for pad locking of valves in the open and closed position.
- 5.19.13 Every valve shall be provided with indicator to show clearly the position of the valve whether open or closed.
- 5.19.14 All valves shall be provided with flanges having machined faces.
- 5.19.15 The drilling of valve flanges shall comply with the requirements of IS:3639.

## 5.20 CONTROL OF COOLER OPERATION

- 5.20.1 Each motor or group of motors shall be provided with an electrically operated contactor and with control gear of suitable design both for starting and stopping the motor manually and also automatically from the contacts on the winding temperature indicating device as specified. Additional terminal for remote manual electrical control of motors shall be provided. Overload and single phasing protection shall be provided. HRC fuses shall be provided for short circuit protection. This equipment shall be accommodated in the marshalling box. The power supply shall be adequately and properly fused.
- 5.20.2 Where small motors are connected in groups, the group protection shall be arranged so that it operates satisfactorily in the event of a fault occurring on a single motor.
- 5.20.3 Where fans and oil pumps are provided, the connection shall be arranged as to allow the motors or groups of motors to be started up and shutdown either collectively or individually.
- 5.20.4 All motor contactors and their associated apparatus shall be capable of holding in and operating satisfactorily and without over heating for a period of ten minutes if the supply voltage falls for that period, to 75% of normal value and at normal frequency. The motor contactors and associated apparatus shall be capable of normal operation with a supply voltage of 85 % of the normal value and at normal frequency.
- 5.20.5 All contacts and other parts which may require renewal, adjustment or inspection shall be readily accessible.
- 5.20.6 The control arrangements are to be so designed as to prevent the simultaneous starting of motors of total rating of more than 20 HP where such an eventually may arise, two step operation shall be preferred.
- 5.20.7 Alarm indication for failure of group of fans and oil pump shall be provided.
- 5.20.8 Alarm indication shall be provided to indicate failure of power supply.



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- 5.20.9 Provision in the cooler control circuit may be made such that tripping of transformer breaker on Differential or Sudden Pressure should lead to supply disconnection to motor of the cooler pump.

## 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 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. 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 (rms) for 1 minute.
- 6.1.2 The temperature of the core shall not exceed that permitted in IS.
- 6.1.3 The design of the magnetic circuit shall be such as to avoid static discharges, development of short circuit paths within itself or to the earthed clamping structure and production of flux component at right angles to the plane of laminations which may cause local heating. The temperature of any part of the core or its support structure in contact with oil shall not exceed 120 deg C under normal operating condition and 130 deg C under most extreme operating condition. Adequate temperature margin shall be provided to maintain longer life expectancy for this material.
- 6.1.4 Core and winding shall be capable of withstanding the shock during transport, installation and service. Adequate provision shall be made to prevent movement of core and winding relative to tank during these conditions.
- 6.1.5 All steel sections used for supporting the core shall be thoroughly sand blasted after cutting, drilling and welding.
- 6.1.6 Each core lamination shall be insulated with a material that will not deteriorate due to pressure and hot oil.
- 6.1.7 The supporting frame work of the core shall be so designed as to avoid presence of pockets which would prevent complete emptying of tank through drain valve or cause trapping of air during oil filling.
- 6.1.8 Adequate lifting lugs will be provided to enable the core and windings to be lifted.
- 6.1.9 The core shall be earthed to the core clamping structure at one point only, through a removable external link suitably located and protected to facilitate testing after installation of the transformer.
- 6.1.10 In case core laminations are divided into sections by insulating barriers or cooling ducts parallel to the plane of the lamination, tinned copper bridging strips shall be inserted to maintain electrical continuity between sections.
- 6.1.11 A drawing furnishing the details of the internal earthing design shall be included in the manual

### 6.2 Tank

- 6.2.1 The tank shall be made of good commercial grade low carbon steel plate of adequate thickness capable of withstanding stress not less than  $0.40 \text{ kg/cm}^2$ , 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

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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 Each tank shall be provided with:
  - a) Lifting lugs suitable for lifting the equipment complete with oil.
  - b) A minimum of four jacking pads in accessible position to enable the transformer complete with oil to be raised or lowered using hydraulic jacks. Each jacking pad shall be designed to support with an adequate factor of safety for at least half of the total mass of the transformer filled with oil allowing in addition for maximum possible misalignment of the jacking force to the centre of the working surface.
  - c) Suitable haulage holes shall be provided.
- 6.2.6 The tank shall be designed in such a way that it can be mounted on the rollers.
- 6.2.7 The base of each tank shall be so designed that it shall be possible to move the complete transformer unit by skidding in any direction without injury when using plates or rails.
- 6.2.8 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.
- 6.2.9 The transformer shall be mounted on rollers, as per manufacturer's standard practice.
- 6.2.10 The roller mounted transformers are to be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.
- 6.2.11 The rail track gauge shall be 1676 mm.
- 6.2.12 To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation.
- 6.2.13 The tank cover shall be designed to prevent retention of rain water and shall not distort when lifted. The internal surface of the top cover shall be shaped to ensure efficient collection and direction of free gas to the buchholz relay.
- 6.2.14 At least one adequately sized inspection openings shall be provided in the transformers for easy access to bushings and earth connections. The inspection covers shall not weigh more than 25 kg. Handles shall be provided on the inspection cover to facilitate lifting.
- 6.2.15 The tank covers shall be fitted with pockets at the position of maximum oil temperature at maximum continuous rating for bulbs of oil and winding temperature indicators. It shall be possible to remove these bulbs without lowering the oil in the tank. The thermometer shall be fitted with a captive screw to prevent the ingress of water.
- 6.2.16 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

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6.2.17 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression. All gasketed joints shall be designed, manufactured and assembled to ensure long-term leak and maintenance free operation. Groove provided to accommodate round nitrile rubber cord for rectangular openings shall be milled.

6.2.18 The maximum temperature on any metal part shall not exceed 130 deg. Celsius.

6.2.19 Seamless pipe shall be used upto 80mm conforming to IS 1978 & IS 1979, ERW mild steels pipes as per IS 1239 (Part 1) medium shall be used for  $\geq 100$ mm and IS 3589 for 150mm. Non-magnetic Stainless-steel materials used shall conform to IS 6911 or ISO 683-13 or EN 10088-2 or AISI 304L or ASTM A240 or J4(S20430 Modified).

### 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 Immediately after winding process, it shall be vacuum dried, dimensionally pre-stabilized and oil impregnated before next process.. The insulation resistance and polarization index of the winding measured after impregnation shall be furnished in the test certificate.

6.3.3 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.

6.3.4 The manufacture shall ensure that windings are made in dust proof, Positive pressure, Desert Climate environment. Movement of windings and active part shall be done on air-casters to prevent shocks and abnormal jerks.

6.3.5 Winding clamping arrangement shall distribute the clamping forces evenly over the ends of the windings. All insulating materials and structures shall be protected from contamination and the effects of humidity during and after fabrication, and after receipt, by storing them in a separate, climate-controlled area.

### 6.4 Insulating Oil

6.4.1 The insulating oil shall be virgin high grade inhibited, conforming to IEC-60296 & all parameters specified below, while tested at supplier's premises. The contractor shall furnish test certificates from the supplier against the acceptance norms as mentioned below, prior to dispatch of oil from refinery to site. Under no circumstances, poor quality oil shall be filled into the transformer and only thereafter be brought up to the specified parameter by circulation within the transformer.

6.4.2 At manufacturer's works the quality of oil used for first filling, testing and impregnation of active parts shall meet at least parameters as mentioned in IEC . The oil test results shall form part of equipment test report.

6.4.3 Prior to filling in main tank at site and shall be tested for

1. Break Down voltage (BDV) : 70kV (min.)
2. Moisture content : 5 ppm (max.)
3. Tan-delta at 90 °C : 0.0025 (max)
4. Interfacial tension : More than 0.004 N/m

6.4.4 Prior to energisation at site oil shall be tested for following properties & acceptance norms as per below generally in line with IEC 60422:

1. Break Down voltage (BDV) : 70 kV (min.)

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2. Moisture content : 10 ppm (max.)
3. Tan-delta at 90 °C : 0.01 (max.)
4. Resistivity at 90 °C :  $6 \times 10^{12}$  ohm-cm (min.)
5. Interfacial tension : 0.035 N/m (min.)
6. \*Oxidation Stability (Test method as per IEC 61125 method C, Test duration: 500hour for inhibited oil)
  - a) Acidity: 0.3 (mg KOH /g) (max.)
  - b) Sludge: 0.05 % (max.)
  - c) Tan delta at 90 °C: 0.05 (max.)
7. \* Total PCB content : Not detectable (2 mg/kg total)

\* For Sr. No. 6 & 7 separate oil sample shall be taken and test results shall be submitted within 45 days after commissioning for approval of Consultant.

Oil sample shall be drawn before and after heat run test and shall be tested for dissolved gas analysis. Oil sampling to be done 2 hours prior to commencement of temperature rise test. For ONAN/ONAF cooled transformers, sample shall not be taken earlier than 2 hours after shutdown. The acceptance norms with reference to various gas generation rates shall be as per IEC 61181.

#### 6.5 Insulation Materials

- 6.5.1 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.
- 6.5.2 The mineral oil shall comply with IS: 335. 10% extra oil shall be supplied along with the transformer in non-returnable drums.
- 6.5.3 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.

#### 6.6 Bushing

- 6.6.1 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 creepage distances of 31mm/kV 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 conductors. Separate neutral bushings shall be provided for earthing the neutral, as required. All bushings shall be marked with the symbols corresponding to the connection diagram indicated in the diagram plate and in accordance with IS.
- 6.6.2 Bushing rated 52 KV class and above shall be oil impregnated paper condenser bushings. Bushing rated below 52KV voltage class shall be solid porcelain or oil communicating type.

#### 6.7 Conservator

- 6.7.1 Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture, and shall be fitted with magnetic oil level gauge with low oil level potential free contacts.
- 6.7.2 OLTC shall have conventional type conservator with prismatic oil level gauge.
- 6.7.3 Conservator tank shall have adequate capacity with highest and lowest visible-levels to meet the requirements of expansion of total cold oil volume in the transformer and cooling equipment from minimum ambient temperature to 100degC. The capacity of the conservator tank shall be such that the transformer shall be able to carry the specified overload without overflowing of oil. The Calculation shall be submitted during design review.

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- 6.7.4 The conservator shall be fitted with integral lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator wherever applicable.
- 6.7.5 Conservator shall be positioned so as not to obstruct any electrical connection to transformer. Pipe work shall neither obstruct the removal of tap changers for maintenance or the opening of inspection or manhole covers.
- 6.7.6 Pipe work connections shall be of adequate size for their duty and as short and direct as possible. Only radiused elbows shall be used.
- 6.7.7 The feed pipe to the transformer tank shall enter the transformer cover plate at its highest point and shall be straight for a distance not less than five times its internal diameter on the transformer side of the Buchholz relay, and straight for not less than three times that diameter on the conservator side of the relay.
- 6.7.8 This pipe shall rise towards the oil conservator, through the Buchholz relay, at an angle of not less than 5 degree.
- 6.7.9 Contact of the oil with atmosphere is prohibited by using a flexible air cell of nitrile rubber reinforced with nylon cloth.
- 6.7.10 The temperature of oil is likely to rise upto 100 deg C during operation. As such air cell used shall be suitable for operating continuously at 100 deg C.
- 6.7.11 Air cell of conservator shall be able to withstand the vacuum during installation /maintenance periods. Otherwise provision shall be kept to isolate the conservator from the main tank when the latter is under vacuum by providing a vacuum sealing valve or other suitable means in the pipe connecting main tank with the conservator.
- 6.7.12 The transformer manual shall give full and clear instructions on the operation, maintenance, testing and replacement of the air cell. It shall also indicate shelf life, life expectancy in operation, the recommended replacement intervals and the supplier.
- 6.7.13 The connection of air cell to the top of the conservator is by air proof seal preventing entrance of air into the conservator.

## 6.8 Neutral Earthing Arrangement

The neutral terminals of transformer shall be brought to the ground level by a brass/tinned copper grounding bar, supported from the tank by using porcelain insulators. The end of the brass/tinned copper bar shall be brought to the bottom of the tank, at a convenient point, for making bolted connection to two (2) 75 x 6 mm galvanised steel flats connected to Owner's grounding mat.

## 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 gasketed 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.



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- 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 All valves in oil line shall be suitable for continuous operation with transformer oil at 115 deg C.
- 7.10 The oil sampling point for main tank shall have two identical valves to be put in series .Oil sampling valve shall have provision to fix rubber hose of 10 mm size to facilitate oil sampling.
- 7.11 A valve or other suitable means shall be provided to fix (in future) on line dissolved gas monitoring system to facilitate continuous dissolved gas analysis. The location & size of the same shall be finalised during detail engineering stage
- 7.12 **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.

In addition to the above, the following equipment shall be provided for remote indication of winding temperature for each of the winding:

a)Signal transmitter for each winding

Signal transmitter shall have additional facility to transmit signal for recording winding temperature at Owner's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for WTI system which will be used for both remote WTI and DAS. Necessary equipment for sending the signal to remote WTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

b) Remote winding temperature indicator

It shall be suitable for flush mounting on Owner's panel. This shall not be repeater dial of local WTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between cooler control cabinet and remote WTI control circuit, shall be in the scope of Contractor. Only one RWTI with a selector switch shall be provided for all the windings (HV and LV).

7.13 **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.

In addition to the above, the following equipment shall be provided for remote indication of oil temperature:

a) Signal transmitter

Signal transmitter shall have additional facility to transmit signal for recording oil temperature at Owner's data acquisition system, for which duplex platinum RTD with nominal resistance of 100 ohms at zero degree centigrade shall be supplied. The RTD shall be three wire ungrounded system. The calibration shall be as per SAMA (USA) standard or equivalent. The RTD may be placed in the pocket containing temperature sensing element and image coil for OTI system which will be used for both remote OTI and DAS. Necessary equipment for sending the signal to remote OTI and DAS shall be provided. In lieu, separate RTD for each of the functions shall be provided.

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b) Remote oil temperature indicator

It shall be suitable for flush mounting on Employer's/RTCC panel. This shall not be repeater dial of local OTI and will operate by signal transmitter. Any special cable required for shielding purpose, for connection between cooler control cabinet and remote OTI control circuit, shall be in the scope of Contractor. Only one ROTI with a four point selector switch shall be provided.

**7.14 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.

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.

**7.15 Marshalling Box**

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.

- i. Terminal boxes, Junction Boxes & Marshalling Panel shall have IP 55 enclosure(min.), dust, weather and vermin proof type.
- ii. 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.

Suitable heavy duty double compression type rolled Aluminium cable glands for all incoming and outgoing cables shall be provided.

**7.16 Current Transformers**

The current transformers 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  $I_{mag}$  for these CTs shall be furnished at the order stage.

**7.17 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.

7.18 All bought out items shall be of reputed make to be approved by Consultant/ Owner.

**7.19 NITROGEN INJECTION FIRE PREVENTION AND EXTINGUISHING SYSTEM**

7.19.1 Nitrogen Injection Fire Prevention and Extinguishing System shall be provided for fire protection of Transformer against fire due to an arc, during internal faults and external fires is for preventing tank explosion. The system design shall also conform to TAC/ NFPA norms.

7.19.2 The system should comprise the following :-

- i. Fire Extinguishing Cubicle with base frame and containing, oil drain assembly, nitrogen cylinder, electric mechanical control unit for oil drain and nitrogen release detections necessary for monitoring system flanges on top panel for connecting pipe connections from transformer, panel lighting etc.
- ii. Control Box for monitoring system operation, automatic control and remote operation, with alarms, indication light switches, push buttons, audio signal, suitable for tripping and signaling on 110V DC supply.

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- iii. Pre-stressed non-return valve (PNRV) working on transformer oil flow rate, with proximity switch for remote alarm indication and with visual position indicator.
- iv. Required number of fire detectors rated for 141<sup>0</sup>C for heat sensing, each fitted with two number cable glands.
- v. Signal box for terminating cable connections from PNRV and fire detectors.
- vi. Pressure relief valve with limit switch.

7.19.3 The following arrangements are required to be made on the transformer Tank at the time of fabrication of the tank :-

- i. Oil drain opening with pipe, flange and manual gate valve at about 120mm below the top cover. Pipe size DN125 for 100 MVA and higher ratings.
- ii. Nitrogen Injection openings with pipe size DN 25 with flange and manual gate valve on tank sides at about 100-200 mm from the bottom plate.
- iii. Flanges having 4 Nos. 18 dia. holes with pcd as 155mm and dummy pipe on the conservator pipe between buchholz relay and conservator tank manual gate valve, for fixing PNRV.
- iv. Fire detector brackets on top cover.
- v. Brackets for fixing signal box at a suitable location on top cover or tank size wall.

#### 7.19.4 **ACTIVATION OF NIFPES:**

Mal-functioning of fire prevention / extinguishing systems is their major shortcoming which leads to interruption in power supply. The Contractor shall ensure that the chances of malfunctioning of NIFPES are practically nil. To achieve this objective, the Contractor shall work out their scheme of activating signals which, while preventing mal-operation, should not be too rigorous to make the operation of NIFPES impracticable in case of actual need. Transformer isolation shall be the mandatory pre-requisite for activation of the system in Automatic mode or Remote mode in the control room.

In addition, at least following electrical-signals shall be provided in series for activating NIFPES.

#### 7.19.5 Auto Mode

- a) For Prevention of Fire :
  - i. Differential Relay Operation
  - ii. Buchholz Relay parallel with Pressure Relief Valve or RPRR. (Rapid Pressure Release Relay)
  - iii. Tripping of all concerned breakers is a prerequisite for initiation of system activation.
- b) For Extinguishing Fire :
  - i. Fire Detector
  - ii. Buchholz Relay paralleled with Pressure Relief Valve or RPRR.
  - iii. Tripping of all connected breakers is a prerequisite for initiation of system activation.

7.19.6 Manual Mode (Local/Remote): Tripping of all connected breakers is a pre-requisite for initiation of system activation.

7.19.7 Manual Mode (Mechanical): Tripping of all connected breakers is a pre-requisite for initiation of system activation.

#### 7.19.8 **General Description of NIFPES**

#### 7.19.9 **Schematic of the System**



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NIFPES should be a stand alone dedicated system for oil filled. It should have a fire extinguishing FE) cubicle placed on a plinth at a distance of 6-10 mtrs. from the transformer. The F.E. cubicle may be connected to the transformer oil tank (near its top) and to the oil pit from its bottom through oil pipes with gate valves. The F.E. cubicle should house a pressurized nitrogen cylinder connected to the transformer oil tank (near its bottom). Cable connections are to be provided from signal box placed on the transformer to the control box in the control room and from control box to F.E. cubicle. Fire detectors placed at the top of transformer are to be connected in parallel to the signal box. The signal box may be connected to a pre-stressed non-return valve fitted between the conservator tank and Buchholz relay. Control box is also to be connected to relay panel in control room for system activation signals.

#### 7.19.10 **Operation**

On receipt of all activating signals, drain of pre-determined quantity of oil commences thus removing high temp. top oil layer. Simultaneously nitrogen is injected under high pressure at a pre-fixed rate, string the oil thus bringing the temperature of top oil layer down. Nitrogen occupies the space created by oil drained out and acts as an insulating layer between the tank oil & fire on top cover. Pre-stressed non return valve blocks oil flow from conservator tank, thus isolating it & preventing aggravation of fire.

#### 7.19.11 **System Components**

Broadly, NIFPES shall consist of the following components. It is emphasized that all components, necessary for fast reliable & effective working of NIFPES shall be considered within the scope.

#### 7.19.12 **Fire Extinguishing Cubicle**

It shall be made of 3mm thick steel sheet, painted dark red from inside & outside with hinged split doors fitted with high quality tamper proof lock. It shall be complete with the base frame and the following:-

- Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer
- Oil drain pipe with mechanical quick drain valve.
- Electro mechanical control equipment for oil drain and pre-determined regulated nitrogen release.
- Pressure monitoring switch for back-up protection for nitrogen release.
- Limit switches for monitoring of the system.
- Flanges on top panel for connecting oil drain and nitrogen injection pipes for transformer.
- Panel lighting (CFL Type)
- Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.

#### 7.20 **Control Box**

Control Box for monitoring system operation, automatic control and remote operation, with following alarms indication, light switches, push buttons, audio signal, line fault detection suitable for tripping and signaling on 110V DC supply :

- System on\*
- PNRV open\*
- Oil drain valve closed\*
- Gas inlet valve closed\*
- PNRV closed^
- Fire Detector Trip^
- Buchholz Relay Trip^
- Oil drain valve open^
- Extinction in pressure^

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- Cylinder pressure low^
- Differential relay trip^
- PRV/RPRR trip^
- Transformer trip^
- System out of service
- Line fault free detector
- Line fault differential relay
- Line fault buchholz relay
- Line fault PRV
- Line fault transformer trip
- Line fault PNRV
- Auto/Manual/Off
- Extinction release on
- Extinction release off
- Lamp test
- Visual / Audio Alarm
- Visual / Audio alarm for DC supply fail

The signals marked (\*) shall be in the topmost row of control box panel. The signals marked (^) shall follow next.

#### 7.21 **Pre-stressed Non Return Valve (PNRV)**

PNRV is to be fitted in the conservator pipe line between conservator & Buchholz relay. It shall have the proximity switch for remote alarm, indication and with visual position indicator. The PNRV should be of the best quality because malfunction of PNRV shall be of serious consequence as its closing leads to stoppage of breathing of transformer.

#### 7.22 **Fire Detectors**

The system shall be complete with adequate number of fire detectors fitted on the top of oil tank, OLTC/Off ckt. Tap changer rated for 1410C for heat sensing each fitted with two no. cable glands (water proof/weather proof).

#### 7.23 **Signal Box**

It shall be fitted on the transformer for terminating cable connections from PNRV & fire detectors and for further connection to the control box.

#### 7.24 **Cables**

Fire survival cables, able to withstand 7500C, 4 core x 1.5mm sq. for connection of fire detectors in parallel shall be used. Fire retardant low smoke (FRLS) cable 12 core x 1.5mm sq. for connection between transformer signal box/marshalling box to control box and control box to fire extinguishing cubicle shall be used.

Fire retardant low smoke (FRLS) cable 4 core x 1.5mm sq. for connection between control box to DC supply source and fire extinguishing cubicle to AC supply source, signal box marshalling box to prestressed non return valve connection on transformer shall be used.

#### 7.25 **Pipes**

Pipes, complete with connections, flanges, bends, tees etc. shall be supplied alongwith the system.

#### 7.26 **Other items**

- a) Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations
- b) Flanges with dummy piece in conservator pipe between Buchholz relay and conservator tank for fixing PNRV.

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- c) Fire detector brackets on transformer top cover.
- d) Spare potential free contacts for system activating signals i.e. differential relay, buchholz relay, pressure relief valve, transformer isolation (master trip relay).
- e) Pipe connections between transformer to fire extinguishing cubicle and fire extinguishing cubicle to oil pit.
- f) Cabling on transformer top cover for fire detectors to be connected in parallel and inter cabling between signal box to control box and control box to fire extinguishing cubicle
- g) Mild steel oil tank with moisture proof coating with capacity as minimum 10% of total oil quantity of transformer, with water tight cover, to be place in the oil pit. This tank shall be provided with the manhole, air vent pipe through silica gel breather, drain valve and a spare gate valve at the top.
- h) Gate valves on oil drain pipe & nitrogen injection pipe should be able to withstand full vacuum. A non-return valve shall also be fitted on nitrogen injection pipe between transformers & gate valve.
- i) Pressure relief valve, wherever not fitted on the transformer.
- j) The F.E. cubicle shall be painted with post office red colour (Shade 538 of IS-5). All the exposed parts i.e. pipes, supports, signal box etc. shall be painted with enameled paint.

#### 7.27 Modification on the transformer

No modification on the transformer shall be allowed which affects its performance (i.e. efficiency, losses, heat dissipation ability etc.), safety, life etc. or its any other useful parameter. This requirement shall be of paramount importance and shall be followed.

However, in any case, performance of transformer should not be affected in any manner by having NIFPES system and the Contractor shall give an undertaking to this effect. All pipes should be washed/rinsed with transformer oil. If any damage is done to the transformer and/or any connected equipment during installation & commissioning full recovery therefore shall be effected from the Contractor.

It shall be solely the responsibility of Contractor/Sub-Contractor to install, carry out pre-commissioning tests & commission NIFPES at Ridge Valley indicated in this Specification, to the entire satisfaction of the Owner/Consultant..

#### 7.28 Interlocks

It shall be ensured that once the NIFPES gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also PNRV shall get closed only if all the connected breakers are open.

#### 7.29 In general, following Fire Exinction period and other data shall be followed :

On commencement of Nitrogen Injection	:	Maximum 30 seconds
From the moment of system activation to complete cooling	:	Maximum 3 minutes
Fire detectors heat sensing temperature	:	141 <sup>0</sup> C
Heat sensing area	:	800mm radius
Pre-stressed non return valve setting for Operation	:	minimum 60 ltr. Per minute
Capacity of Nitrogen cylinder :	:	Minimum 68 litre water capacity And shall hold minimum 10 cubic Meter gas to 150 bar pressure
Power Source	:	
Control Box		220VDC

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Fire extinguishing cubicle for 230VAC lighting

7.30 The following information in detail shall be provided :

- a) The maintenance and testing schedule for NIFPES.
- b) All the steps required to be undertaken for restarting the transformer and connected equipment after operation and mal-operation (if any) of the NIFPES.
- c) The process of venting nitrogen in case nitrogen pressure in the cylinder exceeds the stipulated maximum value.

## 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 The paint should not fade during drying process. The paint should be able to withstand temperature up to 120 deg. C .The detailed painting procedure shall also be submitted along with the bid which shall be finalized before award of the contract.
- 8.6 Unless otherwise specified, the finishing shade shall be light grey Shade No. 631 as per IS 5.
- 8.7 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. Heat run test shall be carried out for one transformer of each rating.
- 9.2 Type test certificate shall be furnished.
  - a. Temperature-rise tests (IEC 60076-2)
  - b. Dielectric tests: Full-wave impulse-voltage withstand test (IEC 60076-3)
- 9.3 Additional tests, wherever specified, shall be carried out on one transformer of each rating.
- 9.4 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.
- 9.5 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
- 10.3 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.

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Bushing shall be wrapped in straw ropes or similar material and complete transformer shall be packed in wooden crates.

- 10.4 The packing box shall contain a copy of the installation, operation and maintenance manual.
- 10.5 All loose pieces shall be separately wrapped in moisture resistant paper and marked with identification mark of the corresponding transformer.

#### **11.0 SPARES**

- 11.1 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.
- 11.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment
- 11.5 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**

Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

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## 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.
22. Ladder with safety device for access to the top of transformer tank.

II. The additional fittings as given below shall also be provided, as per requirement:

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.
6. Cooler units complete with valves, fans, pumps, oil flow indicators, supporting structure with fixing and foundation bolts etc as required and Cooler Control panel.
7. Tap-changing gear complete with tap position indicator, operation counter etc. For OLTC gear(where specified), oil surge relay(OSL) with shut-off valve, Local control cabinet.
8. Nitrogen Injection Fire Prevention and Extinguishing System

**ANNEXURE - II**  
**DOCUMENTATION FOR TRANSFORMERS**

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2	Technical Particulars	N	Y	Y
3	Dimensional drawing for complete Transformer, Marshalling Box, disconnecting chamber, terminal chambers etc.	N	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	N	N	Y
8.	Type test certificates of similar transformer	N	N	Y
9.	Test Certificates	N	N	Y
10.	Guarantee Certificates	N	N	Y
11.	Spare parts list with identification marks	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **NEUTRAL EARTHING RESISTOR**



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12.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR NEUTRAL EARTHING RESISTORS

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## 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.
- 1.2 This standard shall be read in conjunction with the relevant part of Design Philosophy – Electrical.

## 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 350°C.
- 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 40°C.

## 5.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

### 5.1 Resistors

- 5.1.1 The resistance bank shall be of heavy duty non-inductive type having high specific resistance and low temperature co-efficient.
- 5.1.2 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.

5.1.3 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.

5.1.4 The resistance grid shall be properly supported so that damage due to vibration and thermal or mechanical stresses is avoided.

5.1.5 Porcelain / Epoxy insulators rated for the highest system voltage shall be used to insulate the resistor elements from the body of the housing.

5.1.6 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 cadmium plated or 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.

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 of accuracy 5P for stand by earth fault protection and PS for restricted earth fault protection shall be provided, as per requirement. 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 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.

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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.

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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 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.

10.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

10.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

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



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Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General arrangement drawings	N	Y	Y
4.	Illustrative and descriptive catalogues	N	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 for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# TECHNICAL SPECIFICATION MEDIUM VOLTAGE SWITCH BOARDS

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## 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 part of Design Philosophy – Electrical, 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, without exceeding the permissible temperature rise and without any detrimental effect on any part.

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## 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 hardware shall be cadmium plated. 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, 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 fixed/draw out, single 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.



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### 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:
- It shall not be possible to open the compartment door unless the breaker is drawn to isolated position.
  - The withdrawn and engagement of a circuit breaker shall not be possible unless it is in open position.
  - The operation of a circuit breaker shall not be possible unless it is in fully service, test or isolated position.
  - It shall not be possible to close the circuit breaker in service position unless all auxiliary and control circuits are connected.
  - A breaker of the lower rating shall be prevented from engaging with the stationary element of higher rating.
  - Insertion of the manual mechanism shall render the motorised mechanism in operation.
  - 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".
  - 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.
  - 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 either fixed or draw out type in single 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.

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- 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.

### 5.6 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 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:

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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 200°C 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 electrolytic grade copper, 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, 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 bus duct shall be similar to the main bus-bars of the switchboard and as specified above.
- 5.8.3 Bus duct between transformer and incoming breaker panel, if included in Vendor's scope, shall conform to ES-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

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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 Compression type cable glands along with the cable lugs as required shall be provided for termination of cables.



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- 5.13.4 The cable glands shall be of rolled Aluminium 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.
- 5.17 **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.

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## 6.0 COMPONENT DETAILS

Components of the switchgear shall ensure type of coordination 'C' as per IS:60947 (Part 4/ Section 1). Makes of all components shall be subject to owner's / consultant's approval

### 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 The circuit breakers shall be of the 3 phase, 4 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.



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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 per system requirement 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 resettable 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.

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## 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 80°C. 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.

## 6.12 Timers

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.

## 6.13 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 0-90° 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.

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- 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/contactors closed. |
| Green | -- | Circuit breaker/switch/contactors 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.

### 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**

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 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.

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- 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 Unless otherwise specified, the finishing shade shall be light grey having 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 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 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.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

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11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

11.4 All spare parts shall be identical to the parts used in the equipment

## 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	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Feeder Details	N	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	N	Y	N
7.	Terminal Arrangement Drgs.	N	Y	Y
8.	Illustrative and Descriptive Literature	N	N	Y
9.	Catalogues for bought out accessories.	N	N	Y
10.	Installation, Operation and maintenance manual.	N	N	Y
11.	Test Certificates			
	i) Type -- Switchboard	N	N	N
	-- Circuit Breaker	N	N	N
	-- MCCB's	N	N	N
	ii) Routine	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	Spare Parts List	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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## SPECIFICATION SHEET 415V SWITCHBOARD

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>	
				FINAL <input type="checkbox"/>	
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS & IEC			Temp. Max./Min./Design Ref. 46 / 1 / 50°C		
Encl. Docs. :			Relative Humidity 100 %   Alt. above sea : <1000 M		
Vendor :			<b>Atmospheric Pollution</b>		
Vendor Ref. No. :			Dusts : Coal Dust		
			Vapour : Ammonia & Highly Corrosive		
			<b>Location</b>		
			Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
<b>Addl. Scope :</b>		Incoming Bus Duct <input checked="" type="checkbox"/>		Tie Bus Duct <input type="checkbox"/>	
		Erection & Comm. <input checked="" type="checkbox"/>		Supervision of Erection Comm. <input type="checkbox"/>	
TESTS: Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others <input type="checkbox"/>					
<b>BASIC DATA</b>					
<b>TAG NO.</b>	Item No.				
	Description				
	Code No.				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	Auto Trip Alarm Scheme				
	Non Trip Alarm Scheme				
	Trip Circuit Supervision Scheme				
	Auto C/O Scheme				
	P.T. Bus Arrangement				
<b>SYSTEM DETAILS</b>	Nominal Voltage with Variation		415V $\pm$ 10%		
	Rated Frequency with Variation		50Hz $\pm$ 5%		
	Combined V & F Variation		$\pm$ 10%		
	No. of Phases & Wires		3 Ph & 4W		
	Insulation Level		2.5 KV		
	Fault Level		36 MVA		
	Earthing Mode		Solidly Earthed		
<b>BUS BARS</b>	<b>Rating</b>	Continuous			
		Short Time for 1 sec.	50 KA		
	Bare / Insulated		Insulated		
	Type of Insulation		Heat Shrinkable PVC sleeved		
<b>EXECUTION</b>	<b>Breaker</b>	I/C: ST / DT	ST		
	<b>Feeders</b>	Others: ST / DT	DT		
	<b>Other</b>	Single front / Double front	Front		
	<b>Feeders</b>	Fixed / Drawout	Drawout		
	Cable Entry : Top / Bottom		Bottom		
	Bus Duct Entry : Top / Bottom		--		
	Accessibility : Front / Back		Front / Back		
<b>CONTROL SUPPLY</b>	<b>Breaker</b>	Closing & Indication	110V DC		
	<b>Feeders</b>	Tripping	110V DC		
	Contactors		240 V AC		
	Space Heater		240 V AC		
<b>MISC. DATA</b>	<b>Painting</b>	Type	Epoxy		
		Shade	631 of IS: 5		
	Period for which Spares required		2 Years		

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.



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### TECHNICAL PARTICULARS 415V SWITCHBOARD

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ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>	
				FINAL <input type="checkbox"/>	
<b>GENERAL</b>					
Manufacturer's Type					
Ref. Standards					
Rated Operational Voltage with $\pm$ %					
Rated Insulation Voltage					
Rated Voltage of Aux. Circuits with $\pm$ %					
Rated Current					
Short Circuit Rating					
Degree of Protection of Enclosure					
Service Conditions : Indoor / Outdoor					
<b>DRAWOUT FACILITIES</b>	Circuit Breakers				
	P.Ts.				
	Motor Starters				
	Protective Relays				
	Meters				
<b>SINGLE FRONT / DOUBLE FRONT</b>	C.B. Feeders				
	Other Feeders				
Cable Entry :	Top / Bottom				
Accessibility :	Front / Back				
<b>MAXIMUM NOS. OF FEEDERS IN ONE PANEL</b>	Circuit Breakers				
	Motor Starters				
	Switch Fuse				
<b>SHEET STEEL TYPE &amp; THICKNESS</b>	Load Bearing member				
	Non Load Bearing member				
	Base Channel				
Material of Gaskets					
Material of External Hardware					
Operating Height : Max. / Min.					
Space Heater Rating of each Panel					
<b>PAINTING</b>	Method of Pre-treatment				
	Type				
	Thickness of Paint				
	Finishing Shade				
Dimensions : L X B X H / Dim. Drg. Ref. No.					
Shipping Dimensions of Largest Package					
Weight : Static / Dynamic					
<b>BUS - BARS</b>					
Material					
<b>SIZE</b>	HBB : Phase / Neutral				
	VBB : Phase / Neutral				
	Ground				
	Supporting Calculations Attached				
<b>MINIMUM CLEARANCE</b>	Between Phases				
	Between Phase & Earth				
Minimum Creepage Distance					
Current Rating : Continuous / Short Time					
Temp. Rise for : Cont. Load / Short Time Current					
<b>SUPPORT</b>	Material				
	BIL				
	Arrangement : Separate/Common				
Material of Bus-bar Insulation					
Shrouding Material for Joints					
No. & Type of Bolts					

CIRCUIT BREAKERS			
Make			
Maker's Type			
Ref. Standards			
Type of Circuit Breaker			
Short Circuit Category			
Maximum Operating Voltage			
No. of Poles			
<b>CURRENT RATING</b>	Continuous		
	1 second RMS		
	Momentary ( kA Peak )		
<b>BREAKING CURRENT</b>	Symmetrical KA		
	Asymmetrical KA		
	Sym. MVA at Rated Voltage		
Making Current ( Peak )			
<b>INSULATION LEVEL</b>	1 Min. PF withstand Voltage		
	Impulse withstand Voltage		
No. of Breaks per Pole			
<b>TYPE AND MATERIAL OF</b>	Main Contacts		
	Arcing Contacts		
Contact Pressure			
Type of Closing Mechanism			
Type of Tripping Mechanism			
Type of Arc Control Device			
Arc Pumping Features with Details			
Trip Free Features with Details			
Total Closing Time			
Interrupting Time at 10%, 50%, 100% of rated Interrupting Capacity		Total	
		Arcing Time	
<b>SPRING CHARGING MOTOR</b>	Rating		
	Voltage		
	Insulation		
	Duty		
Spring Charging Time			
<b>CONTROL VOLTAGE WITH RANGE</b>	Closing		
	Tripping		
	Alarm and Indication		
<b>POWER/ CURRENT REQUIRED FOR</b>	Closing		
	Tripping		
<b>AUXILIARY CONTACTS</b>	No. of Spare Contacts : NO / NC		
	Contact Rating : AC / DC		
	Convertible : Yes / No		
Net Weight of Breaker			
Type Testing Authority & Test Report Ref. No.			
CURRENT TRANSFORMERS			
Make / Maker's Type			
Ref. Standard			
Type of Primary Winding			
Ratio			
Rated Burden			
Accuracy Class			
ALF / ISF			
Insulation Class & Material			
Ref. Magnetisation Curve No.			
POTENTIAL TRANSFORMERS			
Make / Maker's Type			
Ref. Standard			
Winding Connection			



Ratio	
Rated Burden	
Accuracy Class	
Insulation Class & Material	
<b>SWITCHES</b>	
Make / Maker's Type	
Ref. Standard	
Type of Switch	
Rated Operational Voltage	
Utilisation Category	
Rated Operational Current	
Short Time Withstand Current	
No. of Poles / Break	
Type Test Certificate Ref. No.	
<b>FUSES</b>	
Make / Maker's Type	
Ref. Standard	
Type of HRC Fuse	
Rated Voltage / Current	
Category of Duty	
Prospective Breaking Current	
<b>CURRENT TIME CURVE SHOWING PRE-ARCING AND TOTAL I<sup>2</sup>T VALUES</b>	Ref. No.
	Attached
<b>CONTACTORS</b>	
Make / Maker's Type	
Ref. Standard	
Rated Operational Voltage	
Utilisation Category	
Rated Duty	
Rated Thermal Current	
<b>OPERATING VOLTAGE OF COIL</b>	Pick up Max./Min.
	Drop off Max./Min.
Coil Consumption Pick up / Hold on	
<b>RELAYS</b>	
Make / Maker's Type	
Ref. Standard	
Operating Principle	
Setting Range	
Type of Mounting	
Burden	
Reset : Hand or Self	
Flag Indication Type	
Ref. Characteristic Curve Type	
Ref. Descriptive catalogue	
<b>INSTRUMENTS AND METERS</b>	
Make / Maker's Type	
Ref. Standard	
Operating Principle	
Scale Range	
Accuracy	
Size	
Type of Mounting	
<b>CONTROL SWITCHES</b>	
Make / Maker's Type	
Ref. Standard	
Contact Rating	
Utilisation Category	
<b>PUSH BUTTONS</b>	
Make / Maker's Type	
Ref. Standard	
Contact Rating	

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Utilisation Category	
<b>SIGNAL LAMPS</b>	
Make / Maker's Type	
Ref. Standard	
Rated Voltage / Watts	
Type of Lamp Holder	
Type of Globe	
<b>MINIATURE CIRCUIT BREAKER</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
<b>MOULDED CASE CIRCUIT BREAKERS</b>	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
<b>CABLE GLANDS</b>	
Material	
Type	
<b>TERMINAL BLOCKS</b>	
Make	
Type	
Current Rating	

Note: Technical Particulars shall be filled by the bidder and submitted with the bid.

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# **TECHNICAL SPECIFICATION** **HIGH VOLTAGE SWITCH BOARDS**

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## 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 part of Design Philosophy – Electrical , 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, without exceeding the permissible temperature rise and without any detrimental effect on any part.



## 5.0 DESIGN AND CONSTRUCTIONAL FEATURES

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## 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/IEC:60529. 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 hardware shall be cadmium plated. The hardware 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.



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- 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.

## 5.2 Bus-Bars and Connections

- 5.2.1 The bus-bars shall be for three phases. The bus-bars and connection shall be made of electrolytic grade copper 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 250°C 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.

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#### 5.4 **Bus Duct**

5.4.1 Suitable extension of bus-bars in proper phase sequence on the top, 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.

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- 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.
- 5.9 **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. The interlocks shall be either electrical or mechanical type. Arrangement for defeating the interlock shall also be provided.
- 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.
- 5.12 **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.

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## 6.0 COMPONENT DETAILS

Makes of all components shall be subject to owner's / consultant's approval

### 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 0-3 min-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/double break, horizontal draw-out, vertical/horizontal isolation type. The medium of arc quenching shall be minimum Oil/Bulk oil/vacuum/SF6 as specified elsewhere.
- 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/scraping 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:

<u>Application</u>	<u>Class of Accuracy as per IS: 2705</u>
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.

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- 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 0-90° 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/IEC:60947. 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.



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## 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.

## 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 coats of anti-corrosive paint.

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- 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.
- 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 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.
- 11.2 Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment

#### **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	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Feeder Details	N	Y	Y
4.	General arrangement and Foundation Drawings	N	Y	Y
5.	Schematic/Wiring Diagrams	N	Y	Y
6.	Calculation for Bus-bar sizing	N	Y	N
7.	Terminal Arrangement Drawings	N	Y	Y
8.	Illustrative and Descriptive Literature	N	N	Y
9.	Catalogues for bought out accessories	N	N	Y
10.	Installation, Operation and maintenance manual	N	N	Y
11.	Test Certificates			
	i) Type - Switchboard	N	N	N
	- Circuit Breaker	N	N	N
	- MCB	N	N	N
	ii) Routine	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	Spare Parts List	N	N	Y

**Note:**

- 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 CD 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

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**SPECIFICATION SHEET**  
**11 KV SWITCHBOARD**

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>	
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input checked="" type="checkbox"/>			Temp. Max./Min./Design Ref. : 46 / 1 / 50°C		
Encl. Docs. :			Relative Humidity: 100% Alt. above sea <1000 M		
Make :			<b>ATMOSPHERIC POLLUTION</b>		
Maker's Ref. No. :			Dusts : Coal Dust		
			Vapour : Ammonia & Highly Corrosive		
			<b>LOCATION</b>		
			Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
Incoming Bus Duct <input checked="" type="checkbox"/>		Tie Bus Duct <input type="checkbox"/>			
Erection & Comm. <input checked="" type="checkbox"/>		Supervision of Erection & Comm. <input type="checkbox"/>			
<b>TESTS:</b> Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others <input type="checkbox"/>					
<b>BASIC DATA</b>					
	Description				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	P.T. Bus Arrangement		--		
<b>SYSTEM DETAILS</b>	Rated Voltage with variation		11 kV ± 10%		
	Rated Frequency with variation		50Hz ± 5%		
	Highest System Voltage		12 kV		
	Combined V & F Variation		± 10%		
	No. of Phases & Wires		3 Phase, 3 Wire		
	Insulation Level		75 kVp/ 28kV BIL		
	Fault Level		750 MVA for 3 sec.		
Earthing Mode		Non effectively earthed through resistor			
<b>BUS BARS</b>	<b>Rating</b>	Continuous	4000A		
		Short Time for 3 sec.	40KA for 3 sec.		
	Type of Insulation		Raychem Insulating heat shrinkable Sleeved		
<b>CIRCUIT BREAKER</b>	Type		Vacuum Circuit Breaker		
	<b>Breaking Capacity</b>	Symmetrical	40KA for 3 sec.		
		% DC Component	20% (Min.)		
	Making Capacity ( peak )		2.55 times Breaking Capacity		
<b>CONTROL SUPPLY</b>	Closing & Indication		110V DC		
	Tripping		110V DC		
	Alarm / Signal		110V DC		
	Space Heater		240V AC		
<b>MISC. DATA</b>	Cable Entry Top / Bottom		Bottom		
	Dummy Panel Req'd. Yes / No		As required		
	Width of Dummy Panel		--		
	No. of Dummy Panel		--		
	<b>PAINTING</b>	Type	Epoxy Based		
		Shade	631 of IS: 5		
	Spares Parts Req'd. for a Period of		2 Years		

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<b>GAIL</b> ISSUED FOR : PROPOSAL <input type="checkbox"/> ENQUIRY <input checked="" type="checkbox"/> ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>		<b>SYNTHETIC NATURAL GAS (SNG)</b>	
<b>GENERAL</b>		<b>AMBIENT CONDITION</b>	
Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input checked="" type="checkbox"/>		Temp. Max./Min./Design Ref. : 46 / 1 / 50°C	
Encl. Docs. :		Relative Humidity: 100% Alt. above sea <1000 M	
Make :		<b>ATMOSPHERIC POLLUTION</b>	
Maker's Ref. No. :		Dusts : Coal Dust Vapour : Ammonia & Highly Corrosive	
		<b>LOCATION</b>	
		Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/> Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>	
<b>ADDL. SCOPE</b>	Incoming Bus Duct <input type="checkbox"/> Tie Bus Duct <input checked="" type="checkbox"/>		
	Erection & Comm. <input checked="" type="checkbox"/> Supervision of Erection & Comm. <input type="checkbox"/>		
<b>TESTS:</b> Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/> Others <input type="checkbox"/>			
<b>BASIC DATA</b>			
	Description		
<b>REFERENCE DRAWINGS</b>	Single Line Diagram		
	Feeder Details		
	P.T. Bus Arrangement		--
<b>SYSTEM DETAILS</b>	Rated Voltage with variation		11 kV ± 10%
	Rated Frequency with variation		50Hz ± 5%
	Highest System Voltage		12 kV
	Combined V & F Variation		± 10%
	No. of Phases & Wires		3 Phase, 3 Wire
	Insulation Level		75 kVp/ 28kV BIL
	Fault Level		750 MVA for 3 sec.
<b>BUS BARS</b>	Earthing Mode		Non effectively earthed through resistor
	<b>Rating</b>	Continuous	3150A
		Short Time for 3 sec.	40KA for 3 sec.
<b>CIRCUIT BREAKER</b>	Type of Insulation		Raychem Insulating heat shrinkable Sleeved
	<b>Breaking Capacity</b>	Type	Vacuum Circuit Breaker
		Symmetrical	40KA for 3 sec.
		% DC Component	20% (Min.)
<b>CONTROL SUPPLY</b>	Making Capacity ( peak )		2.55 times Breaking Capacity
	Closing & Indication		110V DC
	Tripping		110V DC
	Alarm / Signal		110V DC
<b>MISC. DATA</b>	Space Heater		240V AC
	<b>PAINTING</b>	Cable Entry Top / Bottom	Bottom
		Dummy Panel Req'd. Yes / No	As required
		Width of Dummy Panel	--
	<b>PAINTING</b>	No. of Dummy Panel	--
		Type	Epoxy Based
		Shade	631 of IS: 5
Spares Parts Req'd. for a Period of		2 Years	

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.

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**TECHNICAL PARTICULARS  
11 KV SWITCHBOARD**

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>	
				FINAL <input type="checkbox"/>	
<b>GENERAL</b>					
Make / Maker's Type :					
Ref. Standards					
Rated Operational Voltage with $\pm$ %					
Rated Insulation Voltage					
Rated Voltage of Aux. Circuits with $\pm$ %					
Rated Current					
Short Time Rating					
Degree of Protection of Enclosure					
Service Conditions : Indoor / Outdoor					
<b>DRAWOUT FACILITIES</b>	Circuit Breaker's				
	P.T.'s				
	Protective Relays				
	Meters				
<b>SHEET STEEL TYPE &amp; THICKNESS</b>	Base Channel				
	Others				
Material of Gaskets					
Material of External Hardware					
Operating Height : Max. / Min.					
Space Heater Rating of each Panel					
<b>PAINTING</b>	Method of Pre-treatment				
	Thickness of Paint				
	Type & Shade				
Final Temperature					
<b>PROVISIONS / FACILITIES</b>	Safety Shutters				
	Interlocks				
	Earthing Facility				
	Base Channels with Fdn. Bolts				
	Gland Plate with Glands				
	Limit of Maximum Nos. of Cables Termination Possible				
Dimensions : L X B X H / Dim. Drg. Ref. No.					
Shipping Dimensions of Largest Package					
Weight : Static / Dynamic					
Heat Dissipation					
<b>BUS – BARS</b>					
Material					
<b>SIZE</b>	HBB				
	VBB				
	Ground				
	Supporting Calculation Attached				
<b>MINIMUM CLEARANCE</b>	Between Phases				
	Between Phase & Earth				
Minimum Creepage Distance					
<b>CURRENT RATING</b>	Continuous				
	Short Time for 3 secs.				
Max. current density for bus-bars					
Temp. Rise for : Cont. Load / Short Ckt. Current					
<b>SUPPORT</b>	Material				
	Voltage Class				
	BIL				
	Arrangement : Separate/Common				
Power Frequency test Voltage for 1 Min. Duration					
Material of Bus-bar Insulation					
Material of Inter Panel / Compartment Barrier					
Shrouding Material for Joints					

 <b>पी डी आई एल</b> <b>PDIL</b>	<b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	<b>PC217-TS-0806</b>	0	
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Bus Bar Phase Identification Mark		
No. & Type of Bolts per Joint		
<b>CIRCUIT BREAKERS</b>		
Make / Maker's Type		
Ref. Standards		
Type of Circuit Breaker		
Principle / Collaborator		
Rated Operating Sequence		
Rated Voltage		
Rated Frequency		
No. of Poles		
<b>CURRENT RATING</b>	Continuous in IPH6 Enclosure	
	3 second RMS	
	Momentary ( Peak )	
<b>BREAKING CURRENT</b>	Symmetrical KA	
	Asymmetrical KA	
	% D.C. Component	
Making Current ( Peak )		
Derating Factor, if any for Site Condition		
<b>LIMITATION OF CURRENT RATING FOR</b>	Motor Duty	
	Capacitor Duty	
	Transformer Switching	
	Cable Charging	
Restriking Voltage ( Peak )		
<b>INSULATION LEVEL</b>	1 Min. PF withstand Voltage	
	Impulse withstand Voltage	
No. of Breaks per Pole		
<b>TYPE AND MATERIAL OF</b>	Fixed Contact	
	Moving Contact	
	Arcing Contact	
Type of Closing Mechanism		
Type of Tripping Mechanism		
<b>ARC CONTROL DEVICE</b>	Type	
	Material of Arc Chamber	
Details of Anti – Pumping Feature		
Details of Trip Free Feature		
Total Closing Time		
Total Interrupting Time at 10%, 50%, 100% of rated		
Interrupting Capacity		
<b>SPRING CHARGING MOTOR</b>	Rating	
	Voltage	
	Insulation	
	Duty	
	Type	
Spring Charging Time		
<b>VOLTAGE / CURRENT REQD. FOR</b>	Closing	
	Tripping	
	A.C. Supply	
<b>AUXILIARY CONTACTS</b>	No. of Spare Contacts NO / NC	
	Contact Rating Ac / Dc	
	Convertible Type	
<b>INSULATING OIL</b>	Ref. Standard	
	Volume of Oil Required	
Mounting Arrangement		
Temp. Rise of Different Parts		
<b>DETAILS FOR SF<sub>6</sub></b>	SF <sub>6</sub> Gas Pressure	
	Wt. Of SF <sub>6</sub> Gas per Breaker	
<b>DETAILS FOR SF<sub>6</sub></b>	Gas Leakage Detector Provided	
	Gas Density Monitor Provided	
<b>DETAILS FOR VCB</b>	Pressure inside the Interrupter	
	Contact Wear Indication Provided	

 <b>पी डी आई एल</b> <b>PDIL</b>	<b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	<b>PC217-TS-0806</b>	0	
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<b>RECOMMENDED TIME INTERVAL FOR</b>	Facility for Checking Loss of Vacuum Provided	
	Inspection of Drives	
	Inspection of Contacts	
	Quenching Devices	
	Replacement of Oil	
Dimensions : L X B X H / Dim. Drg. Ref. No.		
Type Testing Authority & Test Report Ref. No.		
Net Weight of Breaker		
<b>CURRENT TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Type of Primary Winding		
No. of Cores		
Ratio		
Rated Burden		
Accuracy Class		
ALF / ISF		
Thermal Limit		
Dynamic Limit		
Insulation Class / Material		
Basic Insulation Level		
Ref. Magnetisation Curve No.		
<b>POTENTIAL TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Winding Connection : Pri. / Sec.		
Ratio		
Rated Burden		
Accuracy Class		
Insulation Class / Material		
Basic Insulation Level		
Weight		
Dimension		
Rated Voltage Factor		
<b>SURGE DIVERTER</b>		
Type & Maker's Type		
Rated Voltage KV		
Nominal Discharge Current ( 8/20 $\mu$ sec. wave )		
Residual Voltage at Rated Discharge Current		
Power Frequency Spark Over Voltage		
1.2/50 $\mu$ sec. Spark Over Voltage		
<b>RELAYS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Voltage / Current		
Rated Burden		
Setting Range		
Type of Mounting		
Reset : Hand or Self		
Flag Indication Type		
Ref. Characteristic Curve Type		
Ref. Descriptive catalogue		
<b>INSTRUMENTS AND METERS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Burden		
Scale Range		

 <b>पी डी आई एल</b> <b>PDIL</b>	<b>TECHNICAL SPECIFICATION - HIGH VOLTAGE SWITCHBOARDS</b>	<b>PC217-TS-0806</b>	0	
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Accuracy	
Size	
Type of Mounting	
<b>CONTROL SWITCHES</b>	
Application	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>PUSH BUTTON</b>	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>SIGNAL LAMPS</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Voltage / Wattage	
Type of Lamp Holder	
Type of Globe	
Accessibility from Front	
<b>MOULDED CASE CIRCUIT BREAKERS</b>	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
<b>MINIATURE CIRCUIT BREAKER</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
<b>CABLE GLANDS</b>	
Material	
Type	
<b>TERMINAL BLOCKS</b>	
Make	
Type	
Current Rating	

Note: Technical Particulars shall be filled by the bidder and submitted with the bid.

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**SPECIFICATION SHEET  
3.3 KV SWITCHBOARD**

CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/> FINAL <input type="checkbox"/>	
<b>GENERAL</b>			<b>AMBIENT CONDITION</b>		
Ref. Stds. : IS <input checked="" type="checkbox"/> IEC <input type="checkbox"/>			Temp. Max./Min./Design Ref. : 46 / 1 / 50°C		
Encl. Docs. :			Relative Humidity: 100% Alt. above sea <1000 M		
Make :			<b>ATMOSPHERIC POLLUTION</b>		
Maker's Ref. No. :			Dusts : Coal Dust		
			Vapour : Ammonia & Highly Corrosive		
			<b>LOCATION</b>		
			Indoor <input checked="" type="checkbox"/> Outdoor <input type="checkbox"/>		
			Gr. Floor <input type="checkbox"/> 1 <sup>st</sup> floor <input checked="" type="checkbox"/>		
<b>ADDL. SCOPE</b>		Incoming Bus Duct <input type="checkbox"/>		Tie Bus Duct <input type="checkbox"/>	
		Erection & Comm. <input checked="" type="checkbox"/>		Supervision of Erection & Comm. <input type="checkbox"/>	
<b>TESTS:</b>		Routine <input checked="" type="checkbox"/> Type <input type="checkbox"/>		Others <input type="checkbox"/>	
<b>BASIC DATA</b>					
<b>TAG NO. &amp; QTY.</b>	Item No.				
	Switch board No.				
	Description				
<b>REFERENCE DRAWINGS</b>	Single Line Diagram				
	Feeder Details				
	Auto Trip Alarm Scheme				
	Non Trip Alarm Scheme				
	Trip Ckt. Supervision Scheme				
	Auto C/O Scheme				
	P.T. Bus Arrangement				
<b>SYSTEM DETAILS</b>	Rated Voltage with Variation		3.3 KV $\pm$ 10%		
	Rated Frequency with Variation		50Hz $\pm$ 5%		
	Highest System Voltage		3.6KV		
	Combined V & F Variation		$\pm$ 10%		
	No. of Phases & Wires		3 Phase, 3 Wire		
	Insulation Level		40KV		
	Fault Level		150MVA		
	Earthing Mode		Non effectively earthed through resistor		
<b>BUS BARS</b>	<b>Rating</b>	Continuous	1250A		
		Short Time for 3 sec.	26.24KA		
	Type of Insulation		Heat Shrinkable Raychem Sleeved		
<b>CIRCUIT BREAKER</b>	Type		Vacuum Circuit Breaker		
	<b>Breaking Capacity</b>	Symmetrical	26.24KA		
		% DC Component	20%		
	Making Capacity ( peak )		66.81KA		
<b>CONTROL SUPPLY</b>	Closing & Indication		110V DC		
	Tripping		110V DC		
	Alarm / Signal		110V DC		
	Space Heater		240V AC		
<b>MISC. DATA</b>	Cable Entry Top / Bottom		Bottom		
	Dummy Panel Req'd. Yes / No		No		
	Width of Dummy Panel		--		
	No. of Dummy Panel		--		
	<b>PAINTING</b>	Type	Epoxy Based		
		Shade	631 of IS: 5		
	Spares Parts Req'd. for a Period of		2 Years		

Note: Specification Sheet shall be filled by the bidder and submitted with the bid.



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CLIENT : JV OF CIL & BHEL		PROJECT : ELECTRICAL DIST. SYSTEM		PLANT: SYNGAS PURIFICATION UNIT	
ISSUED FOR : PROPOSAL <input type="checkbox"/>		ENQUIRY <input checked="" type="checkbox"/>		ORDER <input type="checkbox"/>	
				FINAL <input type="checkbox"/>	
<b>GENERAL</b>					
Make / Maker's Type :					
Ref. Standards					
Rated Operational Voltage with $\pm$ %					
Rated Insulation Voltage					
Rated Voltage of Aux. Circuits with $\pm$ %					
Rated Current					
Short Time Rating					
Degree of Protection of Enclosure					
Service Conditions : Indoor / Outdoor					
<b>DRAWOUT FACILITIES</b>	Circuit Breaker's				
	P.T.'s				
	Protective Relays				
	Meters				
<b>SHEET STEEL TYPE &amp; THICKNESS</b>	Base Channel				
	Others				
Material of Gaskets					
Material of External Hardware					
Operating Height : Max. / Min.					
Space Heater Rating of each Panel					
<b>PAINTING</b>	Method of Pre-treatment				
	Thickness of Paint				
	Type & Shade				
Final Temperature					
<b>PROVISIONS / FACILITIES</b>	Safety Shutters				
	Interlocks				
	Earthing Facility				
	Base Channels with Fdn. Bolts				
	Gland Plate with Glands				
	Limit of Maximum Nos. of Cables Termination Possible				
Dimensions : L X B X H / Dim. Drg. Ref. No.					
Shipping Dimensions of Largest Package					
Weight : Static / Dynamic					
Heat Dissipation					
<b>BUS - BARS</b>					
Material					
<b>SIZE</b>	HBB				
	VBB				
	Ground				
	Supporting Calculation Attached				
<b>MINIMUM CLEARANCE</b>	Between Phases				
	Between Phase & Earth				
Minimum Creepage Distance					
<b>CURRENT RATING</b>	Continuous				
	Short Time for 3 secs.				
Max. current density for bus-bars					
Temp. Rise for : Cont. Load / Short Ckt. Current					
<b>SUPPORT</b>	Material				
	Voltage Class				
	BIL				
	Arrangement : Separate/Common				
Power Frequency test Voltage for 1 Min. Duration					
Material of Bus-bar Insulation					
Material of Inter Panel / Compartment Barrier					
Shrouding Material for Joints					

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Bus Bar Phase Identification Mark		
No. & Type of Bolts per Joint		
<b>CIRCUIT BREAKERS</b>		
Make / Maker's Type		
Ref. Standards		
Type of Circuit Breaker		
Principle / Collaborator		
Rated Operating Sequence		
Rated Voltage		
Rated Frequency		
No. of Poles		
<b>CURRENT RATING</b>	Continuous in IPH6 Enclosure	
	3 second RMS	
	Momentary ( Peak )	
<b>BREAKING CURRENT</b>	Symmetrical KA	
	Asymmetrical KA	
	% D.C. Component	
Making Current ( Peak )		
Derating Factor, if any for Site Condition		
<b>LIMITATION OF CURRENT RATING FOR</b>	Motor Duty	
	Capacitor Duty	
	Transformer Switching	
	Cable Charging	
Restriking Voltage ( Peak )		
<b>INSULATION LEVEL</b>	1 Min. PF withstand Voltage	
	Impulse withstand Voltage	
No. of Breaks per Pole		
<b>TYPE AND MATERIAL OF</b>	Fixed Contact	
	Moving Contact	
	Arcing Contact	
Type of Closing Mechanism		
Type of Tripping Mechanism		
<b>ARC CONTROL DEVICE</b>	Type	
	Material of Arc Chamber	
Details of Anti – Pumping Feature		
Details of Trip Free Feature		
Total Closing Time		
Total Interrupting Time at 10%, 50%, 100% of rated		
Interrupting Capacity		
<b>SPRING CHARGING MOTOR</b>	Rating	
	Voltage	
	Insulation	
	Duty	
	Type	
Spring Charging Time		
<b>VOLTAGE / CURRENT REQD. FOR</b>	Closing	
	Tripping	
	A.C. Supply	
<b>AUXILIARY CONTACTS</b>	No. of Spare Contacts NO / NC	
	Contact Rating Ac / Dc	
	Convertible Type	
<b>INSULATING OIL</b>	Ref. Standard	
	Volume of Oil Required	
Mounting Arrangement		
Temp. Rise of Different Parts		
<b>DETAILS FOR SF<sub>6</sub></b>	SF <sub>6</sub> Gas Pressure	
	Wt. Of SF <sub>6</sub> Gas per Breaker	
<b>DETAILS FOR SF<sub>6</sub></b>	Gas Leakage Detector Provided	
	Gas Density Monitor Provided	
<b>DETAILS FOR VCB</b>	Pressure inside the Interrupter	
	Contact Wear Indication Provided	


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<b>RECOMMENDED TIME INTERVAL FOR</b>	Facility for Checking Loss of Vacuum Provided	
	Inspection of Drives	
	Inspection of Contacts	
	Quenching Devices	
	Replacement of Oil	
Dimensions : L X B X H / Dim. Drg. Ref. No.		
Type Testing Authority & Test Report Ref. No.		
Net Weight of Breaker		
<b>CURRENT TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Type of Primary Winding		
No. of Cores		
Ratio		
Rated Burden		
Accuracy Class		
ALF / ISF		
Thermal Limit		
Dynamic Limit		
Insulation Class / Material		
Basic Insulation Level		
Ref. Magnetisation Curve No.		
<b>POTENTIAL TRANSFORMERS</b>		
Make / Maker's Type		
Ref. Standard		
Winding Connection : Pri. / Sec.		
Ratio		
Rated Burden		
Accuracy Class		
Insulation Class / Material		
Basic Insulation Level		
Weight		
Dimension		
Rated Voltage Factor		
<b>SURGE DIVERTER</b>		
Type & Maker's Type		
Rated Voltage KV		
Nominal Discharge Current ( 8/20 $\mu$ sec. wave )		
Residual Voltage at Rated Discharge Current		
Power Frequency Spark Over Voltage		
1.2/50 $\mu$ sec. Spark Over Voltage		
<b>RELAYS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Voltage / Current		
Rated Burden		
Setting Range		
Type of Mounting		
Reset : Hand or Self		
Flag Indication Type		
Ref. Characteristic Curve Type		
Ref. Descriptive catalogue		
<b>INSTRUMENTS AND METERS</b>		
Application		
Make / Maker's Type :		
Ref. Standards		
Operating Principle		
Rated Burden		
Scale Range		

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Accuracy	
Size	
Type of Mounting	
<b>CONTROL SWITCHES</b>	
Application	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>PUSH BUTTON</b>	
Make / Maker's Type :	
Ref. Standards	
Contact Rating	
Utilisation Category	
<b>SIGNAL LAMPS</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Voltage / Wattage	
Type of Lamp Holder	
Type of Globe	
Accessibility from Front	
<b>MOULDED CASE CIRCUIT BREAKERS</b>	
Make / Maker's Type	
Ref. Standard	
Current Rating	
Breaking Capacity	
Setting Range of Thermal Release	
Setting Range of Magnetic Release	
<b>MINIATURE CIRCUIT BREAKER</b>	
Make / Maker's Type :	
Ref. Standards	
Rated Current	
Breaking Capacity	
<b>CABLE GLANDS</b>	
Material	
Type	
<b>TERMINAL BLOCKS</b>	
Make	
Type	
Current Rating	

Note: Technical Particulars shall be filled by the bidder and submitted with the bid.

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# **TECHNICAL SPECIFICATION** **BUS DUCT**

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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	LAYOUT
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 BUS DUCT

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## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture testing at works and despatch in well packed condition of bus duct.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 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 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/IEC:60947. 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.

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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 hardware of diameter less than 8 mm shall be stainless steel and those of diameter 8 mm and above shall be mild steel cadmium plated or zinc passivated.

## 5.2 Bus Bars and Connections

5.2.1 The bus-bars in LV Bus duct shall be of three phase and neutral, non-segregated and air insulated type.

The bus-bars in HV Bus duct shall be of three phase, phase-segregated with insulating material.

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 200°C. 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<sup>2</sup>. 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.



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## 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

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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 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.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 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

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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 DEVIATIONS

13.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

**ANNEXURE - I**  
**DOCUMENTATION FOR 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.	N	Y	Y
2.	Design calculations	N	Y	N
	a) Bus bars sizing			
	b) Flexible sizing			
	c) Temperature Rise			
	d) Support Span			
3.	Specification sheet & Technical Particulars	N	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	N	N	N
	ii) Routine & others	N	N	Y
12.	Guarantee Certificates	N	N	Y
13.	List of spare parts	N	N	N

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **SHEET STEEL DISTRIBUTION BOARDS**

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ANNEXURE - I	DOCUMENTATION FOR SHEET STEEL DISTRIBUTION BOARDS

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## 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 part of Design Philosophy – Electrical.

## 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 | - 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, 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/IEC:60947.
- 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

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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 cadmium plated/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 non-drawout type in single 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. 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 90°C. The bus-bars shall also be designed to withstand the system fault current for 1 second without



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exceeding the temperature of 200°C for bare aluminium and 250°C 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.

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## 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 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.

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- 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

The components shall conform to type of co-ordination C as per IS/IEC:60947. Makes of all components shall be subject to owner's / consultant's approval

#### 6.1 Moulded Case Circuit Breakers

- 6.1.1 The circuit breaker shall conform to IS/IEC:60947 and shall be of P2 category having rupturing capacity as per system requirement.
- 6.1.2 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.
- 6.1.3 The thermal and short circuit tripping device shall be adjustable type.
- 6.1.4 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.
- 6.1.5 In addition, under voltage trip shall be provided, if specified.

#### 6.2 Switches

- 6.2.1 The switches shall be Motor duty type AC23 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 Amp and above shall be link type.
- 6.2.2 '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.
- 6.2.3 The fixed contacts shall be shrouded and the contacts shall be silver plated.
- 6.2.4 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.

#### 6.3 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.

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#### 6.4 **Air Break Contactors**

- 6.4.1 The Air Break Contactor shall be of AC3 category unless otherwise specified, conforming to IS/IEC:60947 and flapper type. Gravity operated contactors are not acceptable.
- 6.4.2 The dropout voltage shall not exceed 65% of rated voltage.
- 6.4.3 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.

#### 6.5 **Bimetal Thermal Overload Relays**

- 6.5.1 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.
- 6.5.2 Bimetal relays shall conform to IS: 3231 and shall have built in single phasing preventor.
- 6.5.3 The bimetal relays shall be provided with a manual reset device resetable after opening the cubicle door. Auto reset thermal relays are not acceptable.

#### 6.6 **Current Transformers**

- 6.6.1 The current transformers shall conform to IS: 2705.
- 6.6.2 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.
- 6.6.3 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.
- 6.6.4 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.
- 6.6.5 The C.T.s shall be capable of withstanding momentary open-circuit on the secondary side without injurious effects.

#### 6.7 **Instruments and Meters**

- 6.7.1 All instruments shall be flush mounting type with square face and shall be tropicalized and dust tight.
- 6.7.2 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.
- 6.7.3 Dials shall be parallax free with scale marked in black on white background and shall be suitable for direct reading.
- 6.7.4 Zero adjusters shall be provided for operation from the front of the cases.
- 6.7.5 All ammeters and voltmeters shall have 0 - 240° 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.
- 6.7.6 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.
- 6.7.7 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.

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6.7.8 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.

#### 6.8 Push Button and Control Switches

6.8.1 The switches and push buttons shall conform to utilization category AC 11/DC 11 as per IS/IEC: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.

6.8.2 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.

6.8.3 The selector switches shall be stay-put rotary type and provided with oval shape handles.

6.8.4 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.

6.8.5 Emergency stop push buttons, if specified, shall be lockable in pushed position.

#### 6.9 Miniature Circuit Breakers

6.9.1 The miniature circuit breakers shall conform to IS: 13032 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 A certificate of short circuit rating and current time tripping curve shall be furnished alongwith 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 follows:

Red	--	Switch/Contactor closed.
Green	--	Switch/Contactor open.

6.10.2 The lamps shall be LED type having lumen output 200 milli candela in axial direction.

6.10.3 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.

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- 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 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.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment

## **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.

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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	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Feeder Details	N	Y	Y
4.	General Arrangement and Foundation Drawings	N	Y	Y
5.	Schematic Diagrams with Terminal arrangement drawings	N	Y	Y
6.	Calculation for Bus-bar sizing	N	Y	N
7.	Illustrative and Descriptive literature	N	N	Y
8.	Catalogues for bought out accessories	N	N	Y
9.	Installation, Operation and Maintenance Manual	N	N	Y
10.	Test Certificates			
	-- Type (for MCCB & MCB)	N	N	N
	-- Routine	N	N	Y
11.	Guarantee Certificates	N	N	Y
12.	Spare Parts List	N	N	Y

**Note:**



1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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





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# **TECHNICAL SPECIFICATION** **LIGHTING SUB DISTRIBUTION BOARDS**

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4.0	OPERATING REQUIREMENTS
5.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
6.0	SPECIAL FEATURES FOR FLAME PROOF LIGHTING SUB DISTRIBUTION BOARDS
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ANNEXURE - I	DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS

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## 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.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 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/IEC:60947 - 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, 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/IEC:60947. 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 cadmium plated or zinc passivated.

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- 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 Design Philosophy – Electrical.
- 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)**
- The MCB shall be of duty category M-9 and shall conform to IS/IEC:60898-1:2002. It shall be provided with overload and short circuit protective devices. MCB shall be of C Curve Type.
- 7.2.1 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 PVC insulated, armoured and PVC sheathed 1.1 KV grade incoming and outgoing cables shall be provided.

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## 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 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 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.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 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.

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**ANNEXURE - I**  
**DOCUMENTATION FOR LIGHTING SUB DISTRIBUTION BOARDS**

SL.N O.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical particulars	N	Y	Y
3.	General arrangement Drgs.	N	Y	Y
4.	Certificate for flameproofness from statutory testing authority wherever applicable	N	N	Y
5.	Schematic diagram	N	Y	Y
6.	Descriptive literature of Various equipment	N	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 for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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



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# **TECHNICAL SPECIFICATION** **INDUCTION MOTOR**

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ANNEXURE - I	DOCUMENTATION FOR INDUCTION MOTORS



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## 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.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 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 IP-54 and IPW-55 respectively as per IS/IEC:60529, unless otherwise specified.
- 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 hardware shall be zinc passivated or cadmium plated.

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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 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.

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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 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.

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- 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 90°C for grease lubricated bearings and 70°C 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.
- 4.9 **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. For M.V. Motors, design of terminal boxes shall be such that it may be possible to arrange top/bottom/side entry of cables at site.
- 4.9.3 The power terminal boxes shall be as follows:
- For H.V. motors - Phase segregated type capable of with standing the system fault level for 0.2 Sec. or more.
  - 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.

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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 throughout 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 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 starting current.

The starting current of 11 KV & 3.3 KV motors shall not exceed 550% of FLC. No positive tolerance is acceptable over 550% FLC.

5.1.4 The motors shall be suitable for the following starting cycle:

- With the motor at ambient temperature - 2 successive starts and 3rd start after 5 minutes.
- 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.

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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 10°C 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 200°C.

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 - 300°C
- 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  $\pm 66\%$  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.



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## 7.0 ACCESSORIES

The motors shall be complete with all 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.

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 0°C and temperature coefficient as  $3.850 \times 10^{-3}$ .

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.

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#### 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:
- 2 Nos. 100% rated motor driven pumps with motors
  - 1 No. oil tank complete with oil level gauge and thermometer
  - 1 No. oil cooler
  - 1 No. oil filter
  - 1 No. differential pressure switch for filter
  - 2 Nos. pressure switches
  - Necessary piping
  - 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 shall be used.
- 10.3 Unless otherwise specified, the finishing shade shall be light grey having shade No. 631 as per IS: 5.



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## 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 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.
- 14.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 14.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 14.4 All spare parts shall be identical to the parts used in the equipment

## 15.0 DEVIATIONS

- 15.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

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**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	N	Y	Y
2.	Dimensional Drawings	N	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	N	Y	Y
8.	Illustrative and Descriptive catalogues	N	N	Y
9.	Catalogues of bought out accessories	N	N	Y
10.	Spare parts list	N	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	N	N	Y
13.	Guarantee Certificates	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **INTERLOCKING SWITCH SOCKET AND PLUG**

## CONTENTS

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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
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ANNEXURE - I	DOCUMENTATION FOR INTERLOCKING SWITCH SOCKET AND PLUG

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## 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.
- 1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 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 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/IEC:60947 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.

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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 cadmium plated or 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 Design Philosophy - Electrical.

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

Makes of all components shall be subject to owner's / consultant's approval

### 7.1 Air Break Switches

7.1.1 The switches shall be quick make, quick break rotary type and of utilisation category AC-23 as per IS/IEC:60947.

7.1.2 Switches shall be hand operated from outside the cover. The switch handle shall remain fixed to the front cover while removing the front cover.

### 7.2 H.R.C. Fuses

7.2.1 The sockets shall be provided with link type HRC fuses.

7.2.2 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.

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### 7.3 **Socket Outlets**

- 7.3.1 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.
- 7.3.2 The socket contacts shall maintain satisfactory spring pressure and contact with the corresponding plug under normal service conditions.
- 7.3.3 The socket contacts shall be sunk well below the surface of the socket- outlets so as to make it impossible to be touched unintentionally.
- 7.3.4 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.

### 7.4 **Plugs**

- 7.4.1 The plugs shall be so constructed so that these can be easily fitted in to the socket outlets.
- 7.4.2 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.
- 7.4.3 The plug base and cover shall be firmly secured to each other and shall be sufficiently robust in construction to withstand normal usage.
- 7.4.4 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.
- 7.4.5 The plug and socket contacts shall be self aligning type with best electrical continuity.
- 7.4.6 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.
- 7.4.7 Insulating barriers forming an integral part of the plug shall ensure separation of metals and bare flexible conductors at different potentials.

### 7.5 **Cable Termination**

- 7.5.1 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 PVC insulated armoured and PVC sheathed cables of size.
- 7.5.2 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.

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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 PACKING

11.1 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.

11.2 The packing box shall contain a copy of the installation, operation and maintenance manual.

## 12.0 SPARES

12.1 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.

12.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

12.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

12.4 All spare parts shall be identical to the parts used in 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 INTERLOCKING SWITCH SOCKET AND PLUG

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General arrangement and foundation drawing	N	Y	Y
4.	Schematic / wiring diagram	N	Y	Y
5.	Illustrative and descriptive literature	N	N	Y
6.	Catalogue for bought out accessories	N	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.	N	N	Y
11.	Spare parts list with identification marks	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **BATTERY CHARGER**

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ANNEXURE - I	REQUIREMENT OF PROTECTIONS, METERING, CONTROL AND INDICATIONS / ANNUNCIATIONS FOR BATTERY CHARGER
ANNEXURE - II	DOCUMENTATION FOR BATTERY CHARGER

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## 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.
- 1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.

## 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 without exceeding the temperature rise limits specified in relevant standards and without any detrimental effect on any part.
- 4.2 The battery charger board shall consist of two units as follows:
- (a) Float cum load cum -- Boost Charger 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.
  - (b) A stand by unit for (a) above.
- 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 voltage of the float charger for Ni-Cd shall be minimum 1.4 Volt/ Cell and final charging voltage of the boost charger shall be minimum 1.7 Volt/ Cell. The rated output voltage of the charger under 4.2 (a) above shall be adjustable by  $\pm 5\%$  of the rated value manually.

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- 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  $\pm 2\%$  irrespective of the input supply variations 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.

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- 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.

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- 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 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

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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/IEC:60947.

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

## 7.0 ACCESSORIES

The supply shall include the following accessories:

### 7.1 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.

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- 7.2 Name Plates
- 7.2.1 The board shall have a large name plate on the top to indicate its name and designation.
- 7.2.2 Each cubicle shall be provided with a name plate.
- 7.2.3 All control switches, push buttons, lamps etc. shall have function identification labels.
- 7.2.4 Name plate shall be of black perspex with white engraving of minimum 3 mm thickness.
- 7.3 Fuse Puller
- 7.4 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 required, 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

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- 11.1** 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.
- 11.2** Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3** Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4** All spare parts shall be identical to the parts used in the equipment
- 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.	<b>A.C. Input Side</b>			
	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.	<b>Rectifiers</b>			
	i) Semiconductor fuses	Yes	Yes	Yes
	ii) Filters with fuses	Yes	Yes	Yes
	iii) Surge Suppressors	Yes	Yes	Yes
3.	<b>DC Output Side</b>			
	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



**ANNEXURE - II**  
**DOCUMENTATION FOR BATTERY CHARGER**

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General arrangement drawings showing overall dimensions of the charger board and mounting details of various equipment inside the charger panel	N	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.	N	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	N	N	Y


**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **BATTERY**

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7.0	TESTS AND INSPECTION
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ANNEXURE - I	DOCUMENTATION FOR BATTERY



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## 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.
- 1.2 This standard shall be read in conjunction with the relevant part of Design Philosophy - Electrical.

## 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 lead acid plante type and rated for 220V. 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).

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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 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.

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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 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.

9.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

9.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

9.4 All spare parts shall be identical to the parts used in the equipment

## 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.

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## ANNEXURE – I



### DOCUMENTATION FOR BATTERY

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Dimensional drawings showing the cell arrangement on stand (Plan, front and side elevation) for each type of battery.	N	Y	Y
4.	Illustrative and descriptive literature giving the complete details of construction of battery	N	N	Y
5.	Operation and maintenance instructions	N	N	Y
6.	Test Certificates			
	-- Type	N	N	N
	-- Acceptance	N	N	Y
7.	Guarantee Certificates	N	N	Y
8.	Spare Parts lists	N	N	Y

#### Note:

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **CABLES**

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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
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10.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR CABLES

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## 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.
- 1.2 The standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

## 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 elsewhere in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated elsewhere 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 without exceeding the permissible temperature rise and without any detrimental effect on any part.

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## 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 XLPE 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.



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#### 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  $\pm 5\%$  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	-	250°C
-	Maximum acid gas generation	-	20%
-	Maximum smoke density rating	-	60%

#### 6.2 Heat Resistant Cables

Heat resistant cables 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  $\pm 2.5\%$ . 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:

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- 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	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Illustrative and Descriptive catalogues	N	N	Y
4.	Installation, Termination and Jointing Instructions	N	N	Y
5.	Test certificates			
	a) Routine	N	N	Y
	b) Type	N	N	Y
6.	Guarantee Certificates	N	N	Y



**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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



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# **TECHNICAL SPECIFICATION** **PREFABRICATED LADDER TYPE CABLE RACKS**

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3.0	GENERAL DESIGN AND CONSTRUCTIONAL FEATURES
4.0	MARKING
5.0	TESTS AND INSPECTION
6.0	DRAWINGS AND DOCUMENTS
7.0	DEVIATIONS
ANNEXURE - I	DOCUMENTATION FOR PREFABRICATED LADDER TYPE CABLE RACKS

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## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, fabrication, testing at works and delivery in well-packed condition of prefabricated ladder type cable racks.
- 1.2 The standard shall be read in conjunction with Drawing Nos. PDS: E 530 to 538 (9 Sheets).

## 2.0 STANDARDS TO BE FOLLOWED



- 2.1 The design, manufacture and testing of the cable racks covered by this standard shall comply with the latest issue of following and other relevant Indian Standards, unless otherwise specified. Equipment complying with equivalent IEC standards shall also be acceptable.

- |          |    |  |
|----------|----|--|
| IS: 733  | -- | Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes |
| IS: 2629 | -- | Recommended practice for hot dip galvanising on iron and steel                                 |
| IS: 4759 | -- | Hot dip zinc coatings on structural steel and other allied products                            |

- 2.2 Wherever any requirement, laid down in this standard, differs from that in Indian Standard Specifications, the requirement specified herein shall prevail.

## 3.0 GENERAL DESIGN AND CONSTRUCTIONAL FEATURES

- 3.1 Ladder type cable racks shall be fabricated as per attached Drawing Nos. PDS: E 530 to PDS: E 538 (9 Sheets).
- 3.2 Cable racks and accessories such as coupler plate, tees, bend, elbows etc. shall be fabricated from 3 mm thick mild steel galvanised sheet or 4 mm thick aluminium 19000 H2 alloy sheet extrusion conforming to designation No. 64430 and condition WP as per IS: 733.
- 3.3 G.I. racks and accessories shall have zinc coating of 800 gm/sq. metre applied by hot dip galvanising process. Galvanising shall be uniform, adherent, smooth and free from defects.
- 3.4 The finished rack and accessories shall be free from sharp edges and corners, burrs and un-evenness. Stepped arrangement of bending is not acceptable. The channel members in the bending shall have uniform curvature and shall be made out of single piece.
- 3.5 The racks shall be supplied in minimum length of 2.4 metre.
- 3.6 Each straight length and bend shall be supplied with two coupling plates fitted at each side channel at one end. The coupling plates shall be supplied with bolts, nuts and washers fitted at the other four holes for fixing to adjoining member.
- 3.7 Coupling plate shall be designed to permit longitudinal adjustment upto  $\pm 10$  mm and skew upto  $10^\circ$ .

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- 3.8 Clamping arrangement as per attached drawings shall be provided for fixing the rack with the cross support as required.
- 3.9 All the bends, tees and junctions shall be made sufficiently rigid by providing suitable reinforcement on rungs as required.
- 3.10 The rungs shall be connected to the side channels by continuous welding alongwith three sides of rung. Aluminium rack shall be welded by TIG welding process.
- 3.11 All hard wares such as nuts, bolts, washers and crank bolts shall be cadmium plated.
- 3.12 Tolerances in various dimension shall be follows:
- |           |    |              |
|-----------|----|--------------|
| Length    | -- | $\pm 5$ mm   |
| Width     | -- | $\pm 2$ mm   |
| Height    | -- | $\pm 1$ mm   |
| Bend      | -- | $\pm 1$ mm   |
| Thickness | -- | $\pm 0.2$ mm |
- Positive tolerance on total quantity upto  $\pm 5\%$  is acceptable. However, negative tolerance on total quantity is not acceptable.

#### 4.0 MARKING

The packing shall be clearly marked on the outside (on top side & ends) in indelible ink with the following minimum details:

- Part No.
- Size of Tray (Length x Width x Height)
- No. of Tray / Section, Total Weight
- Material Specification
- Client's Name
- Purchase Order No.
- Manufacturer's Name

#### 5.0 TESTS AND INSPECTION



- 5.1 Following tests shall be carried out on prefabricated cable racks:

Visual inspection and checking for

- i) Quality and thickness of raw material
- ii) Dimensions as per drawing.
- iii) Quality of welding (before galvanising for G.I. racks)
- iv) Preparation of metal surfaces (for G.I. racks).

- 5.2 After galvanising, G.I. cable racks shall be subjected to following tests as per IS:4759.

- i) Mass of galvanising coating -- At any location the thickness of zinc coating shall not be less than 90 micron. However, average thickness of zinc coating shall not be less than 113 micron.

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- ii) Uniformity of galvanising coating.
- iii) Adhesion of galvanising coating.
- iv) 3 samples from each lot shall be taken for testing.
- v) From each lot and size of rack, measure length of 10 trays and average length to be multiplied by number of trays to arrive for total length.

5.3 All the above tests shall be carried out in the manufacturer's works in the presence of Purchaser's representative. In addition to the above tests, the cable racks and its accessories shall be subjected to stage inspection at works and inspection at site for final acceptance.

5.4 These tests and the Purchaser's inspection shall, however, not absolve the vendor from their responsibility for making good any defect which may be noticed subsequently.

## 6.0 DRAWINGS AND DOCUMENTS

6.1 Drawings and documents as per Annexure-I shall be supplied, unless otherwise specified.



6.2 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

## 7.0 DEVIATIONS

7.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.



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### ANNEXURE - I

#### DOCUMENTATION FOR PRE-FABRICATED LADDER TYPE CABLE RACKS

Sl. No.	Document Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Illustrative and Descriptive catalogues	N	N	Y
2.	Installation, Termination and Jointing Instructions	N	N	Y
3.	General Arrangement Drawings, showing details of rack, coupling pieces, fasteners, etc.	N	Y	Y
4.	Test certificates	N	N	Y
5.	Guarantee Certificates	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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

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# **TECHNICAL SPECIFICATION** **LOCAL CONTROL STATION**

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6.0	SPECIAL FEATURES FOR FLAMEPROOF LOCAL CONTROL STATION
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ANNEXURE - I	DOCUMENTATION FOR LOCAL CONTROL STATIONS

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## 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.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified therein.

## 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/IEC:60947 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 elsewhere in Design Philosophy - Electrical.

### 3.2 System Details

These shall be as indicated elsewhere 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/IEC:60947. 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.

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- 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 cadmium plated or 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 as indicated in Design Philosophy - Electrical.
- 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

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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 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.

### 7.2 '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.

### 7.3 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.

- 7.4 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.

### 7.5 'Off-Auto-On' Switch

- 7.5.1 '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.

- 7.5.2 The switch shall have sliding contact between 'AUTO' and 'ON' position. In 'OFF' position the contact shall be completely broken from 'AUTO' position.

### 7.6 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.

- 7.7 The switches and push buttons shall conform to utilization category AC11/ DC11 as per IS/IEC:60947. 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.

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## 7.8 Indication Lamps

7.8.1 LED type indication lamps shall be provided to indicate the various circuit conditions as shown in the terminal drawings.

7.8.2 The LEDs shall provide good illumination through a viewing angle of 180°. The LEDs shall have lumen output of 200 milli Candella in the axial direction.

7.8.3 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

## 7.9 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 0-240°. 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.

## 7.10 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.

## 7.11 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<sup>2</sup>. These shall be of pressure clamp type design mounted on the base channel. The minimum rating of terminal block shall be 16 Amp.

## 7.12 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 per requirement. 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.

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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 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.

11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

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	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General Arrangement Drawings	N	Y	Y
4.	Schematic Diagrams	N	Y	Y
5.	Illustrative and Descriptive catalogues	N	N	Y
6.	Catalogues of bought out accessories	N	N	Y
7.	Spare parts list	N	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	N	N	Y
10.	Guarantee Certificates	N	N	Y



**Note:**

- 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 CD 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



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# **TECHNICAL SPECIFICATION** **JUNCTION BOX**

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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

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## 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.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical and other relevant references as specified their in.

## 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/IEC:60529.
- 4.2 The junction boxes shall be of die cast aluminium alloy LM-6 with domed / suspension covers.
- 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 cadmium plated or 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.

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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 hazardous area.
4.16	<b>15 Amp. Junction Box</b>
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	<b>63 Amp. Junction Box</b>
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.

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## 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 in classified hazardous area.
- 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.

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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 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.



10.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.

10.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.

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.

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**ANNEXURE - I**  
**DOCUMENTATION FOR JUNCTION BOXES**

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		With Bid	For Approval	Final
1.	Specification Sheet	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	Certified dimensional drawing, including mounting details	N	Y	Y
4.	Drawing showing constructional details	N	Y	Y
5.	Illustrative and Descriptive catalogues	N	N	Y
6.	Spare parts list	N	N	Y
7.	FLP/Exe certificates for junction boxes and terminals conforming to IEC/ISS (CMRI, CCE, DGFASLI and BARC for terminals)	N	N	Y
8.	Certificate for weather proof construction for junction boxes as per IPW-55	N	N	Y

**Note:**


1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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





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# **TECHNICAL SPECIFICATION** **ELECTRICALS FOR OVERHEAD CRANES & HOISTS**

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ANNEXURE - I	DOCUMENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS

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## 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.

## 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.

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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 duty cycle with the system variation under the ambient conditions 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/IEC:60529.

4.4 Equipment to be located outdoor shall be weather proof and have IPW-55 protection as per IS/IEC:60529 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 housed 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.


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- 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 cadmium plated or 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 as mentioned in the Design Philosophy - Electrical.
- 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:
- Disconnecting links shall be provided where necessary.
  - All cable lugs and terminals shall be numbered in a permanent form corresponding to the wiring diagram.
  - 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 or otherwise as per requirement.
- 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.

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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.

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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 140° 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.

5.7 The rating of the transformers shall be at least 2.5 times the continuous load.

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## 5.8 Junction Box

5.9 Junction boxes shall be of cast aluminium construction and adequately sized to enable easy termination of cables.

## 5.10 Hand Lamps

5.10.1 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.

5.10.2 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 PVC insulated armoured and PVC sheathed overall, and shall conform to IS: 1554 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.



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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.

## 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 shall be provided.

## 10.0 TESTS AND INSPECTION



10.1 All equipment shall be routine tested as per relevant Indian Standard Specifications.

10.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

10.3 All the above mentioned tests shall be carried out in presence of owner's representative.

10.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defects which may be noticed subsequently.

10.5 Despatch of materials shall be subject to written consent of owner or his representative.

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## **11.0 INSTALLATION, TESTING AND COMMISSIONING**

- 11.1 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.
- 11.2 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.
- 11.3 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.
- Insulation test.
  - Continuity test.
  - High voltage test.
  - Simulation test.

## **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 :
- Name of client
  - Name of consultant
  - Enquiry / Order Number with plant / project name
  - Code No. and Description

## **13.0 SPARES**

- 13.1 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.
- 13.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 13.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 13.4 All spare parts shall be identical to the parts used in the equipment.

## **14.0 DEVIATIONS**

- 14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.

### ANNEXURE - I

#### DOCUMENTATION FOR ELECTRICALS FOR OVERHEAD CRANES & HOISTS

Sl. No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification sheet and technical particulars	N	Y	Y
2.	Composite schematic diagram	N	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	N	N	Y
8.	Test certificates	N	N	Y

**Note:**

- 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 CD 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

- The tenderer shall also quote for any other spares as deemed necessary to be kept in stock for stipulated time.

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# **TECHNICAL SPECIFICATION** **HIGH VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM**

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## 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/ Synchronous Motor as specified in data sheet, 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 and data sheets. 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 drive systems having converter input voltage above 1000 V AC and up to and including 11000V AC.

## 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: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/data sheet and statutory regulations the following order of priority shall govern:

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- Statutory regulations
- Data sheets
- Job specification
- This 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 Vendor shall ensure proper co-ordination with the driven equipment supplier in selection/sizing of offered variable frequency drive system.

### 4.0 SITE CONDITIONS

- 4.1 The drive system shall be designed to operate under specified site conditions as specified in the data sheets. 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 or pressurized room, as specified in data sheet. Transformer installation (outdoor/ indoor) shall be as indicated in datasheet. Motor shall be installed outdoors in safe or hazardous area as specified in datasheet.
- 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 REQUIREMENTS

#### 5.1 Performance Requirement

- 5.1.1 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.
- 5.1.2 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  $\pm 10\%$  and frequency variation of  $\pm 3\%$ . 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.
- 5.1.3 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 or specified in the data sheet:
  - a. Variable torque changing as a function of speed i.e. Speed squared
  - b. Constant torque over a specific speed range

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- c. Constant power over a specific speed range where the torque decreases when speed Increases
- d. Any other as specified in data sheet
- 5.1.4 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.
- 5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 10-100 % unless otherwise specified in data sheet with speed set accuracy of  $\pm 1\%$  of rated maximum speed and steady state regulation of  $\pm 0.5\%$  of rated speed.
- 5.1.6 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.
- 5.1.7 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 which shall be installed at owner's power system unless otherwise specified. 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 from owner's switchgear etc.
- 5.1.8 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.
- 5.1.9 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.
- 5.1.10 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.
- 5.1.11 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.
- 5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.
- 5.1.13 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.



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5.1.14 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 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. Unless otherwise specified, 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 as defined in the datasheet.

5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.

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5.2.10 The closed loop control feed back for the drive system having out put transformer shall be tapped from the secondary side of the output transformer.

### 5.3 Panel Construction

5.3.1 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.

5.3.2 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 1900 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<sup>2</sup>, and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 600mm clear 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.

5.3.7 All the 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 owner's 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

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inside the panel shall be done with BIS approved, PVC insulated, fire retardant, low smoke, copper conductor wire 1.5mm<sup>2</sup> size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm<sup>2</sup> size for control fuse rating above 16 A for electrical circuits and 0.5mm<sup>2</sup> 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 if specified in data sheet.

#### 5.4 Cooling

- 5.4.1 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.
- 5.4.2 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 in the data sheet 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.
- 5.4.3 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

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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.

- 5.4.4 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 /data sheet for High Voltage Induction / Synchronous Motor, in addition to the following requirements:

- The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.
- The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.
- 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.
- 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, unless otherwise specified in datasheets.
- The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- The motor insulation shall be designed to accept the applied voltage waveform, within the Vpeak and dv/dt limits as per IEC-61800-4 and necessary co-ordination between the VPD manufacturer & motor manufacturer W.r.t. incorporation of VPD output parameter in the design of motor shall be carried out.
- 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.
- Motors shall be provided with Resistance Temperature Detectors (RTDs).

### 5.5.2 Converter Transformer/ Output transformer

- The converter transformer shall be dry type or oil filled type as specified in the data sheet. In case of the dry type transformer, it shall be mounted in the drive system panel unless specified otherwise in the datasheet. Offered transformer shall be as per enclosed Specifications/data sheet.
- 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.

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- 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. Adequate short circuit and over voltage protection shall be provided for the converter and inverter system.
- c. All power converter devices shall include protective devices, snubber networks and dv/dt networks as required.
- d. 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.
- e. All power diodes shall be of silicon type with minimum  $V_{BO}$  rating as 2.5 times the rated operating voltage.
- f. 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.
- g. 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.
- h. 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.
- i. 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 unless otherwise specified in the data sheet.

### 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.
- b. Unless otherwise specified, the reactor shall be air-cooled or fan cooled type located within the panel.
- 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

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reduced to less than 50 V DC within 300 seconds 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

- a. Bypass feature along with motor protection relay and output side isolator/breaker shall be provided by purchaser unless otherwise specified in the datasheet. All necessary interlocks as required for safe and reliable operation of VFD system along with bypass feeder and output side isolator/breaker provided by Purchaser 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.



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- 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 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

#### 5.6.6 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

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- 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.

#### 5.6.7 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 speed and motor current in DCS unless otherwise specified for other parameters.
- XI.

#### 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 unless otherwise specified in the datasheet.

Vendor shall include supply of all control transformers, protective devices, associated



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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.

## 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 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 as per IEC 61800-4. Moreover, combined test for VFD and motor at vendor's works shall be carried out.

6.4 String Test with driven equipment

If a string test with driven equipment is specified in the data sheet 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) alongwith recommended quantity & item-wise unit price shall be furnished.

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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.

## 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.

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# **TECHNICAL SPECIFICATION** **MEDIUM VOLTAGE VARIABLE FREQUENCY DRIVE SYSTEM**

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## 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 Medium Voltage, AC Variable Frequency Drive system. The VFD system shall be complete with Squirrel Cage Induction Motor/ Synchronous Motor as specified in data sheet, 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 and data sheets. 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.

## 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  |
| 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/data sheet and statutory regulations the following order of priority shall govern:

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- Statutory regulations
- Data sheets
- Job specification
- This 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 and attached data sheets.

### 4.0 SITE CONDITIONS

- 4.1 The AC drive system shall be designed to operate under specified site conditions as specified in the data sheets. 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 or pressurized room, as specified in data sheet.
- 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 REQUIREMENTS

#### 5.1 Performance Requirement

- 5.1.1 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.
- 5.1.2 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  $\pm 10\%$  and frequency variation of  $\pm 3\%$ . 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.
- 5.1.3 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 or specified in the data sheet:
  - 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 in data sheet

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- 5.1.4 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.
- 5.1.5 The System shall be suitable for single quadrant operation and the speed variation shall be with range 1:100 unless otherwise specified in data sheet with speed set accuracy of  $\pm 1\%$  of rated maximum speed and steady state regulation of  $\pm 0.5\%$  of rated speed.
- 5.1.6 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.
- 5.1.7 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 which shall be installed at owner's power system unless otherwise specified. These harmonic studies shall be conducted with maximum and minimum system fault level, cable capacitance, system equipment reactance etc.
- 5.1.8 The controller output overload capacity 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 demand exceeds the current limit for more than 1 minute, the drive shall shut down to prevent over heating of the motor and damage to the drive.
- 5.1.9 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.
- 5.1.10 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.
- 5.1.11 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.
- 5.1.12 Maximum noise level from the drive at 1-meter distance, under rated load with all normal cooling fans operating shall not exceed 85 dBA.
- 5.1.13 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.
- 5.2 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.

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- 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 Medium Voltage Motors.
- 5.2.5 The power controller shall be regulated 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.
- 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.
  - 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.
  - 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 PLC/DCS (located at remote control room) including the details of communication module and data transfer facility, I/O details shall be furnished. The communication interface shall be via serial communication link with industry standard open protocol i.e. MODBUS/IEC-61850/ RS-485 etc. and same shall be coordinated with the interfacing equipment. In case the vendor is using their proprietary software, the interface software for use with owner's system (software) shall be provided.
- 5.2.9 Drive system shall have provision for interface with upper level automation such as Substation monitoring system or electrical control system in case specified in the data sheet/job specification.
- 5.2.10 The closed loop control feed back 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 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



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protective devices, reactors, filters, output isolating device, control circuit, control accessories, indication and annunciation etc.

- 5.3.2 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, as specified in data sheet. Devices shall be lockable in the open position and shall have a minimum interrupting capacity as specified in data sheet. Interlock shall be provided between the door, so that door cannot be opened unless the breaker/switch is open.
- 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 except the doors & covers that may be made of 2mm 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 1900 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<sup>2</sup> and terminal for higher sizes shall be bolted type suitable for cable lugs. Minimum space for power cable termination shall be 300mm clear.
- 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 and control switches shall preferably be mounted on the door and shall be operable externally. All the analogue instruments, wherever provided, shall be switch board type, back connected, 96x96mm size. Scale shall have red mark indicating maximum permissible operating rating.
- 5.3.8 Each panel shall be provided with illuminating lamp/II 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 mm size shall be provided at the bottom of the panel extending outside the panel on both sides. All the non-metallic components/parts shall be connected to the main earth bus bar. In case a separate earth bus for electronic control system is required, the same shall be indicated in the drawings.
- 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<sup>2</sup> size wire shall normally be used provided the control fuse rating is 10 Amps or less and 2.5 mm<sup>2</sup> size for control fuse rating above 16 A for electrical circuits and 0.5mm<sup>2</sup> for electronic circuits. All wires shall be ferruled and terminals shall be properly numbered, minimum 20% spare terminals shall be provided.

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- 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 DC link capacitor and pre-charging & discharging circuit shall be preferably mounted in the rear of the panel.
- 5.3.14 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.
- 5.3.15 Acrylic type transparent insulating material shall be used for covering live components.
- 5.3.16 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 if specified in data sheet.

#### 5.4 Cooling

- 5.4.1 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 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 attached standard specification for Medium Voltage Induction Motor, in addition to the following requirements:

- The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control.
- The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive.
- The motor shall be designed to operate continuously at any speed over the range (10-100%) of rated speed unless otherwise specified in data sheet.
- Motor shall be provided with thermistor type temperature detector
- The motors shall be provided with Class 'F' insulation with temperature rise limited to Class 'B'.
- 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.
- 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, unless otherwise specified in datasheets.

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- h. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.
- i. The motor insulation shall be designed to accept the applied voltage waveform, within the  $V_{peak}$  and  $dv/dt$  limits as per IEC-61800-2.
- j. 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.
- k. Motors shall be provided with Resistance Temperature Detectors (RTDs).
- l. 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

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  $\pm 5\%$  off circuit taps in steps of  $\pm 2.5\%$ .

### 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.
  - a. 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.
  - b. All power converter devices shall include protective devices, snubber networks and  $dv/dt$  networks as required.
  - c. 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.
  - d. All power diodes shall be of silicon type with minimum  $V_{BO}$  rating as 2.5 times the rated operating voltage.
  - e. 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.
  - f. 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.

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- g. 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.
- h. All the power transistors, thyristors and diodes shall be protected with high-speed semiconductor grade fuse. I2t 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, shall be suitable for harmonic suppression and fault current limitation.
- b. The reactor shall be dry type, 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 shall be inherently sinusoidal at all speeds, with harmonic limits as per C1.5.1.6. 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 after a loss of AC voltage. 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

- 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, if specified in the data sheet. Accordingly Bypass feature with Bypass starter shall meet the following requirements, unless otherwise specified in the data sheet:-

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 & upto 55kW unless otherwise specified in the data sheet. 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, ACB/MCCB 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.

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### 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 for motors rated above 5.5kW shall be suitable for 4-20mA transducer outputs and shall be calibrated for the actual motor current unless specified otherwise. Further, for drives with bypass facility, the meters shall be capable of reading bypass full load and starting currents, as well as the drive current. Local-off-Remote selector switch shall be provided in the LCS for selection of control from Local (i.e. LCS in Field) and Remote (i.e. from VFD panel / DCS / PLC).

## 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.

5.6.4 User-friendly software for operation and fault diagnostic shall be loaded in the drive system panel before commissioning.

### 5.6.5 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:

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- 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

#### 5.6.6 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.

#### 5.6.7 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

#### 5.6.8 Indications

Vendor shall provide indications as required for normal operation and for ease of maintenance, which shall not be limited to the following indications. Motor running

- I. Motor stopped
- II. VFD System Fault
- III. System ready to start
- IV. AC mains ON
- V. Motor over speed
- VI. Rectifier output 'ON'
- VII. Motor zero speed



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- VIII. Remote breaker trip
- IX. 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.

#### 5.6.9 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.

#### 5.6.10 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

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Control supply for devices external to VFD module i.e contactors control, space heater supply for Motor / VFD, indicating lamps digital meters (Ammeter, Speedometer) etc. shall operate on 240 V control supply derived from single-phase control supply transformer, with switchfuse provided in primary and MCB in secondary, located inside the drive controller.

## 5.9 Reliability Features

The expected life time of the VFD shall be minimum 20 years. The VFD 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
- Printed circuit boards shall be plug connected.
- 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 color 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 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.
- 6.2 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.



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**6.3** All Routine & Type Tests shall be conducted as per the NIT for MV variable frequency drive as per IEC 61800-2. Moreover, combined test for VFD and motor at vendor's works shall be carried out.

**6.4** String Test with driven equipment

If a string test with driven equipment is specified in the data sheet 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) alongwith 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**

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.

## **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.

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## TECHNICAL SPECIFICATION COMMUNICATION AND FIRE ALARM CABLES

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## 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-694	PVC insulated cables for working voltages upto and including 1100V.
IS-1554 (Part-I)	PVC insulated (heavy duty) electric cables-(Part-I for working voltages up to and including 1100V).
IS-5831	PVC insulation and sheath of electric cable.
IS-8130	Conductors for insulated cables and flexible cords.
IS-9938	Recommended Colours for PVC insulation for LF wires and cables.
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.

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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 PVC compound applied over the conductor by extrusion.

4.2.2 PVC insulation, when used shall meet the following requirements:

Conductor (Area)	Diameter	Type of Insulation	Thickness of Insulation
Upto 0.63 (0.3mm <sup>2</sup> )	mm	Type-2 of Table-3 as per IS-13176	As per Table-I of DOT Specs. GR/WIR-09/02
Above 0.63mm (Above 3.0 MM <sup>2</sup> )		Type-A as per IS-5831	Table-2 as per IS-1554 (Part-I)

4.2.3 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

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effect on the electrical, mechanical or ageing properties of basic insulation nor shall get damaged by any friction etc.

4.2.4 For single pair cables, the colour shall be incorporated in the insulation.

4.2.5 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.

4.2.6 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.

4.2.7 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<sup>2</sup>, 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.

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#### 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 *104mm* 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 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  $27\pm 2^{\circ}\text{C}$  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-1554 (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  $\pm 2$  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.

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#### 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



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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  $52 \pm 3$  nF/km.



However, the mutual capacitance of individual pairs shall be within the limits of  $52 \pm 4.5$  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.

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- 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.

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### 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.

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# **TECHNICAL SPECIFICATION** **CAPACITOR BANK & ASSOCIATED EQUIPMENT**

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## 1.0 SCOPE

- 1.1 This standard covers the technical requirements of design, manufacture, testing at works and delivery in packed condition of “ Indoor type Shunt Capacitor Bank & Associated Equipment” required for system power factor improvement.
- 1.2 This standard shall be read in conjunction with relevant part of Design Philosophy - Electrical.
- 1.3 The capacitor bank and associated equipment shall generally consist of the following.
- Basic Star connected capacitor bank
  - Basic capacitor unit with built in fuse
  - Discharge resistor
  - Series reactor
  - Residual V. T. for mounting voltage unbalance
  - Set of Raychem make heat insulated sleeved of suitable voltage rating for bus bars.
  - Copper bus bar interconnecting the basic units.
  - Set of supporting insulators
  - Hot dip galvanised Steel stand/racks / cabinets of mounting capacitor units complete with interconnection insulator etc.
  - Door limit switch
  - Control panel for automatic operation
  - 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: 13925-1,2,3 /IEC 60871	Shunt Capacitor for power system
IS:5553/IEC60289	Series reactors
IEC60076-6/IEC 726	
IEC60186	Voltage Transformers
IEC:593/IS 12672	Internal Fuse for shunt capacitor
IS/IEC:60947	Switch gear and control-gear for voltage up to & including 1000V & 1200V DC
IS/IEC:60947	General requirements for switchgear and control-gear for voltage not exceeding 1000V & 1200V DC
IS :9921	AC Isolator & Earthing switches for voltage above 1000V
IS 2099/ IEC 60137	Bushing for voltage above 1000V
IS 13067	Impregnant For power capacitors
IS 5	Colour of mixed paints
IS 2629	Recommended practice for Hot-Dip Galvanizing of Iron and Steel
IS 4759	Hot-dip zinc coatings on structural steels and other allied products.
IS 60270	High Voltage test technique-Partial Discharge measurements
IS 8084	Interconnecting Bus bars for AC voltage above 1 kV up to and including 36 kV.

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IEEE 1036	Guide for application of shunt power capacitors
IEEE 18	Standard for shunt power capacitors
IE Act	Indian Electricity Act

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 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 The capacitor units shall have overload capacity as per IS 13925. The capacitor bank shall be suitable for continuous operation at 110% of rated RMS voltage and at 130% of rated RMS current.

5.1.5 Capacitor units shall be all high grade All Polypropylene type with non-PCB base, bio degradable, non-toxic impregnant. The capacitors offered shall be built from best material and shall develop minimum losses. Capacitor bank losses shall be given at

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45°C. Capacitor shall be compact in size, metal enclosed and hermetically sealed. Internal silver wire fuses shall be provided for protection of each capacitor element.

- 5.1.6 The Capacitor bank and associated equipments shall be suitable for parallel switching and withstand the thermal and dynamic stresses by transient during switching operation.
- 5.1.7 All the fasteners and bolts shall be hot dip galvanized or zinc passivated.
- 5.1.8 Capacitors shall be provided with Overpressure protection as necessary for safety. Overpressure switches shall be fitted to the capacitor units and connected to trip the capacitor bank.
- 5.1.9 Each unit shall have required number of capacitor elements housed in sealed, leak proof, sheet steel container. The container shall be provided with suitable mounting brackets, supporting insulators, terminal & bushing for external connections.
- 5.1.10 The indoor capacitor bank units shall be installed in metallic housing with minimum IP-43 protection.
- 5.1.11 Each capacitor unit shall be mounted so that it can be easily removed from the racks and replaced without removing other units, de-assembling any part of the rack.
- 5.1.12 The outside of the capacitor units and other structures should have smooth and tidy look and should be coated with weather-proof, corrosion resistant epoxy paint of light gray shade, shade no. 631 of IS 5. The structure shall be suitably GI coated. Minimum coating shall not less than 600 micron / sq meters.
- 5.1.13 Each element of basic units has its own built in fuse which shall isolate the faulty element automatically without affecting the healthy elements. In case of one element failure, harmful over voltage shall not be generated across remaining elements and shall not make appreciable change in the operation of capacitor bank. An operation of a single fuse element does not cause cascaded fuse blowing. Permissible over voltages and surges do not cause fuse blowing.
- 5.1.14 The operating & design temperature category of the capacitor unit shall be +5°C as per IS-13925 part-1. Only 5°C temperature rise is permissible above the design temperature of 45°C. So maximum temperature in any case shall not exceed 50° C {i.e. 45°C (design) +5°C (temperature rise)}.
- 5.1.15 The capacitor shall have low value of loss which shall not exceed 0.2 watt per KVAR. The loss value of discharge device/resistor and capacitor unit shall be indicated. The tan delta characteristics of the capacitor units shall be furnished. The losses in watts for each capacitor unit including losses in fuses and discharge resistors forming integral part of the capacitors along with losses for series reactor shall be guaranteed. If these figures of capacitor losses exceed 0.2 watt per KVAR, the capacitors will be liable for rejection. However owner reserve the right to use the faulty capacitor unit till the same are replaced/rectified. The loss temperature characteristics, capacity temperature characteristics and insulation resistance temperature characteristics shall also be furnished.
- 5.1.16 The bidder shall furnish calculations for rise in voltage in other units in the event of failure of element(s) of a capacitor unit. The maximum rise in voltage shall not be more than 10% of rated voltage even if the entire capacitor unit failed/short circuited and relevant calculations in support of this shall also be furnished.
- 5.1.17 The bidder shall furnish calculation of voltage drop at rated capacitor unit per phase & losses of the reactor.
- 5.1.18 For both capacitor and reactor, mounting arrangement and minimum clearance required from live parts shall be indicated clearly and shall be as per Indian Electricity Act/BS162 & IS-13925-Part2 / IEC-60871-2.



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## 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 PROTECTIVE FUSES

- 5.3.1 An internal current limiting fuse with high rupturing capacity conforming to relevant IS/IEC and the specific requirements mentioned in IS13925-Part-3/IEC 60871- 3, shall be provided. The characteristics of the fuse shall be such that it shall isolate the faulty unit only, and protect it against mechanical destruction due to internal failure. The fuses shall not melt or deteriorate when subjected to inrush currents which occur during the life of the bank.
- 5.3.2 The fuses shall not make any healthy capacitor element out of circuit, either in course of isolating the faulty element or due to any external fault.
- 5.3.3 The selection of fuse to be done in such a manner that characteristic of fuse shall match suitably with over-current withstand characteristic of associated capacitor unit.
- 5.3.4 The fuses shall be of adequate thermal capacity to cater for the increased heating which may occur due to harmonics and capacitor current fluctuations.
- 5.3.5 The number of externally connected capacitors and the available short-circuit current of the supply system should not affect the current-limiting of internal fuses.
- 5.3.6 It may be noted that provided internal fuses do not lead to case rupture.

## 5.4 Series Reactor

- 5.4.1 A suitable series reactor conforming to IS: 5553 to limit the inrush current and suppress the harmonics shall also be provided whenever required.
- 5.4.2 The reactor shall be copper wound, non-magnetically shielded, oil immersed, natural cooled, sealed type and shall be provided with following fittings.
- Oil sampling cum drain valves.
  - Filter valves with plugs.
  - Buchholz relay with shut off valves, air release device & alarm and trip contact.
  - Oil temperature indicator with minimum marking.
  - Oil level indicator with minimum marking.
  - Oil conservator complete with drain plugs and oil filling hole with cover.
  - Silica gel breather with oil seal & connecting pipes.
  - Explosion vent.
  - Bi-directional rollers.
  - Thermometer pocket.
  - Radiator with isolating valves.
  - Marshalling box.
  - Rating plate, wiring diagram plate & terminal marking plate.
  - Lifting lugs.
  - Earthing terminals.
  - Air release device.
  - Cable termination arrangement for incoming & outgoing device.

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5.4.3 Dry type/ Oil filled reactor shall only be offered. Such reactors shall be class F/H insulated.

5.4.4 The reactor shall have linear volt ampere characteristics upto 150% of rated capacitor current.

#### 5.5 **Residual voltage transformer**

5.5.1 3 phase dry type residual voltage transformer of adequate capacity to facilitate neutral unbalance protection and rapid discharging of capacitor shall be provided.

5.5.2 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.

5.5.3 The accuracy class shall be 3P for protection & 1 for metering.

5.5.4 RVT shall have primary and secondary windings made of copper.

#### 5.6 **Door limit switch**

5.6.1 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 be used to trip the power supply to capacitors with initiation of opening action of the door of the capacitor room.

5.6.2 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.

#### 5.7 **Capacitor control panel**

5.7.1 Capacitor control panel for control, protection and automatic switching operation of MV capacitor bank shall be provided.

5.7.2 Capacitor control panel shall be of dust, damp & vermin proof construction having enclosure class IP-51 as per IS/IEC:60947.

5.7.3 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.

5.7.4 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.

5.7.5 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.

5.7.6 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.

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- 5.7.7 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.
- 5.7.8 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.
- 5.7.9 The control panel shall be complete with its base channels, foundation bolt etc.
- 5.7.10 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.
- 5.7.11 Components Details
- 5.7.11.1 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/IEC:60947.
- 5.7.11.2 The fuses shall be of non-deteriorating HRC link type and suitably rated for capacitor switching. These shall conform to IS: 13703.
- 5.7.11.3 All contactors shall be of capacitor duty type rated for 50% higher than rated capacitor current & shall conform to IS/IEC:60947. 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.
- 5.7.11.4 Ammeter, Voltmeter & power factor meter shall be of accuracy class 1.5 as per IS: 1248 of minimum 96 sq.mm size & shall have 0-240<sup>0</sup> scale.
- 5.7.11.5 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 handles.
- 5.7.11.6 The signal lamps shall be LED type. Colour of lamp shall be "Red" for "ON" & "Green" for "OFF" signals.
- 5.7.11.7 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 be 16A. 20% extra terminals shall be provided in the terminal block.
- 5.8 **Bus Bars**
- 5.8.1 All bus bars interconnecting the basic units shall be of copper and shall be fully insulated by using Raychem make heat shrinkable sleeves. All bus bar joints and tap-off connections shall be provided with removable FRP shrouds. The sleeves shall be rated to withstand the system Line-to-Line voltage for 1 minute.
- 5.8.2 The minimum clearances shall be as per relevant standards suitable for the nominal voltage of capacitor banks.
- 5.9 **External cable termination**
- 5.9.1 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.

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5.9.2 A cable box for termination of control cables shall be provided on the RVT. The cable boxes shall be provided with adequately sized cable entries and suitable double compression cable glands made of stainless steel. Tinned copper lugs shall be provided for the connection of all cable cores.

#### 5.10 **Interlocks**

All necessary interlocks to ensure correct & safe operation of capacitor banks shall also be provided.

#### 5.11 **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 these 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 **Warning Plates**

7.3.1 Warning plates shall be provided on the door and inside of the equipment, comprising following information:

CAUTION: HIGH VOLTAGE CAPACITORS.

AT BLOWN FUSES, CHARGES MAY REMAIN

7.3.2 The warning plates shall be UV resistant engraved plastic.

#### 7.4 **Steel racks**

7.4.1 Sheet steel racks shall be provided to house the capacitor units, residual P. T. etc. in tier formation.

7.4.2 The racks shall be suitable for assembly at site. The racks & hardware used for assembly shall be hot dip galvanized.

7.4.3 The rack shall be complete with rack insulators, foundation bolts or any other hardware etc. for assembly into complete bank.

7.4.4 Complete assembly of capacitor bank shall be mounted on a pedestal GI frame, which shall be 300 mm high.

7.4.5 Any other accessories required but not specified, shall be supplied to make the capacitor installation complete in all respect and ensure safe & proper operation.

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## 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 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.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 11.4 All spare parts shall be identical to the parts used in the equipment.

## 12.0 PACKING

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- 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	N	Y	Y
2.	Technical Particulars	N	Y	Y
3.	General Arrangement Drgs. with Overall dimensions of the following equipment. - Capacitor bank - Reactor - Control panel	N	Y	Y
4.	Foundation plan indicating certified dimensions floor opening, weight, clearance etc. - Capacitor bank - Reactor - Control panel	N	Y	Y
5.	Schematic & wiring diagram	N	N	Y
6.	Descriptive literature of Various equipment	N	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	N	N	Y

**Note:**

1. 4 hard copies & 1 soft copy shall be supplied for approval after order within 4 weeks from the date of LOI.
2. 8 hard copies & 2 soft copies in CD 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



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# **TECHNICAL SPECIFICATION** **FIRE DETECTION AND ALARM SYSTEM**





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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



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## 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/ NEMAINFPA 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/ data sheets 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)                        |

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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.

Bidder shall consider adequate nos. of Fire Alarm panels which shall be located at plant and control room of building/substation.

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.



Repeater panel shall be replica of main fire alarm panel.

Minimum 3 nos. Siren shall be provided with 5 Km audio range.

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.

The Fire Alarm System envisaged for Building shall be "2-Wire Analog Addressable" type.

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.

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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.

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.

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.

The response sensitivity shall also be field adjustable and not only from fire panel over a wide range to suit site shall conditions. It 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.

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.

The fire alarm system shall work without any problem both in networked mode and in standalone mode.

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.

The circuit shall be protected against usual electrical transients, electromagnetic and electrostatic interference (EMI&RFI) present in the Building.

Reverse polarity or fault in the field wiring shall not damage the detector.

No moving parts subject to wear & tear shall be provided.



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.

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, UL, FM or equivalent. 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.

Fire alarm system shall be interfaced with the owner's system.

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.

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- 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. The spares shall be available ex-stock with the vendor.
- 3.3 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.
- 3.4 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 and attached data sheets.
- 3.5 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.
- 3.6 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

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.



The switch over from mains to back up, in the event of mains failure, shall be automatic.

Batteries shall be Ni-Cd type. Suitable and adequately rated battery charger shall be supplied as a part of back up battery system.

The secondary power supply capacity required shall include all power supply loads that are not automatically disconnected upon the transfer to secondary power supply.

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.

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. 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.

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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.

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

The offered equipment shall be capable of operating continuously and maintaining its guaranteed performance at the site ambient conditions indicated in data sheet.

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

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.

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.

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.



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.

6.2.3 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

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.



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## 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 2Cx1.5sqmm 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 FACP's 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 FACP's.
- 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.

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- 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 and 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 1 sec.
- 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 receive data from 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.

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- 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 PVC insulated wires having stranded copper conductors. 1.5mm<sup>2</sup> size of wire shall normally be used for circuits with control fuse rating of IOA or less. Control wiring for electronic circuits shall be through ribbon

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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<sup>2</sup> 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.

The FACP's 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 aluminum. 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 undersurface shall be made free from all imperfections before undertaking the finishing coat.

10.5.2 After preparation of the undersurface, 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



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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, UL / FM/ equivalent international 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 away 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.

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- 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 PVC 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 30cm<sup>2</sup> 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 1.5mm<sup>2</sup> 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.



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### 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 1-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/ CO<sub>2</sub> to be released. In the event a signal for clean agent/CO<sub>2</sub>, 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 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.

### 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.

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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<sub>2</sub> 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 / CO<sub>2</sub>. 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<sub>2</sub>. Release switches shall have inscription:

"PULL TO RELEASE CLEAN AGENT / CO<sub>2</sub>"



And inhibit switches shall have inscription:

"PULL TO INHIBIT CLEAN AGENT / CO<sub>2</sub>"

#### 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<sup>2</sup> copper conductor, screened cable.



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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/ UL/ FM or Equivalent 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.

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### 13.0 CABLE AND CABLE ACCESSORIES

- a) Supply and laying of FA cables shall be as per the requirement. Vendor shall provide JB's 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, PVC insulated, overall screened, PVC inner sheathed, armoured, FR type PVC outer sheathed as the minimum requirement. Fibre Optic cables, if supplied, shall be armoured, overall FR 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 highway 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.

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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.

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# **TECHNICAL SPECIFICATION** **AUXILIARY SERVICE TRANSFORMER**

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## 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.
- 1.3 This standard shall be read in conjunction with the relevant specification sheet.

## 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 -- Outdoor type 3 phase distribution transformers up to and  
- 1 & 2 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 specification sheet 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.

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## 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  $\pm 2.5\%$  and  $\pm 5\%$ .

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 75°C 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 aluminium cable glands and cable lugs for receiving cables as indicated in specification sheet. 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.

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## 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 cadmium plated.

### 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



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- 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, if indicated in specification sheet.

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

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## 11.0 SPARES

- 11.1 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.
- 11.2 Spare Spares for 2 Years operation (Mandatory), as specified shall be supplied.
- 11.3 Recommend 2 years Operational Spares (other than mandatory spare) alongwith recommended quantity & item-wise unit price shall be furnished.
- 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.
- 13.2 Deviations, if any, from the data furnished in specification sheet shall be indicated therein beside the data by encircling it.

## ANNEXURE – I

### DOCUMENTATION FOR AUXILIARY SERVICE TRANSFORMERS

Sl.No.	Description	Documents Required (Y / N)		
		With Bid	For Approval	Final
1.	Specification Sheet, duly completed	N	Y	Y
2.	Technical Particulars, duly filled-in	N	Y	Y
3.	Dimensional drawing with terminal arrangement details	N	Y	Y
4.	Illustrative and descriptive literature	N	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	N	N	Y

**Note:**

- 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 CD 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



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## ENGINEERING STANDARD

### VENTILATION SYSTEM

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1	16.01.06	30.01.06	ISSUED FOR IMPLEMENTATION	AV	BKC	BB
0	FEB'99	--	ISSUED FOR IMPLEMENTATION	SC/SC/JKT/RNS	JKT	HSW
REV	REV DATE	EFF DATE	PURPOSE	PREPD	REVWD	APPD

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**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.
- 1.2 This standard shall be read in conjunction with relevant specification sheets.
- 1.3 The broad scope of work shall be as indicated in specification sheet.
- 1.4 The work outside the scope of supply and to be carried out by the owner shall be as indicated in specification sheet.
- 1.4.1 The owner shall provide starter feeders for each blower motor from their own PMCC/ MCC located within 50 metre from the blowers.
- 1.4.2 The owner shall provide local control stations with ammeter near each motor.
- 1.4.3 Supply, laying & termination of power, control cables up to motors and local control stations shall be arranged by owner.
- 1.4.4 The vendor shall furnish the rated power of each blower motor to enable the owner to provide suitable starter feeders.
- 1.4.5 The owner shall carry out all the civil works such as provision of foundations for blowers and motors, plate inserts, wall and floor cut-outs necessary for installation of ventilation equipment.
- 1.4.6 The vendor shall supply the civil scope drg. (Good for construction) and necessary information as per agreed time schedule.
- 1.4.7 If the civil data and drawing furnished by the vendor require any modification after the execution of the civil work, the same has to be carried out by the vendor free of cost after having the modification approved by the owner.

**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.

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- 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 specification sheet

**3.2 System Details**

These shall be as indicated in specification sheet.

**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 indicated in specification sheet.
- 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.



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- 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 as specified in specification sheet. 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 as indicated in specification sheet. 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.

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- 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.

## 5.7 Cable laying and terminations

- 5.7.1 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.
- 5.7.2 The installation of cables shall be carried out as per the best practices and shall be in line with guidelines contained in IS: 1255.
- 5.7.3 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.
- 5.7.4 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.
- 5.7.5 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.
- 5.7.6 Individual cores of control cables shall be provided with plastic interlocked type identification ferrules at both ends.
- 5.7.7 All cable termination shall be solderless crimping type.

## 6.0 EARTHING

- 6.1 Complete earthing installation shall be done as per IS: 3043.
- 6.2 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.

## 7.0 PAINTING

- 7.1 The surfaces to be painted shall be pretreated to remove all dust, scale and foreign adhering matter by suitable treatment.
- 7.2 All steel surfaces shall be painted with suitable anti-rust and anti-corrosive paints. Epoxy paints shall be used, if indicated in the specification sheet.

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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 Unless otherwise specified, the finishing shade shall be light grey shade no. 631 as per IS: 5.

**8.0 CO-ORDINATION WITH OTHER CONTRACTORS**

8.1 The successful vendor shall co-ordinate with owner's other vendors and shall freely exchange all technical information required for this purpose.

8.2 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  $\pm 10\%$ . Beyond this limit, their extra claim at any stage of the contractual period, if any, shall not be entertained.

**9.0 TESTS AND INSPECTION**

9.1 All equipment shall be routine tested as per relevant Indian Standard Specification.

9.2 Additional tests, wherever specified, shall be carried out on one equipment of each rating.

9.3 All the above mentioned tests shall be carried out in the presence of purchaser's representative.

9.4 The owner's inspection shall, however, not absolve the vendor from his responsibility for making good any defect which may be noticed subsequently.

**10.0 ERECTION, TESTING AND COMMISSIONING**

10.1 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.

10.2 The vendor shall arrange all the necessary erection tools and tackles, testing and measuring instruments and shall supply the required erection materials.

10.3 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.

10.4 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.

10.5 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.

**11.0 DRAWINGS AND DOCUMENTS**

- 11.1 The drawings and documents as per Annexure-I shall be furnished unless otherwise specified.
- 11.2 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
- 11.3 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.
- 11.4 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 as per intent of the specification.

**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-II for the period as indicated in the specification sheet.
- 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 MAKE OF EQUIPMENT**

The make of all the electrical equipment shall be as indicated in specification sheet. The vendor shall supply the equipment of specified make only.

**ENGINEERING STANDARD**

PC217-TS-8205

2

**VENTILATION SYSTEM**

DOCUMENT NO.

REV.

SHEET 11 OF 13

**14.0 DEVIATIONS**

- 14.1 Deviations, if any, from this standard shall be clearly indicated in the offer with reasoning.
- 14.2 Deviations, if any, from the data furnished in specification sheet shall be indicated therein beside the data by encircling it.

**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 CD 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**

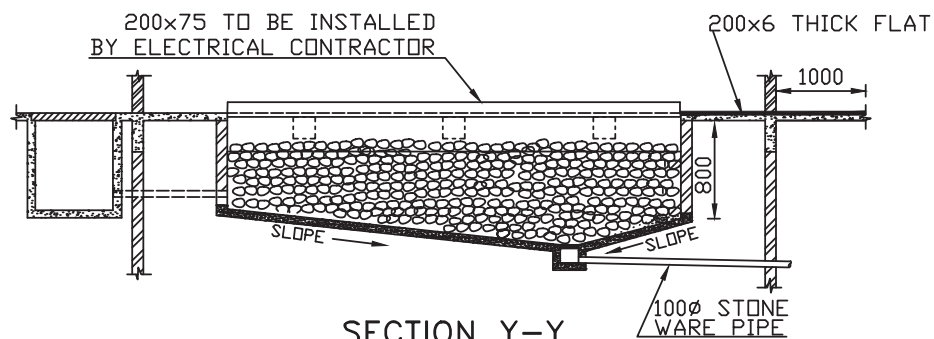
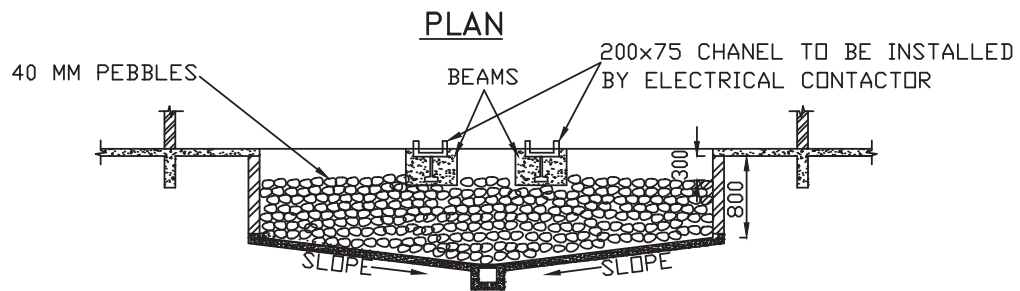
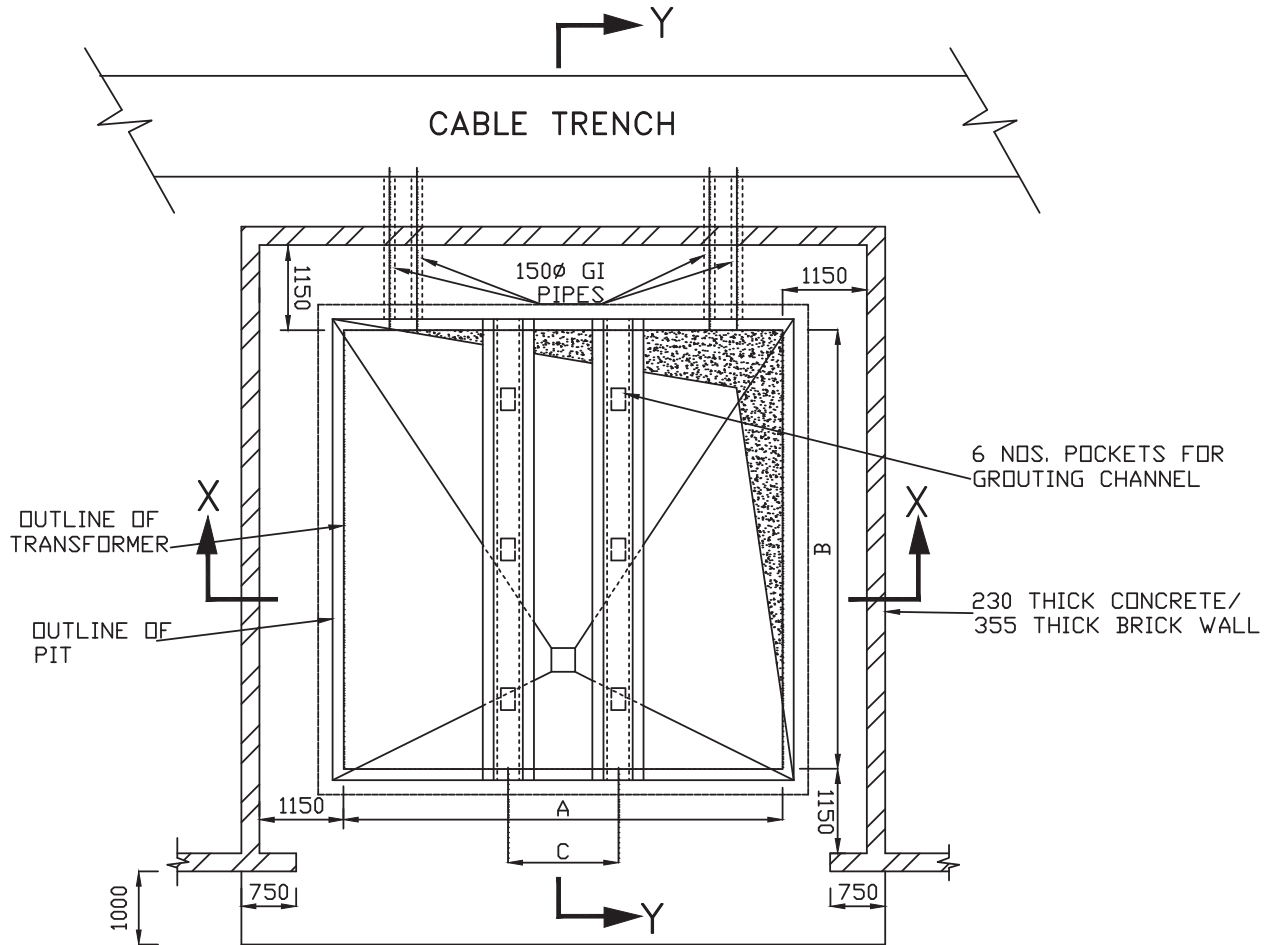
1. Set of Blower Bearings
2. V-Belts

**FILTER**

1. Pre-filter
2. Fine Filter



TRANSFORMERS RATED ABOVE 10MVA SHALL BE MOUNTED ON 200MM x 8MM THICK PLATES.



**NOTE :**

TRANSFORMERS RATED ABOVE 10MVA SHALL BE MOUNTED ON 200MM x 8MM THICK PLATES.



# TYPICAL DETAILS OF TRANSFORMER ROOM DOOR

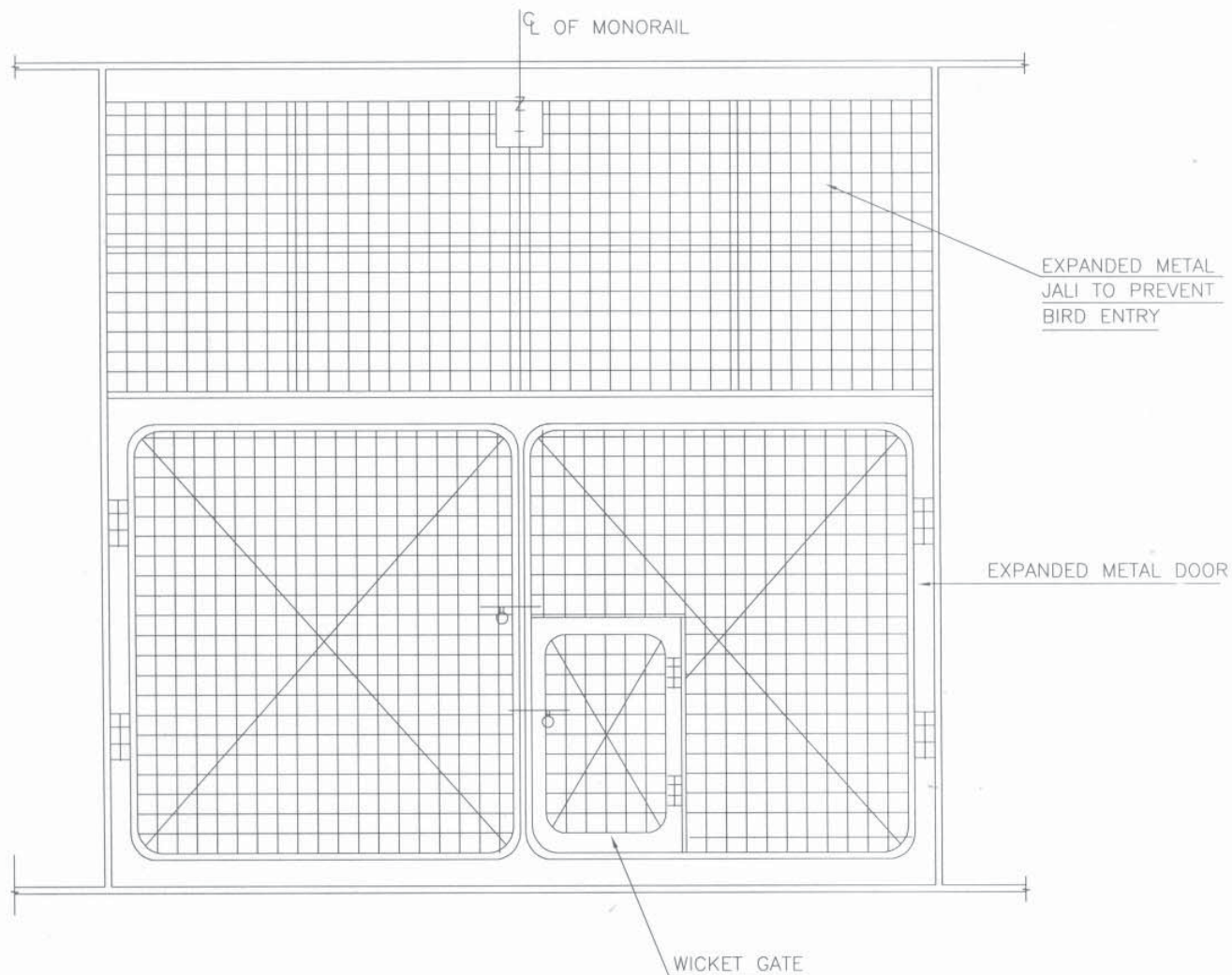
PC217 E 115

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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.

0	20.01.07	01.02.07	ISSUED FOR IMPLEMENTATION	<i>Shweta</i> RUNDA/AV	<i>SC</i> SC	<i>P. S. S.</i> BB
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD



# SUMP PIT FOR TRANSFORMER OIL

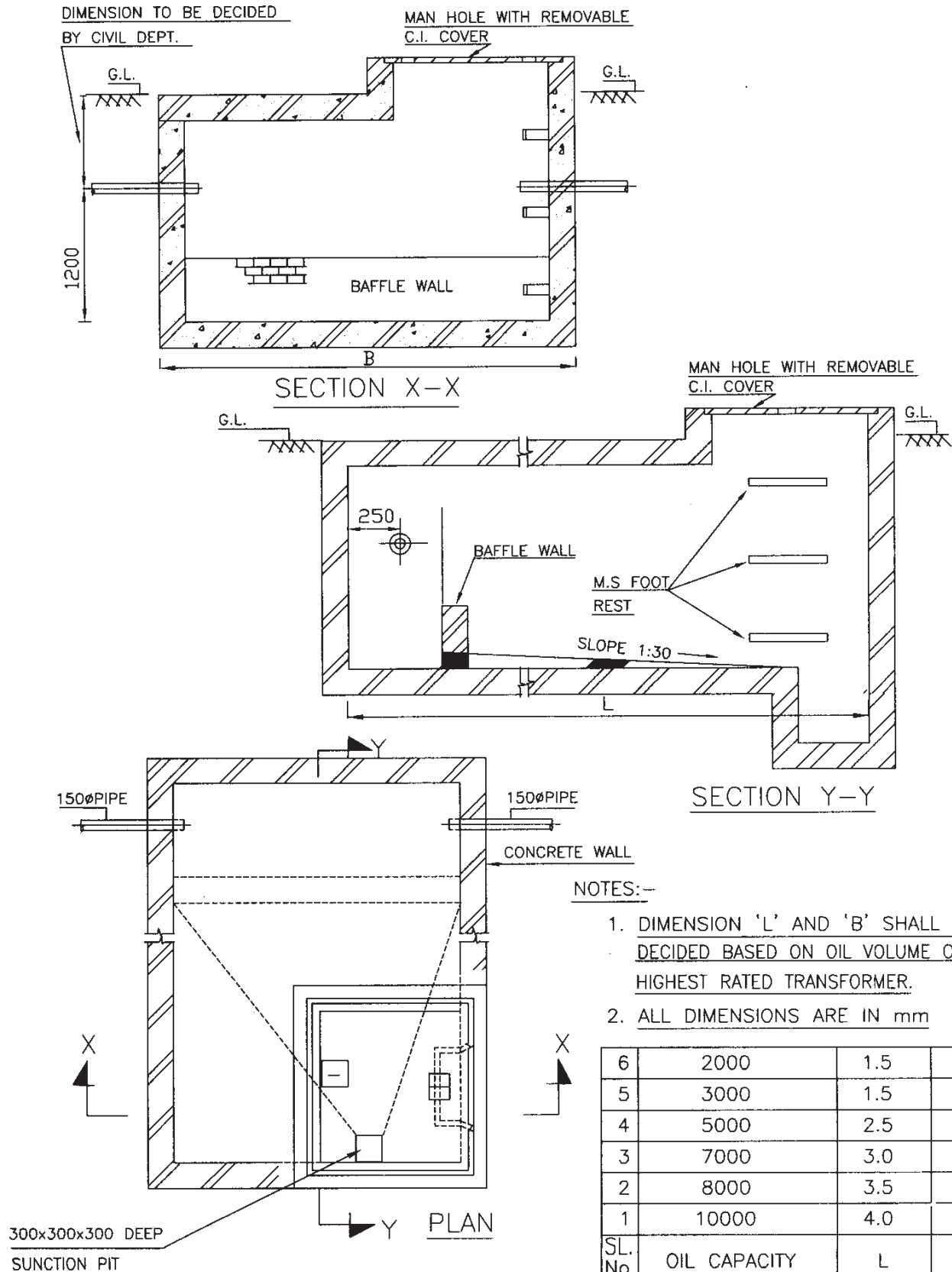
PC217 PDS: E116

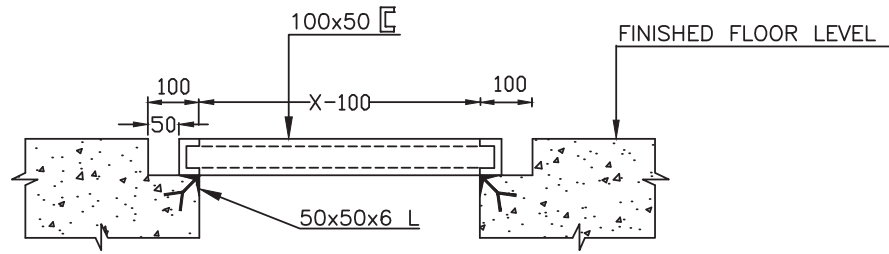
1

DOCUMENT NO.

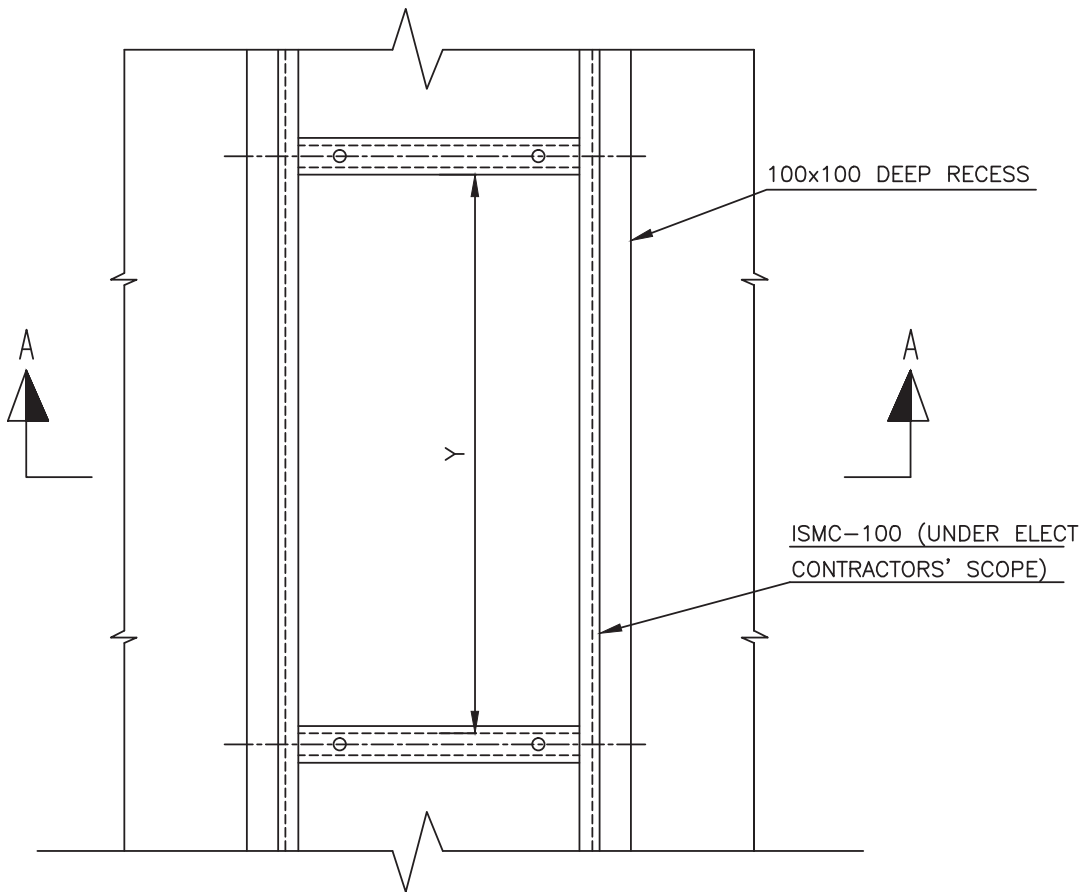
REV

SHEET 1 OF 1





SECTION-A A



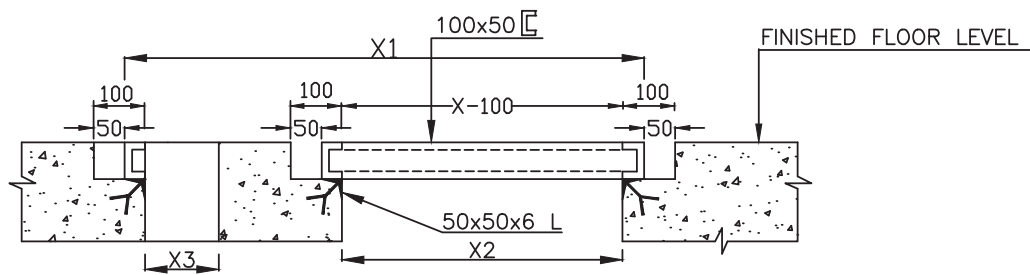
PLAN

X- DEPTH OF PANEL

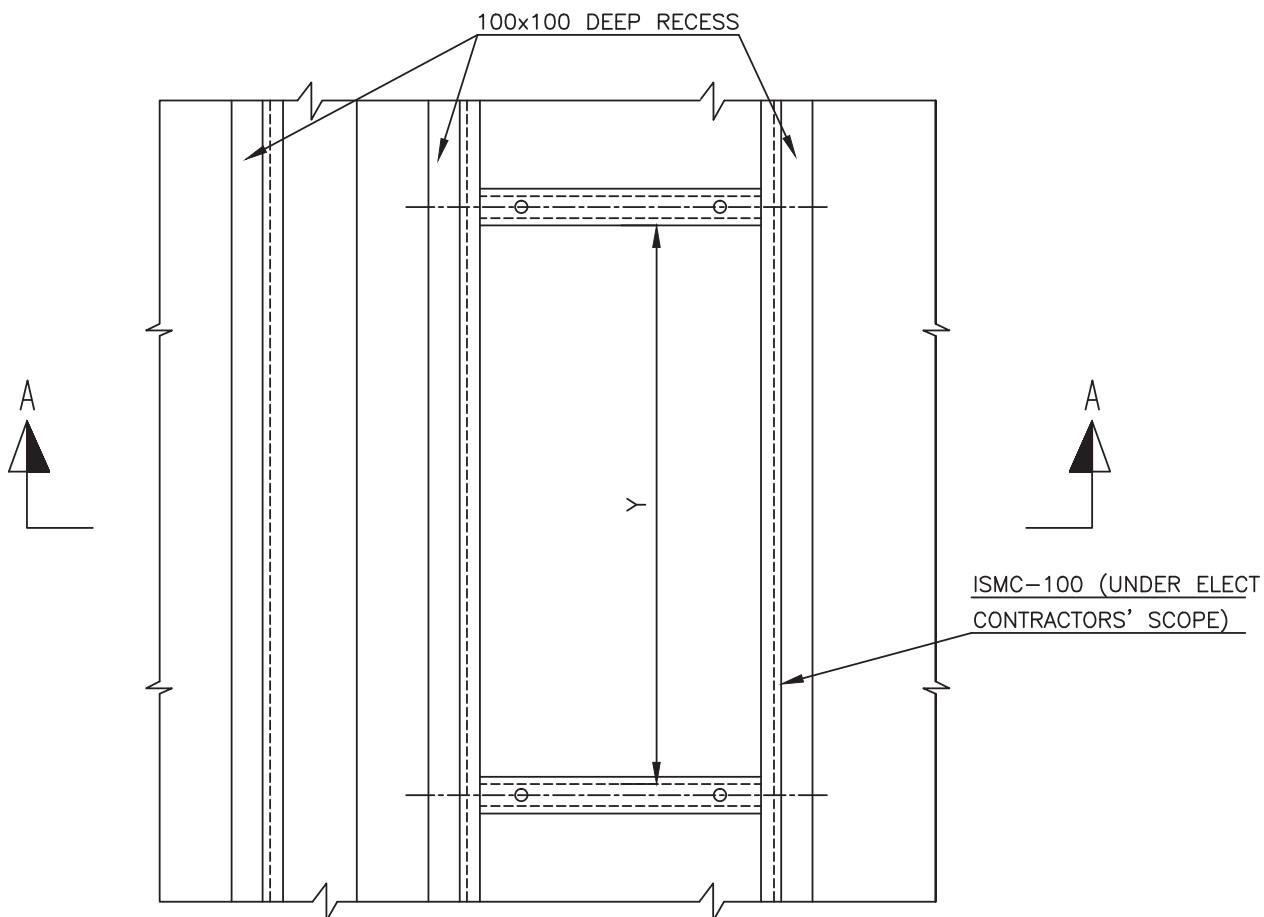
Y- LENGTH OF TWO PANELS

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



SECTION-A A

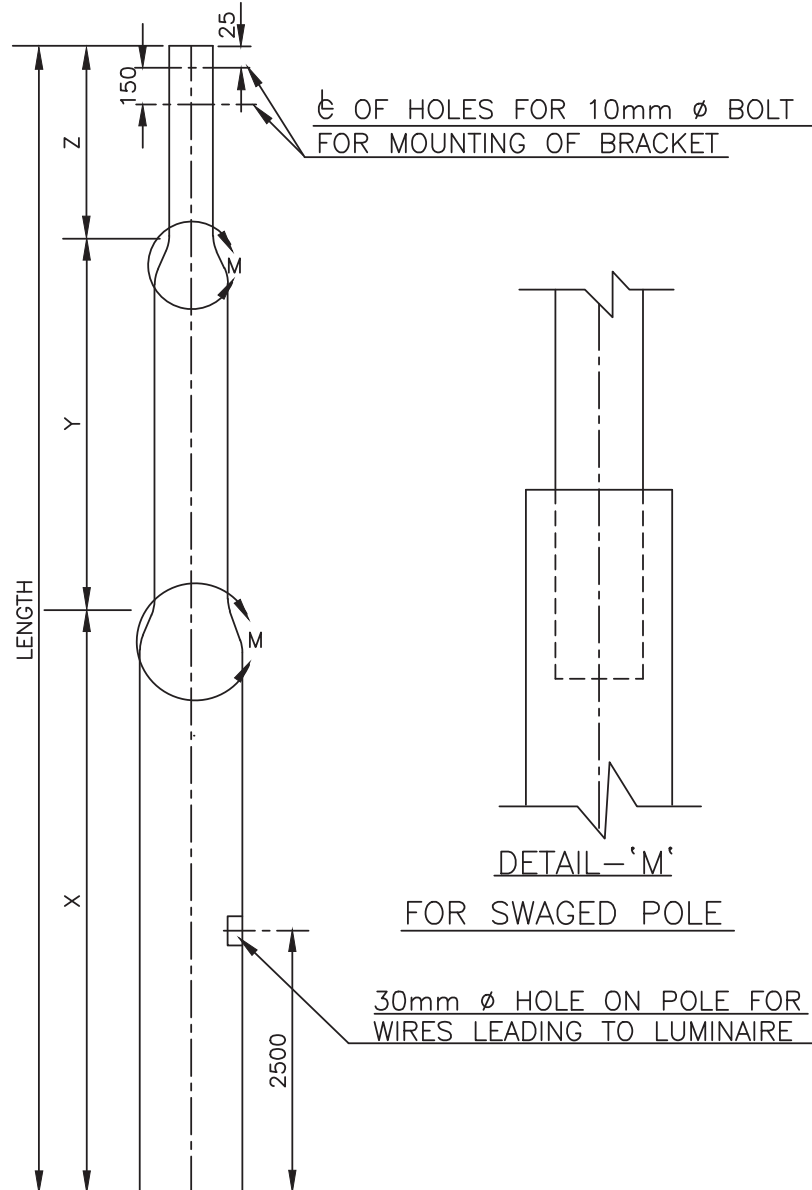


X1 = DEPTH OF PANEL  
X2 = FLOOR OPENING  
X3 = FLOOR OPENING  
Y = LENGTH OF PANEL

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.

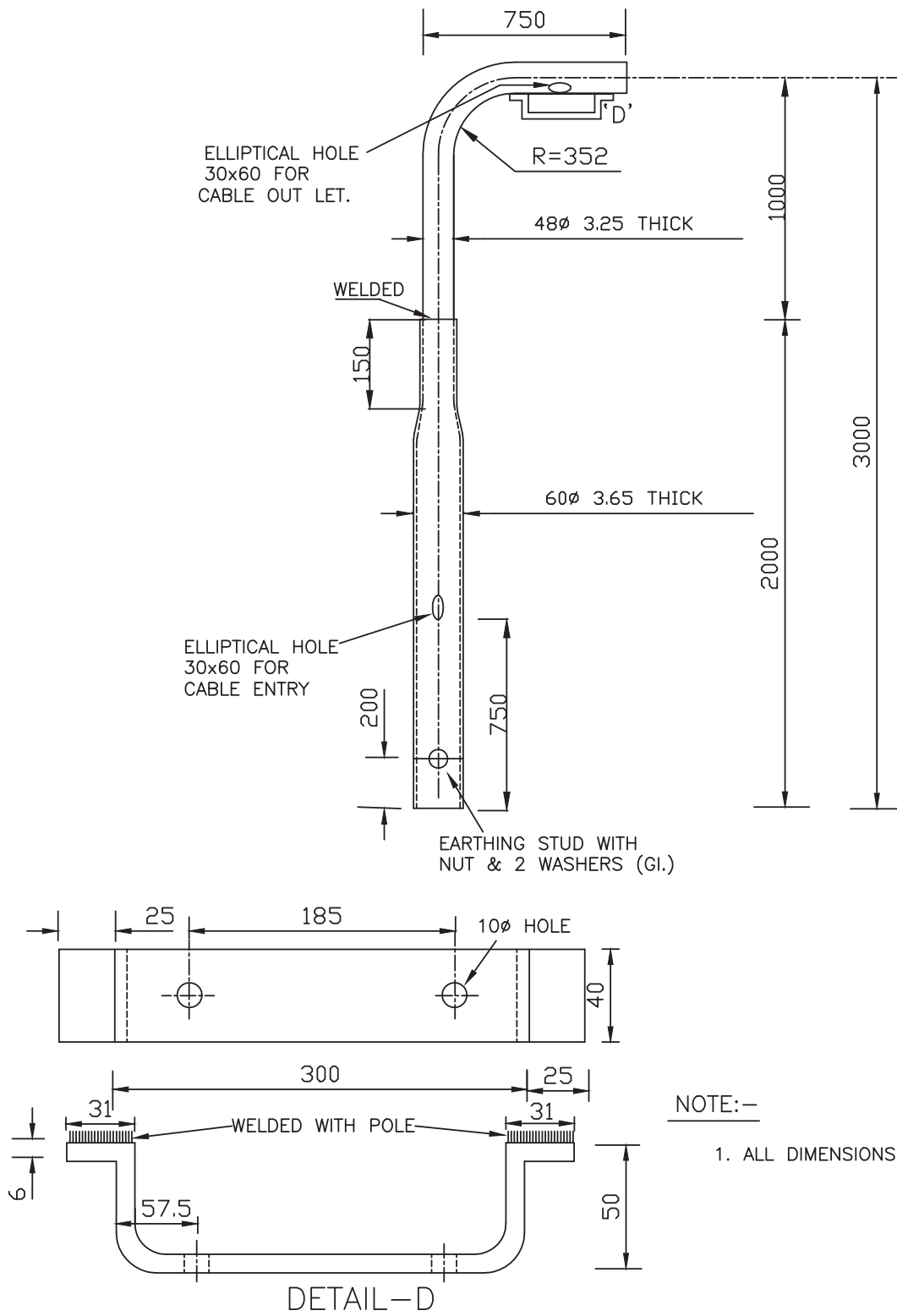


POLE DESIGNATION	LENGTH(M) $X+Y+Z=L$	PLANTING DEPTH(M)	DIAxTHICKNESS BOTTOM(mm)	DIA MIDDLE(mm)	DIA TOP(mm)	WEIGHT OF POLE (Kg)
410 TP3/SP3	$X+Y+Z=7$	1.25	114.3x4		78.1	87/85
410 TP12/SP12	$X+Y+Z=8$	1.5	114.3x4		78.1	101/97
410 TP13/SP13	$X+Y+Z=8$	1.5	139.7x4		88.9	125/119
410 TP27/SP27	$X+Y+Z=9$	1.5	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:-

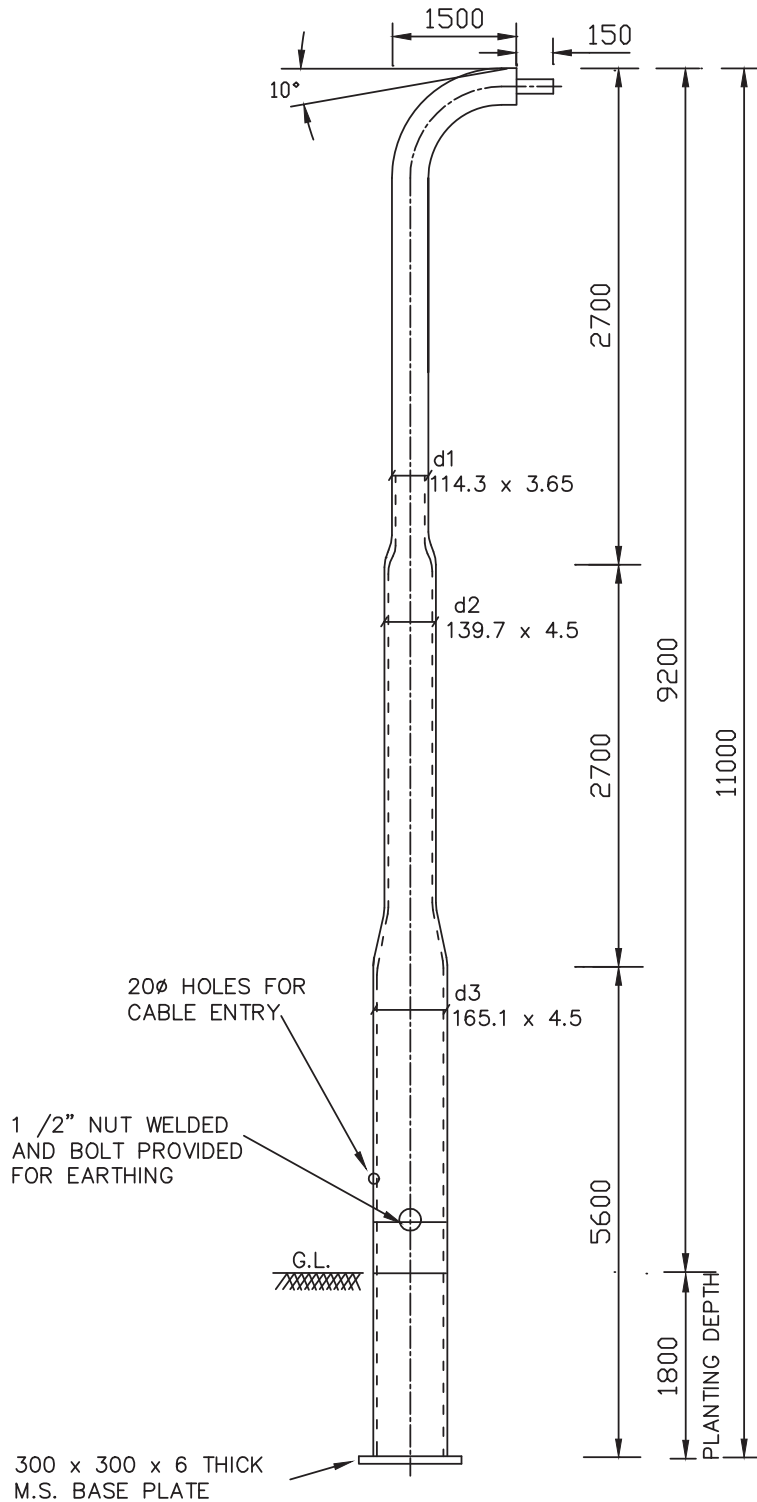
1. TP REFER TO STEPPED POLE.
2. SP REFER TO SWAGED POLE.
3. POLE DESIGNATION IS AS PER IS: 1239

SWAGED POLE TYPE 'B'



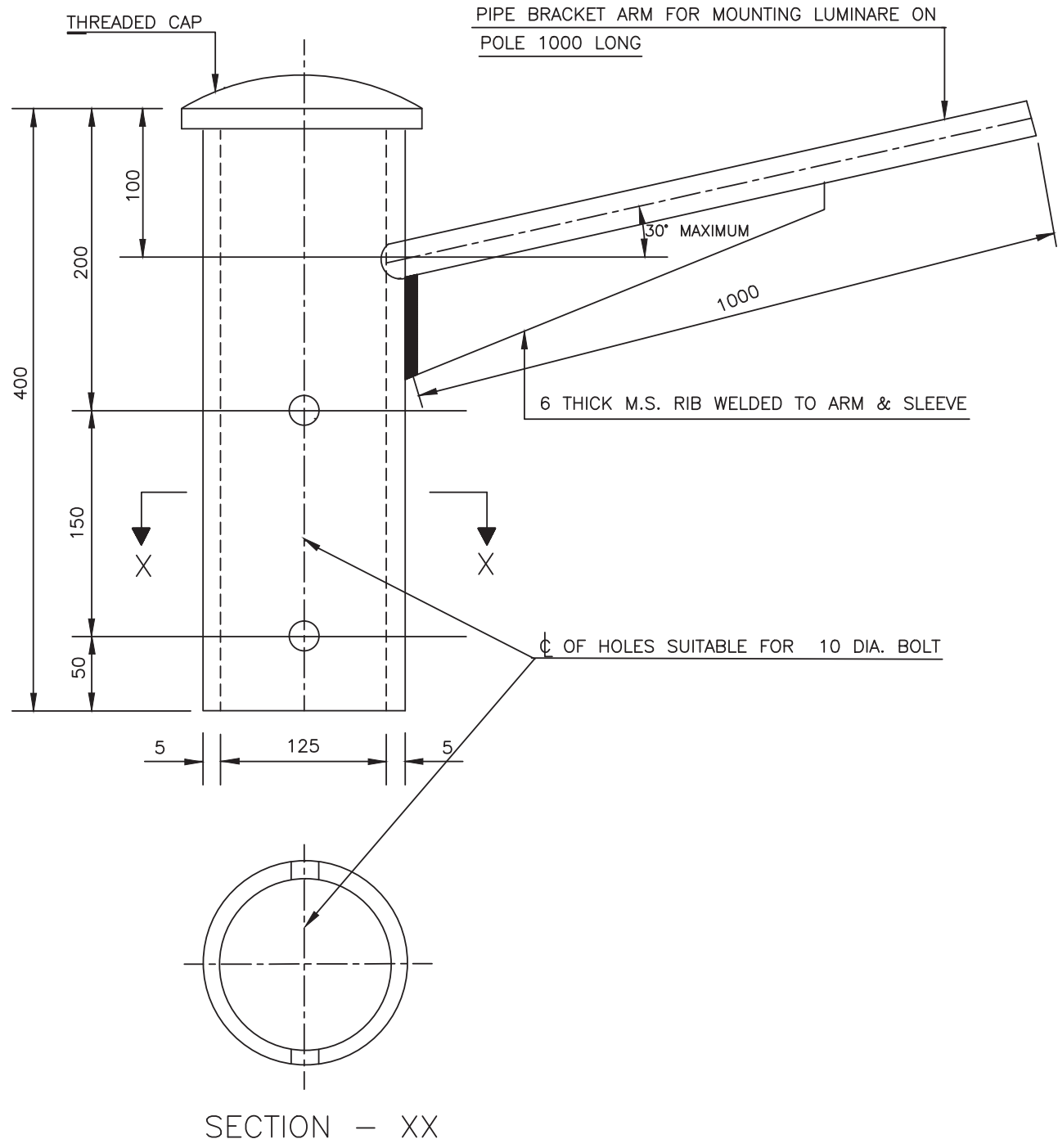


SWAGED POLE TYPE 'C'  
(FOR PLANT GROUND MOUNTING)



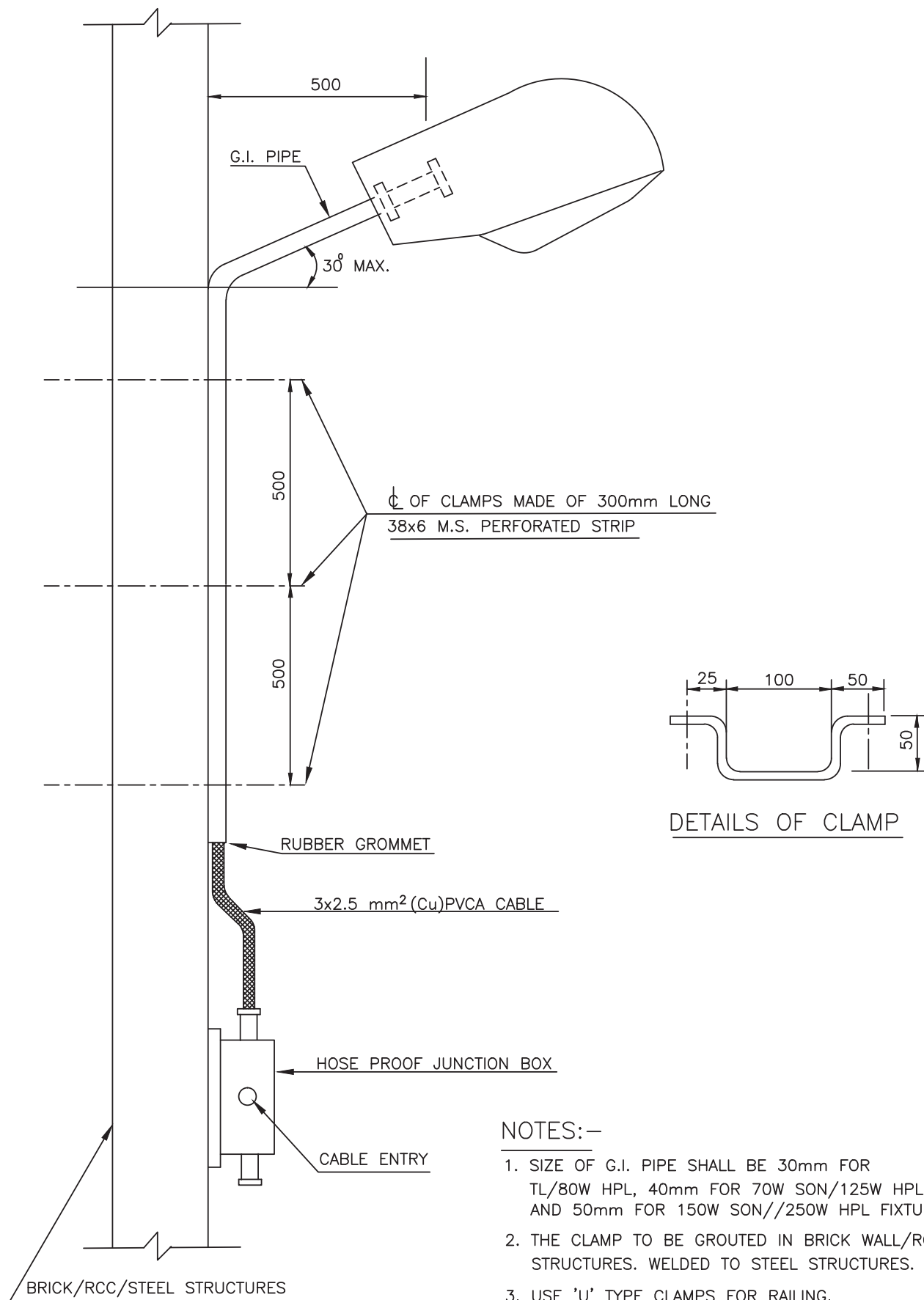
NOTES: -

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 PAINTED 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



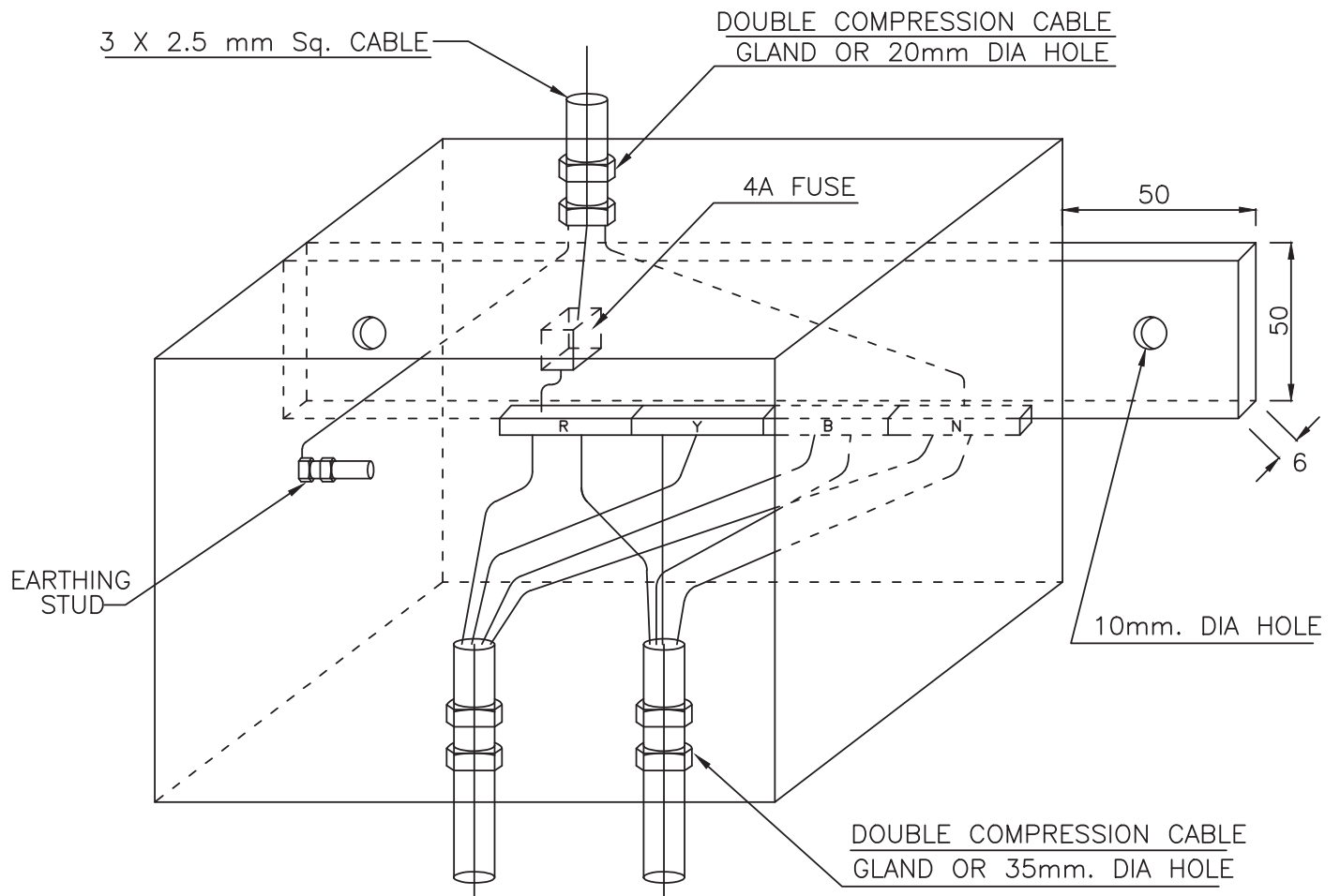
NOTES:-

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.



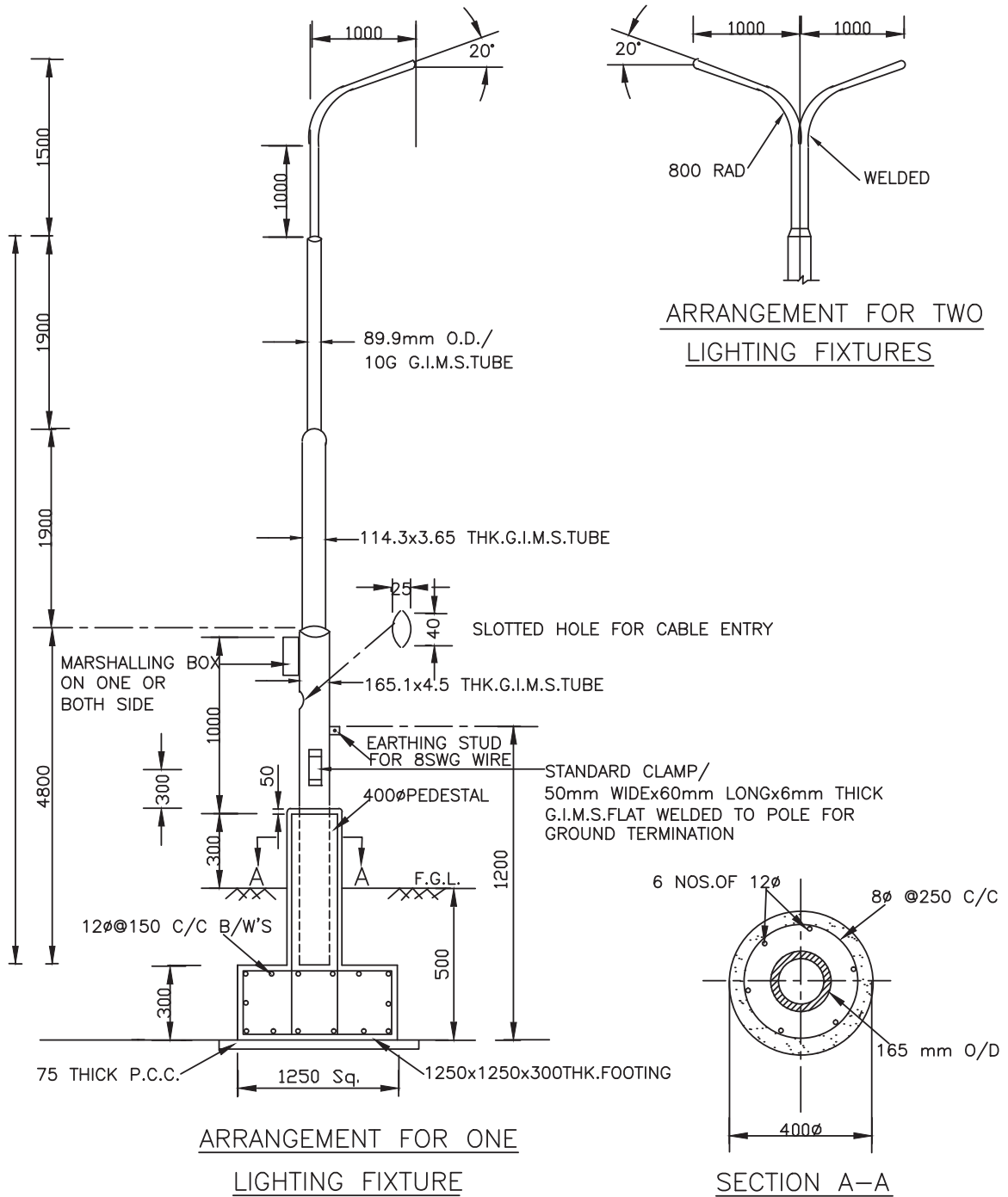
NOTES:—

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.



NOTE:—

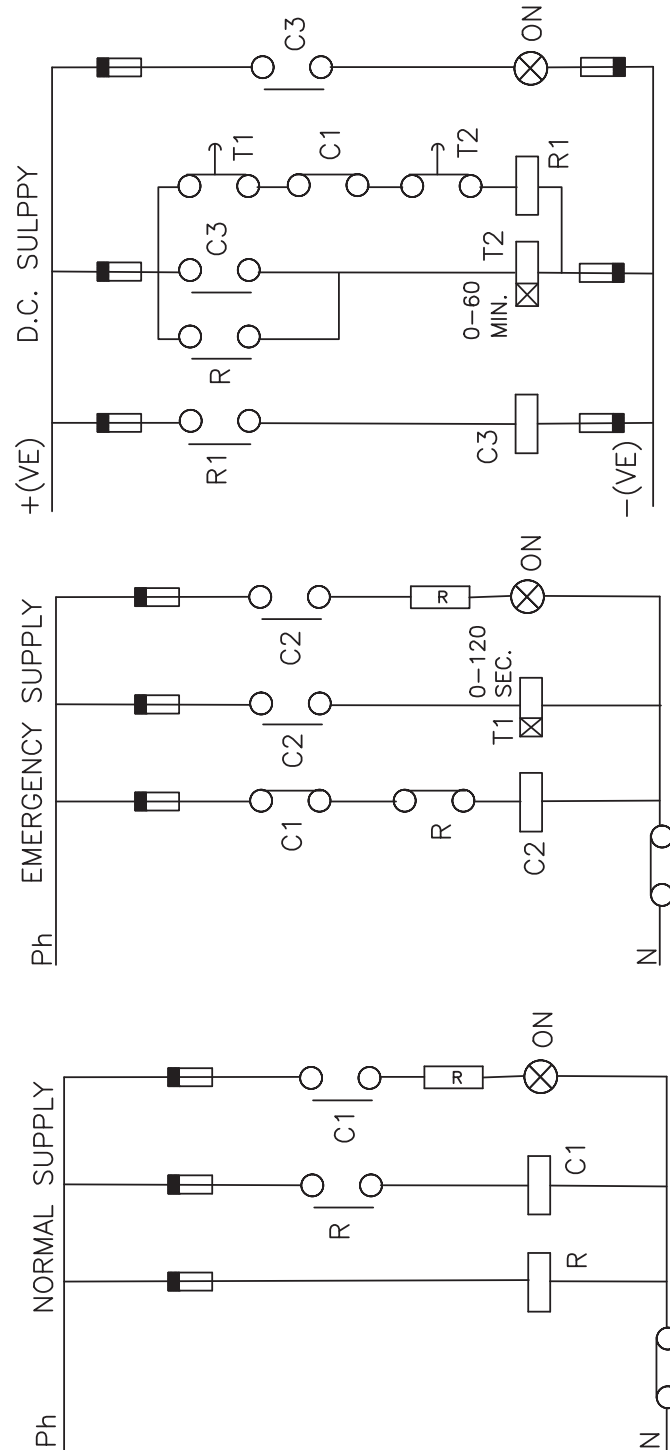
1. THE MINIMUM INTERNAL DIMENSION OF THE J.B. SHALL BE 152 X 152 X 152.
2. THE FRONT DOOR SHALL BE HINGED & LOCKABLE TYPE.
3. THE CONNECTION OF FUSE TO THE PHASE 'R' IS TYPICAL ONE THE EXACT PHASE TO WHICH CONNECTION SHALL BE MADE SHALL BE DECIDED AT SITE.
4. FOR HAZARDOUS AREA'S THESE JUNCTION BOXES 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.



NOTE :-

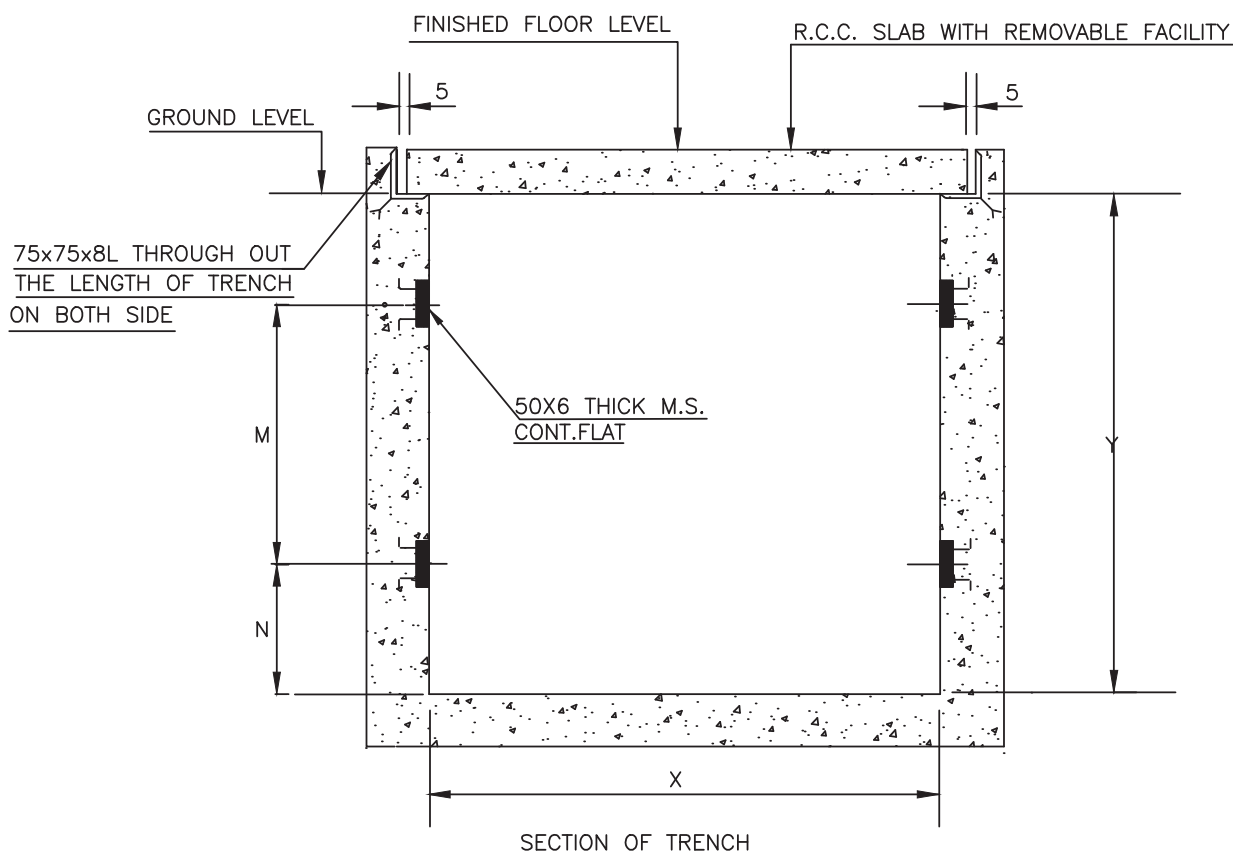
1. CONCRETING AND APPROVED MOUNTING HARDWARE FOR LIGHTING FIXTURES ARE INCLUDING IN SCOPE OF SUPPLY.
2. CONCRETE FOUNDATION OF GRADE M15 SHALL BE PROVIDED.

ALL DIMENSIONS ARE IN mm.



NOTE:-

CONTACTORS C1,C2 AND C3 CONTROLS THE LIGHTING FEEDERS FOR NORMAL,EMERGENCY AND D.C. SUPPLY RESPECTIVELY.



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.



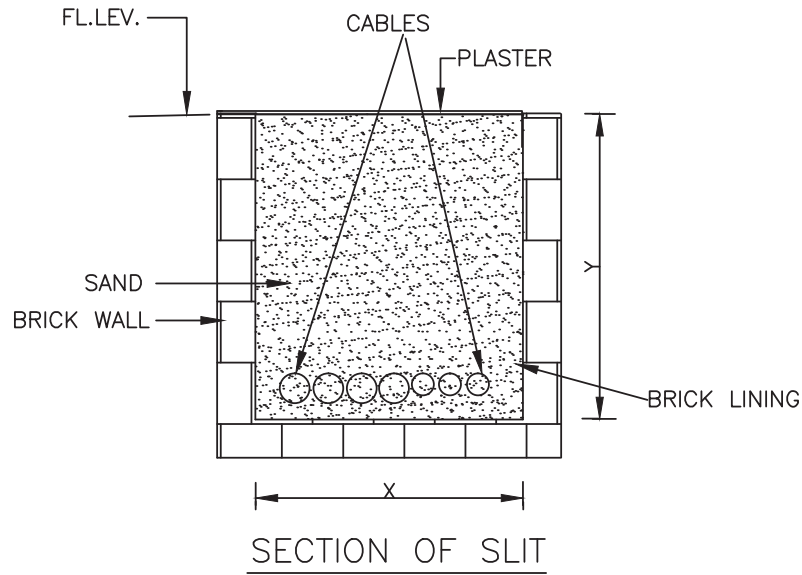
50x6 FLAT

DESIGN T
5T-35
4T-35
3T-35
5T-35
4T-35
3T-35
5T-25
4T-25
3T-25
5T-25
4T-25
3T-25

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.

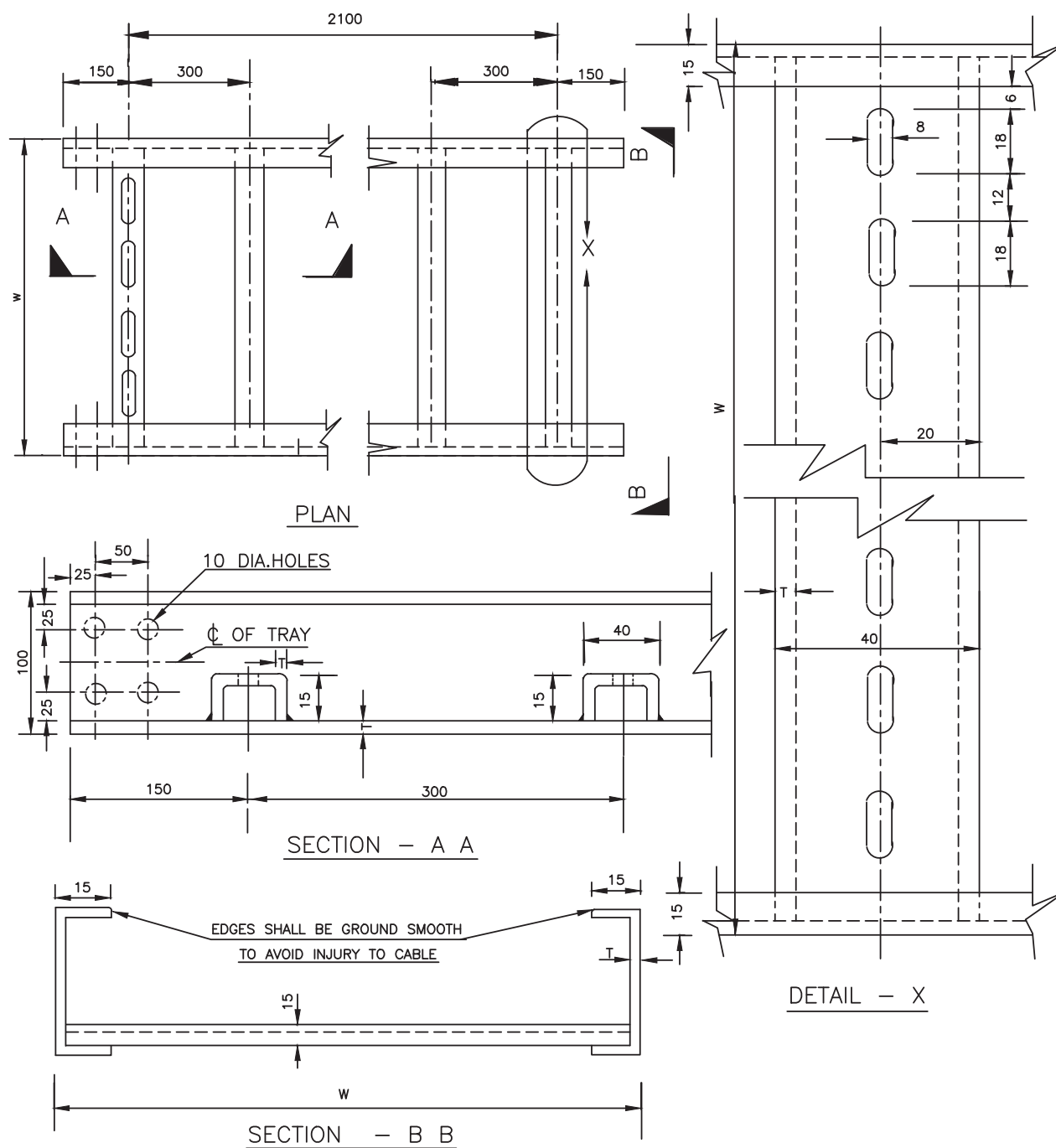




DESIGN TYPE	X	Y
S 300	300	300
S 200	200	200

NOTE:—

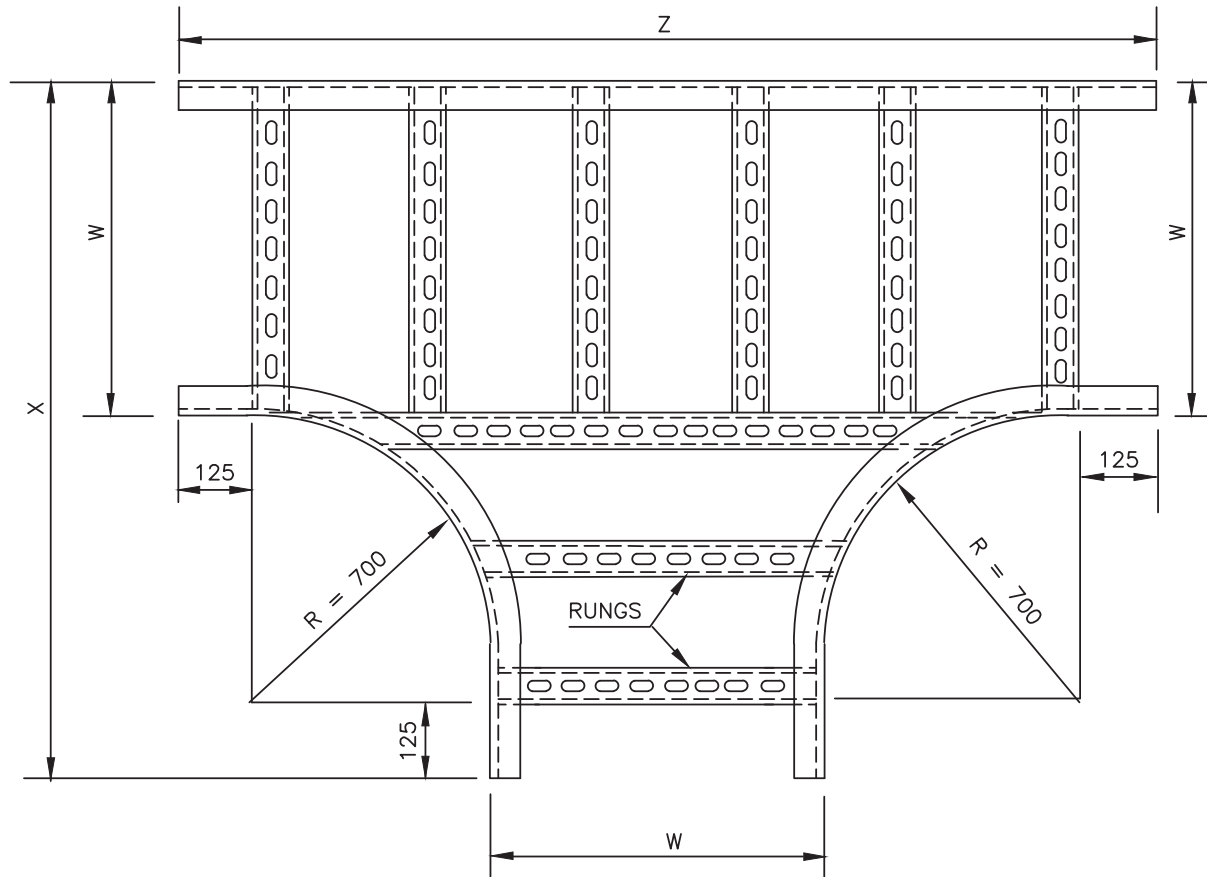
1. CABLE SLITS SHALL BE FILLED WITH SAND AND PROPERLY PLASTERED WITH LEAN CONCRETE AFTER LAYING OF CABLES.
2. WHEREVER CABLES ARE COMING OUT OF THE SLIT, SUITABLE MECH.PROTECTION TO BE PROVIDED.



DESIGN TYPE (WIDTH)	MAX.SUPPORTING SPAN		WEIGHT/METER APPROX. IN Kg.	
	G. I.	A. L	G. I.	A. L
SR 900	2000	2000	10.5	3.6
SR 600	2000	2000	8.9	3.05
SR 450	2000	2000	8.0	2.75
SR 300	2000	2000	7.6	2.6
SR 150	2000	2000	6.8	2.33

NOTE:—

THICKNESS " T " SHALL BE 3mm FOR G.I.  
AND 4mm.FOR AL.

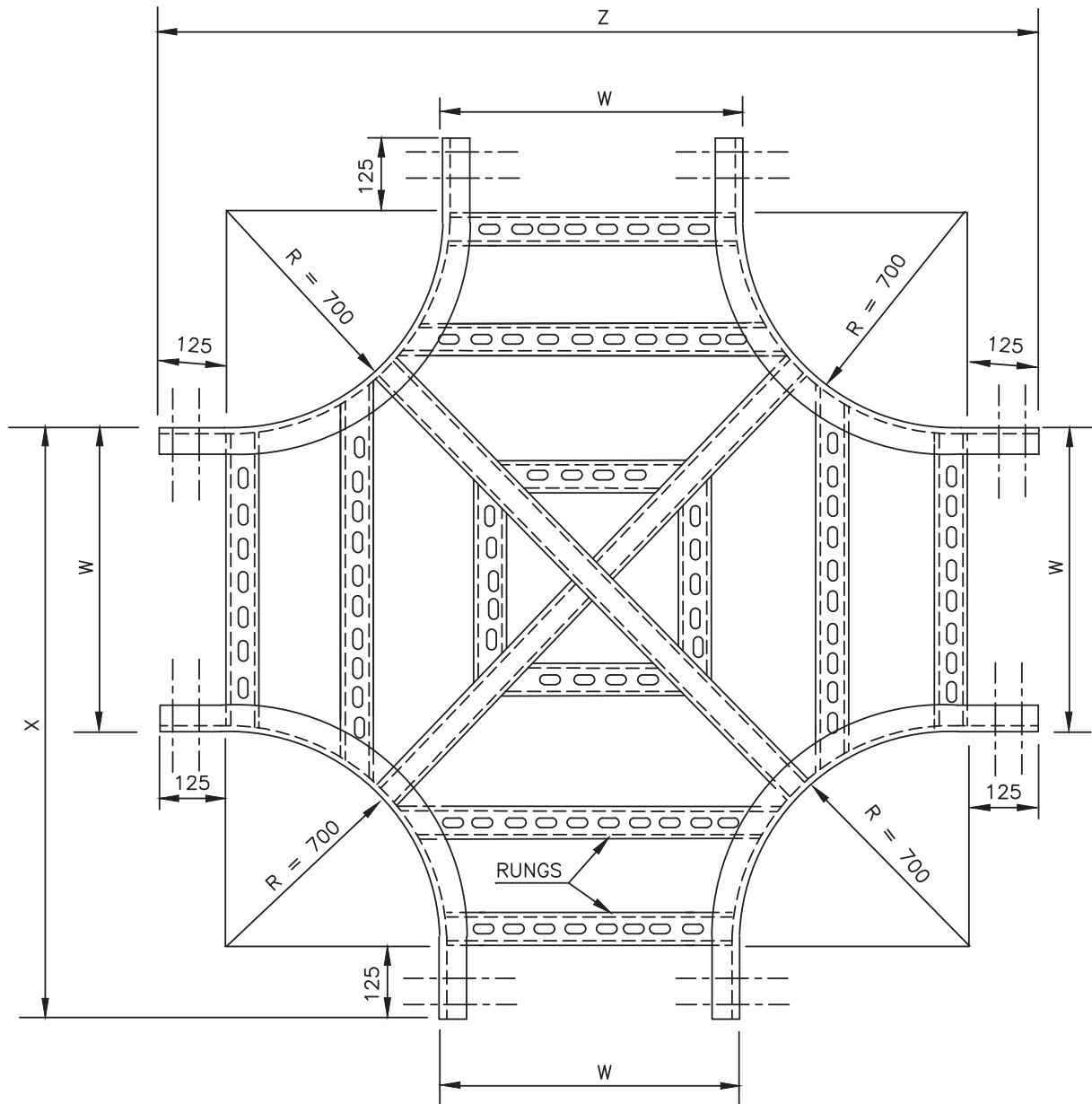


PLAN

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.

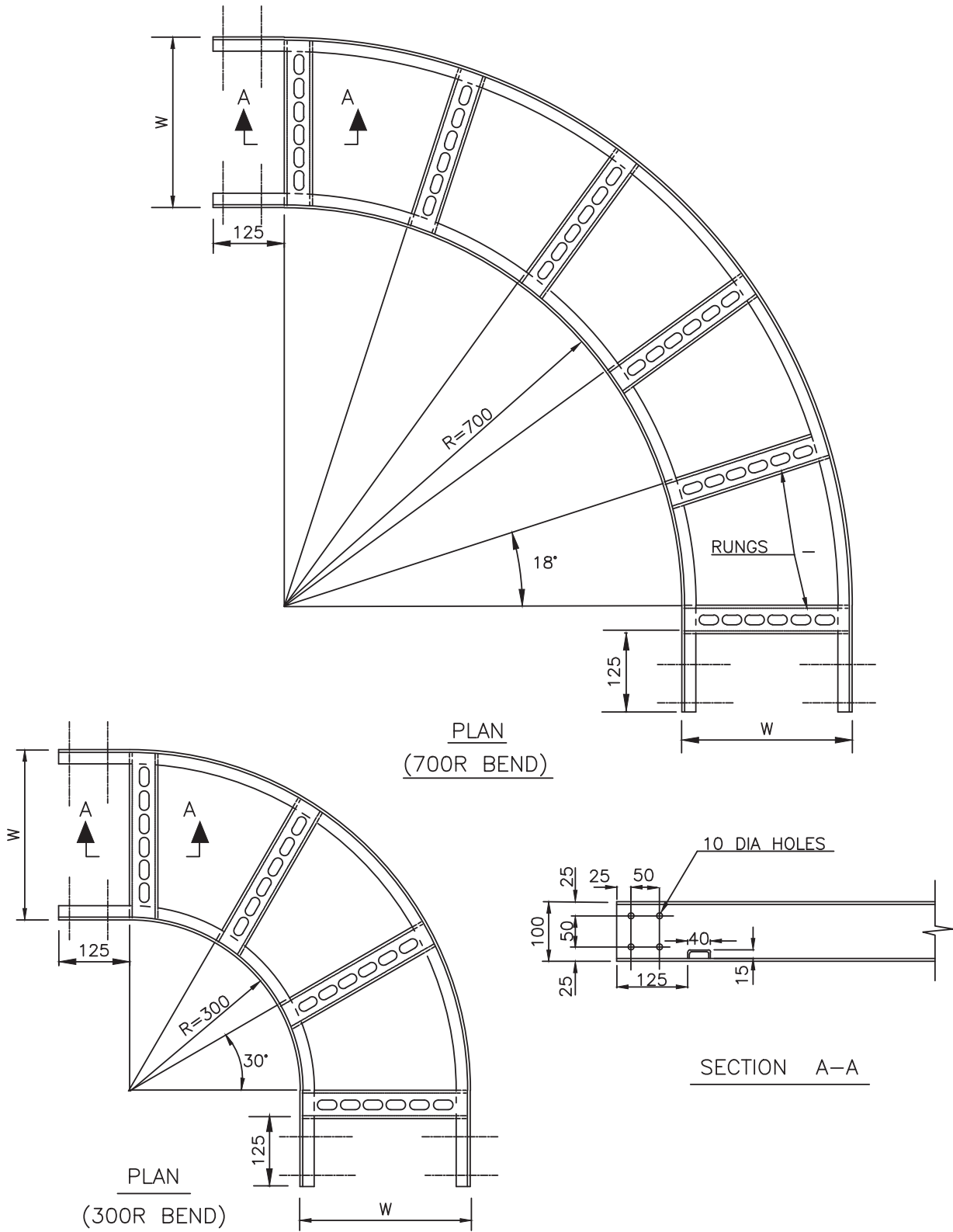


PLAN

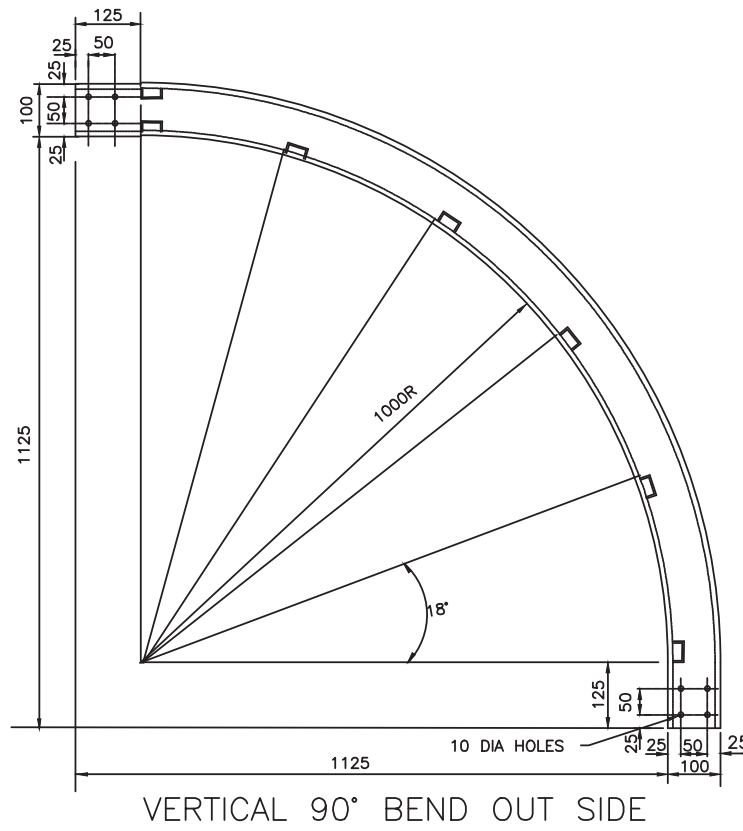
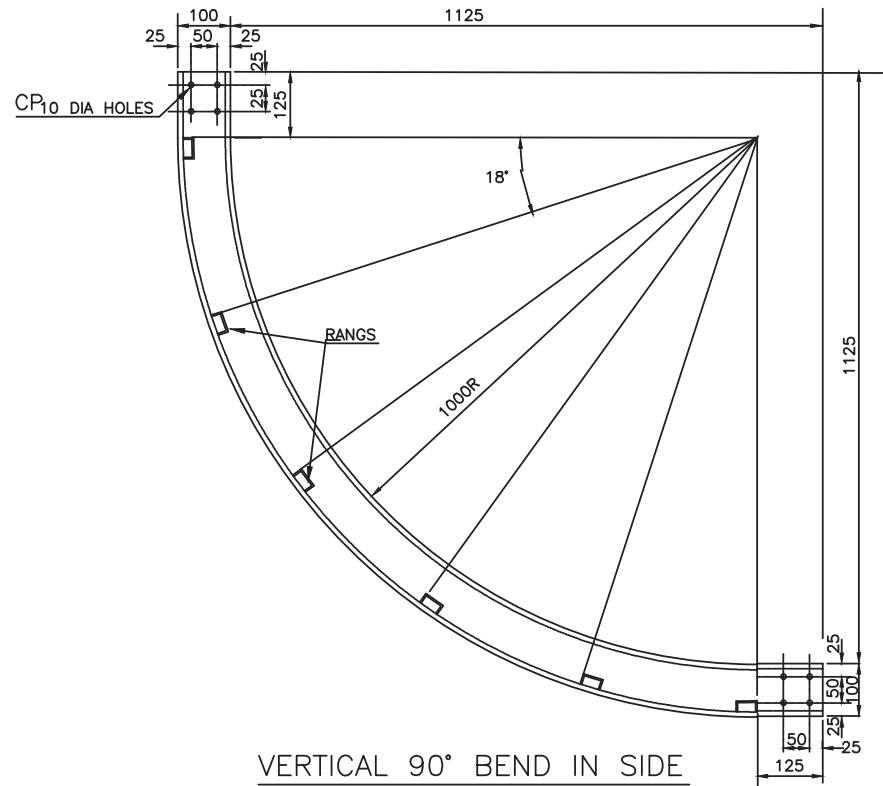
DESIGN TYPE	W	$X=R+W+125$	$Z=2R+W+250$
HC 900	900	1725	2550
HC 600	600	1425	2250
HC 450	450	1275	2100
HC 300	300	1125	1950

NOTES :-

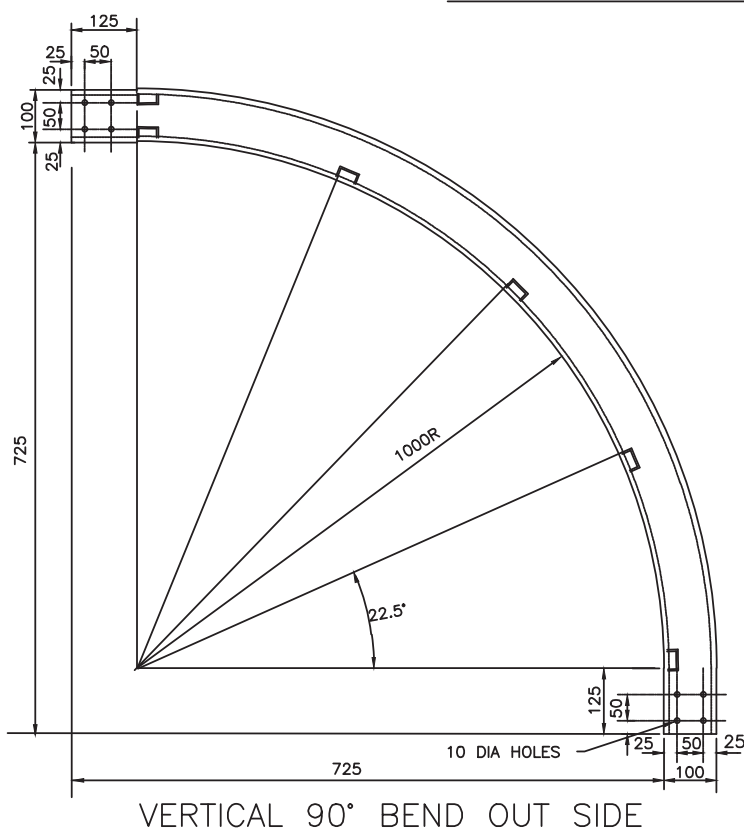
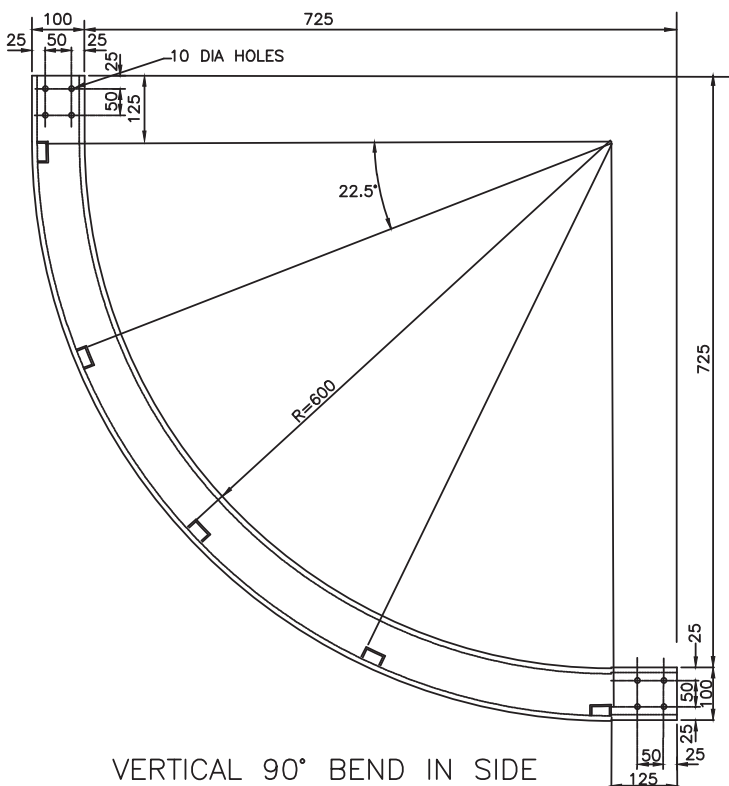
1. DISTANCE BETWEEN TWO RUNGS SHOULD BE APPROX. 300mm.
2. ALL DIMENSIONS ARE IN mm.



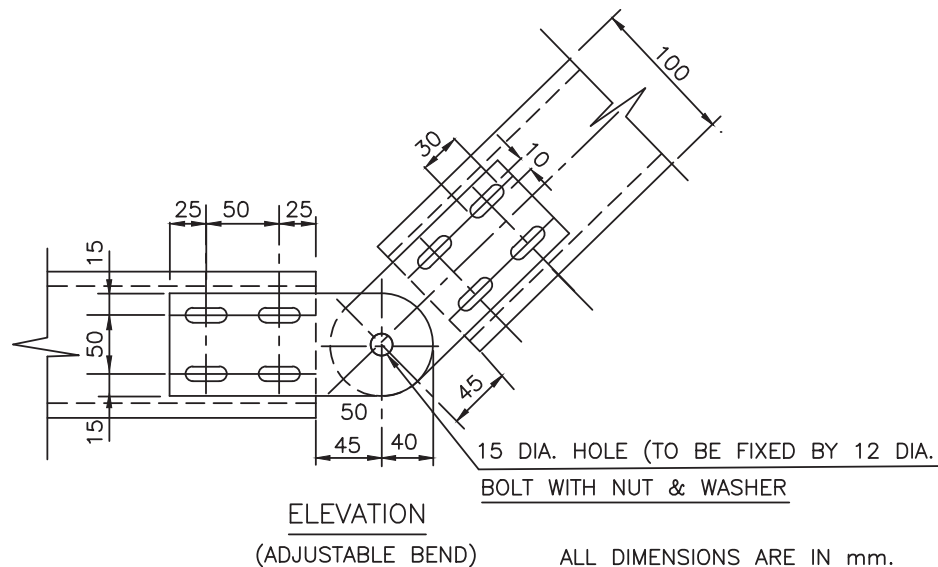
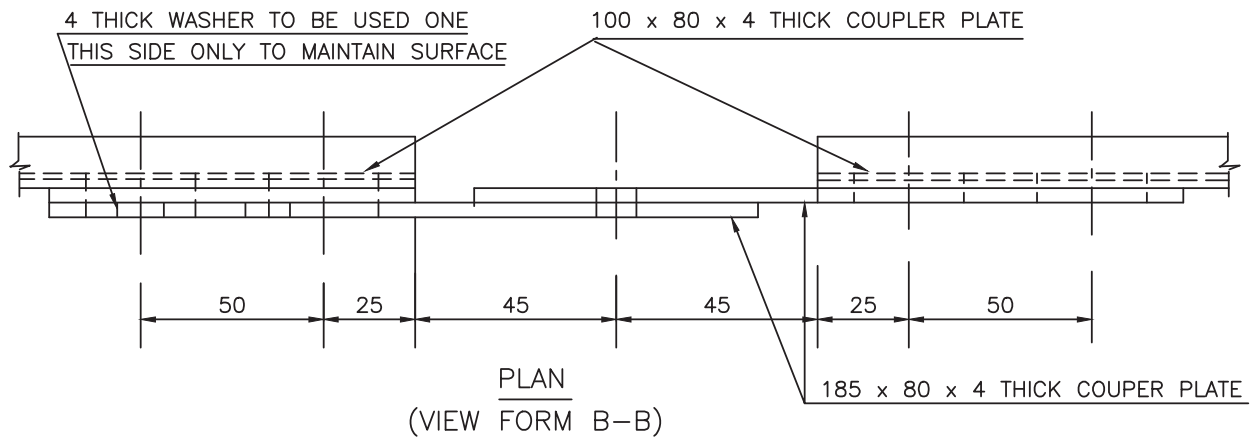
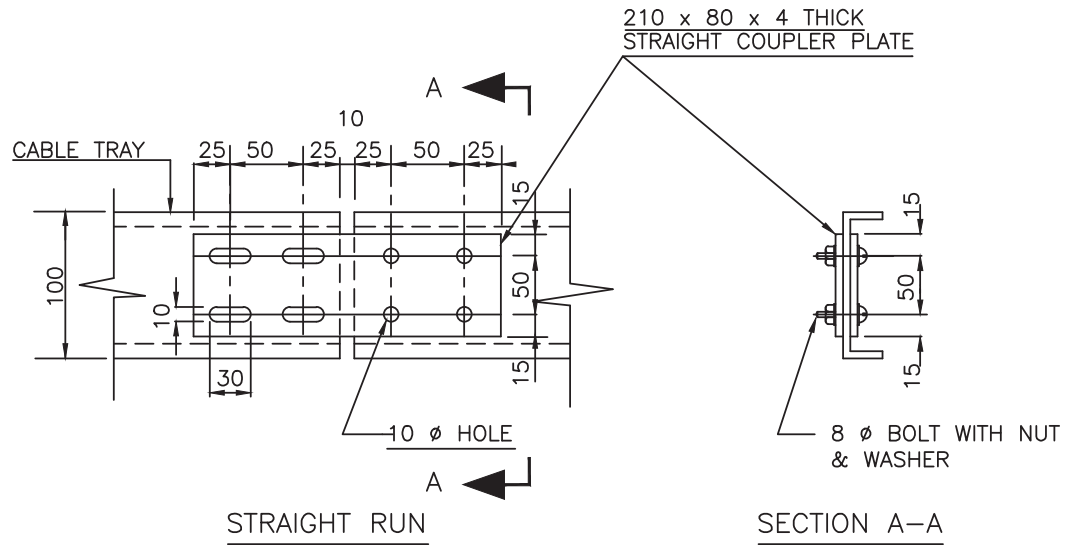
ALL DIMENSIONS ARE IN mm.



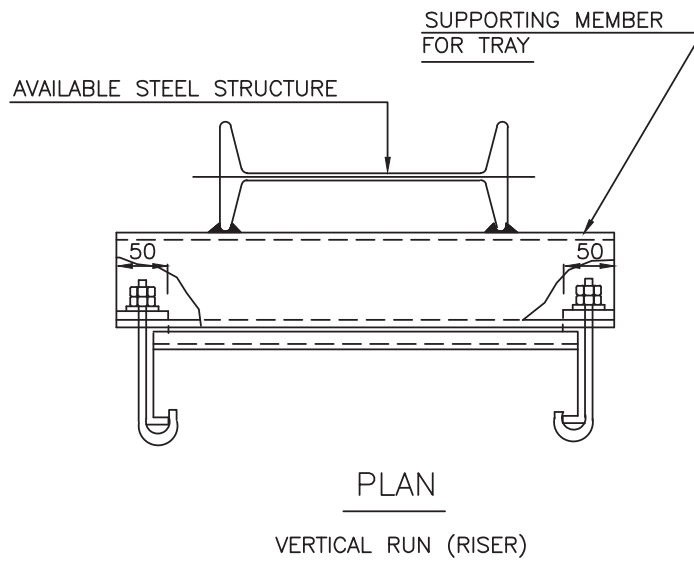
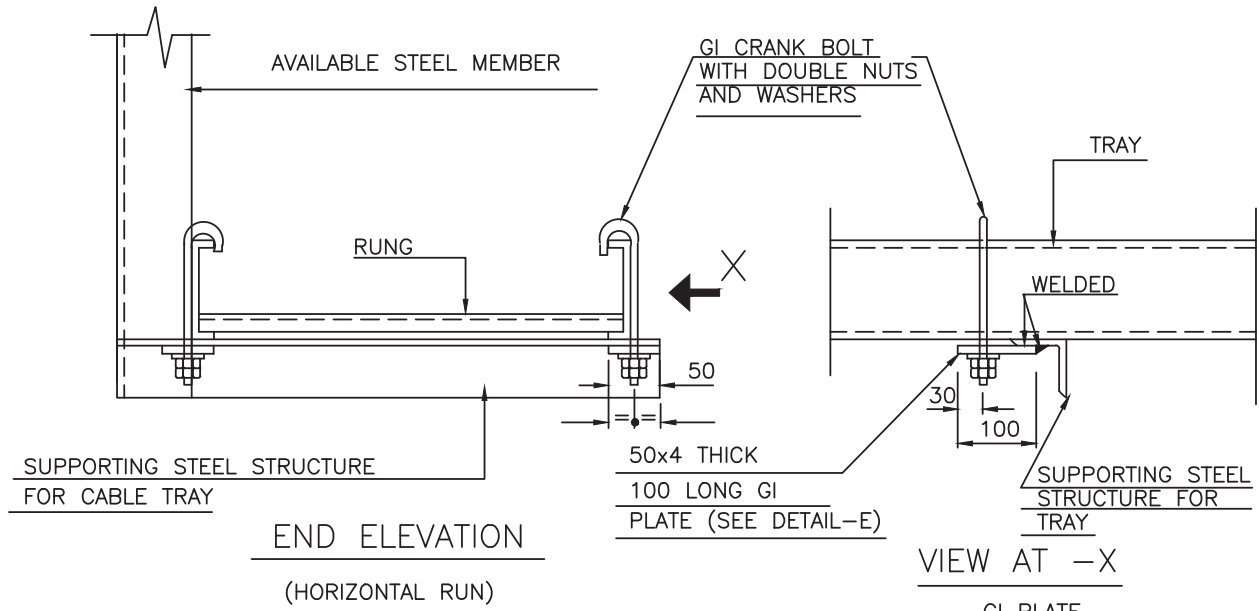
DIMENSIONS ARE IN mm.



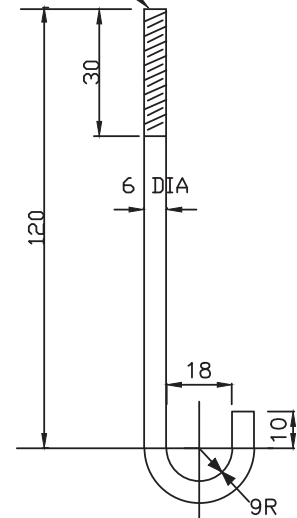
ALL DIMENSIONS ARE IN mm.







GI CRANK BOLT  
WITH DOUBLE NUTS  
& WASHERS.



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 SHALL BE GALVANISED ITEMS.
4. ALL DIMENSIONS ARE IN mm.



ALL DIMENSIONS ARE IN mm.



# GENERAL NOTES ON EARTHING AND LIGHTNING PROTECTION

PDSE: 601	0
DOCUMENT NO.	REV
SHEET 1 OF 2	

## A. GENERAL

1. EARTHING AND LIGHTNING PROTECTION SHALL BE CARRIED OUT IN ACCORDANCE WITH IS : 3043 AND IS : 2309 RESPECTIVELY AND SHALL ALSO CONFORM TO THE REQUIREMENTS OF INDIAN ELECTRICITY RULES.
2. THESE NOTES SHALL BE READ IN CONJUNCTION WITH EARTHING & LIGHTNING PROTECTION LAYOUT DRGS. AND RELEVANT EARTHING STANDARDS (PDSE)
3. THE SIZE OF EARTH CONDUCTORS & SYMBOLS SHOWN IN THE LAYOUT DRGS. SHALL AS PER PDSE: 602
4. AS FAR AS POSSIBLE, THE EARTH CONDUCTORS SHALL BE TAKEN ALONG POWER & CONTROL CABLE ROUTES.
5. EARTHING CONDUCTORS BURIED UNDER THE GROUND SHALL BE LAID ATLEAST 500 MM BELOW THE GROUND LEVEL UNLESS REQUIRED OTHERWISE, e.g FOR CROSSING ANY UNDER GROUND PIPE OR TRENCH ETC. WHERE THE EARTHING CONDUCTORS SHALL RUN AT A MINIMUM DEPTH 300 MM BELOW THE BOTTOM OF THE PIPE/TRENCH.
6. BARE ALUMINIUM CONDUCTORS SHALL NOT BE BURIED DIRECTLY UNDER THE GROUND.
7. TAPPING FROM THE UNDER GROUND EARTH GRID SHALL BE TAKEN ONLY FROM EARTH PIT OR A PIT WITHOUT ELECTRODE PROVIDED FOR THIS PURPOSE.
8. JOINTING OF UNDERGROUND EARTHING STRIPS SHALL BE AVOIDED TO THE EXTENT POSSIBLE. HOWEVER, IF JOINTING IS TO BE DONE DUE TO UNAVOIDABLE REASONS, THIS SHALL BE DONE BY ELECTRIC ARC WELDING.
9. TERMINAL JOINTING & CLAMPING ARRANGEMENT SHALL BE AS SHOWN IN PDSE:603. ALL WELDED OR BOLTED JOINTS SHALL BE PAINTED WITH EPOXY RESIN PAINT OR BITUMINOUS PAINT.
10. EARTH BUSES, AS PER CONVENIENCE, SHALL BE PROVIDED IN PLANTS FOR EARTHING GROUPS OF EQUIPMENT TO EARTHING GRID. THESE EARTH BUSES, SHALL BE AS SHOWN IN PDSE: 615.
11. DETAILS OF EARTH PIT CONNECTIONS & ACCESSORIES FOR EARTH ELECTRODES SHALL BE AS SHOWN IN PDSE :604, 605 , 610 AND 611.
12. EARTH PITS FOR EQUIPMENT EARTHING, SYSTEM NEUTRAL EARTHING & LIGHTNING PROTECTION SHALL BE SEPARATE. HOWEVER, THESE PITS SHALL BE INTERCONNECTED.
13. SPACING BETWEEN TWO EARTH PITS SHALL NOT BE LESS THAN 10 M & THESE MAY BE LOCATED ABOUT 4M AWAY FROM THE BUILDING / STRUCTURE.
14. TYPICAL ARRANGEMENT OF NEUTRAL & EQUIPMENT EARTHING SHALL BE AS SHOWN IN PDSE: 617.

## B. SYSTEM NEUTRAL EARTHING

1. THE NEUTRALS OF H.T & L.T SYSTEMS SHALL BE EARTHED BY USING 2 NOS. 150 SQ. MM ALUMINIUM CABLE OF RESPECTIVE VOLTAGE GRADE. EACH EARTH CONNECTION SHALL BE TERMINATED ON SEPERATE EARTH PITS. HOWEVER, FOR ECONOMY REASONS, 2 EARTH CONNECTIONS OF 2 DIFFERENT EQUIPMENT CAN BE TERMINATED ON THE SAME EARTH PIT AS SHOWN IN PDSE: 617.
2. THE NEUTRAL OF H.T. SYSTEM SHALL BE CONNECTED TO EARTH PIT AS ABOVE THROUGH THE NEUTRAL EARTHING RESISTOR (N.E.R.) AS REQUIRED, WHERE AS THE NEUTRAL OF L.T. SYSTEM SHALL BE SOLIDLY EARTHED THROUGH RESPECTIVE L.T. SWITCH BOARD.
3. FOR D.C. SYSTEM, POSITIVE POLE SHALL BE EARTHED THROUGH HIGH IMPEDANCE IN BATTERY CHARGER.

## C. ELECTRICAL EQUIPMENT EARTHING

1. ALL EQUIPMENT RATED ABOVE 250V SHALL HAVE TWO EXTERNAL EARTH CONNECTIONS & THOSE RATED 250V & BELOW SHALL HAVE ONE EXTERNAL EARTH CONNECTION.  
FLAME PROOF EQUIPMENT, IN ADDITION, SHALL HAVE ONE INTERNAL EARTH CONNECTION THROUGH ADDITIONAL CORE OF POWER / CONTROL CABLE.

0	03.01.07	15.01.07	ISSUED FOR IMPLEMENTATION			
REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD





# GENERAL NOTES ON EARTHING AND LIGHTNING PROTECTION

PDSE: 601	0
DOCUMENT NO.	REV
SHEET 2 OF 2	

- EARTHING CONNECTION TO INDIVIDUAL EQUIPMENT SHALL BE TAPPED ONLY FROM THE EARTHING GRID / RING OR EARTH BUS EXCEPT FOR EQUIPMENT RATED 250V & BELOW, FOR WHICH THE CONNECTION MAY BE TAKEN FROM THE NEAR BY EARTH CONDUCTOR OF A LARGER EQUIPMENT OR FROM THE BODY OF THE LARGER EQPT.
- EARTHING ARRANGEMENT OF MOTOR AND ASSOCIATED LOCAL CONTROL STATION SHALL BE AS SHOWN IN PDSE: 608.
- EARTHING ARRANGEMENT OF RAILS SHALL BE AS SHOWN IN PDSE: 609 WITH BOTH ENDS EARTHED.
- 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.
- EARTHING ARRANGEMENT OF LIGHTING FIXTURES & PLUG SOCKETS RATED 250V AND BELOW SHALL NOT BE SHOWN IN THE EARTHING LAYOUT DRGS. HOWEVER, PLUG SOCKETS SHALL BE EARTHED BY 10 SWG SIZE G.I./AL. CONDUCTOR TAKEN FROM THE NEAREST EARTHING GRID/CONDUCTOR AND LIGHTING FIXTURES SHALL BE PROVIDED EARTHING THROUGH CABLE ARMOURS.
- IN SWITCH YARD AND GENERATING STATIONS SUITABLE EARTHING MAT SHALL BE PROVIDED TO REDUCE THE VALUE OF STEP/TOUCH POTENTIAL TO PERMISSIBLE VALUE.
- SWITCH YARD FENCE SHALL BE CONNECTED TO EARTH AT A REGULAR INTERVAL, NOT EXCEEDING 10 M.






















## D. STATIC EARTHING









- ALL PROCESS EQUIPMENT WHICH ARE LIKELY TO GET STATICALLY CHARGED, e.g. STORAGE TANKS, HIGH PRESSURE & MEDIUM PRESSURE VESSELS/PIPES, HIGH PRESSURE COMPRESSORS, HIGH PRESSURE STEAM EJECTORS ETC. SHALL BE EARTHED AGAINST STATIC CHARGE ACCUMULATION.
- EARTHING ARRANGEMENT ACROSS PIPE JOINTS/VALVES SHALL BE AS SHOWN IN PDSE: 612.
- DETAILS OF EARTHING OF VESSELS SHALL BE AS SHOWN IN PDSE: 613.
- MOBILE EQUIPMENT, REQUIRING EARTHING AGAINST STATIC CHARGE, SHALL BE TEMPORARILY EARTHED AS SHOWN IN PDSE: 608.
- PIPE TRESTLE CARRYING PIPES WITH HYDRO CARBONS SHALL BE CONNECTED TO EARTH GRID AT REGULAR INTERVALS, NOT EXCEEDING 25 M.
- WHEREVER PROCESS EQUIPMENT ARE MOUNTED ON STEEL STRUCTURE, THE BASE OF THE STRUCTURES SHALL BE EARTHED INSTEAD OF EARTHING THE INDIVIDUAL EQUIPMENT.

## E. LIGHTNING PROTECTION


- FIXING ARRANGEMENT ON AIR TERMINATION AND ROOF/DOWN CONDUCTOR FOR LIGHTNING PROTECTION SYSTEM SHALL BE AS SHOWN IN PDSE: 614.
- FOR LIGHTNING PROTECTION OF TALL STEEL STRUCTURES/VESSELS/TANKS, DOWN CONDUCTOR SHALL BE TAKEN FROM THE BASE AND CONNECTED TO EARTH PITS. AIR TERMINATION ROD SHALL NOT BE REQUIRED.
- LIFT SHAFT SHALL NOT BE USED FOR FIXING THE DOWN CONDUCTOR.
- 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 NEAR BY STEEL COLUMN. ELECTRICAL CONTINUITY OF THE STRUCTURES, HOWEVER, SHALL BE CHECKED AND ENSURED.
- FOR ALL HIGH RISE CONCRETE STRUCTURES, TEMPORARY LIGHTNING PROTECTION NEED 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.

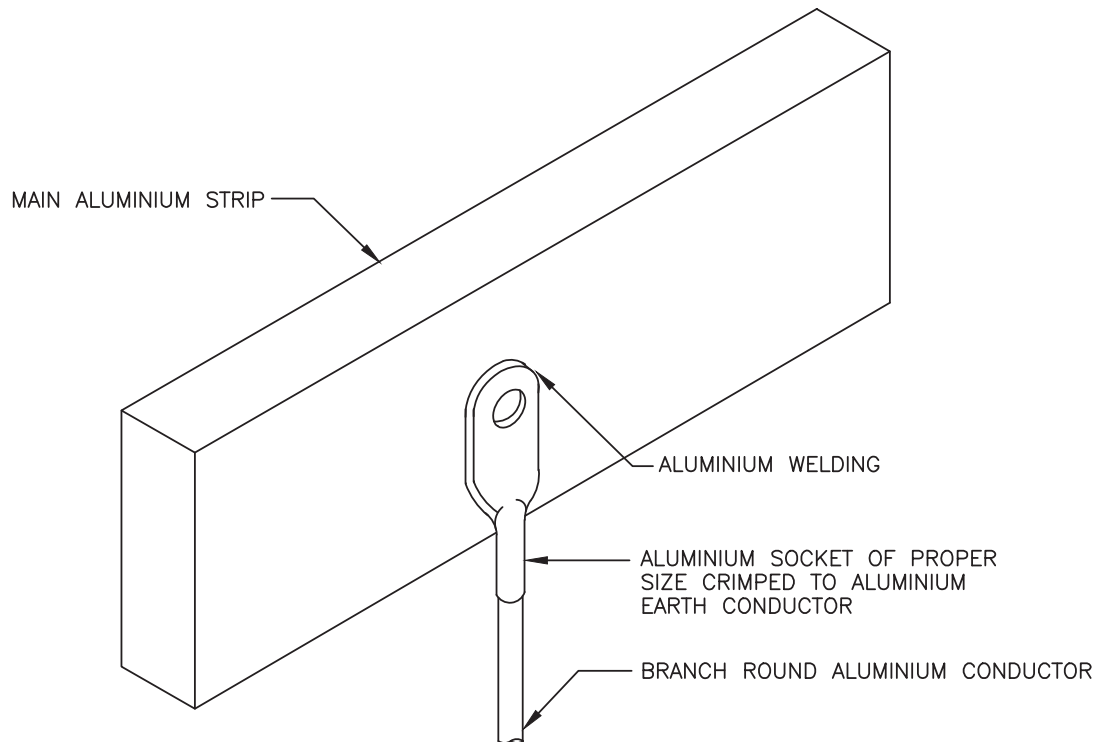
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REV	REV.DATE	EFF.DATE	PURPOSE	PREPD	REVWD	APPD

SL. No.	EQUIPMENT TO BE EARTHED	FAULT LEVEL (MVA)	G.I.STRIPS/WIRES			ALUMINIUM			REMARKS	
			MIN.SIZE (mm <sup>2</sup> )	SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	MIN.SIZE (mm <sup>2</sup> )	STRIPS/WIRES			1.1kv PVC SINGLE CORE CABLE SIZE (mm <sup>2</sup> ) SYMBOL
							SIZE TO BE USED (mm <sup>2</sup> )	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		491	2-38.1x6.35=484		500	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		328	50.8x6.35=323		400	-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		272	50.8x6.35=323		300	-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		229 218 218	38.1x6.35=242		240	-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		163	31.75x4.78=152		185	-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		120	38.1x3.18=121		120	AS PER CLAUSE 12.3.2 OF IS:3043
1C	ALL M.V.SWITCH BOARDS		210	50x6		120	38.1x3.18=121		120	AS PER CLAUSE 12.3.2 OF IS:3043
2	H.V. MOTORS		210	50x6		120	38.1x3.18=121		120	-DO-
3	TRANSFOMER NEUTRALS		-	-	-	120	-		150	-
4	M.V. MOTORS RATED 75KW & ABOVE		210	50x6		120	38.1x3.18=121		120	AS PER CLAUSE 12.3.2 OF IS:3043
5	M.V. MOTORS ABOVE 30KW &LESS THAN 75KW		175	35x6		93	31.75x3.18=101		95	-DO-

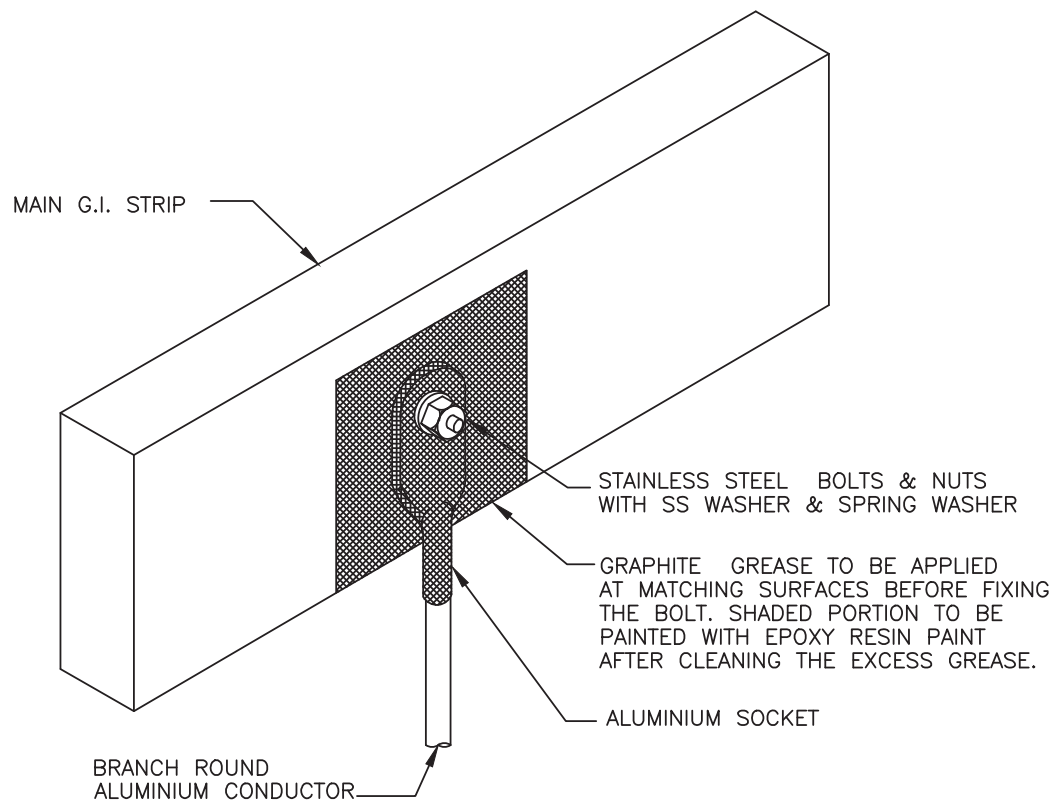
SL. No.	EQUIPMENT TO BE EARTHED	FAULT LEVEL (MVA)	G.I. STRIPS/WIRES		ALUMINIUM STRIPS/WIRES			1.1kv PVC SINGLE CORE CABLE		REMARKS
			MIN. SIZE (mm <sup>2</sup> )	SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	MIN. SIZE (mm <sup>2</sup> )	SIZE TO BE USED (mm <sup>2</sup> )	SYMBOL	SIZE (mm <sup>2</sup> )	
6	M.V.MOTORS ABOVE 5.5KW & LESS THAN 30KW 63A SW.SOCKETS,BATTERY CHARGERS,LIGHTING SUB-DIST.BDS.,D.C.BDS.		44	25x6		25	2 SWG=38.6		25	AS PER CLAUSE 12.3.2 OF IS:3043
7	M.V.MOTORS RATED 5.5KW & BELOW		7	8 SWG=13		5	10 SWG=8.3		6	-DO-
8	ALL MINOR EQUIPMENT RATED FOR 250V & BELOW		-	10 SWG=8.3		-	10 SWG=8.3		6	
9	NON ELECTRICAL EQUIPMENT,SUCH AS VESSELS STRUCTURES IN HAZARDOUS AREA & LIGHTNING PROTECTION CONDUCTORS		32x6	35x6		-	25.4x3.18=81		-	AS PER IS:2309

NOTE :—EARTHING CONDUCTOR SIZES FOR ITEMS AT SL.No.4,5,6 & 7 SHOULD BE CHOSEN AS HALF THE POWER CABLE SIZES ACTUALLY USED.

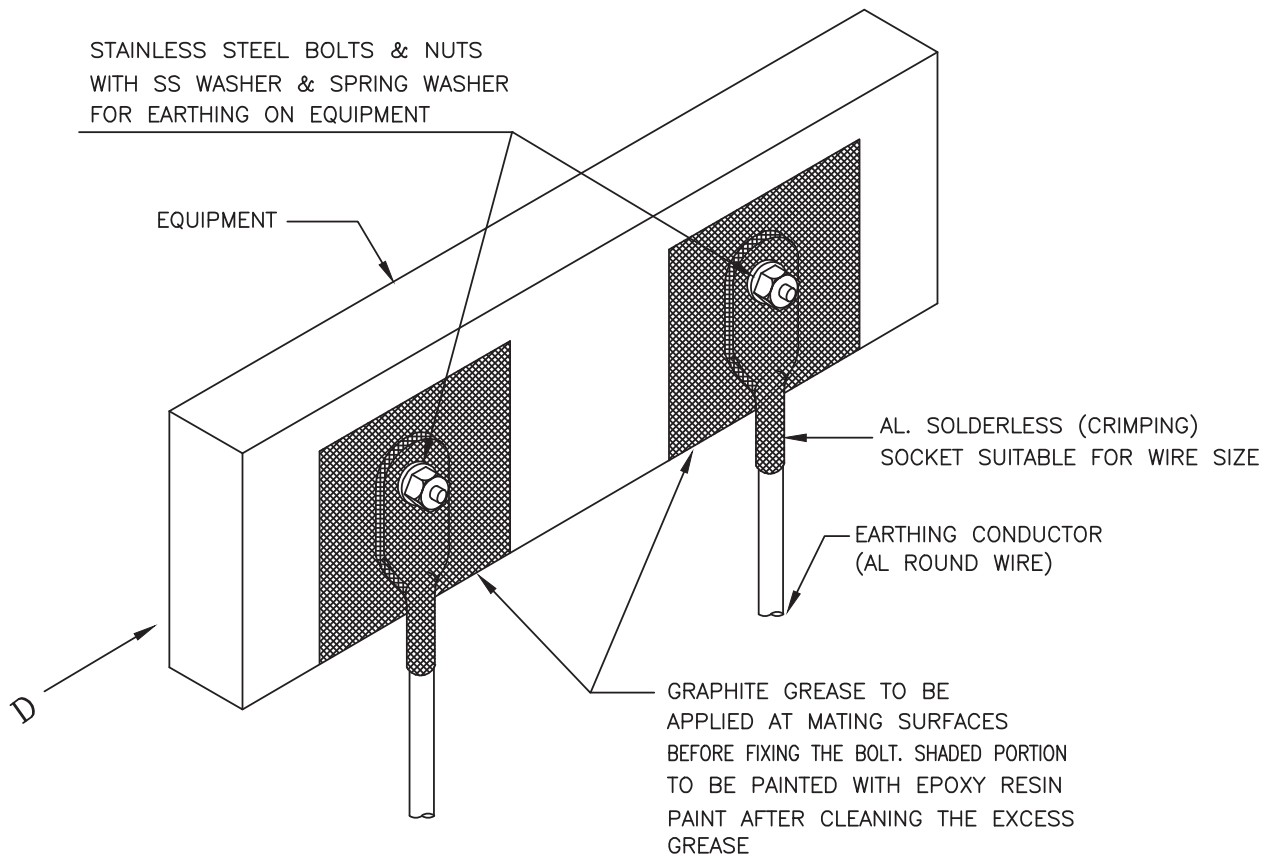
	ARRANGEMENT OF CONNECTIONS		PC217-PDS:E 603	0
	OF EARTH CONDUCTORS		DOCUMENT NO.	REV.
	(T-JOINT AL STRIP & GI STRIP TO ROUND AL CONDUCTOR)		SHEET 1 OF 6	



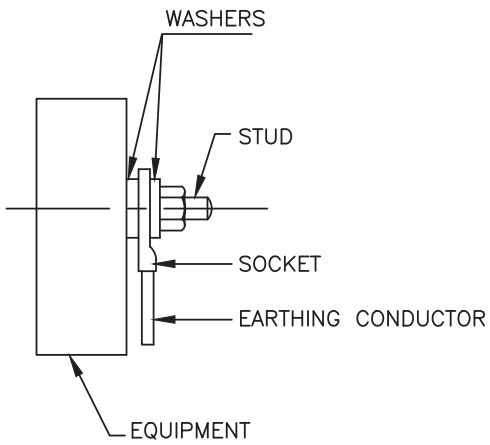
' T ' JOINT ALUMINIUM STRIP TO ROUND ALUMINIUM CONDUCTOR



' T ' JOINT G.I. STRIP TO ROUND ALUMINIUM CONDUCTOR

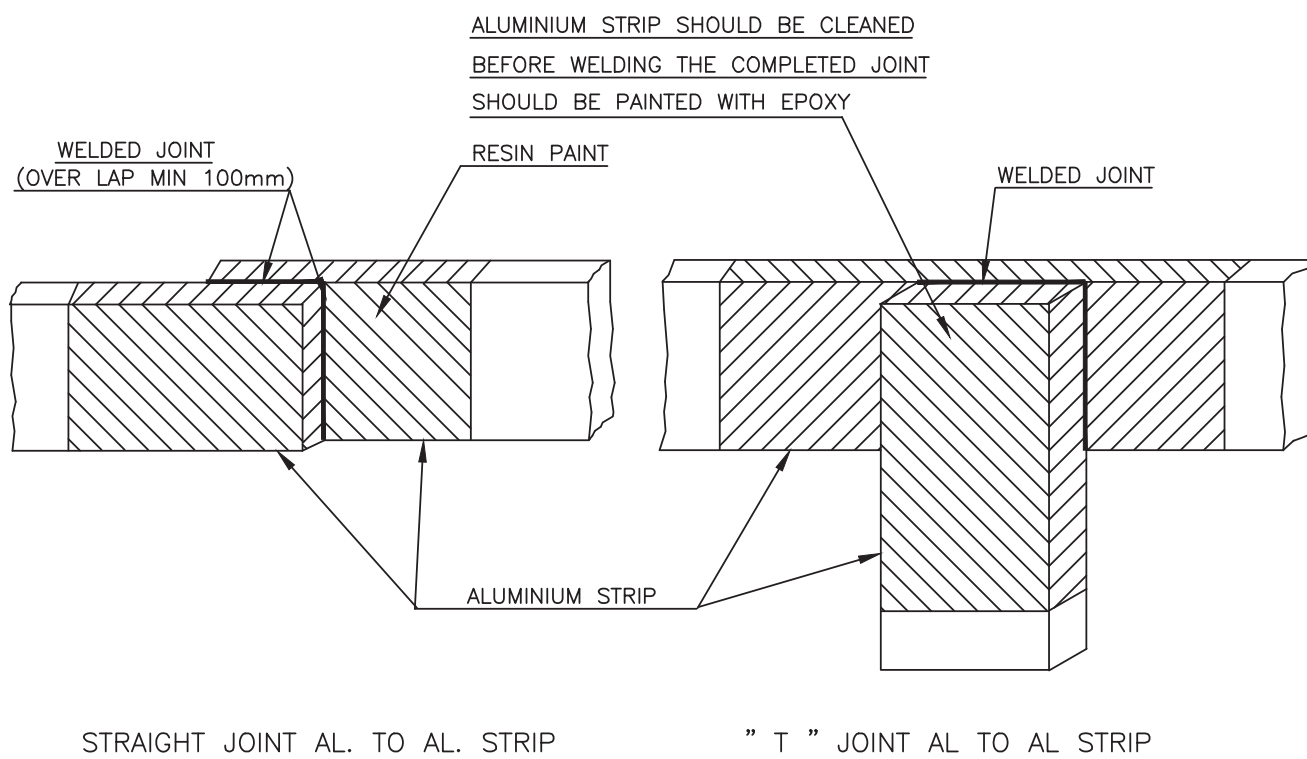


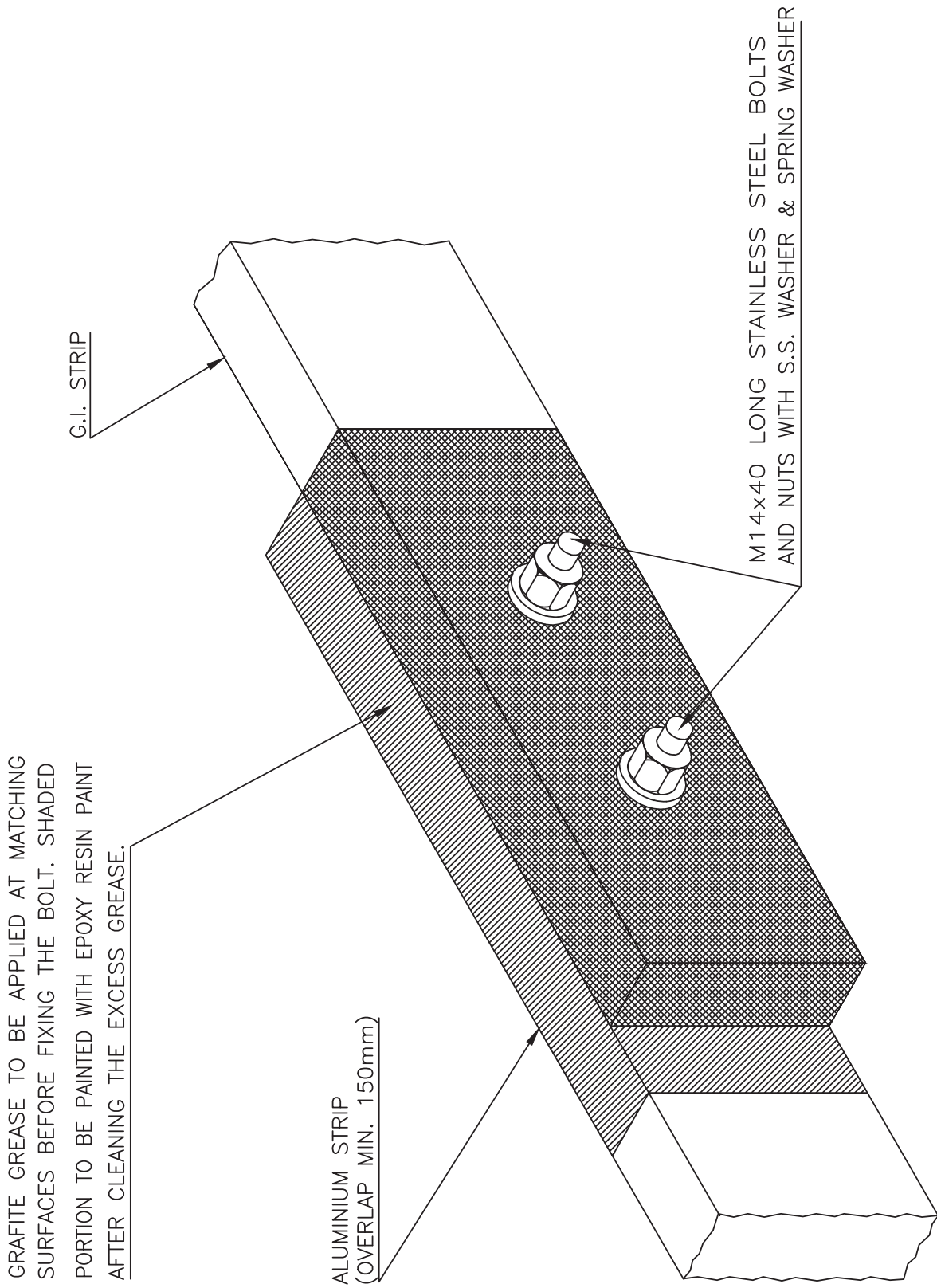
ARRANGEMENT OF DOUBLE EARTH CONNECTIONS TO EQUIPMENT



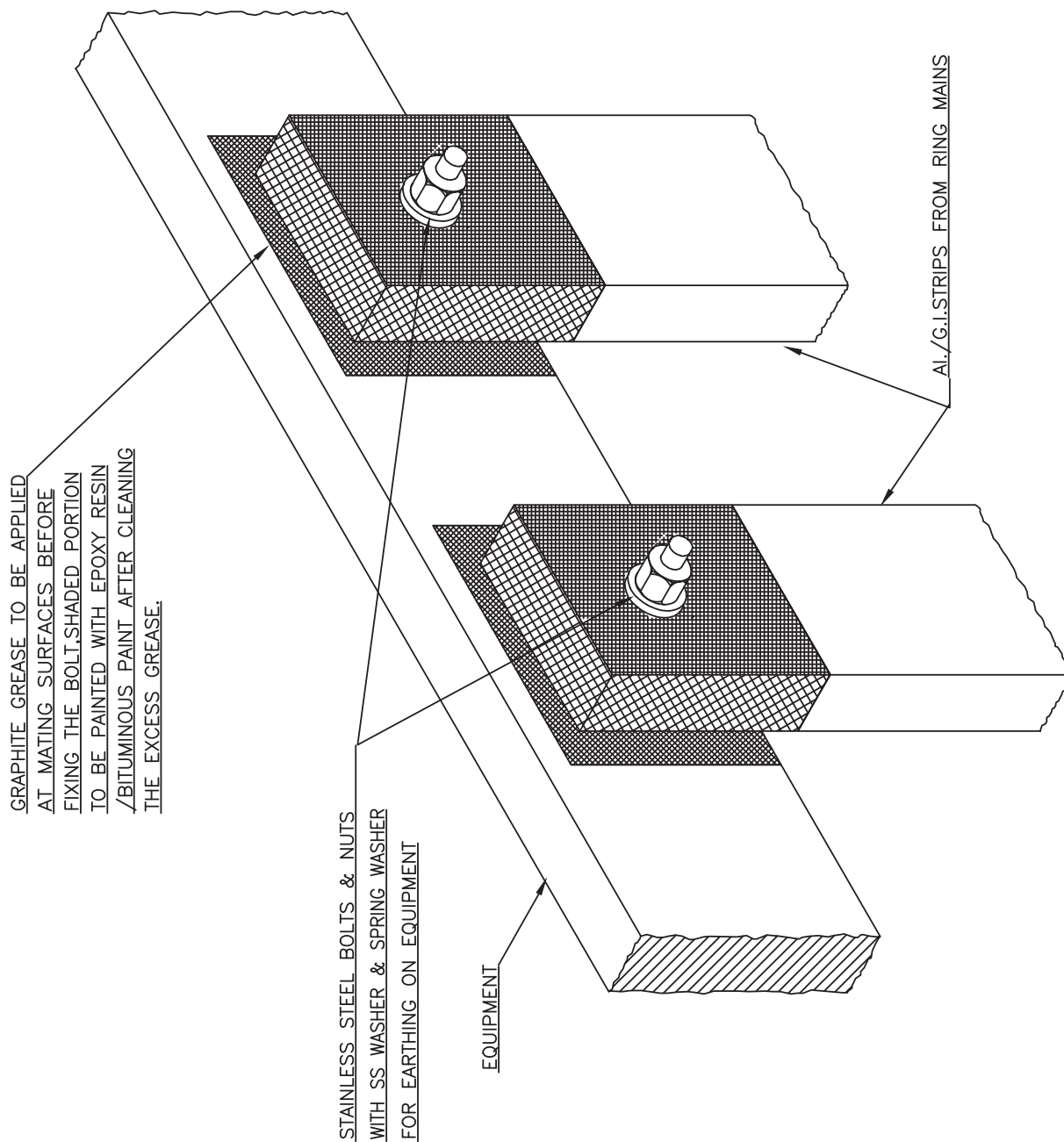
V I E W F R O M - D







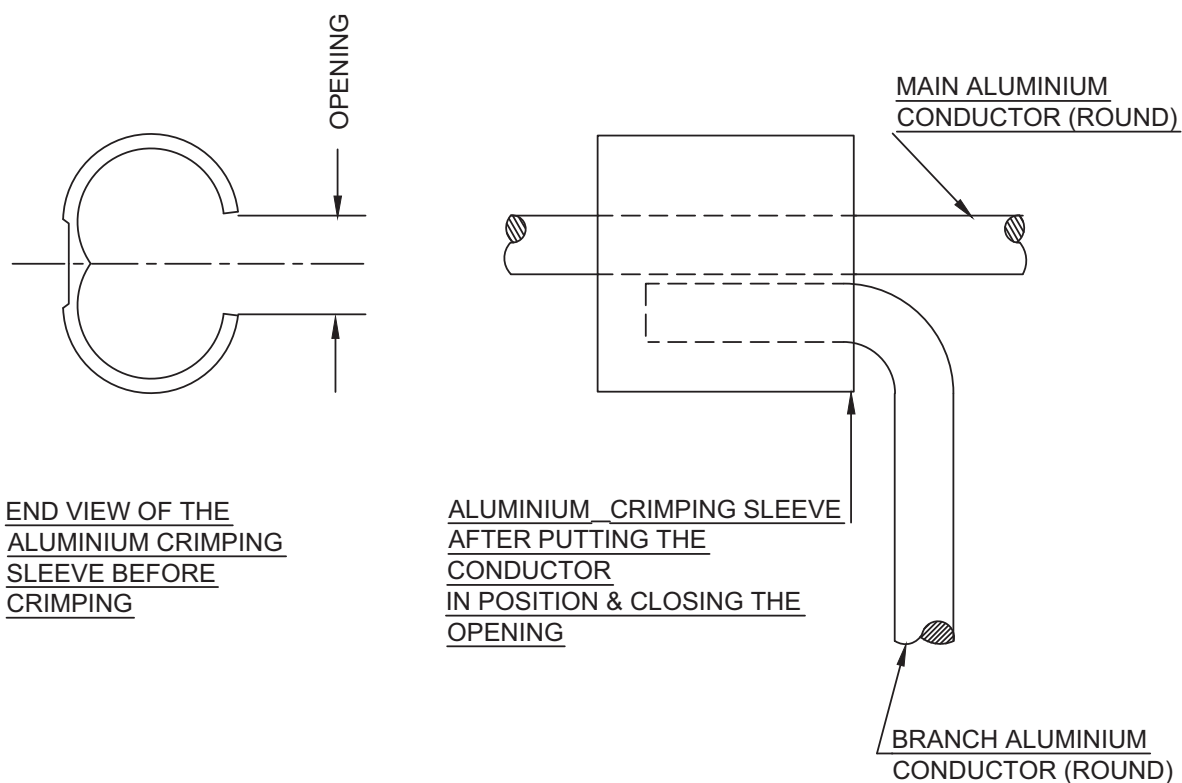
ARRANGEMENT OF LAP JOINT BETWEEN  
AL. EARTH STRIP TO G.I. EARTH STRIP



ARRANGEMENT OF DOUBLE EARTH CONNECTION ON EQUIPMENT

NOTE:-

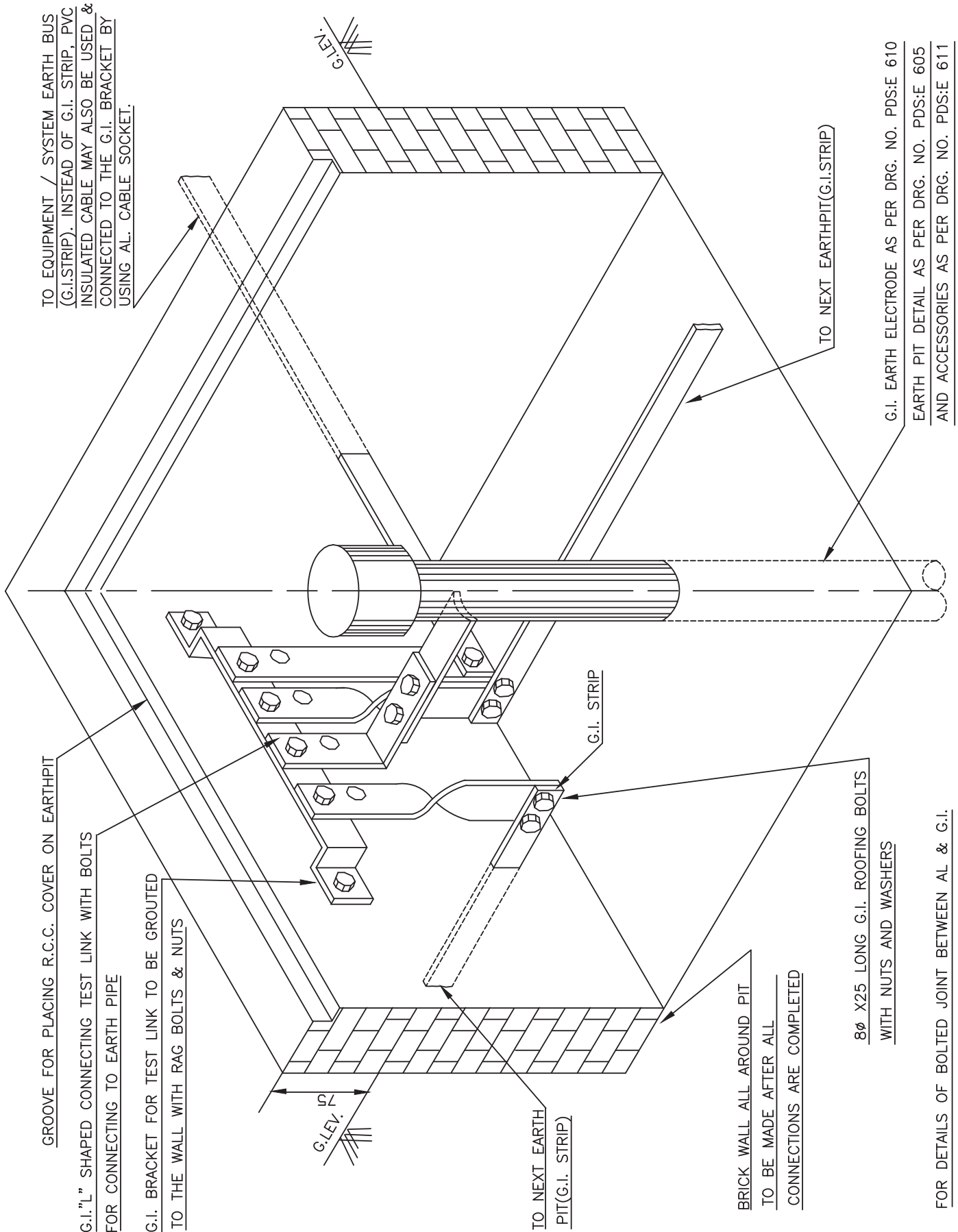
EPOXY RESIN PAINT SHALL BE USED FOR AL STRIP AND BITUMINOUS PAINT FOR G.I. STRIP.

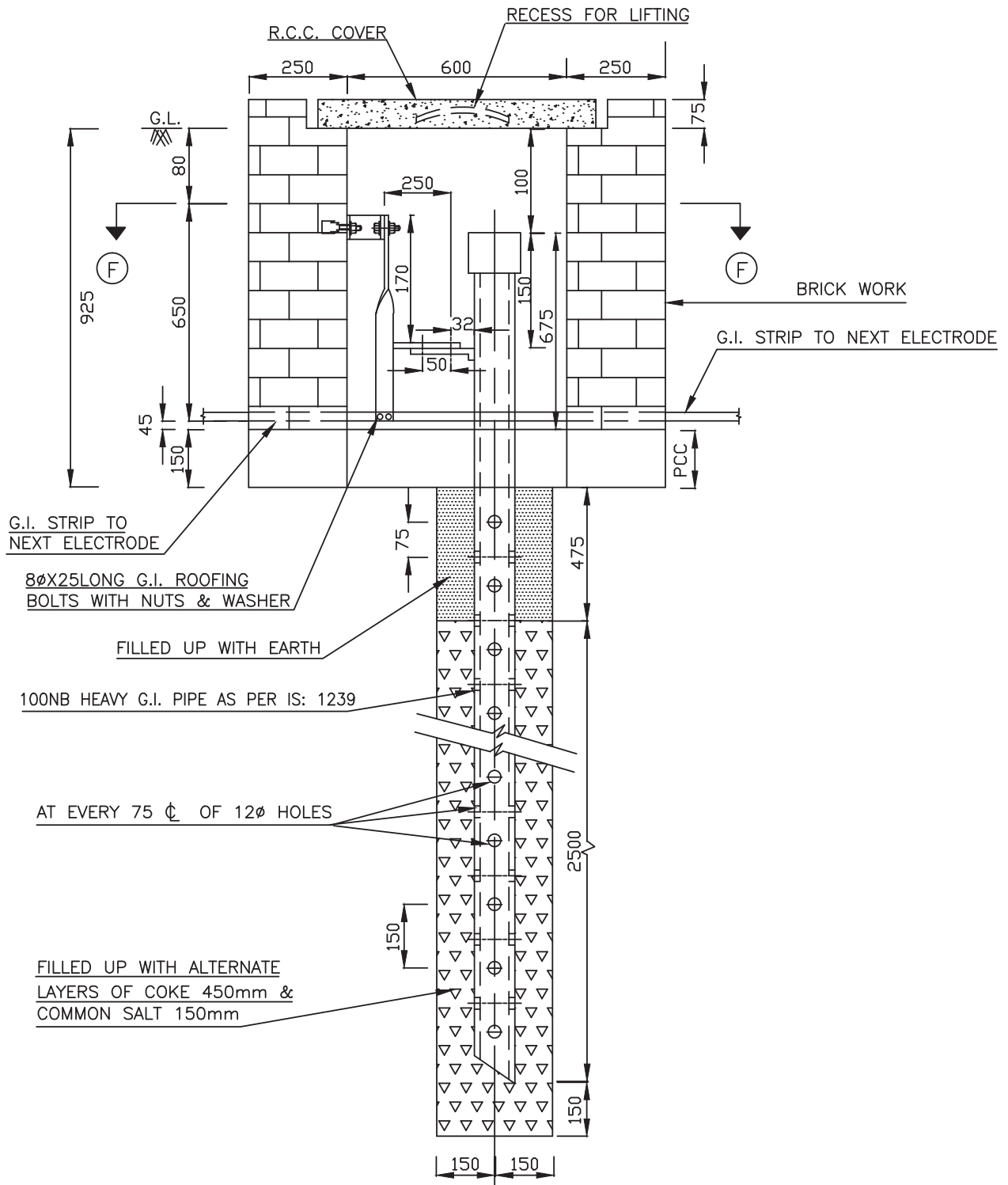


"T" JOINT ROUND ALUMINIUM CONDUCTOR TO ROUND ALUMINIUM CONDUCTOR ( CRIMPING TYPE )

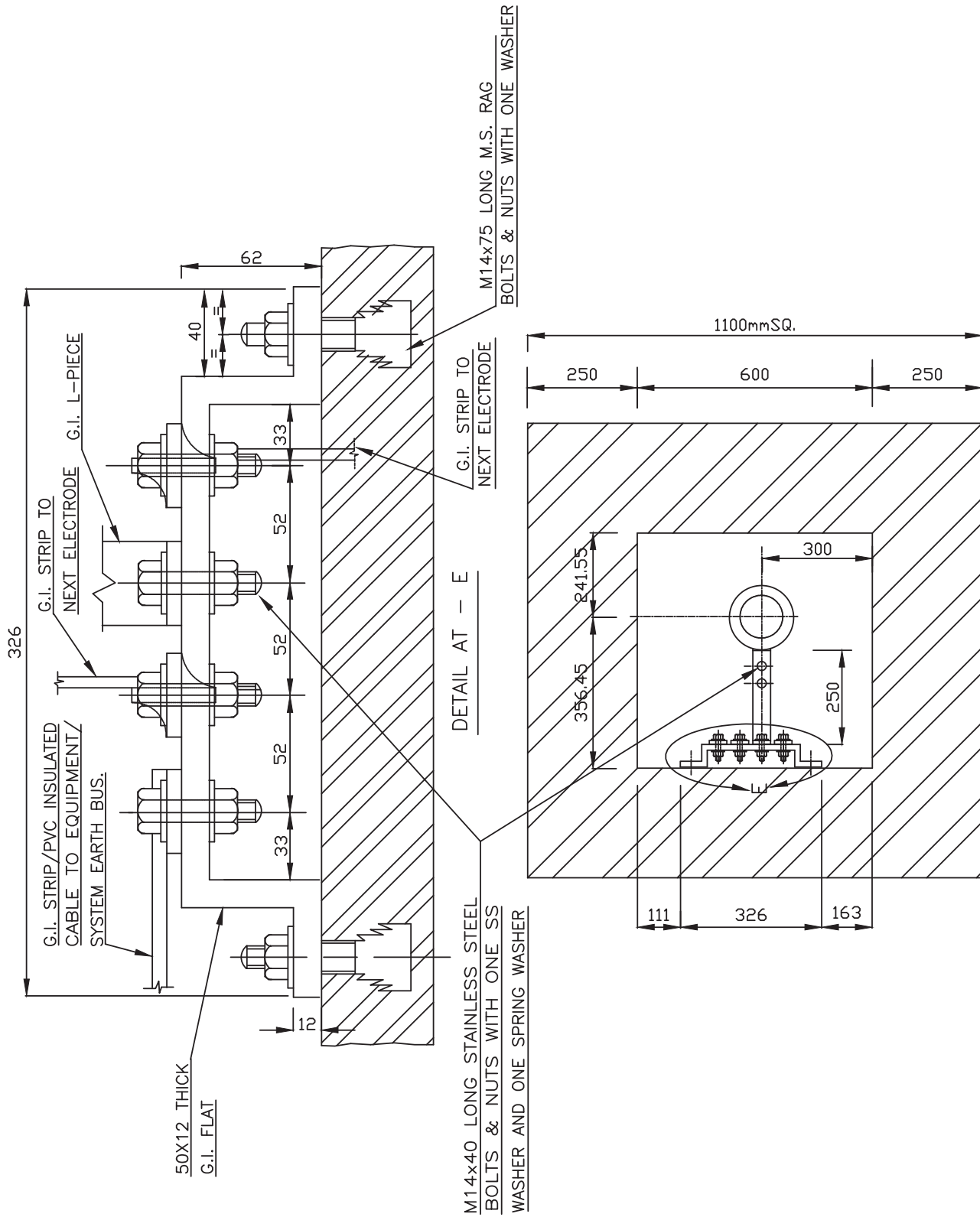
NOTE :-

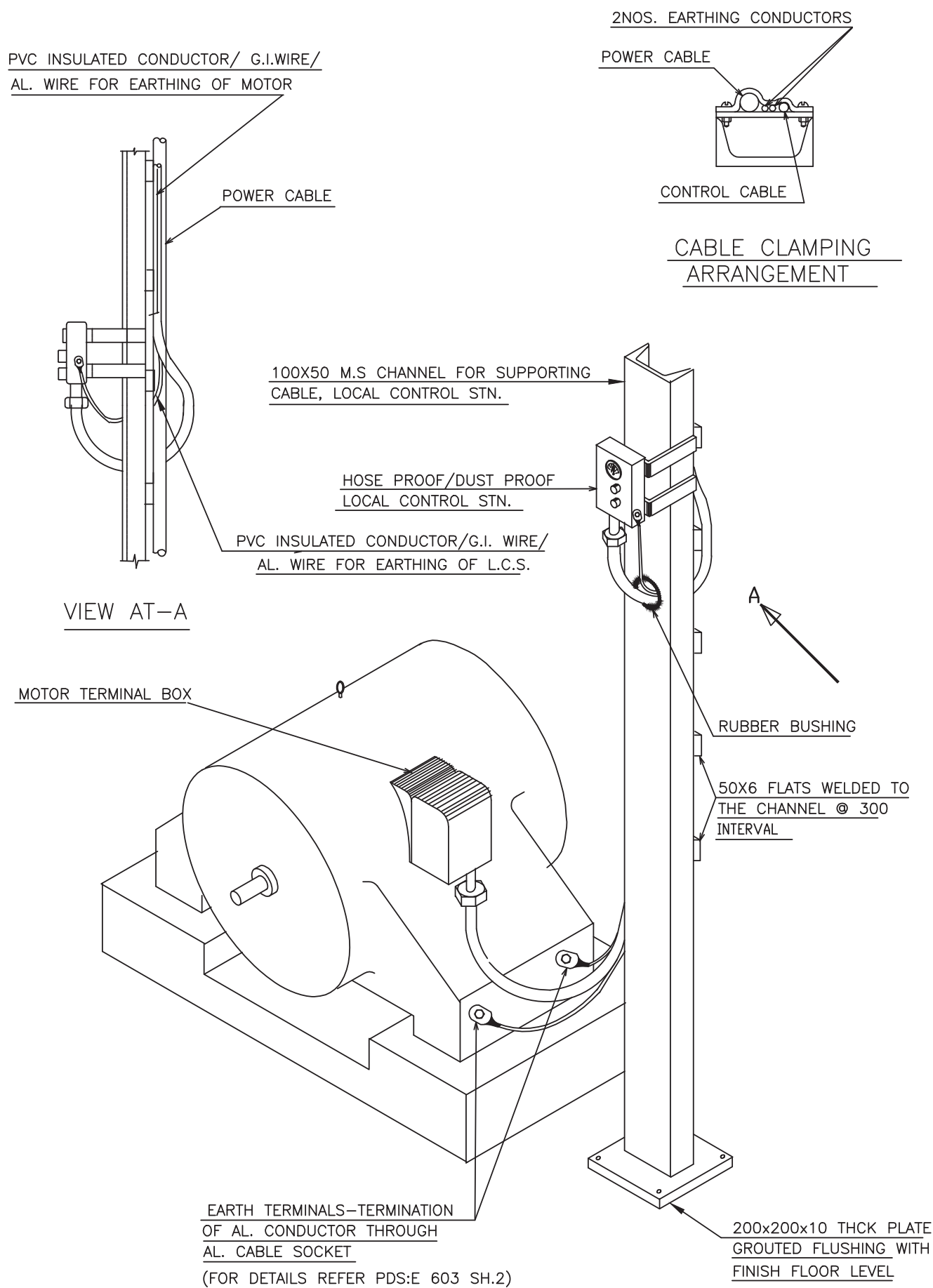
USE CORRECT SIZE OF COMPRESSION DIES.



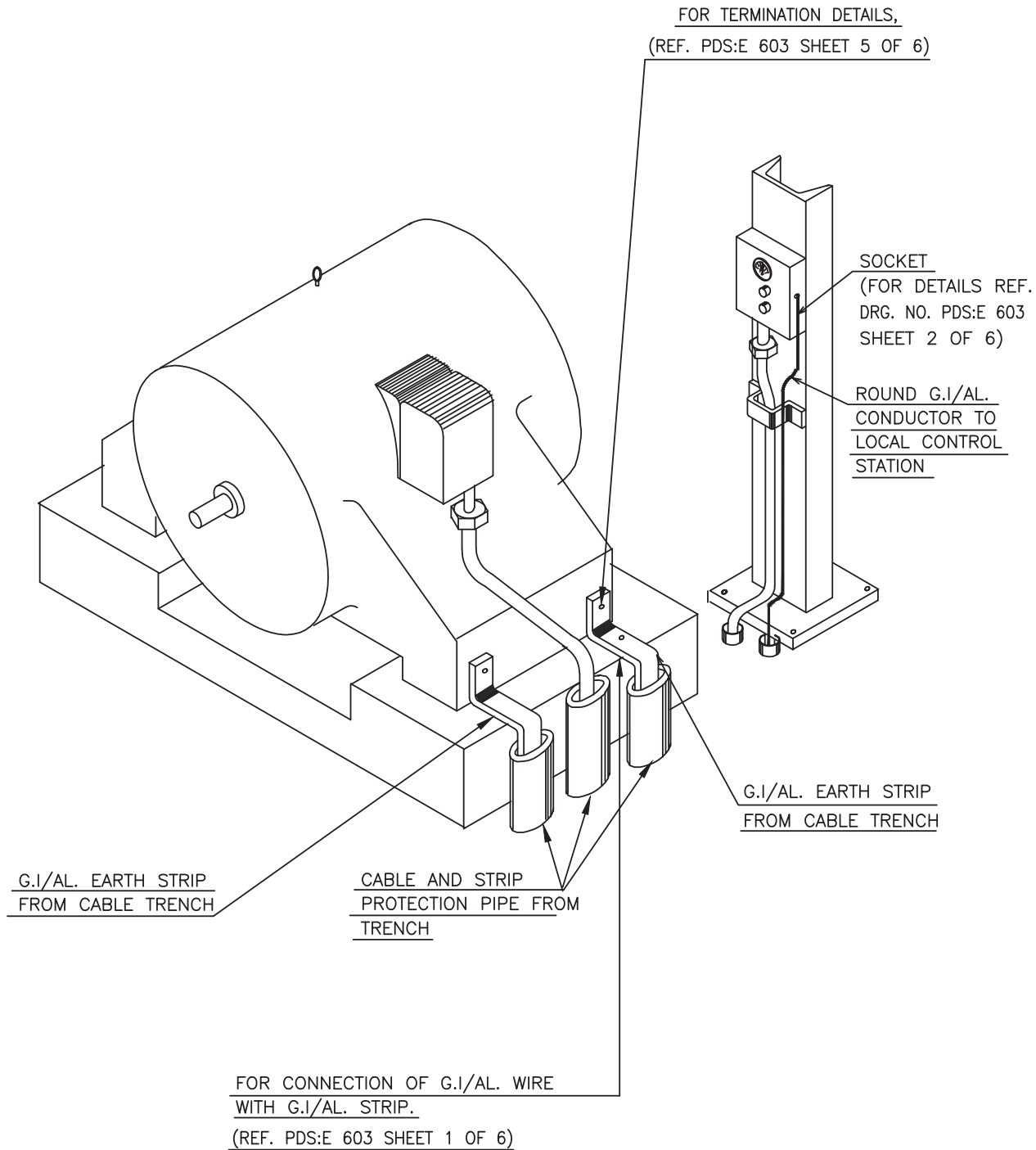


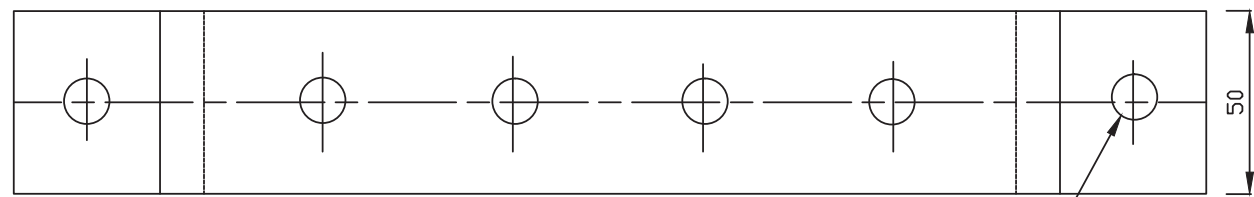
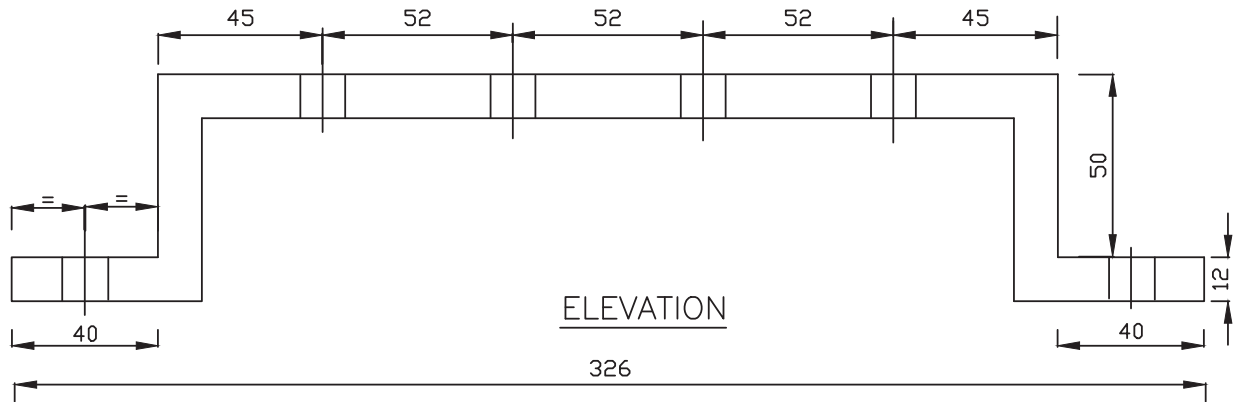
SECTIONAL ELEVATION OF EARTH PIT





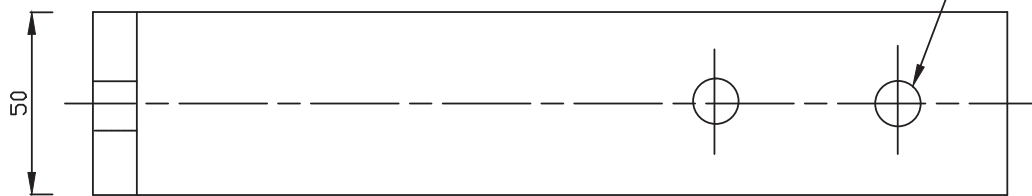




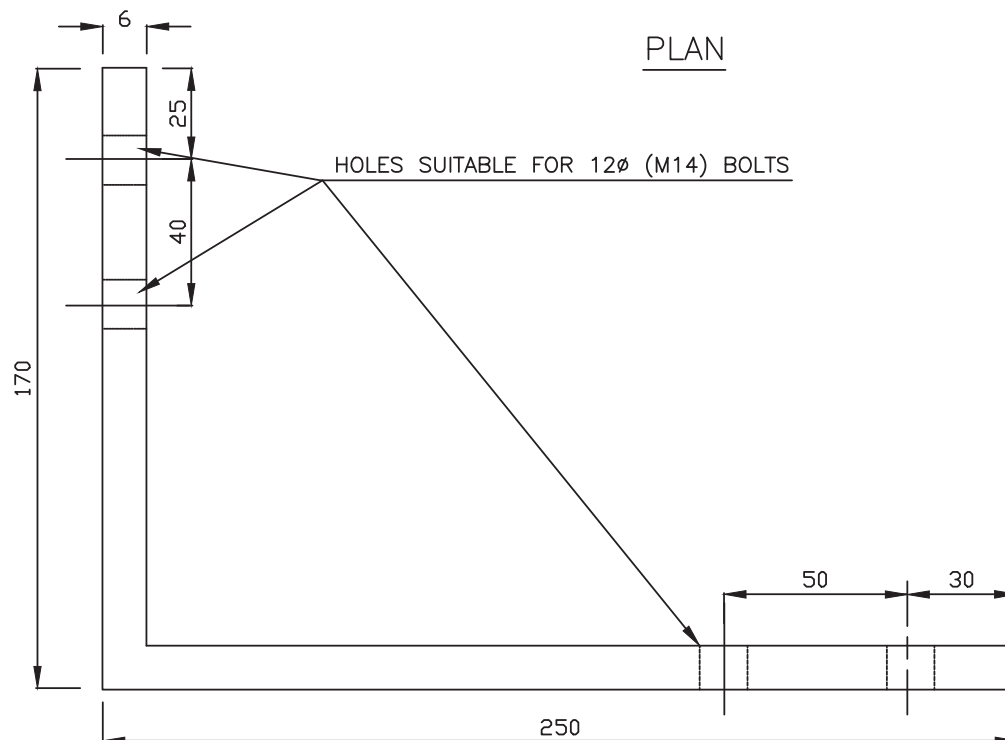


G.I. TEST LINK

HOLES SUITABLE FOR 12 $\phi$  (M14) BOLTS



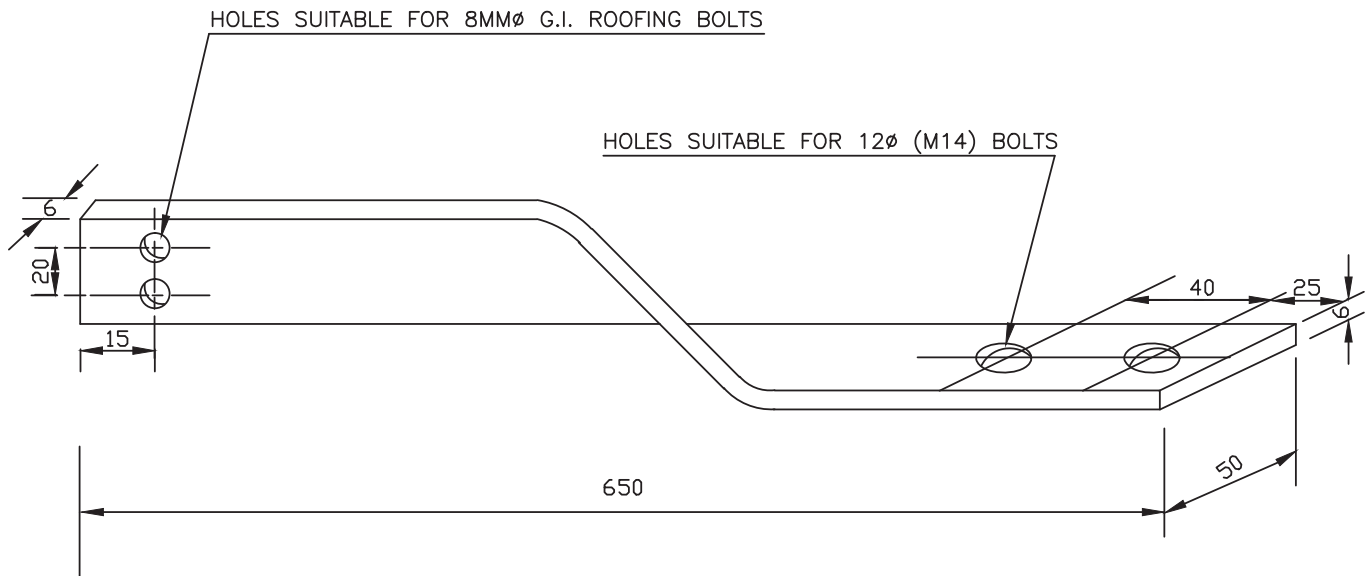
PLAN



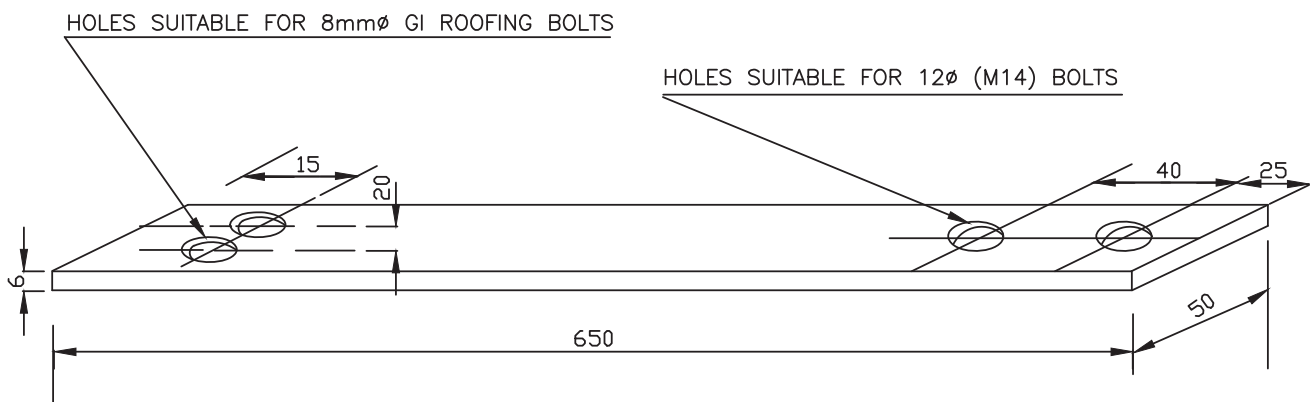
ELEVATION

G.I. 'L' PIECE

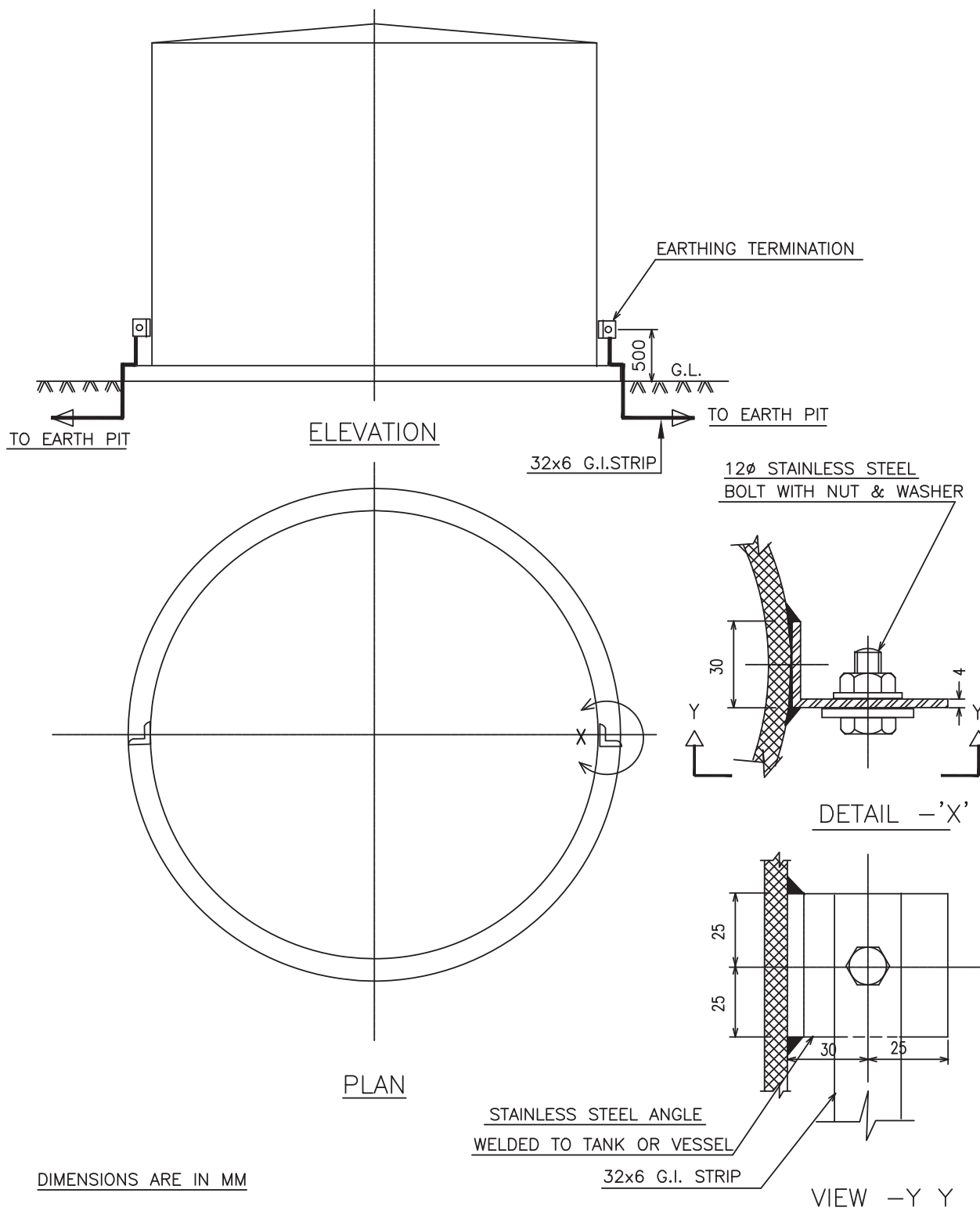
HOLES SUITABLE FOR 12 $\phi$  (M14) BOLTS



CONNECTING TWISTED ALUMINIUM FLAT PIECE

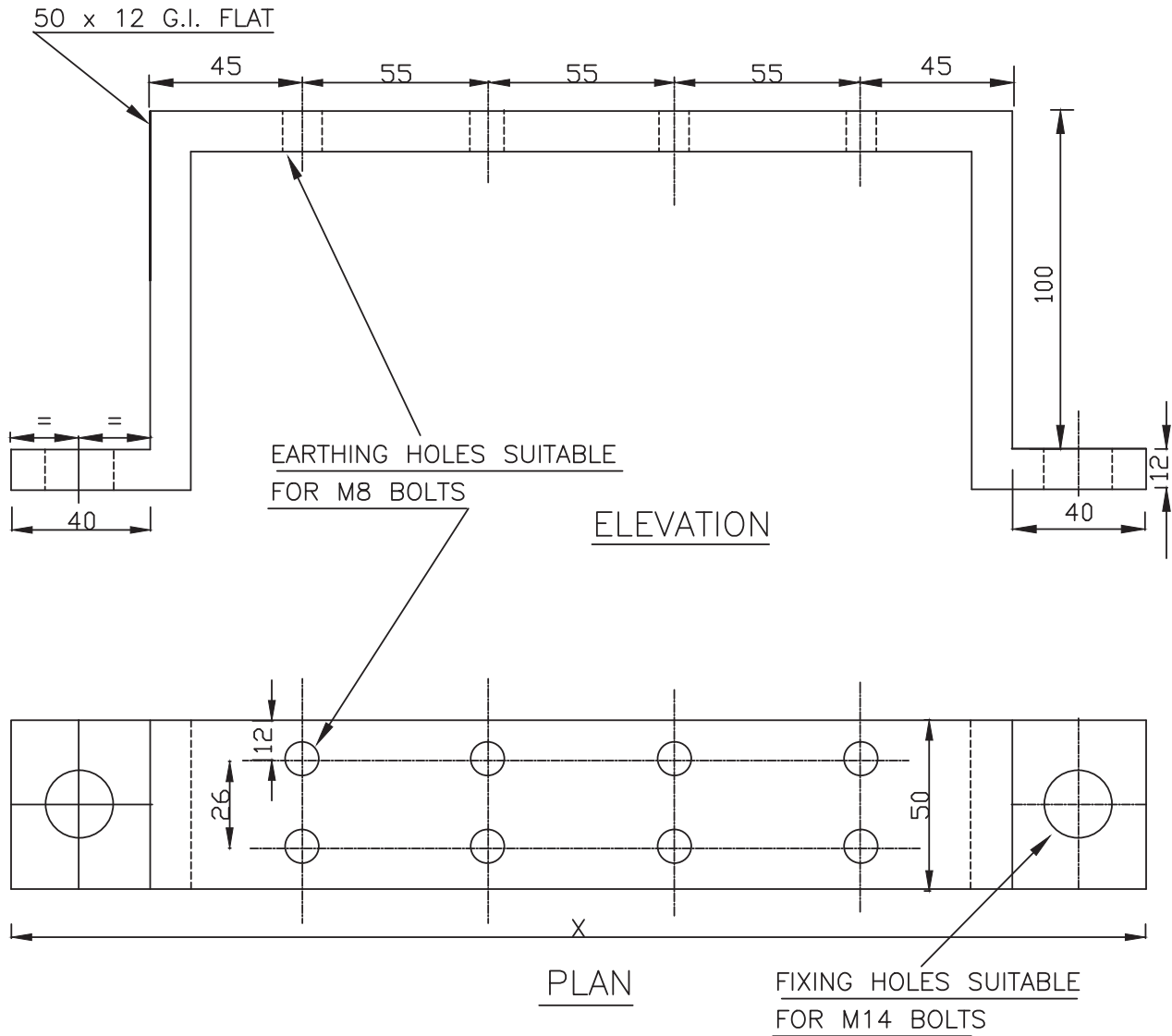


CONNECTING ALUMINIUM / G.I. FLAT PIECE



THE NO. OF EARTH CONDUCTOR SHALL BE AS FOLLOWS

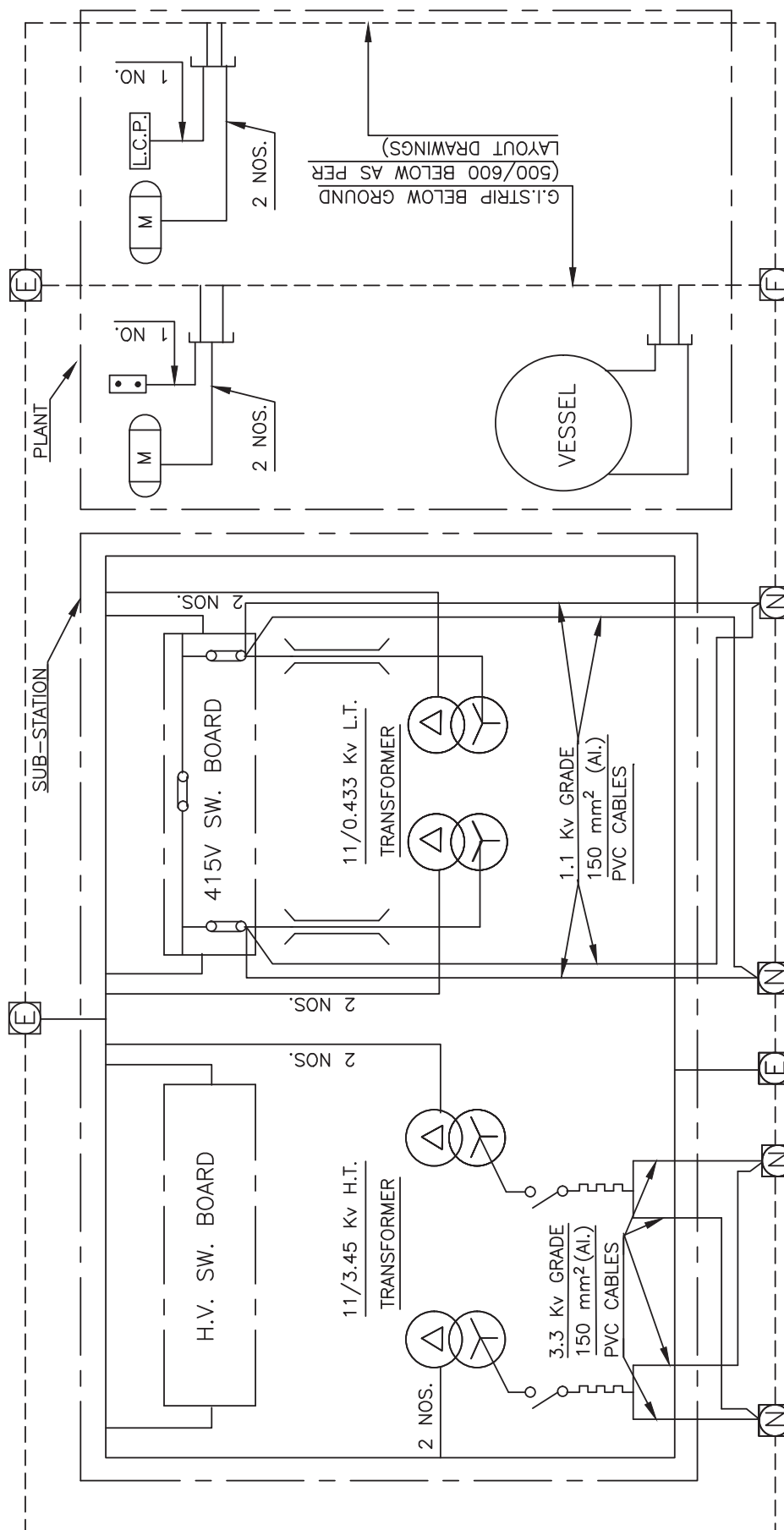
EQUIPMENT WITH ANY DIMENSION	HAZARDOUS AREA	NON-HAZARDOUS AREA
≤ 3 Mts.	1	1
> 3 Mts. ≤ 30 Mts.	2	1
> 30 Mts.	3	2



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













REF. DRGS.

1. EARTH PIT DETAILS - PDS:E 605
2. EARTH CONDUCTOR SIZES - PDS:E 602  
(2 SHEETS)

NOTE :-

EARTH BUS SHALL BE 500 ABOVE FROM FLOOR LEVEL

## LEGEND

- |   |                       |   |                           |
|---|-----------------------|---|---------------------------|
|  | MOTOR                 |  | NEUTRAL LINK              |
|  | LOCAL CONTROL PANEL   |  | TPN BUS DUCT              |
|  | LOCAL CONTROL STATION |  | NEUTRAL EARTHING RESISTOR |
|  | NEUTRAL EARTH PIT     |  | SWITCH                    |
|  | EARTH PIT FOR SYSTEM  |  | EARTH BUS                 |