PART II: TECHNICAL

INDEX

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) PLANT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL)

TELANGANA, INDIA

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PART II: TECHNICAL

SECTION – 1.0

PROJECT DESCRIPTION

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

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1.0 INTRODUCTION

RAMAGUNDAM FERTILIZERS & CHEMICALS LIMITED (RFCL) hereinafter also referred to as "OWNER" was incorporated on 17th Feb, 2015 to set up natural gas-based ammonia urea complex along with offsite & utility facilities at Ramagundam, Telangana with design capacity of 2,200 MTPD Ammonia Unit and 3,850 MTPD Urea Plant.

RFCL is a Joint Venture Company of National Fertilizers Limited (NFL), Engineers India Limited (EIL) and Fertilizer Corporation of India Limited (FCIL) (Promoters) with 26% equity each by NFL & EIL. FCIL has been granted 11% equity in terms of CCEA approval. Govt. of Telangana has taken equity participation of 11% equity. GAIL (India) Ltd. has Equity capital participation of 14.3% and 11.7% of Equity Capital by HTAS Consortium.

The present NIT intends to invite Bids on Domestic Tender basis to establish ZERO LIQUID DISCHARGE UNIT within RFCL, RAMAGUNDAM on Lumpsum Turn Key (LSTK) basis on single point responsibility. For detailed scope or work, refer Technical Specification (Part 2 of NIT)

Projects & Development India Ltd. (PDIL) is Consultant for providing Engineering Consultancy Services and Project Management Services for the aforesaid project.

Brief Scope of work of the LSTK Contractor shall include Project Management, Basic Design Engineering & Detailed Engineering; Dismantling; Procurement; Fabrication; Inspection by Third Party Inspection Agency (TPI) as applicable; Supply; Supply of all spares and consumables; Supply of chemicals (including proprietary chemicals, if any); Manufacture; Insurance; obtaining all necessary statutory approvals; Transportation of all equipment / materials to work site & Storage at Site including Loading, Unloading; Assembly, Erection & Installation; Construction and Erection of all Civil and Structural, Mechanical, Electrical, Instrumentation & Piping works (including Tie-in points), Acid/Alkali resistant proof tiling; Painting, Testing; Mechanical Completion, Pre-Commissioning, Trial Run for 30 days before commissioning; Commissioning; Training of RFCL personnel & Performance Guarantee Test Run (PGTR) for 72 hours; Operation & Maintenance of the plants for a period of 3 years including supply of spares, chemicals & consumables; 5 (Five) years Post Warranty Annual Maintenance Contract (PWAMC) for Control system and handing over of the plants and facilities under contractor's scope of work duly completed on single point responsibility basis.

The following plants/units shall be under the scope of the LSTK Contractor:

"Reverse Osmosis (RO) – Evaporator based Zero Liquid Discharge Plant (ZLD)"

2.0 PLANT LOCATION

Ramagundam site is located at Ramagundam in Peddapalli district of Telangana on the State Highway one. The nearest railway station is Ramagundam at about 10 km from the site. Nearest airport Hyderabad Airport is ~~220~~ km. Nearest sea port is, Vishakhapattanam Port.

3.0 PLANT CAPACITY & CONFIGURATION

RFCL Ramagundam Plant consists of natural gas-based based Ammonia and Urea plants and related off-site and utility facilities. The broad provision of plants and facilities envisaged for the LSTK contractor has been presented in following Tables:

Sl. No.	Plants & Facilities	Capacity
1	REVERSE OSMOSIS (RO) BASED TREATMENT PLANT	300 (MINIMUM) M^3/HR
2	MECHANICAL VAPOUR RECOVERY (MVR) TYPE EVAPORATOR	AS REQUIRED
3	ELECTRICAL DISTRIBUTION	AS REQUIRED
4	PLC & INSTRUMENT CONTROL STATION	AS REQUIRED
5	CONTROL ROOM FOR TREATMENT PLANT	AS REQUIRED

3.1 REVERSE OSMOSIS (RO) BASED TREATMENT PLANT

All liquid effluents generated in the fertilizer complex shall be routed to existing guard pond of total 20000 m3 capacity (two compartments of 10000 m3 capacity each). The mixed effluent from existing guard pond shall be pumped to flash mixer where it will be treated with PAC (Poly aluminium chloride), polyelectrolyte, soda ash, dolomite, ClO2 & lime etc. (based on bidder's requirement) & then will be fed to HRSC (High Rated solid contact clarifier) clarifier for clarification. The clarified effluent shall be stored in clarified water storage tank and then shall be filtered in Dual media filters and UF (Ultra filter) system for removal of colloidal particles. Provision for UF bypass shall also be made to collect treated water directly in UF filtered water storage tank (UFWST).

The sludge from HRSCC clarifier shall be collected in sludge sump from where it will be pumped to thickener. The thickened sludge shall be treated in one (1) no. Centrifuge to

further solidify the sludge. Capacity of centrifuge shall be selected by bidder considering 16 hrs running per day. The solid sludge shall be collected in tractor trolley for disposal. Storage capacity for Fifteen (15) days is required dedicated for sludge storage.

The filtered effluent water shall be passed through cartridge filter and ULTRFILTRATION membrane and shall be stored in UF permeate water storage tank. UF permeate water shall be pumped by HP pumps to RO module in two/three stages. Numbers of RO stages shall be finalised by bidder so as to achieve minimum capacity of MVR evaporator.

3.2 MECHANICAL VAPOUR RECOVERY (MVR) TYPE EVAPORATOR

The RO reject water shall be treated in 2*50 % nos. (2W) MVR type evaporators with 15% design over and above calculated capacity to treat the RO Reject in condensate form which shall be collected in RO permeate tank and sludge from evaporator shall be fed to crystallisers to concentrate sludge in powder form. The powder sludge shall be packed in PVC bags and shall be stored in covered shed of 15 Days capacity.

The RO permeate water can be used as cooling water make-up, transferred by pumping into Cooling tower sumps of existing UCT and ACT with individual isolation valve i.e., Ammonia Cooling tower & Urea Cooling tower. However, provision for diverting the RO permeate water to Fire water reservoir / pump sump in case Main plants are under shut down will also be provided. Provisions for transferring RO/ZLD permeate to existing Cooling water sump including lying of piping will be under scope of supply of LSTK contractor.

Bidder has to furnish the composition of inlet feed to each dual media filter, each UF, each RO and Evaporators.

Brief Description is given above describing the minimum requirement, in addition to this any item/s required shall be provided by the bidder for meeting the guaranteed parameters and for safe, reliable trouble free continuous operation and maintenance requirement of the system.

3.3 SLUDGE HANDLING SECTION

Sludge from ETP clarifier shall be fed to thickener for further thickening. Supernatant from Thickener shall be recycled back to High Rate Solid Contact Clarifier (HRSCC). Settled Sludge from thickener shall be fed to Centrifuge. Dewatering polyelectrolyte shall be dosed at the inlet of centrifuge. Supernatant from Centrifuge shall be fed to HRSCC. Sludge from Centrifuge shall be collected for disposal in tractor trolleys. Storage capacity for Fifteen (15) days is required dedicated for sludge storage.

3.4 CHEMICAL LABORATORY

Bidder shall provide local Chemical Lab/operator cabin along with required lab instruments & equipments to meet the minimum laboratory measurement & analysis requirement of the plants for day to day operation of the plant. Main chemical laboratory is already provided in the existing main plant buildings, no modification is required in the existing chemical lab building for installation of these lab instrument. Bidder shall provide laboratory instruments as mentioned below:

LIST OF LABORATORY INSTRUMENTS FOR ZLD PLANT				
SNO	**ITEM DESCRIPTION**	**QTYY**	**MAKE**	**SPECIFICATION**
1.	pH Meter	1	Metrohm, Mettler Toledo, Hach	Detection range from pH 0-14
2.	Conductivity Meter	1	Metrohm, Mettler Toledo, Hach	Detection range from 0-12800µS/cm
3.	Colorimeter	1		Detection range from 0-500 Hazon
4.	Turbidity Meter	1	Systronics, Hach, Thermo Scientific	Detection range from 0-4000NTU
5.	Hach DR 6000 Meter UV/Vis	1	Hach	
6.	AAS	1	Shimadzu, Agilent, Perkinelmer	For detection of Fe, Zn, Al, Cr, Mn,V, Hg, As, Ca, Mg, Cu, Ni
7.	Flame Photometer	1	Systronics, Aimil	Detection of Na and K from 0-100 PPM
8.	TOC Analyser	1	Shimadzu, Mettlor Toledo, Hach	
9.	Ion Chromatography	1	Metrohm, Shimadzu, Thermo Scientific	For detection of CI, F, NO2, NO3, SO4, PO4, in the detection range of 0-50PPm
10.	Do meter With sensor	1	Hach, Themo scientific	Detection of DO from 0-14PPM
11.	Fume Hood	1		

3.5 TEMPORARY CONSTRUCTION FACILITIES

The LSTK contractor shall arrange following minimum facilities at his own cost for Construction/Erection purpose:

i. **Construction power supply facilities:** Construction Power shall be provided at single point at 415 V (1 no. feeder) on chargeable basis. Further distribution 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 shall be in LSTK Contractor's scope.

ii. **Construction Water Supply facilities:** Construction water shall be supplied at one point at plant battery limit on non-chargeable basis. Further distribution shall be in LSTK contractor's scope.

iii. Construction sheds

iv. Material storage

v. Construction offices

vi. Temporary Communication facilities

vii. Office furniture

PART II: TECHNICAL

SECTION – 2.0

EFFLUENT WATER & TREATED WATER QUALITY

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1.0 FEED EFFLUENT QUALITY

The contaminated liquid effluent generated from various sources shall be collected in existing guard pond after blending it shall be treated in effluent treatment plant to achieve zero liquid discharge (ZLD) from the complex. The quality of blended effluent at discharge of existing guard pond is listed below:

Typical quality of Effluent available at existing guard pond will be:

Sr. No.	Parameters unit Quality	Unit	Quality		
			(Normal)	(Minimum)	(Maximum)
1.	pH		6.5 to 8.5	3	10
2.	Odour and colour		Odour and colourless	Odour and colourless	Odour and colourless
3.	Suspended solid	ppm	35	12	70
4.	Oil and grease	ppm	2 to 5	2	10.0
5.	BOD	ppm	15	7	50
6.	COD	ppm	80	30	250
7.	Ammonical nitrogen as N	ppm	20	10	50
8.	Nitrate nitrogen as N ppm	ppm	15	10	25
9.	Total Kjeldahl nitrogen as N	ppm	**75**	10	90
10.	TDS	ppm	1000	630	**2500**
11.	Conductivity	µmho/cm	**1677**	1050	**3200**
12.	Turbidity	NTU	10	4	**20**
13.	Total Alkanity as $CaCO_3$	mg/L	**200**	170	360
14.	Total Hardness	mg/L	**353**	230	700
15.	Ca Hardness as $CaCO_3$	ppm	**160**	104	315
16.	Mg Hardness as $CaCO_3$	ppm	**193**	126	385
17.	Chloride (as Cl)	mg/L	**306**	**130**	**400**
18.	Sodium (as Na)	ppm	**300**	140	600
19.	Total Iron (Fe)	mg/L	1	0.1	2
20.	Potassium (K)	mg/L	**12**	**5**	**25**
21.	Silica as SiO_2	ppm	**40**	<40	**90**
22.	Nitrate as NO_3	ppm	**25**	0.5	**65**
23.	Sulphate as SO_4^{2-}	mg/L	**165**	**80**	**500**
24.	Manganese as Mn	mg/L	0.2	0.1	1
25.	Zinc as Zn	mg/L	0.6	0.1	**2**
26.	Urea	ppm	5	0	**20**
27.	Phosphate as PO_4^{2-}	ppm	**3**	0.4	5
28.	Total Phosphate	ppm	**8**	**5**	**12**

(1) Since, additional waste water will also be generated in ETP, which will be collected in sump & transfer to flash mixer. Blended quality & quality of effluents shall be re-worked out by bidder & system to be designed for treating stringent quality.

2.0 TREATED WATER QUALITY FROM ZLD

2.1. HRSC clarifier

Clarified water total suspended solid 10 ppm max

Sludge consistency Bidder to indicate.

2.2 DMF

Filtered water total suspended solid 1.0 ppm max

2.3 UF membrane

SDI <3.0

2.4 RO-1/RO-2

Sr. No.	Parameters	RO-1 permeate	RO-2 permeate
1.	pH	7-8.5	7-8.5
2.	Total suspended solids, ppm	NIL	NIL
3.	Total dissolved solids, ppm	100	150
4.	Total hardness as CaCO3, ppm	*	*
5.	Ca hardness as CaCO3, ppm	*	*
6.	Mg hardness as CaCO3, ppm	*	*
7.	Mo alkalinity as CaCO3, ppm	*	*
8.	Chloride as Cl,	*	*
9.	Sulphate as SO4	*	*
10.	Total iron	*	*
11.	Sodium as Na	*	*
12.	Potassium as K	*	*
13.	Reactive silica as SiO2	*	*
14.	colloidal silica as SiO2	BDL	BDL
15.	Organic matter as KMnO4	*	*
16.	Recovery (min).	80%	70%

Figures marked as * are to be indicated by Bidder based on the actual RO membrane projections. In case of consideration of RO-3 train for optimization of Evaporator (i.e. MVR) capacity, recovery shall be min 50%. Guaranteed Quality of permeate water from RO-3 train will be same as mentioned for RO-2.

***2.5* MECHANICAL VAPOUR RECOVERY (MVR) TYPE EVAPORATOR SYSTEM**

Solid waste consistency Minimum 50%

Process condensate TDS 300 ppm

Final salt from Evaporator System shall be Free Flowing powder form.

3.0 UTILITIES

1.	**L.P Steam (for start-up only)**			
		Operating	**Design**	
	Pressure, kg/cm^{2}g (Min/Nor/Max)	2 /3/3.5	6 / FV	
	Temperature, ^{o}C (Min/Nor/Max)	Saturated/154/160	235	
2.	**Cooling Water (Added with suitable chemicals)**			
	Supply Header Pressure, kg/cm^{2}g	4.0		
	Return Header Pressure, kg/cm^{2}g	3.0		
	Mechanical Design Pressure, kg/cm^{2}g	8.5		
	Supply Header Temperature, ^{o}C	35°C		
	Return Header Temperature, ^{o}C	44°C		
	Mechanical Design Temperature, ^{o}C	65°C		
	ΔT	9°C max.		
3.	**Instrument Air**	**Min.**	**Nor./Max**	**Design**
	Pressure, kg/cm^2 g	4.5	7.0/8.0	12
	Supply Temperature, °C		40	
	Design Temperature, °C	65		
	Dew point	-40 ^{o}C at Atmospheric pressure		
4.	**Service Water**	**Min.**	**Nor./Max**	**Design**
	Pressure, kg/cm^2 g	3.5	5.0/6.0	10.1
	Supply Temperature, °C	Amb.		65
5.	**Drinking Water**	**Min.**	**Nor.**	**Design**
	Pressure, kg/cm^2 g	4.0	5.0	7.5
	Supply Temperature, °C	Amb.		65
6.	**Power (refer Electrical design philosophy of NIT)**			

PART –II: TECHNICAL

SECTION – 3.0

CONTRACTOR SCOPE OF WORK

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

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1.0 GENERAL

The LSTK Bidder's scope of work shall include Basic Design Engineering & Detailed Engineering; Dismantling; Procurement of complete materials & bought out items whatever deemed necessary for Fabrication; Inspection by Third Party Inspection Agency (TPI) as applicable; Supply; Manufacture; Insurance; obtaining all necessary statutory approvals; Transportation of all equipment / materials to work site & Storage at Site including Loading, Unloading; assembly, erection & Installation; construction and erection of all civil and structural, mechanical, electrical, instrumentation & Piping works (including Tie-in points), Acid/Alkali resistant proof tiling; Supply of all spares and consumables,; Supply of chemicals (including proprietary chemicals, if any); Painting, testing; Mechanical Completion, Pre-Commissioning, Trial Run for 30 days before commissioning; Commissioning; Training of RFCL personnel & Performance Guarantee Test Run (PGTR) for 72 hours Operation & Maintenance of the plants for a period of 3 years including supply of spares, chemicals & consumables; 5 (Five) years Post Warranty Annual Maintenance Contract (PWAMC) for Control system including Project Management and handing over of the plants and facilities under contractor scope of work duly completed on single point responsibility basis.

In the proposed plot location for ZLD, there are 2 nos. Raw water storage tanks (abandoned). Dismantling of these abandoned tanks shall be in the scope of LSTK contractor. There are few utility lines (service water, Fire water & Instrument air) which are to be re-routed; same shall be in the scope of LSTK contractor. Existing pumps Tag no. 307-PA-005 A&B (Treated effluent pump for using Toilet flushing) are to be dismantled and new effluent transfer pumps (of the required capacity) for Treatment plant are to be installed. Required piping modification to retain the existing scheme (including allied civil works) has to be done. These works shall be in the scope of LSTK contractor. For detail refer Section- 5.5 Civil–of NIT.

Any work not listed herein but is necessary for completion and smooth & trouble free operation of the ZLD plant as well as those required as part of good engineering practices shall be deemed to be included.

The detailed scope of LSTK Bidder's work includes but not limited to the following:

I. One (1) RO based Treatment Plant of net capacity 300 M3/hr followed by Mechanical Vapour Recovery (MVR) Type Zero Liquid Discharge Plant (ZLD) and

related equipments designed and constructed in accordance with the specifications stated herein.

II. Detailed process design including preparation of P&ID, mass balance diagram, control and logic diagram, interlock schemes, etc.

III. Detailed design of plant and equipment, instrumentation, electrical and control system, control and logic diagram, interlock schemes, etc., detailed design of structural work.

IV. Detailed equipment layout, piping GAD & isometrics, 3D modelling, battery limit hook ups and other works as required.

V. The piping required for the utilities required to ZLD from the hook-up location shall be in contractor's scope of work..

VI. The piping required for the lines to/from guard pond, water to cooling water make-up/fire water reservoir shall be in contractor scope".

VII. The complete civil and structural work for ZLD plant including site grading, site survey & soil investigation, modification of existing control room, detailed design, preparation of all drawings for construction, fabrication, erection, grouting, etc. of all structural works e.g. platforms, stairs, ladders, hand railing (including insert plates) and wherever required, pipe and cable racks / supports, underground & above road crossing (including culvert / trench) for piping and cabling, etc. are to be included.

VIII. Procurement as per vendor list, Appointment of Third Party Inspection Agency (TPI) as per TPI list mentioned in NIT & arranging inspection as per approved QAP (Quality assurance plan).

IX. Bidder scope of Work (For Static Equipment) shall include but shall not be limited to following:

- Complete mechanical design & thermal design (For heat exchanger)
- Detailed engineering of equipment including all mountings, accessories & bought-out items
- Procurement of all materials & bought out items
- Shop/site fabrication (as applicable) & assembly
- Route survey if required
- Inspection, testing (including hydro testing)
- Surface preparation, painting, insulation, pickling and Passivation (for SS equipments), internal and/or external coating, epoxy coating, rubber lining etc.
- Packing (seaworthy when sea transportation) forwarding, transportation to site etc.
- N2 filling of equipment

- Storage and preservation at site
- Statutory approvals
- Stage wise and final inspection by appointed TPIA/Owner
- Fire proofing as per requirement of the bid package
- Any other requirement for safe and smooth operation
- Submission of engineering drawing & document for Owner/PDIL review. All drawing submitted to owner/PDIL shall be thoroughly checked by contractor before submission
- Supply of "As Built documentation and QC dossiers

The above mentioned activities shall be carried out in accordance with applicable code and all technical requirements covered in the bid package.

In case of conflict between the above referenced documents, the same shall be reported in writing to Owner/ consultant for clarification and resolution. However in case of conflict stringent condition shall be governed

X. Bidder scope of supply shall include but shall not be limited to following:

- Supply of static equipment (Vessels, Tanks, etc.) including their accessories
- Supply of all fabricated and proprietary internals for all equipment as applicable
- Supply of mandatory (Spare parts for (2) Two year operation) and commissioning spares attached elsewhere in bid package
- Insulating material, primer paints fire proofing material etc.
- Supply of material & equipment required for blast cleaning, chemical cleaning, pickling Passivation, surface preparation & polishing & coating of internal surface, epoxy coating, rubber lining, and FRP lining etc. for equipment as applicable
- Supply of all equipments, tool & tackles including torque wrench, bolt tensioner etc. as per specification and all material required for inspection and testing (i.e. NDT, Hydro testing, performance testing etc.) erection & Hydro testing including all site re-hydro tested equipment.
- Supply of all tools and tackles, template for foundation for heavy lift equipment and for the erection for all equipment
- Lifting lugs / erection lugs
- Cleats for earthing connections
- Name plate with bracket
- Test blind flanges. (for hydro testing)
- Cover flanges for manholes, hand holes, inspection openings etc. with bolting and gaskets

- Supply of all other materials whether specifically mentioned or not but required for completion of the job in all respect as per bid package

XI. RCC Drains, storm water drainage system and roads within the ZLD battery limit. Approach road and fencing are also included in LSTK Bidder's scope.

XII. Construction of RCC pavements, foundations and inside kerbs as and where required, pipe/cable racks and supports. LSTK Bidder shall rectify the road as per specification, if damaged during construction of road crossing for piping and cabling.

XIII. All architectural works including plastering, painting, roof treatment, doors, windows, ventilators / exhausts, flooring, skirting, rain water pipes, sanitary fittings, wash basin and tiling in laboratory/wash rooms, etc. as per specific requirements, standards, specifications and drawings etc., all complete.

XIV. Complete mechanical works, design, and procurement of materials, supply, fabrication, erection and testing.

XV. Storage & handing at site.

XVI. Complete instrumentation work for smooth operation, control and monitoring.

XVII. Complete design, procurement, supply erection, testing and pre-commissioning & commissioning of electrical & instrumentation Works, including lighting switch gears, earthing, power for instrumentation, drives, power and control cabling, cable trays/trenches all complete as per standards etc.

XVIII. Erection & Installation of all equipments and materials at site including Mechanical, Electrical & Instrumentation work at site.

XIX. 25 NB discharge line from ZLD to water analysis room, instrument rooms, oil and gas analysis room, resin and raw material testing room and pollution control room of chemical laboratory with isolation valves shall be provided.

XX. 25 NB instrument air pipeline be provided in all the rooms mentioned under clause (q) above

XXI. Complete plant lighting i.e. inside the control room and outside within plant battery limits for area lighting including fixtures, accessories, cabling, conduiting, earthing switch gear, welding receptacles, etc. all complete.

XXII. Cleaning and external painting of all vessels, tanks equipments, piping, structural hand railing, platforms, ladder, stairs, inserts, etc. for relevant environment.

XXIII. Clear the Battery Limit of all construction aids, debris, etc. and provide a tidy work plan.

XXIV. All documents/drawings shall be submitted by LSTK Bidders as per documentation schedule & general specification as referred in technical specifications of Civil, Mechanical, electrical and Instrumentation.

XXV. Mechanical Completion, Pre-Commissioning, Trial Run for 30 days before commissioning; Commissioning; Training of RFCL personnel & Performance Guarantee Test Run (PGTR) for 72 hours.

XXVI. Arrange all necessary instruments, tools/tackles required to aid pre-commissioning, commissioning and performance guarantee tests.

XXVII. Any other item required.

XXVIII. Monthly progress report (with S-curve).

XXIX. Documentation & approvals including approvals from statutory authorities including those required to be taken by client.

XXX. All statutory approval shall be in the scope of LSTK Bidder except consent to establish & consent to operate.

XXXI. Design calculations sheet shall be furnished for all chemical consumption based on the inlet effluent quality parameters as per ZLD Plant design basis. This may be used for any corrections required during performance guarantee test run.

XXXII. Supply of all spares and consumables, supply of chemical (including proprietary chemical, if any) required for plant operation during start-up, pre-commissioning and commissioning, Trail runs & performance guarantee test run shall be in the scope of LSTK contractor.

XXXIII. Submission of O &M Manuals.

XXXIV. Preparation of Tender for disposal of sludge / salt generated by the ZLD system, along with list of recommended agencies.

XXXV. 5 (Five) years Post Warranty Annual Maintenance Contract (PWAMC) for Control system.

XXXVI. Operation & maintenance (O&M) of the ZLD plant for three (03) years from the date of commissioning of the plant. The scope of 3 (Three) year O&M activities shall be inclusive of Manpower/Operators, Supply of all spare and consumables including RO/UF membrane, Tools & tackle and supply of all chemical (including proprietary chemical, if any). The start date (Zero date) of O&M activities shall be the data of successful commissioning of the plant.

2.0 STATUTORY CLEARANCES

All the applicable safety codes, national laws and local regulations shall be followed by the successful bidder for the design, engineering, fabrication, erection, commissioning & handing over of the Plant / Equipment and necessary approvals shall be obtained from the concerned statutory authorities by the contractor. Statutory bodies from which approvals may have to be taken include State Pollution

Control Board, chief Inspector of Boilers / IBR, Factory Inspectorate, Labour Authorities, Electrical Inspectorate and Chief Controller of Explosive, Directorate General of Mines and Safety requirements etc. The contractor shall ascertain requirement of approvals as applicable in such Plants and initiation of action as required shall be in contractor's scope.

3.0 SAFETY

These activities shall be carried out by contractor as specified elsewhere in the tender document. All safety procedures for different types of work as per the safety rules from time to time by PDIL/Owner shall be binding and adhered to by the contractor. Safety report generation for different situations as per the rules and required by PDIL/Owner are to be adhered to. HAZOP shall be arranged by contractor. This shall be carried out for the system by an Independent agency approved by PDIL/Owner. Any requirement arising thereof shall be implemented by the contractor without any time and cost implication to the owner.

4.0 SUPPLY OF CONSUMABLES & CHEMICALS

Supply of all chemicals, spares and consumables required for the Operation and Maintenance of the plant during start-up, pre-commissioning, commissioning, trial runs and performance guarantee test runs shall be in the scope of supply of the LSTK contractor. Special chemicals required, if any, shall be clearly defined by the bidders during bid stage with respect to quality & quantity and the supply of the same shall be in contractor's scope. Unloading, handling and storage of all chemicals and consumables (including provision of necessary facilities) shall be done by the Operation & maintenance (O&M) of the ZLD plant for two years from the date of commissioning of the plant. The scope of 3 (Three) year O&M activities shall be inclusive of Manpower/Operators, Supply of all spare and consumables including RO/UF membrane, Tools & tackle and supply of all chemical (including proprietary chemical, if any). The start date (Zero date) of O&M activities shall be the data of acceptable of PGTR.

5.0 SPARES

- **Mandatory spares:**

Requirement of mandatory spares as mentioned elsewhere shall be provided by the bidder. Mandatory spares are to be provided by the bidder within the quoted lump sum price. Refer Document no. PC211/E/001/P-II/Sec-9.0 for mandatory spares.

- **Special tools and tackles:**

  Contractor to ensure supply of all special tools and tackles for operation and maintenance of the entire plant. The lump sum price, for the Package, quoted shall be deemed to be inclusive of cost of such tools.

PART –II: TECHNICAL

SECTION – 4.0

DESIGN BASIS

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

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1.0 DESIGN CAPACITY

RO based treatment plant with Zero Liquid discharge (MVR type) system - 300 m3/hr

2.0 PROCESS DESCRIPTION

2.1 RO based Treatment Plant

All liquid effluents generated in the fertilizer complex shall be routed to existing one guard pond of total 20000 m3 capacity (two compartments of 10000 m3 capacity each). The mixed effluent from existing guard pond shall be pumped to flash mixer where it will be do treated PAC (Poly aluminium chloride), polyelectrolyte, soda ash, dolomite, ClO2 & lime etc. (based on bidder's requirement) & then will be fed to HRSC clarifier for clarification. The clarified effluent shall be stored in clarified water storage tank and then shall be filtered in Dual media filters and UF (Ultra filter) system for removal of colloidal particles. Provision for UF bypass shall also be made to collect treated water directly in UF filtered water storage tank (UFWST). Numbers of RO stages shall be finalised by bidder so as to achieve minimum capacity of MVR.

The sludge from HRSCC clarifier shall be collected in sludge sump from where it will be pumped to thickener. The thickened sludge shall be treated in One (1) no. Centrifuge to further solidify the sludge. The solid sludge shall be collected in tractor trolley for disposal. Storage capacity for 15 days is required for sludge storage.

2.2 Mechanical Vapour Recovery (MVR) Type Evaporator:

The RO reject water shall be treated in 2*50 % nos. (2W) MVR type evaporators with 15% design over and above calculated capacity to treat the RO Reject in condensate form which shall be collected in RO permeate tank and sludge from evaporator shall be fed to crystallisers to concentrate sludge in powder form. The powder sludge shall be packed in PVC bags and shall be stored in covered shed of 15 Days capacity.

The RO permeate water can be used as cooling water make-up, transferred by pumping into Cooling tower sumps of existing UCT and ACT with individual isolation valve i.e., Ammonia Cooling tower & Urea Cooling tower. However, provision for diverting the RO permeate water to Fire water reservoir / pump sump in case Main plants are under shut down will also be provided. Provisions for transferring RO/ZLD permeate to existing Cooling water sump including lying of piping will be under scope of supply of LSTK contractor.

Steam shall only be available during the start-up and during the normal operation of the plant, if steam is required in ZLD contractor to make arrangements accordingly.

2.3 Sludge handling Section

Sludge from clarifier shall be fed to thickener for further thickening. Supernatant from Thickener shall be recycled back to High Rate Solid Contact clarifier (HRSCC). Settled Sludge from thickener shall be fed to Centrifuge. Dewatering polyelectrolyte shall be dosed at the inlet of centrifuge. Supernatant from Centrifuge shall be fed to HRSCC. Sludge from Centrifuge shall be collected for disposal in tractor trolleys.

3.0 TECHNICAL SPECIFICATION

3.1 Zero Liquid Discharge Plant

1	**Guard pond (Existing)**		
	Capacity	M3	20000
	Compartments		Two compartments of 10000 m3 capacity each
2	**HRSCC Feed Pump**		
	No.		2 (1W+1S)
	Capacity		As per deign requirement
	Type		Horizontal Centrifugal
	MOC		
	Casing		2%Ni, Cast Iron IS-210 FG260, ASTMA48 No. 35
	Impeller		SS-CF-8M
	Shaft		SS-410
	Shaft Sleeves		SS-316
	Flow Transmitter i.e. (FT) at discharge shall be provided.		
3	**Clarifier -I**	Type	High Rate Solid Contact Clarifier
	Number of Clarifier	No.	1
	Capacity	M3/hr	As per design requirement
	Type & Construction		RCC epoxy painted

	Inlet turbidity	NTU	500 (for design)
	Effluent quality	NTU	<20
	Retention in Draft Tube	min	1
	Retention in Flocculation Zone	min	20
	Rise rate projected	$M^3/hr/m^2$	1.8
	Bridge		Fixed – Full length-MSEP
	Shaft		MS
	Sludge blow-off:		
	a) Continuous		By gravity through pipe for continuous discharge.
	b) Intermittent		Through timer operated blow-off valve
	Sludge Consistency		2%
	Hydraulic Loading margin in Civil work		20%
4	**Clarified I Water sump**		
	Number	No.	One (1)
	Effective capacity	m^3	600
	MOC		RCC, above ground, covered
	Free board	mm	300 (min)
5	**DMF feed pump**		
	Numbers	Nos.	Three (3) (2W+1S)
	Type		Horizontal
	Pump Capacity each (Net)	CMH	As per design requirement
	Head	MWC	As per system req.
	Material of Construction		
	Casing		2.0% Ni-Cast iron IS210 FG260, ASTM A48 No 35
	Impeller		SS-CF 8M
	Shaft		SS-410
	Shaft sleeves		SS-316
6	**Chemical House**		
	Number	No	One (1)
	Type		Two (2) storied building RCC for 30 days storage
	Ground Floor		Chemical storage for Effluent treatment Plant
	First Floor		Location of Chemical Tanks EL

			Approx. 5.0m.				
	Handling Facility		Mono-rail with motor operated pulley block capacity 1.0 MT				
7	**Dosing System**	Nos.	PAC/FeCL3	Lime	Poly	Soda ash	Dolomite
	Dosing Tanks		PAC Tank	Lime Tank	Polyelectrolyte Tank	Soda ash tank	Dolomite tank
	Numbers required Minimum		two	Two	Two	Two	Two
	Construction		RCC	RCC	MSRL	SS-316	CS
	Minimum total effective Capacity of each tank	m^3	Adequate to hold 7 days requirement on design flow & dosing with 20% margin				
	Free Board	Mm	300 min.				
	Solution strength	%	10		5		0.1
	Agitator – type		Vertical		Vertical		Vertical
	- MOC		SS		SS		SS
	Dissolving basket		In SS Construction with 10 mm dia holes on 50mm triangular pitch.				
	M.O.C. for piping valves, & fittings		CPVC schedule 40 for PAC & poly electrolyte & lime				
	Dosing Pumps		2 (1W+1S)		2 (1W+1S)		2 (1W+1S)
	Type of pump		Positive Displacement Diaphram		Screw		Positive Displacement Diaphram
	MOC		SS		SS with Nitrile Stator		SS

	Minimum Capacity	LPH	As per requirement	As per requirement	As per requirement

8	**Dolomite Dosing Tank**				
	No.		2		
	Capacity		Adequate to hold 12 hours requirement on design flow & dosing with 20% margin		
	MOC of Tank		MSRL		
	Dosing Pump		2No. (1W+1S)		
	MOC of Dosing Pump		SS-316		
9	**Sludge Sump**				
	No. of sludge sump	No.	Sufficient to hold sludge for 4 hours operation at design load		
	Construction		RCC; outdoor location with 5 mm thick coal tar epoxy screed lining		
	type		Dual Compartment with mixing arrangement		
	Free Board	mm	300		
	Inlet Line		Pressure Type		
10	**Sludge discharge pumps**				
	a) Number	No.	2(1W+1S)		
	b) Type		Horizontal type (Non clog type)		
	c) Capacity		As per design requirement/ to empty sludge sump in maximum 2 hours		
	d)discharge head		By bidder		
	MOC		Carbon Steel		
11	**Centrifuge**				
	a) Number	No.	2(1w+1s)		
	b) Type		Centrifugal		
	c) Capacity		By bidder		
	MOC		SS		
	Running Time		16Hr/day		
	Installation		In Shed		
	Disposal Trolley shall be in the scope of bidder.				
12	**Dual Media Filters with Auto-**	Nos.	(2W+1S) Vertical		

	backwash filter arrangement		
	Design Flow per unit (net)	m^3 / hr	As per design requirement
	Design Surface Flow Rate	$m^3/m^2/hr$	15
	Free Board Space	%	75 min.
	Fill Material		Quartz sand free from Carbonate & impurities & anthracite as per BSEN: 12909.
	Media Trap	No.	Two (2) per unit. At service & rinse outlet of filter.
	MOC Shell & Dish		IS:2062 for Shell and IS: 2002, Gr I/SA515 Gr. 70 for Dish.
	Material of Construction for Vessel Internals		MSRL Natural Rubber, 4.5 (minimum) in 3 layers, 65 ± 5 shore A to IS:4682 Part-I
	Manhole /Handhole	No. mm	One (1) No. dia 500 mm/100 mm
	Sight windows.	No.	One (1)
	Guaranteed Effluent		
	a. Turbidity		<2
	Back wash flow rate	$m^3/m^2/$ hr	Bidder to decide
	Filter Material depth min	mm	1000
	Under Drain System		Strainers on plate
	Air Scouring rate		By Bidder
	Operation Mode		Automatic
	Corrosion Allowance		3mm Epoxy Coating
13.	**Filter Backwash pumps**		
	Numbers	Nos.	Two (2) (1W+1S)
	Type		Horizontal
	Pump Capacity each minimum	CMH	Bidder to decide
	Head	MWC	As per system req.
	Type of lubrication		Self-lubrication
	Speed of pump	RPM	1450
	Material of Construction		
	a) Casing		2.0% Ni-Cast iron IS210 FG260, ASTM A48 No 35
	b) Impeller		SS-CF 8M
	c) Shaft		SS-410
	d) Shat sleeves		SS-316
14	**Backwash Blowers**		
	Numbers	Nos.	Two (2) (1W+1S)
	Type		ROTATRY LOBE
	Capacity each	CMH	By bidder
	Head	MWC	As per system req.
	Type of lubrication		Self-lubrication

	Material of Construction		
	e) Casing & lobe		2.0% Ni-Cast iron IS210 FG260, ASTM A48 No 35
	f) Shaft		SS-410
	g) Shat sleeves		SS-316
15	**Hypo Dosing Tank**		
	Numbers	Nos.	One (1)
	Capacity		Adequate to hold 7 days requirement on design flow
	MOC		FRP
16	**Hypo Dosing Pump**		
	Numbers		Two (2) (1W+1S)
	MOC		PP
17	**Dilution water pumps**		(If Required)
	Numbers	Nos.	Three (3) (2W+1S)
	Type		Horizontal
	Pump Capacity each	CMH	By bidder
	Head	MWC	As per system req.
	Speed of pump	RPM	1450 /2900
	Material of Construction		
	Casing		2.0% Ni-Cast iron IS210 FG260, ASTM A48 No 35
	Impeller		SS-CF 8M
	Shaft		SS-410
	Shaft sleeves		SS-316
18	**Ultra-Filtration (U.F.) Module-I**		
	No. of Skid	Nos.	Three (3) (2W+1S)
	Feed flow rate	m^3/hr	150
	Permeate flow rate	m^3/hr	135
	Recovery	%	90 % (min.)
	Membrane Material		PVDF/PES
	a) Molecular Wt. Cut off value		100000 MWCO Daltons
	b) Pore Size		Bidder to furnish (micron)
	Net flux Rate		25 GFD (US Gallon)

	Membrane flow mode/ configuration		From outside to inside/Inside to outside				
	Frontal pipes, valves, manifolds		SS 316/PVC				
	Chlorine Resistance	-	pH 2-10				
	Basket filter at inlet of UF to be considered as per UF Vendor recommendation.						
19	**Ultra Filter Water Tank**						
	Number	No.	One (1)				
	MOC		RCC epoxy painted				
	Capacity		300 m3				
	Free Board	mm	300				
	Tank shall be covered.						
20	**RO Feed Pumps with cartridge filter (2W + 1S)**						
	Numbers	Nos.	Three (3) (2W+1S)				
	Type		Horizontal				
	Head/Capacity	MWC/m³/hr	By bidder				
	Type of lubrication		Self-lubrication				
	Material of Construction						
	i. Casing		SS 304				
	ii. Impeller		SS-CF 8M				
	iii. Shaft		SS-410				
21	**Chemical Measuring / Solution Preparation Tanks**		SMBS	Anti-scalant	Acid	Chemical Cleaning Skid	
	Number	No.	2 (1W+1S) for each				
	Type		Vertical cylindrical				
	Effective capacity	m³	One (1)				
	Tank – M.O.C.		SS-316				
	Agitator – Type		Slow speed (Not needed for Acid)				
	Agitator - M.O.C.		SS-316 / Alloy 20				
22	**Metering Pumps**						

	Number	Nos.	Two (2) (1W + 1S) for each tank	
	Type	-	Positive displacement, constant speed, variable stroke, diaphragm operated reciprocating type	
	Duty	_	Continuous	Intermittent
	Suction condition	_	Flooded	
	Head	MWC	As per Process requirement	
	Pump speed	SPM	100	
	Pump - M.O.C.	-	All Wetted parts in SS-316 /Alloy20	
23	**Micron Cartridge Filter**		R.O.Module	C.I.P.
	Number	Nos.	Three (3)	One (1)
	Vessel – M.O.C.	-	SS-316	
	Filter Element - M.O.C.	-	Synthetic non-degradable material (PP)	
	Efficiency of the Filter Element	% minimum	90	
	Pore size	micron	5	
24	**High Pressure Pumps**			
	Number	Nos.	Three (3) (2w+1s) with VFD	
	Head/Capacity	MWC/m^3/hr	By bidder	
	M.O.C.			
	(i) Casing	-	SS-316	
	(ii) Impeller	-	SS-316	
	(iii) Shaft	-	SS 316	
25	**Reverse Osmosis System - I**			
	No. of Streams	Nos.	Three (3) (2W+1S)	
	Type of Membrane	-	Spiral wound, Thin film composite polyamide	
	Average Flux		20 LMH	

	Recovery rate	%	80 minimum
	Permeate capacity/Stream	m^3/hr	By bidder
	RO CIP System shall be Manual operated.		
26	**Reverse Osmosis System - II**		
	No. of Streams	Nos.	Three (3) (2W+1S)
	Type of Membrane	-	Spiral wound, Thin film composite polyamide
	Average Flux		20 LMH
	Recovery rate	%	70 minimum
	Permeate capacity/Stream	m^3/hr	By bidder
	Permeate – TDS (ROI + RO II) @ 35 Deg C	ppm	< 150
	RO CIP System shall be Manual operated.		
	Bidder may propose RO-III for optimization of ZLD plant. However, RO-III recovery rate shall be min 50%.		
27	**RO Permeate Water storage tank**		
	Number	Nos.	One (1)
	Capacity	m^3	600
	Type & Material of construction	-	MSEP
28	**RO Reject Water storage tank**		
	Number	Nos.	One (1)
	Capacity	m^3	For 24 hours retention time or 100 m3 minimum (whichever is Greater).
	Type & Material of construction	-	CSRL
	Free Board	mm	300
	Tank shall not be covered.		
29	**Clarifier -II**	Type	High Rate Solid Contact Clarifier
	Number of Clarifier	No.	1
	Capacity	M3/hr	By bidder

	Type & Construction		RCC epoxy painted
	Inlet turbidity	NTU	500 (For design)
	Effluent quality	NTU	<20
	Retention in Draft Tube	min	1
	Retention in Flocculation Zone	min	20
	Rise rate projected	$M^3/hr/m^2$	1.8
	Bridge		Fixed – Full length-MSEP
	Shaft		MSFRP
	Sludge blow-off:		
	c) Continuous		By gravity through pipe for continuous discharge.
	d) Intermittent		Through timer operated blow-off valve
	Sludge Consistency		2%
	Hydraulic Loading margin in Civil work		20%
	Clarified II Water sump		
	Number	No.	One (1)
	Effective capacity	m^3	60
	MOC		RCC, above ground, covered
	Free board	mm	300 (min)
30	**DMF feed pump II**		
	Numbers	Nos.	Three (3) (2W+1S)
	Type		Horizontal
	Pump Capacity each	CMH	By bidder
	Head	MWC	As per system req.
	Material of Construction		
	Casing		Duplex Grade 3A/4A
	Impeller		Duplex Grade 3A/4A
	Shaft		Duplex Grade 3A/4A
	Shaft sleeves		Duplex Grade 3A/4A
31	**Ultra-Filtration (U.F.) Module-II**		

	No. of Skid	Nos.	Three (3) (2W+1S)
	Feed flow rate	m^3/hr	By Bidder
	Permeate flow rate	m^3/hr	By Bidder
	Recovery	%	90 % (min.)
	Membrane Material		PVDF/PES
	a) Molecular Wt. Cut off value		100000 MWCO Daltons
	b) Pore Size		Bidder to furnish (micron)
	Net flux Rate		25 GFD
	Membrane flow mode/ configuration		From outside to inside/Inside to outside
	Frontal pipes, valves, manifolds		SS 316/PVC
	Chlorine Resistance	-	pH 2-10
32	**Ultra Filter Water Tank-II**		
	Number	No.	One (1)
	MOC		RCC epoxy painted
	Capacity		100 m3
	Free Board	mm	300
	Tank shall be covered.		
33	**RO Feed Pumps-II**		
	Numbers	Nos.	Three (3) (2W+1S)
	Type		Horizontal
	Head/Capacity	MWC/m^3/hr	By bidder
	Type of lubrication		Self-lubrication
	Material of Construction		Duplex Steel Grade 3A/4A
34	**MVR Feed Pump**		
	Number	Nos.	2W+2S
	capacity		By bidder
	Type		Horizontal Centrifugal
	Operation		Continuous
	Suction condition		Flooded
	Discharge pressure		As per system requirement

	Material of Construction		Duplex SS
35	**MVR Type Evaporatoer**		
	Number	Nos.	2W (2 * 50 %) with 15% overdesign
	Capacity of each evaporator system		By Bidder (min 5 m3/hr)
	Type		Multiple effect evaporator
	Operation		Continuous
	Concentration		Slurry of Concentration less than 50% at outlet of MEE
	MOC		
	Heat Exchanger Shell		SS-316/SS-316L
	Tube		Titanium Grade 2
	Tube Sheet		SS-316+Titanium Cladding
	Vessels with Brine Solution		SDSS (Super Duplex Stainless Steel)
	Recirculation Pump		SDSS
	MVR vapour ducts		SDSS
	Mechanical Vapor Recompression		SDSS
	Treated water from evaporators shall be transferred to RO Permeate Tank.		
	Evaporator shall be designed for Continuous operation of 7 Days with Maximum down time of 4 hrs/week.		
36	**CRYSTALLIZER**		
	Number	Nos.	2 (1W + 1S)
	Settling tank		As per requirement, One (1) No.
	MOC		SS 316
	Pusher Centrifuge		As per system requirement 2 (1W + 1S)
	MOC		SS 316
	Mother Liquor tank		As per system requirement
	Crystallizer sludge storage shed sufficient for 1 Month storage shall be provided by bidder.		
37	**Sludge Handling System**		
	Thickener capacity	M3/hr	50 m3/hr
	Solid loading rate	Kg/m2	80
	Thickener mechanism		MOC MSEP
	Centrifuge	M3/hr	As per design requirement

	qty	nos	2 (1w+1s)
	Centrifuge feed pump	M3/hr	As per design requirement
	type		Single screw
	Rotor/stator/casing		Ss 316/ Nitrile Rubber/ cast iron
	Dewatering Polyelectrolyte		
	Min . dosage		25 ppm
	Dosing pump		SS 316 plunger type
	Nos of pumps		2 (1w+1s)
38	**Stilling Chamber**		
	Retention Time		5 Minutes
	MOC		RCC Epoxy Painted
	Free Board		300mm Minimum
40	**RO Permeate Transfer Pump**		
	No.		2 (1W+1S)
	Type		Horizontal Centrifugal
	Capacity		As per system requirement
	MOC		Casing :- 2.0% Ni-Cast iron IS 210 FG260, ASTM A48 No. 35 Impeller :- SS-CF-8M Shaft :- SS 410
	Pressure		Minimum 3.5Kg/cm2g at battery limit of plant
41	**Bulk Acid Storage tank**		
	Number	Nos.	2 (Two)
	Capacity		Sufficient to hold Sol for 15 days or Minimum 30 m3 with unloading facilities
	MOC		FRP
42	**Bulk Caustic storage tank**		
	Number	Nos.	2 (Two)
	Capacity		Sufficient to hold Sol for 15 days or Minimum 30 m3 with unloading facilities
	MOC		MSRL
43	**Bulk PAC/FeCL3 storage tanks**		
	Number		2 (Two)
	Capacity		Sufficient to hold Sol for 15 days or Minimum 30 m3 with unloading facilities

	MOC		MSRL

Note:

1. Above listed equipment data sheet are indicative only, any other equipment required for the completeness of the plant shall be supplied by bidder.
2. Common RO CIP System shall be considered for RO-I & RO-II.
3. Common UF CIP System shall be considered for UF-I & UF-II.
4. Common chemical dosing system for RO-I & RO-II shall be considered.
5. Common CEB System shall be considered for UF-I & UF-II.

4.0 CONTROL PHILOSOPHY

4.1 RO Based Treatment Plant

ZLD facility shall be operated and controlled through a PLC based control system. The control system shall be provided in line with the engineering specifications / standards / drawings attached elsewhere in the tender document. Backwash sequence for the DMF, UF/RO skids shall be automatic. The Instrumentation and Control Philosophy for the Plant shall be as applicable to the smooth, safe & trouble free operation of Unit and shall be defined in detail in Process specifications.

Following on line analyzers shall be installed for smooth, safe & trouble free operation of ETP:

1. pH & conductivity analyzer at the discharge of Equalization Tank. pH analyzer at inlet of DMF Inlet.
2. Residual chlorine & turbidity analyzer at downstream of each Dual Media Filter – I & II.
3. Turbidity analyzer at downstream of Ultra Filter – I & II.
4. ORP Analyzer with 2oo3 logic at inlet of RO-I & RO-II High pressure feed pump.
5. Conductivity analyzers at the Permeate & reject of RO-I & RO-II.
6. pH & conductivity & FRC analyzers at the inlet of each RO-I & RO-II.
7. pH meter at out let of RO permeate water storage tank.
8. Analyzers as required for guaranteed water quality requirement.

Following Flow Transmitter shall be installed for smooth, safe & trouble free operation of ETP:

1. Flow Transmitter at discharge of HRSCC-1 feed pump/DMF-I & II feed pump/UF backwash pump/RO permeate transfer pump/ Cooling water /Steam.
2. DPT across each Dual media filters-I & II (DMF)/UF-I & II/RO-I & II/MCF of RO-I & II. FT at outlet of each DMF /UF-I & II / RO-I & II. FT at Inlet of each RO-I & II.

3. All Pumps shall be equipped with Pressure Transmitters.
4. All tanks shall be equipped with Level Transmitters.
5. All Incoming /outgoing lines from ZLD Plant shall have PG, PT, TG, TT & FT with totalizer.

In addition to above mentioned instruments/analyzers, bidder to provide all necessary Instruments during detail engineering for smooth, safe & trouble free operation without any cost & time implication

4.2 **MVR Type Evaporator**

A. The TDS in condensate water will be within 300 mg/L.

B. Recovery to be ensured > 90 %

C. Fluoride in condensate water will be <1.5 ppm.

D. MEE will be electrically driven (Mechanically vapour compression)

5.0 SELECTION OF MATERIAL OF CONSTRUCTION

Minimum requirements of materials of construction for some critical piping are as follows. However, Vendor shall provide any superior material than as specified as required by the process.

5.1 Critical Piping:

Material of construction for pipes carrying fluids shall be as below:

1.	Raw Water	Carbon Steel
2.	Filtered Water	Carbon Steel
3.	Acidic Water	CSRL
4.	DM water/ RO Treated water	SS 304
5.	Acid (Hydrochloric)	CPVC
6.	Alkali (Sodium Hydroxide) Dilute / Strong	CPVC
7.	Lime solution	CPVC
8.	Coagulant aid solution	CPVC
9.	Chlorine dioxide	CPVC
10.	Chlorinated Water	CPVC
11.	Process Air	Galvanised CS
12.	Waste effluent from DM Plant	CSRL
13.	RO-I & II PERMEATE	SS 304
14.	RO-I REJECT upto HRSCC-II	SS 316
15.	RO-II REJECT upto RO-II reject tank	SDSS
16.	RO-II REJECT tank to Evaporator system	SDSS
17.	Evaporator system brine solution	SDSS
18.	Evaporator Vapour/condensate	SS316
19.	Pipe line from inlet of UF-I up to RO-I skid	SS-304
20.	Pipe line from HRSCC-II up to RO-II Feed pump	CSRL
21.	Pipe line from RO-II Feed pump discharge to RO-II skid	SDSS
22.	DMF , UF-1 & II Backwash	CSRL
23.	Steam	CS (IBR)
24.	Instrument Air	SS-304
25.	RO/UF CIP piping	CPVC
26.	Service Water	CS

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6.0 OPERATION AND CONTROL PHILOSOPHY

1) The MVR and crystallizer plant shall be operated, monitored and controlled through one central programmable logic controller (PLC) with complete automation to perform normal operation, sludge removal, valve operation etc. However, the total plant shall have provision of manual intervention and operation of the same, locally or from remote. PLC based control system shall be provided to start, stop, monitor and control the plant from one central place. All the local push buttons required for the plant shall be housed near the plant. Temperature measurement for various as mentioned above shall be sensed by individual temperature indicating transmitter and displayed in the panel/monitor. Operator can read those temperatures automatically in sequence or manually at any of the above points randomly to operate the plant effectively.

2) An interlock sequence shall be provided for starting and stopping of the plant in pre-determined correct sequence only and not otherwise due to any mistake in operation.

3) An alarm annunciator indicates tripping of any drive and also abnormal parameters if any in the plant. This will provide extra facility to monitor the plant from panel and operate the plant correctly in manual mode.

4) An automatic PID based level control loop shall be provided for MVR to regulate product flowing out from the MVR. This ensures constant level in the system and avoids fluctuations in performance of total plant. The loop consists of level sensor (indicating transmitter), PID controller (electronic type), I/P converter to convert electronic signal to pneumatic signal and pneumatic control valve.

5) An automatic PID pressure control loop at inlet of live steam line to ensure steam supply during start-up at desired condition to the plant. This also ensures exact required temperature of 1st effect.

6) A control valve (or double solenoid valve) shall be provided which will control the flow to ensure the safe boiling temperature in calendria. These safe temperatures ensures no overheating of product at any stage, which otherwise may cause undesired fouling in the tubes.

7) An automatic PID feed flow control loop shall be provided in the feed line of the plant so that operator is able to control the feed rate to the plant. (Flow control valve shall be provided in HRSCC feed pump discharge).

8) With the PID control loop arrangement constant feed rate to the plant and constant supply of steam to the plant can be ensured.

9) All equipment and valve status (On/off/trip status or open/close) should be indicated. Necessary failure in operation/trip shall have visual and sound alarms.

10) The local push buttons with control boxes of individual pumps, equipment shall have selector switches with position of manual and automatic.

11) The remote selection facility at the HMI shall have the override over the local selector switch position in the local control boxes.

12) Preparation and dosing of chemical (Operation of pump from local control panel) shall be controlled manually.

13) All pumps shall work on level sensing.

14) In general operating pumps selected shall be rotated on a daily basis or after fixed time interval.

15) PLC shall have indications of all instrument/transmitter readings in HMI.

NOTE:

For detail Instrumentation and control system, refer Instrument design philosophy (section: 5.4)

- Specification of equipment and design data are general in nature and may require changes based on specific selection and application. Tenderer is required to make their own judgment for proper selection of equipment in their offer or during detail engineering if LOA is placed on them. Tenderer is required to submit proper design calculation.
- Responsibility of selection of equipment rests entirely on the bidder considering that bidder is required to provide guarantee on the equipment selected, which will undergo performance testing at site during PG test.
- Where specification of all equipment required for completeness of the system is not specified herewith, tenderer is required to make selection of proper equipment based on their judgment.

7.0 SITE METEOROLOGICAL DATA

S.NO.	Parameter	Unit	Min.	Nor.	Max.
1.	Barometric Pressure	mmHg	745	750.29	765
2.	Ambient temperature	DEG C	8.4	36.6	46.8/47.(*)
3.	Relative humidity ambient @ temperature	%	11		97.4 (#)
4.	Total rainfall, mm per year	mm	Avg 1331.3 (Note-1)		
5.	Rainfall data for 24-hour period	Mm			138.2
6.	Wind Velocity	Km/hr	0		44

Note-1 Maximum rainfall is 439 mm/Month. Design rainfall intensity is 80 mm/hr.

PART –II: TECHNICAL

SECTION – 5.0

ENGINEERING DESIGN SPECIFICATION

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

CONTENTS

PART –II: TECHNICAL

SECTION – 5.1

DESIGN SPECIFICATION – PROCESS

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

CONTENTS

1.0 GENERAL

The plants shall be designed to operate safely and satisfactorily at a capacity of 50 to 110% of 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 with 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 PMC/Owner. 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)	Buildings & Structural	Relevant Indian Standard (BIS)
c)	Electricity	Indian Electricity Rules.
d)	Sanitary	Relevant Indian Standard (BIS)
e)	Safety	a) Manual of Chief Inspector of Explosives, Govt. of India.
f)	Water Pollution	Relevant Indian Standard (BIS) / Telangana Pollution Control Board limits
g)	Noise & Air quality	Relevant Indian Standard (BIS) / Telangana Pollution Control Board limits

1.1 System of Measurements

The system of measurement shall be Metric as follows:

Parameter	Preferred Units	Alternative Units
Temperature	°C	
Pressure - absolute	kg/cm² abs	
Pressure - gauge	kg/cm² g	
Flow (liquid)	m³/hr	kg/hr
Flow (gas)	Nm³/hr	kg/hr
Flow (steam)	kg/hr	
Length, Level	mm	M
Time	hr	sec, min

Heat	kcal	Gcal
Power	kW	
Fouling resistance	m² 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^3	
Vapor flowing density	kg/m^3	
Furnace draft	mm of WC	
Storage tank pressure	mm of WC	
Vacuum	mm of Hg, mm WC	
Standard vapor	Nm^3/hr at 0°C & 1.033 kg/cm^2a	
Standard liquid	m^3/hr at 15.6°C	
Thermal conductivity	kcal/hr-m-°C	
Heat Transfer coefficient	kcal/hr-m^2-°C	
Enthalpy, Entropy	kcal/kg	
Heat rate	10^6kcal/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 max. Expected continuous operating pressure. Malfunction and EQUIPMENT failure shall be taken into consideration by safety devices. Design pressure shall be selected from the list below.

a) For max operating pressure below 2 kg/cm^2 g use 3.5 kg/cm^2 g

b) For max operating pressure between 2 kg/cm^2g and 15 kg/cm^2g use Max. Operating Pressure + 1.5 kg/cm^2

c) For Max. Operating Pressure between 15 kg/cm^2 g and 100 kg/cm^2 g use Max. Operating pressure x 110 %

d) For Max. Operating Pressure equal and above 100 kg/cm^2 g use the Maximum Operating Pressure + 10 kg/cm^2 g.

Note:

1. If the equipment contains liquid, the design pressure shall not be less than the vapour pressure of the liquid at design temperature except if a safety device is installed to limit the pressure
2. Maximum operating pressure shall be the highest possible pressure during operation, start up, shut down & upset condition.
3. Design pressure shall be regarded as acting at top of the vessel.

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.

For design of UF system, 5th year projection shall be considered by the bidder.
For design of RO system, 3rd year projection shall be considered by the bidder.

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 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:

a) Maximum operating temperature + 15 °C (+25ºC for Feed/Effluent exchanger)

b) Boiling temperature at design pressure of process medium inside, if applicable.

c) Design temperature shall be rounded up to full 5°C steps.

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 standard design.

4.0 VELOCITY IN PIPES

Acceptable range velocity to be followed is as follows:

- Pump Suction & Gravity Flow : 0.5-0.8m/s
- Pressure Line : 1.2-1.8m/s
- Air Velocity : Not more than 20m/s
- Steam line less than 20 m/sec.

5.0 CORROSION ALLOWANCE

Materials of construction and corrosion allowance for all Equipment and machinery shall be for a design life of 20 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 Contract with operating fluid)	0.75 mm
For stainless steel/titanium	0 mm
Carbon steel with epoxy resin coating	3 mm

6.0 HYDRAULIC RETENTION TIME

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

Type of Service	Retention Time
Storage tanks	As per requirement of NIT
Measuring tanks	By vendor
Acid storage tanks	2 nos. Total capacity 15 days
Alkali storage tank	2 nos.total capacity 15 days.
Clarifier	2 hrs.
Equalization tank	-
Clarifier water storage tank	-
Evaporator	-
Neutralisation pit	2 compartments each sufficient to hold Waste water generated in 24 Hr.

7.0 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.

8.0 PUMPS

Normally pumps shall be designed to 110 % of their maximum required flow rate in worst case of operation.

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

a) Differential head at rated flow x 120 % + LH (level high) suction static head + max operating pressure suction side.

b) 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.

9.0 PRESSURE RELIEF VALVES

Pressure relief valves sparing philosophy will be as mentioned below:

- PSV for operational failures shall have installed spare: YES
- PSV exclusively for non-operational failures (external fire or Heat exchanger tube rupture) shall have installed spare: NO
- PSV for thermal relief shall have installed spare: NO
- PSV in IBR steam service shall have installed spare YES
- PSV in spared equipment shall have spare PSV: NO

Pressure relief valves isolation philosophy will be as mentioned below:

In case downstream is connected to an open system:

- In general, PSV shall have only upstream isolation: YES
- PSV in IBR steam service shall have no isolation: YES

LSTK Contractor shall take care of any additional requirement as per guidelines. 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 solenoid operated on-off valve 4" and above shall be butterfly valve.

10.0 COLUMNS AND VESSELS

10.1 Nozzle:

a) Minimum size 3/4" (for S.S shall be 1 inch).

b) Nozzle rating according to once of connected piping for instrument min. Class 150 ANSI rating.

10.2 Manhole:

Manhole size 24" (*)

10.3 Hand hole or Inspection hole:

a) Preferable Size 8 inches

b) 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^3 or mm)	Vent diameter (inches)	Drain diameter (inches)
V < 75 or D <= 4,500	2	2
75 < V <= 220 4,500 < D <= 6,000	3	3
220 < V <= 420 or D > 6,000	4	4
V > 420	6	4

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

10.5 Storage (Resin/Chemicals):

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

Notes:

- All pumps shall be with 10% margin over normal capacities of pumps and motor rating shall be suitable for end of curve operation of pump.
- All strainers, filters shall have Differential Pressure Transfer (DPT) with local and DCS indication – Alarms to be provided.
- Motor (5KW and above) current status in DCS and all motors shall have running status in the DCS.
- All chemical dosing discharge lines shall have minimum Rotameter flow meter.
- All dosing / bulk chemical storage tank shall have separate vent / overflow line with fume mitigation system.
- RO permeate shall be diverted to UF permeate tank automatically in case of off spec.
- All centrifugal pumps shall be provided with automatic minimum circulation line.
- All reciprocating / diaphragm pump shall have pressure safety valve & diaphragm rupture alarm.
- Sample points to be provided at various locations.
- All lines at B/L shall be provided with lockable isolation valve along with drain and vent valve. Tanks shall be provided with local level gauge, transmitters with indication & alarms in CCR, auto trip & auto start as applicable.

- Pumps shall be provided with local pressure gauge at suction & discharge, transmitters with indication & alarms in CCR, auto trip & auto start as applicable.
- Flow transmitters with pressure & temperature compensation shall be provide at inlets lines, All DMF inlet & individual outlets, UF outlets, RO inlets & RO outlets permeate & rejects,
- All trips shall be 2 out of 3 logic & auto start shall be 1 out of 2 logic.
- Final permeate outlet, steam lines, CWS, RO reject inlet to Evaporator system. All utilities & other places as required for guarantees.
- All media & Resin traps shall be provided with PDG.
- Basket Type Strainers (1W + 1S) to be provided at UF inlets.
- Micron Cartridge filters (1W + 1S) Low & high pressure RO feed pumps.
- Telescopic device to be provided wherever applicable.
- All required safety interlocks

These are the minimum instrumentation however, bidder to provide any other instruments required for trouble free, smooth, safe, continuous operation and maintenance of the plant

11.0 TAGGING PHILOSOPHY

Unit number to be used as follows:

Facility	Unit number
ZLD	320
Offsite piping	321

ANNEXURE–II

P1	EFFLUENT TRANSFER PUMP	2W+1S
P2	DMF FEED PUMP	2W+1S
P3	B/W WASTE PUMP	1W+1S
P4	SLUDGE PUMP	1W+1S
P5	RO–I FEED PUMP	2W+1S
P6	UF B/W PUMP	1W+1S
P7	DMF–II FEED PUMP	1W+1S
P8	UF–II B/W PUMP	1W+1S
P9	RO–II FEED PUMP	2W+1S
P10	RO–II PERMEATE PUMP	1W+1S
P11	RO–II REJECT PUMP	1W+1S
P12	SLUDGE FEED PUMP	1W+1S
P13	DOSING PUMP FOR ClO_2	1W+1S
P14	DOSING PUMP FOR HCL	1W+1S
P15	METERING PUMP	1W+1S
P16	HIGH PRESSURE PUMP	2W+1S
P17	EVAPORATOR FEED PUMP	2W+1S
P18	DILUTION WATER PUMP	2W+1S
P19	FILTER BACK WASH PUMP	1W+1S
P20	DMF BACKWASH SUMP PUMP	1W+1S
P21	DMF–I BACKWASH AIR BLOWER	1W+1S
P22	DMF–II BACKWASH AIR BLOWER	1W+1S

ClO_2 PACKAGE
ClO_2 DOSING (THROUGH PUMP)
EXISTING GUARD POND x 2
EFF. CAP: 10000m^3 (EACH)
P1
NOTE 6
LIME DOSING
DOLOMITE DOSING
POLY DOSING
PAC DOSING
FLASH MIXER
HIGH RATE SOLID CONTACT CLARIFIRE (HRSCC)
CLARIFIED WATER STORAGE TANK
P2
P20 DMF BACKWASH SUMP
BASKET STRAINER
DUAL MEDIA FILTER–I
UF–I
P21 DMF–I BACKWASH AIR BLOWER
P6
UF–I PERMEATE WATER STORAGE TANK
P5
ACID, ALKALI, ClO_2
ACID, ALKALI
ANTI SCALANT
SMBS
MICRON CARTRIDGE FILTER (2+1)
RO–I
RO–I
DISCHARGE FROM CENTRIFUGE TO EQUALIZATION TANK
POLY
SLUDGE (DISPOSAL BY TROLLEY)
CENTRIFUGE 1+1
P12
THICKNER
P4
SLUDGE SUMP
P3
BACKWASH WASTE SUMP
POLY DOSING
PAC DOSING
LIME DOSING
DOLOMITE DOSING
INLET CHAMBER
TO THICKNER
HRSC
CLARIFIED WATER STORAGE TANK
RO PERMEATE
ACID, ALKALI, ClO_2
ACID DOSING
SMBS DOSING
ANTI–SCALENT DOSING
BASKET STRAINER
UF
UF PERMEATE WATER STORAGE TANK
DUAL MEDIA FILTER–II
P7
P22 DMF–II BACKWASH AIR BLOWER
UF REJECT
P8
P9
MICRON CARTRIDGE FILTER
RO–II
RO–II
RO PERMEATE WATER STORAGE TANK
TO COOLING WATER SUMP/ FIRE WATER RESERVOIR
P10 1W+1S
VENDOR CLIENT
UF WATER WASTE
P19
DMF / UF BACK WASH SUMP RO–II REJECT
STEAM (FOR EVAPORATOR)
CHEMICAL DOSING
ZLD PLANT
CONDENSATE
P11
RO REJECT SUMP
SALT (DISPOSAL BY TROLLEY)

NOTES:–

1. THIS IS AN INDICATIVE PFD SHOWING MAJOR EQUIPMENTS WHICH SHALL BE FURTHER DEVELOPED BY THE CONTRACTOR AS PER REQUIREMENTS.
2. VENDOR TO INDICATE NORMAL/DESIGN FLOW & OPERATING PRESSURE & TEMPERATURE OF EACH STREAM.
3. ALL DRAINS SHALL BE ROUTED TO N.PIT.
4. ADEQUATE CHEMICAL & TYPE SHALL BE DOSED AT VARIOUS POINTS BY THE BIDDER TO MEET SYSTEM REQUIREMENTS & GUARANTEES.
5. RO 2UF CIP TANK & (1W+1S) PUMPS ALONG WITH FILTER TO BE PROVIDED.
5. BIDDER TO DECIDE DOSING LOCATION (i.e. FLASH MIXER / HRSCC).

REV	DATE	DESCRIPTION	PPD.	CKD.	APPD.
0	11.07.2023	ISSUED FOR TENDER	KC	KR	M.N

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL), TELANGANA, INDIA

SHEET 1 OF 1
SCALE: NTS

PROJECT: CONSULTANCY SERVICES FOR IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) AT RAMAGUNDAM PLANT

TITLE: SCHEMATIC PROCESS FLOW DIAGRAM – EFFLUENT TREATMENT PLANT WITH ZLD & SEWAGE TREATMENT PLANT

DRG. NO. PC211–7611–046

PROJECTS & DEVELOPMENT INDIA LTD. NOIDA

SECTION – 5.2

DESIGN PHILOSOPHY - MECHANICAL

PLANT: RAMAGUNDAM PLANT

PROJECT: IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT AT RFCL, RAMAGUNDAM PLANT

CLIENT: RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL), TELANGANA, INDIA

CONTENTS

SECTION – 5.2.1

DESIGN PHILOSOPHY-STATIC EQUIPMENT

PLANT: **RAMAGUNDAM PLANT**

PROJECT: **IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT AT RFCL, RAMAGUNDAM PLANT**

CLIENT: **RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL), TELANGANA, INDIA**

CONTENTS

LIST OF ATTACHMENTS

1.0 DESIGN CRITERIA

1.1 This specification covers the requirements for the design, procurement, fabrication, construction/erection, insulation, painting, Pickling & Passivation, inspection and testing of static equipment such as Pressure Vessels (i.e. Horizontal/vertical Vessel, Reactors Columns, Filter e.tc.),Shell & Tube Heat Exchangers, Plate type heat exchanger, Storage Tanks and other similar equipment for Implementation of ZLD unit at M/s Ramagundam Fertilisers Limited (RFCL), Telangana, India in accordance with this specification, standards ,codes and other attachment etc. listed in NIT document.

1.2 The equipment shall be designed & constructed as per the latest edition of the following codes and standards: LSTK Contractor shall be responsible for addition of code and standards as applicable to the scope. LSTK Contractor shall ensure use of latest version of applicable codes and standards at the time of design.

Code	Description
ASME Section VIII Div 1	Rules for construction of Unfired Pressure Vessels
TEMA 'R' / API 660	Standards of Tubular Exchangers Manufacturer's Association / For Shell & Tube Heat Exchanger
HEI	Heat Exchanger Institute standards for steam surface condensers and steam jet ejectors
API 661	Air Cooled Heat Exchangers
API 662	Plate type Heat Exchangers
IBR	Indian Boiler regulations
API 650	Welded Steel Tanks for Oil Storage
ASME RTP-1	Reinforced Thermo set Plastic Corrosion Resistant Equipment
API RP 2000	Venting Atmospheric and Low pressure storage Tanks
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	Properties
ASME Section V	Non-destructive Examination
ASME Section IX	Welding Qualification
ASME SEC X	Fiber-Reinforced Plastic Pressure Vessels
EN-13121	GRP Tanks and vessels
ASME B 16.5	For Flanges
ASME B 16.47	For large diameter flanges
ASME B 16.20	For Metallic Gaskets for Pipe Flanges: Ring-Joint, Spiral Wound, and Jacketed
ANSI	Pipes, Flanges, Fittings and Valves
IS: 875/SITE DATA	For wind load consideration
IS: 1893 (Part 4) & IS: 1893 (Part 1) / SITE DATA	For seismic design consideration
IS:4682 (Part-1) with Amendment No. 3	Code of Practice for Rubber Lining of Vessels & Equipment for Chemical Process

Factory Act, 1948 BS CP 3003 (Part 1)	Factory Act & State Govt factory rules Code of Practice on lining of Vessels and equipment for Chemical Process.
WRC 537	Local Stresses in Spherical & Cylindrical Shells due to External Loadings
WRC 297	Local Stresses in Cylindrical Shells due to External Nozzle Loadings

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 shall also be complied with.

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

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.

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

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

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

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

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

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

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

1.14 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.

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

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

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

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

1.19 Local load analysis, WRC 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.

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

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

1.22 Mechanical Design of equipments shall be done on internationally reputed software such as PV-Elite etc. No hand calculations are acceptable.
Strength calculation shall be performed in latest version of PV-elite software. LSTK contractor/ Vendor shall send soft copy of PV-elite (.pvdb file) along with equipment document submission during detail engineering to PMC/Owner

1.23 Material test certificates shall comply with EN10204 Type 3.1 certification for pressure parts and EN10204 Type 2.2 for Non-pressure parts.

1.24 Bidder to ensure the ladder along with nuts and bolts provided for the access of the top of the chemical storage tanks shall be chemical resistant. FRP Ladder may be used with a redundant ladder for chemical storage tanks to avoid damage due to corrosion issues."

1.25 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.

1.26 **REGULATIONS**

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

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.

1.27 DESIGN DOCUMENTATION

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

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

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

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

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

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

1.28.1 CONSTRUCTION & ERECTION

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.

1.28.2 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.

1.28.3 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

.

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

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

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

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

.

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

1.29 QUALITY ASSURANCE & CONTROL

1.29.1 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.

1.29.2 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.

1.29.3 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.

1.29.4 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.

2.0 MATERIAL OF CONSTRUCTION

2.1 Wherever CS/KCS/SS is specified as material in data sheets, following shall be followed, as a minimum.

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

Shell /Head plates	SA 516 Gr. 70 (Epoxy /rubber Lined as applicable) & SA 516 Gr 60 for caustic, amine , hydrogen, sour (Wet H2S) or lethal service tanks, vessel and heat exchangers (Epoxy /rubber Lined as applicable)
Nozzle Flange	SA 105 (Epoxy /rubber Line as applicable)
Nozzle Neck (Pipe/Plate)	SA 106 Gr. B (Nozzle size < 10"); SA 516 Gr. 70 ((Epoxy /rubber Lined as applicable) (Nozzle size > 10")
Non standard forging	SA 266 Gr 2 (Epoxy /rubber Line as applicable)

b) Pressure Vessel (SS)

Shell /Head plates	SA240 Gr*
Nozzle Flange	SA 182 Gr*
Nozzle Neck (Pipe/Plate)	SA 312 Gr* (Nozzle size < 10"); SA 240 Gr * (Nozzle size > 10")
*SS grade as specified in datasheet	
c) Heat exchangers (KCS/CS)	
Shell /Channel plates	SA 516 Gr. 70 (Epoxy /rubber Lined as applicable) & SA 516 Gr 60 for caustic, amine , hydrogen, sour (Wet H2S) or lethal service tanks, vessel and heat exchangers Tube sheet : SA266 Cl2 (Forged) Tubes : SA210 Gr A1 (Seamless)
Nozzle Flange	SA 105 (Epoxy /rubber Lined as applicable)
Nozzle Neck (Pipe/Plate)	SA 106 Gr. B (Nozzle size < 10"); SA 516 Gr. 60/70 (Epoxy /rubber Lined as applicable) (Nozzle size > 10")
d) Heat exchangers (SS)	
Shell /Channel plates	SA240 Gr *
Tube sheet	SA336 Gr*(Forged)
Tubes	SA213 Gr* (Seamless)
Nozzle Flange	SA 182 Gr*
Nozzle Neck (Pipe/Plate)	SA 312 Gr* (Nozzle size < 10"); SA 240 Gr * (Nozzle size > 10")
Non standard forging	SA336 Gr * / SA 965 Gr *
*SS grade as specified in datasheet	
e) CS Tanks/ Non- Coded Vessel	
Shell/ Roof /Bottom Plates	: IS2062 GR B/SA36 with Epoxy /rubber lining as applicable)
Nozzle Flange	: SA 105 (Epoxy /rubber Lined as applicable))
Nozzle Neck (Pipe/Plate)	: SA 106 Gr. B (Nozzle size < 10"); IS 2062 GR B/SA36 (Epoxy /rubber Lined as applicable) (Nozzle size > 10")
Stud/ bolts and nuts for nozzles fitted with blind flange	SA193 Gr B7/ SA 194 Gr. 2H
f) **SS Tanks/ Non- Coded Vessel**	
Shell/ Roof /Bottom Plates	: SA240 Gr *
Nozzle Flange	: SA 182 Gr*
Nozzle Neck (Pipe/Plate)	: SA 312 Gr* (Nozzle size < 10"); SA 240 Gr * (Nozzle size > 10")
Non standard forging	: SA336 Gr *
*SS grade as specified in datasheet	

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

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

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

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

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

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

2.2.6 All forgings including nozzle flanges shall be examined for surface defects by MP/PT testing after matching 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 and grade as that of equipment, unless specified otherwise.

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

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

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

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

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

For Carbon Steel:

a. Cold formed dished ends or knuckles up to 16 mm nominal thickness shall be stress relieved.
b. Cold formed dished ends or knuckles above 16 mm nominal thickness shall be normalised.
c. For Low alloy Steel: - Cold Formed Dish ends or Knuckles shall be stress relieved.
d. Hot formed dished ends or similar parts, which have not been uniformly heated in the normalising range in the final stages of manufacture shall be normalised.
e. When the completed vessel involves post weld heat treatment, heat treatment recommended in (a) above shall not be applicable.
f. Vessels in caustic service, Amine or Sour gas service shall be stress relieved.
g. All internal and external attachments, clips, insulation studs, name plate bracket, and the like shall be welded to the vessel before post weld heat treatment.

2.2.14 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.

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.

2.2.15 All Nozzle Flanges & Gaskets size, rating & type etc. shall be as per applicable piping Specifications & instrument specification as applicable enclosed with the enquiry and Selected bolting shall match with corresponding companion flanges.

2.2.16 Equipment under Caustic service shall essentially be PWHT with 100 % radiography. The hardness of the parent weld, weld & HAZ shall be Limited to 200 BHN.

2.2.17 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.

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

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

2.2.20 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.

2.2.21 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.

2.2.22 All Equipment shall preferably be supplied in single piece. However, in exceptional cases, Site fabrication / Field assembly may be permitted with prior approval of Owner. LSTK contractor to furnished list of site fabricated equipment along with constraints in the bid.

Additional requirements For Site fabricated Equipment: Transportation, Loading/Unloading, handling of pre-fabricated/ pre- rolled components/ petals / subassemblies to the Owner designated Fabrication yard, fabrication, assembly, inspection (including inspection by 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.}

3.0 TECHNICAL REQUIREMENTS

3.1 Storage Tanks

3.1.1 The following design codes shall be adopted for tank design as applicable:

i) API 650 Welded Steel Storage Tanks for Oil Storage
ii) PDIL standard PDS: SR 005 Storage Tanks with Flat Cover (CS/SS) wherever Applicable

3.1.1.1 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).

3.1.2 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. Corrosion allowance shall be added to the thickness specified.

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3.1.3 Storage tanks up to 4meter in diameter shall be shop fabricated items. Tanks with diameters greater than 4 meter shall be field erected.

3.1.4 Tanks constructed of stainless steel shall comply with API 650, Appendix S.

3.1.5 Shell seams shall be located to clear openings to the maximum extent possible in accordance with API 650.

3.1.6 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.

3.1.7 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.

3.1.8 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.

3.1.9 Anchor bolts shall be provided based on design considering wind/seismic loads, uplift due to internal pressure etc. However, tanks having diameter ≤10 meter shall be provided with anchor Bolts and shall be spaced at approximately 1.8M of circumference.

3.1.10 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.

3.1.11 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.

3.1.12 Unless otherwise specified bottom plate slope shall be 1:100 from the centre of the tank

3.1.13 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.

3.1.14 Fabrication tolerance on shell, bottom, and foundation e.t.c. shall be as per applicable code.

3.1.15 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 excluding any corrosion allowance on bolt diameter. Tanks with diameter ≤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 ≤10 m. Anchor bolt shall be protected with Canopy to avoid water in-grassing.

3.1.16 The roof plates shall be self supported of 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.

3.1.17 Inside/outside painting of tanks shall be carried out based on product stored and as per Process data sheet enclosed elsewhere in NIT package.

3.1.18 Epoxy painting is required for all storage tanks including internals in water treatment plant where carbon steel is selected. The details of the application of the Epoxy paint will be finalized during the detailed engineering stage.

3.1.19 For the Rubber Lined Equipments, Equipment corners shall be grounded & corners on rubber lined surface shall be grounded to 6mm radius & all interior welds surfaces shall be grounded flush, the internal surface finishes to be suitable for rubber lining with no curves dents or surface imperfections for air entrapment.

3.2 Shell and Tube Heat Exchangers

3.2.1 Complete Process/Thermal/Mechanical design & Thermal/Mechanical guarantee shall be in the scope of the LSTK Contractor. ASME Section VIII Div. 1 & TEMA-R shall be considered for design and engineering of all exchangers.
(TEMA Class 'C' may be used for auxiliary heat exchangers for rotating and packaged equipment exchangers.)

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

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

3.2.4 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.

3.2.5 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 be considered on the exchanger supports and foundation.

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

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

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

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

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

3.2.11 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.

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

3.2.13 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

3.2.14 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.

3.2.15 Tube to tube sheets joints shall be leak tested with air & soap solution at pressure of 2.0 kg/cm2 g .

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

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

3.2.18 After testing, all exchangers shall be completely dried.

3.2.19 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.

3.2.20 Bidder shall check adequacy of tube bundle against flow induced vibration.

3.2.21 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.

3.2.22 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 extent at least 25 mm beyond the projection of the nozzle bore. The clear distance from the nozzle (at the inner surface) to the impingement plate shall be at least 0.25 x nozzle diameters. The nominal thickness of the impingement baffle shall be at least 6 mm.

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

3.3 Pressure Vessel

3.3.1 Mechanical Design of pressure vessels such as Reactors, Columns, filters & Horizontal/vertical vessels e.tc. (I.e. design of shell, heads, supports, anchor bolts, weight calculation, wind and seismic analysis, foundation loadings, RF pad, Self Reinforced Nozzles, etc.) Shall be performed by LSTK Contractor as per above listed code/specifications, unless otherwise specified.

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

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

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

3.3.4. Minimum nozzle thicknesses shall be Schedule Extra Strong above 2” NPS, and Schedule 160 for 2” NPS and below.

3.3.5 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.

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

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

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

3.3.9 Maximum permissible deflection for columns when subjected to design wind loadings shall not exceed 0.005 x Vessel height.

3.3.10 Minimum man way size shall be equal to 24” nominal pipe size.

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

3.3.12 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.

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

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

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

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

3.3.17 All manhole/hand hole/blind holes/LG/LT/Valves e.t.c shall be accessible by suitable platform.

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

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

3.4 PLATE TYPE HEAT EXCHANGER

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

3.4.2 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

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

3.4.4 Lock washers shall be provided for all rotated nuts.

3.4.5 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.

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

3.4.8 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.

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

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

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

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

3.4.13 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.

3.5 FRP/GRP TANKS

Codes

Construction

- ASME X Rule for Construction
- EN-13121: For Fiber-Reinforced Plastic Pressure Vessels

Materials and material testing

- ASTM C-581 Chemical resistance of Resins
- ASTM D-2150 Woven roving Laminated FRP
- ASTM D-2583 FRP hardness test
- ASTM D-2584 Ignition loss of cured FRP
- ASTM D-2990 Flexural creep and Creep-rupture
- ASTM D-2997 Machine made FRP pipe
- ASTM D-3299 Filament-wound reinforcing
- ASTM D-3892 Resin and FRP packaging
- ASTM D-4024 Machine made FRP flanges
- ASTM D-4097 Contact-moulded FRP tanks
- ASTM D-5421 Contact-moulded FRP flanges
- ASTM D-618 Plastics testing conditions
- ASTM D-638 Plastics tensile properties testing.
- ASTM D-695 Plastics compressive testing
- ASTM D-883 Plastics terminology
- ASTM F-412 Plastics piping terminology

Equipment testing

- ASME V Non-destructive examination

Flange Drilling and bolting

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

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

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

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

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

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

3.5.6 High frequency spark testing

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

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

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

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

3.6 RUBBER LINING

3.6.1 The type of rubber (i.e. Natural, Butyl, Nitrile, Ebonite, and Hypalon etc.), its minimum Thickness shall be 4.5 mm & hardness shall be decided as per design code/specification.

3.6.2 For vacuum service, the Triplex lining shall be adopted. It shall consist of 3 layers:

1^{st} layer : 60 ±5 shore A
2^{nd} layer : 35 ±5 shore B
3^{rd} layer : 60 ±5 shore

3.6.3 In general for all other services the preferred hardness of rubber shall be 65 ±5 shore A.

3.6.4 Lining up to 6 mm may be applied in single layer. Above this thickness it shall be applied in 2 or more layers. Except when the sheets shall be prepared by calendaring as follows:

Thickness of Lining (mm)	Minimum no. of Plies
Up to 3	2
3 to 5	3
6	4

3.6.5 The surfaces which are to be covered with rubber shall be easily accessible & free from pitting or other physical imperfection.

3.6.6 Spark testing shall be done for Lining.

3.6.7 The internal surfaces requiring rubber lining shall be prepared by Tank Fabricator to suit rubber lining. All welds shall be ground smooth and radiused to min. rubber lining thickness. All welds shall be free from pin holes, pits, pockets and nipples. Porous welds are to be peened until tight. Since the internal surface preparation of the tank including roof (like grinding of the weldments etc.) is to be done by the tank contractor, the same surfaces will also be inspected and approved by the rubber lining contractor during tank fabrication and/or on handing over of the tank to him for rubber lining.

In the event of any surfaces found unsuitable, the tank contractor shall carry out necessary rectifications and make all surfaces suitable as per instructions of the rubber lining contractor or his authorised representative.

3.6.8 Rubber Lining shall be designed as per IS 4682 (Part 1) Latest Edition (Code of Practice for Lining of Vessels and Equipment for Chemical Processes).

3.6.9 For critical service or when required the supplier shall furnish rubber sheets to be used for checking up its suitability by concerned inspector/ owner for the service conditions specified.

3.7 **Safety**

3.7.1 Safety standards and features which are inherent in the specific mechanical equipment design codes, standards and regulations are applicable.

3.7.2 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

4.0 FABRICATION

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

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

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

a) In two pieces, with the welding seam included in the middle third and preferably on the centre line
b) In petal construction, with meridianal seams and a central cap of diameter not larger than 0.75 times the vessel outside diameter

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

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

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

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

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

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

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

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

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

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

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

5.0 INSPECTION & TESTING

5..1 Equipment shall be inspected and tested in accordance with the relevant codes, standards and specifications by TPIA. All equipment shall be inspected during various stages of manufacturing starting from identification of raw materials to final completion as per agreed Quality Assurance Plan (QAP) which shall be prepared by Successful Bidder after award of contract. In case of site fabricated/assembled equipment same inspection agency shall be responsible for inspection and testing at site. However all the bought-out items must be supplied with test certificate and inspection reports.

5.2.2 The equipment shall be inspected by Third party inspection agency (TPIA) 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. Cost of TPIA shall be in LSTK Contractor scope.

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

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

5.2.5 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.

5.2.6 Formed heads when fabricated in pieces shall be normalised and weld seams fully radiographed after forming.

5.2.7 Vessel containing lethal, toxic and highly inflammable substance shall be fully radiographed and stress relieved.

5.2.8 Tube to tube sheet joints in heat exchanger shall be leak tested with air & soap solution at 2 kg/cm2 g.

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

5.2.10 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 per applicable codes& standards.

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

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

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

A) UT examination

i) All butt - welds in thickness greater than 50mm as supplement to radiograph
ii) FPW of nozzle attachments of thickness above 50mm as supplement to radiography
iii) Clad Plates and formed heads from clad plates in all thicknesses
iv) All forgings

B) MP / PT examination

i) All edges of plates and opening in shell of CS having thickness equal to & above 40mm and LAS / SS having thickness more than 25mm
ii) Root and final layer of all butt welds
iii) Fillet welds of SS
iv) All weld surfaces after PWHT
v) Each layer of weld deposit in SS overlay
vi) Knuckle surfaces of dished ends, expansion bellows and pipe bends
vii) All forgings after machining
viii) Skirt to head joint
ix) Each pass of tube to tube sheet joint
x) Bent portion of all U-tubes

C) Radiography:

i) All weld seams of formed head, if made in more than one segment shall be full radiographed after forming
ii) When spot radiography is specified, all T – Joints & minimum 5% of total weld length excluding T joints shall be radiographed
iii) All nozzles fabricated from plates shall be 100% radiographed
iv) Radiography of welds in C - 1/2 Mo & Cr - Mo - Steel preferably be carried out after PWHT.

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

D) Rubber lining Inspection & Testing as per IS: 4682 (part 1)

6.0 PICKLING AND PASSIVATION

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

6.1.1 Pickling

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

i) Swabbing or spraying

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

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

6.1.2 **Passivation**

After pickling and water rinsing, an aqueous caustic permanganate solution containing NaOH 10 weight % and KMnO4 4 weight % shall be used for neutralising pickling solution. This shall be followed by thorough water rinsing.
Water used for pickling and washing shall not have chloride contents exceeding 30 ppm.

7.0 PAINTING

7.1 All CS external surfaces of shop fabricated equipment shall be primer and final painted as per Section-6 of NIT.

8.0 INSULATION

8.1 The equipment shall be insulated as defined elsewhere Listed in NIT document.

9.0 SPARES (ERECTION & COMMISSIONING, MANDATORY SPARES (2 YEARS OPERATION SPARES) ETC.)

9.1 **COMMISSIONING SPARES**

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

9.2 **Mandatory spares (2 years operation spares)**

9.2.1 Mandatory spares (2 years operation spares) shall be supplied by the contractor as per Section-9 of NIT.

10.0 DOCUMENTATION

Documents shall be submitted as per "Documentation schedule" in Section-8 of NIT.

11.0 VENDOR LIST

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

12.0 PACKAGING, IDENTIFICATION AND STORAGE INSTRUCTIONS

12.1 All equipments shall be properly packed/ crated to provide adequate protection during shipment to site.

12.2 Detailed packing list in waterproof envelope shall be inserted in the package together with the equipment.

12.3 The equipment shall have an identification plate giving salient equipment features such as make, year of manufacture, equipment no., name of manufacturer etc.

12.4 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.

12.5 All equipment, internals shall be properly stored at site within temporary shed by LSTK Contractor.

13.0 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.

14.0 GUARANTEE

14.1 LSTK Contractor shall be responsible for complete design, materials, workmanship and performance of the equipment supplied by him.

14.2 LSTK Contractor shall, upon notice from Purchaser, make good at his own expense all defects found during the guarantee period expeditiously.

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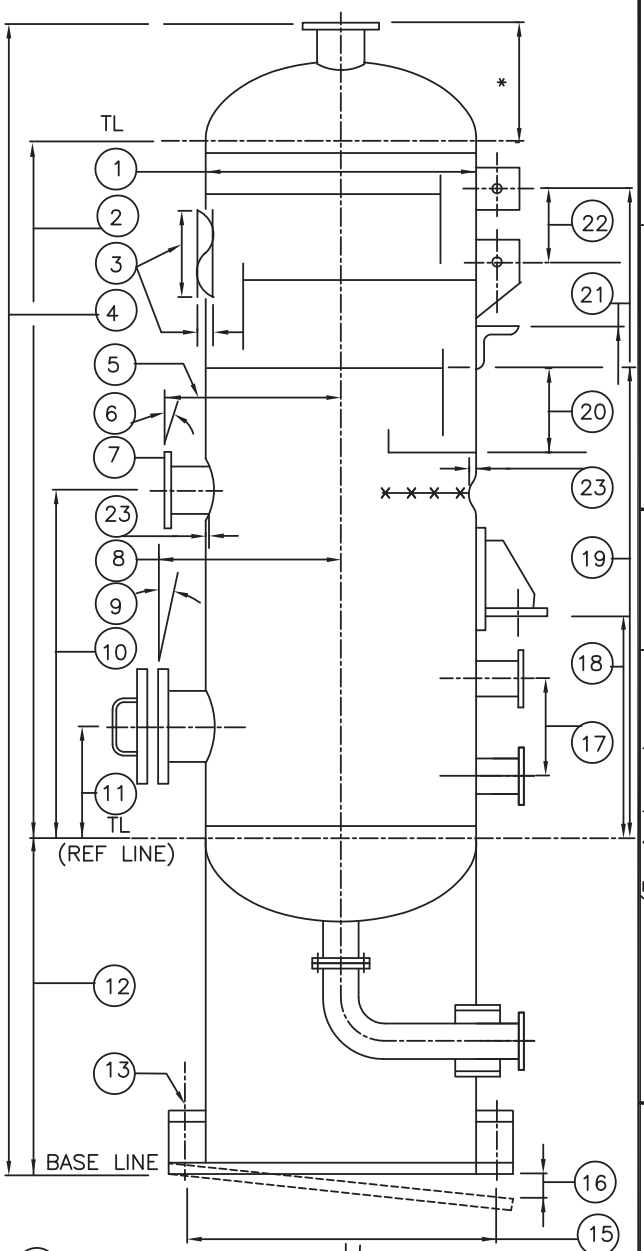
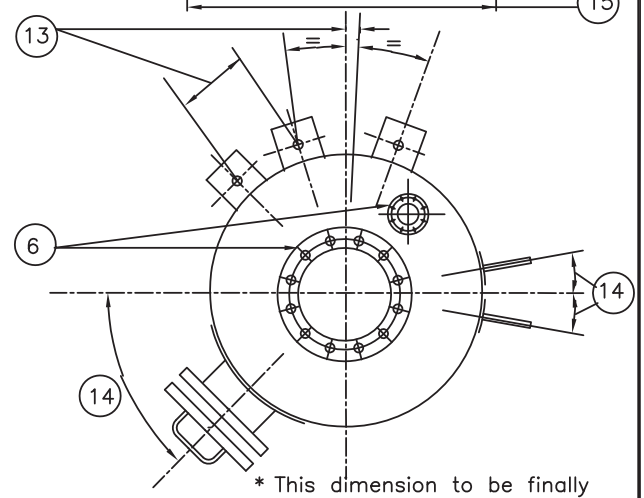
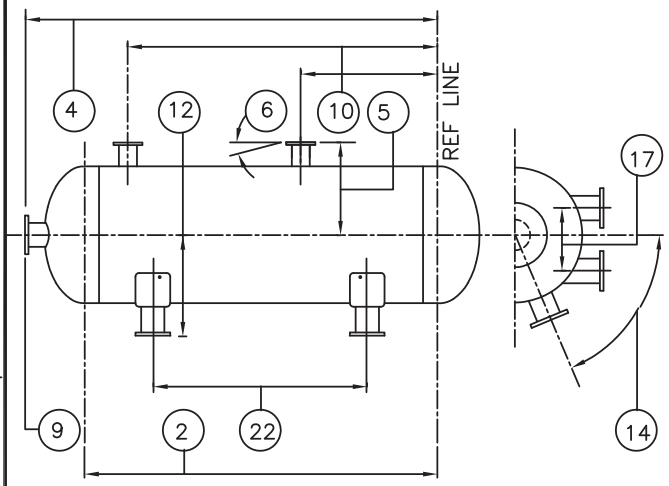
VESSEL TOLERANCES

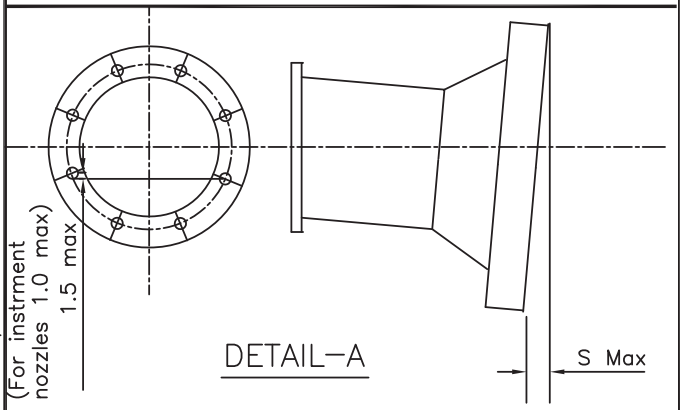




* This dimension to be finally adjusted to suit total height

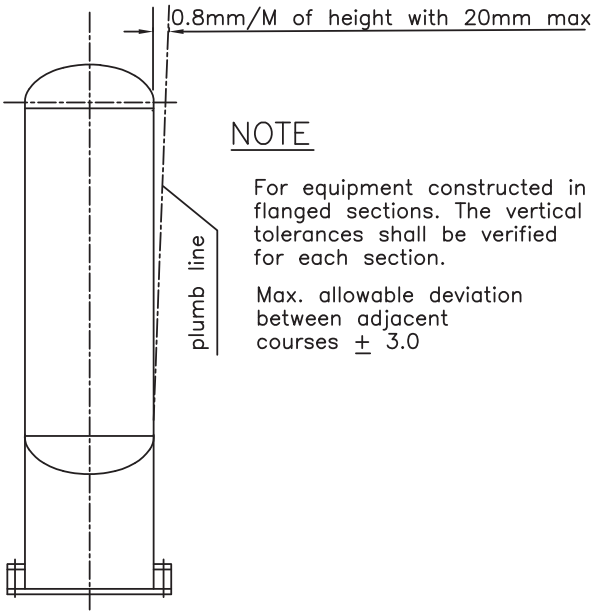


TOLERANCES FOR HORIZONTAL VESSEL



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

S max shall be ± 0.5mm for instrument nozzle



NOTE

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

Max. allowable deviation between adjacent courses ± 3.0

VERTICAL TOLERANCES AS ERECTED

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

FILE NAME :STD/NCR/PV001

1) Shell Tolerances

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

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

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

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

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

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

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

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

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

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

11) Location of manhole from reference line , ± 12

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

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

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

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

16) Maximum deviation of skirt base

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

17) Distance between level control nozzles, ± 1.0 mm

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

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

20) Tolerance between adjacent tray plates, ± 3

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

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

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

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

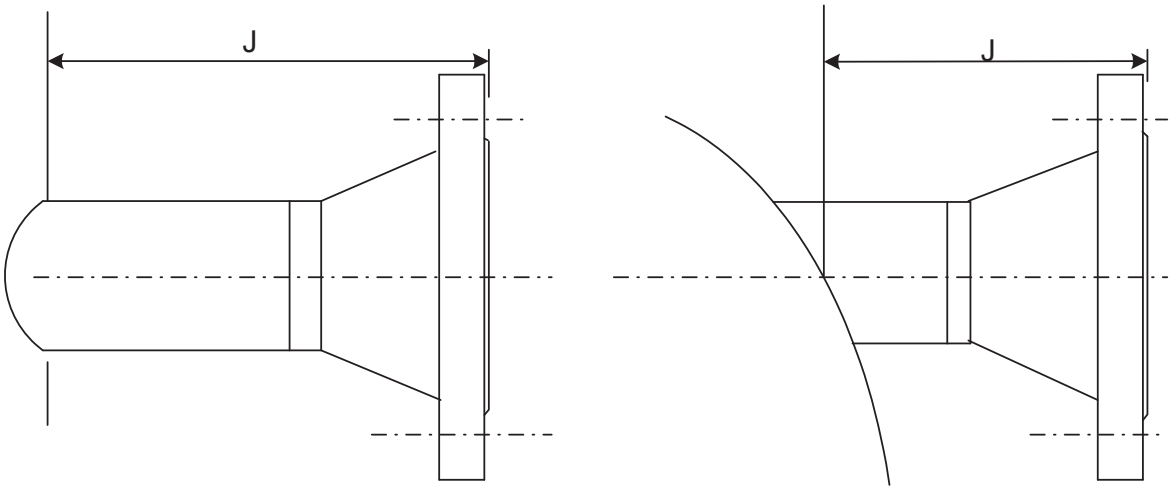
Notes :

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

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

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

4) All dimensions are in mm unless otherwise specified.



VALUES OF 'J'

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

NOTES :-

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

DATE	PURPOSE	PREPARED	REVIEWED	APPROVED
30/09/99	ISSUED FOR IMPLIMENTATION			

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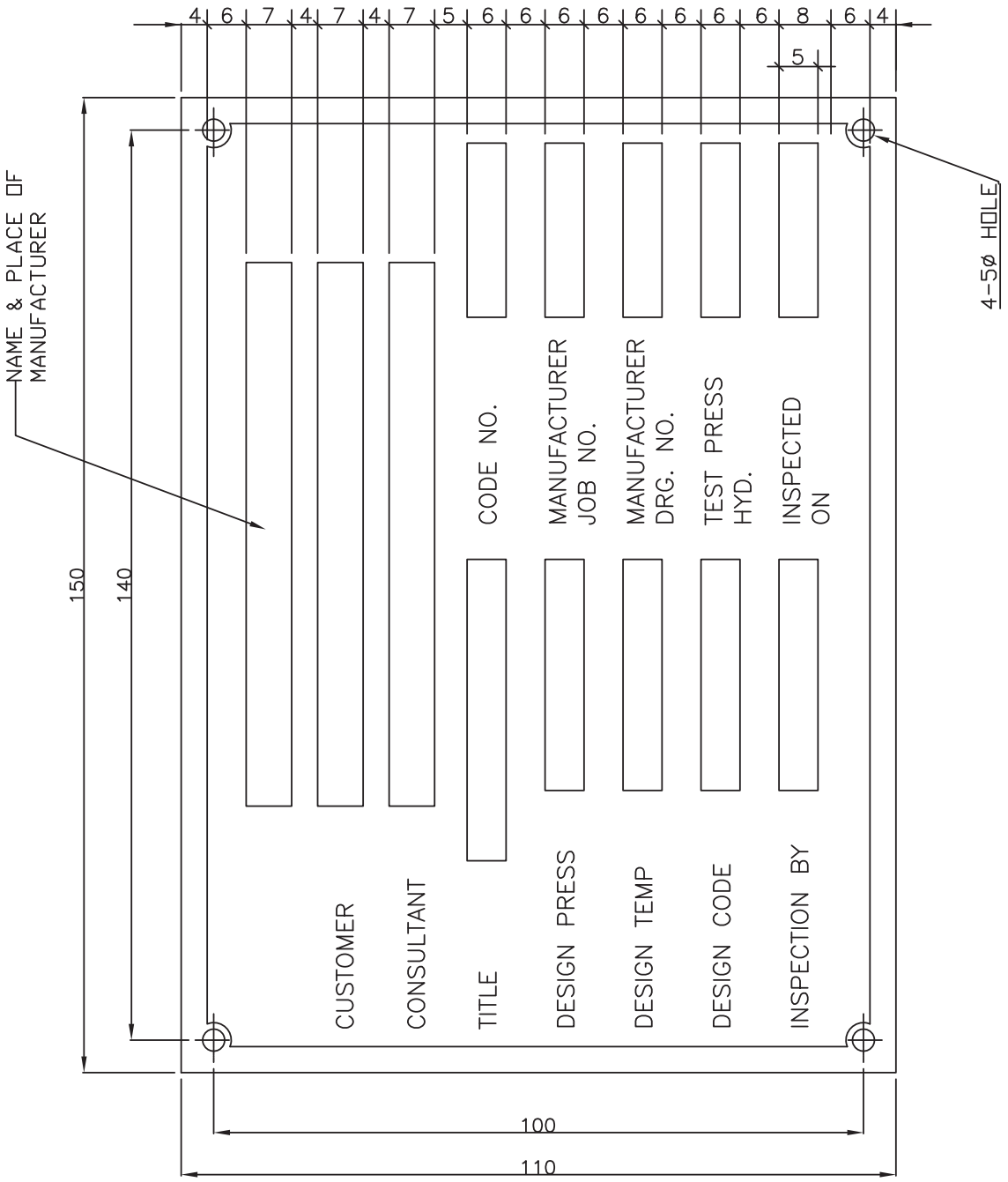
NAME PLATE FOR VESSEL & TOWER

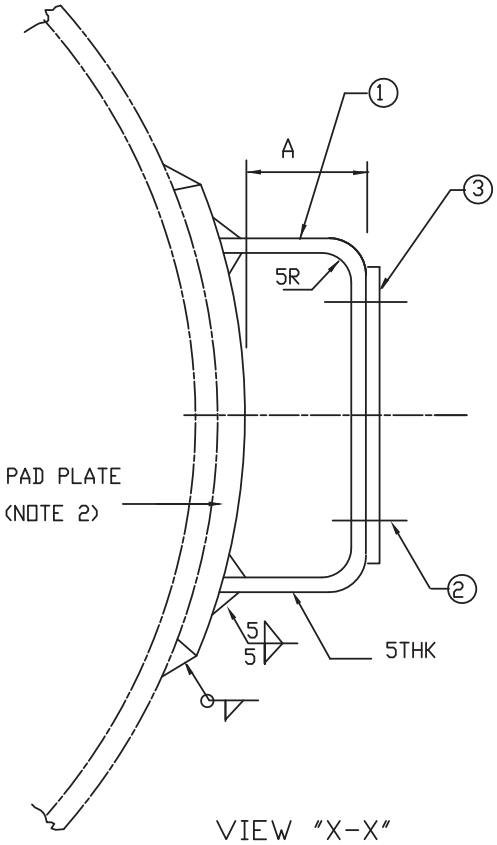
PDS:PV 003
ISSUE: AUG. 1999
SHEET 1 OF 2



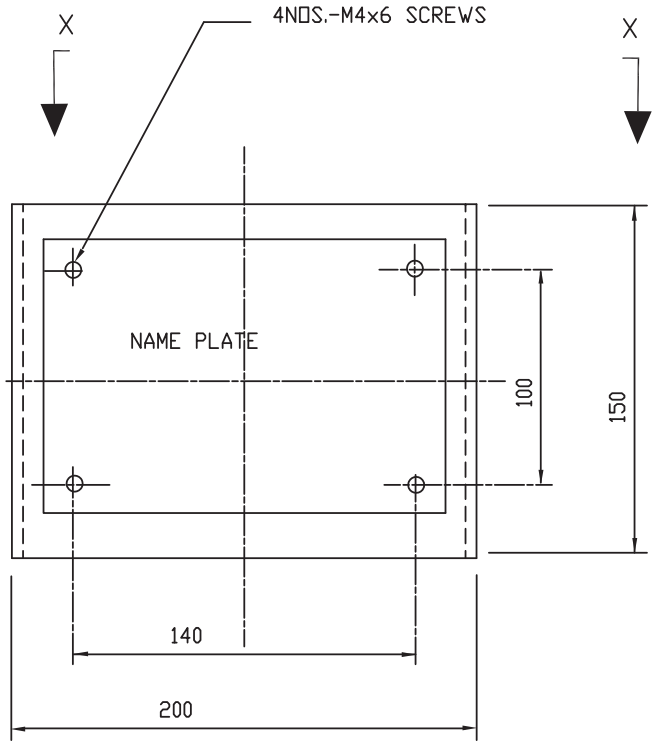
AUG. 99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APPROVED

FILE NAME :STD/RCP/PV003SH1

NAME PLATE BRACKET



VIEW "X-X"



ELEVATION

DIMENSION "A"

a) VESSELS WITHOUT INSULATION = 25 mm

b) VESSELS WITH INSULATION = INSULATION THK + 25 mm

NOTES:

1 MATERIALS:

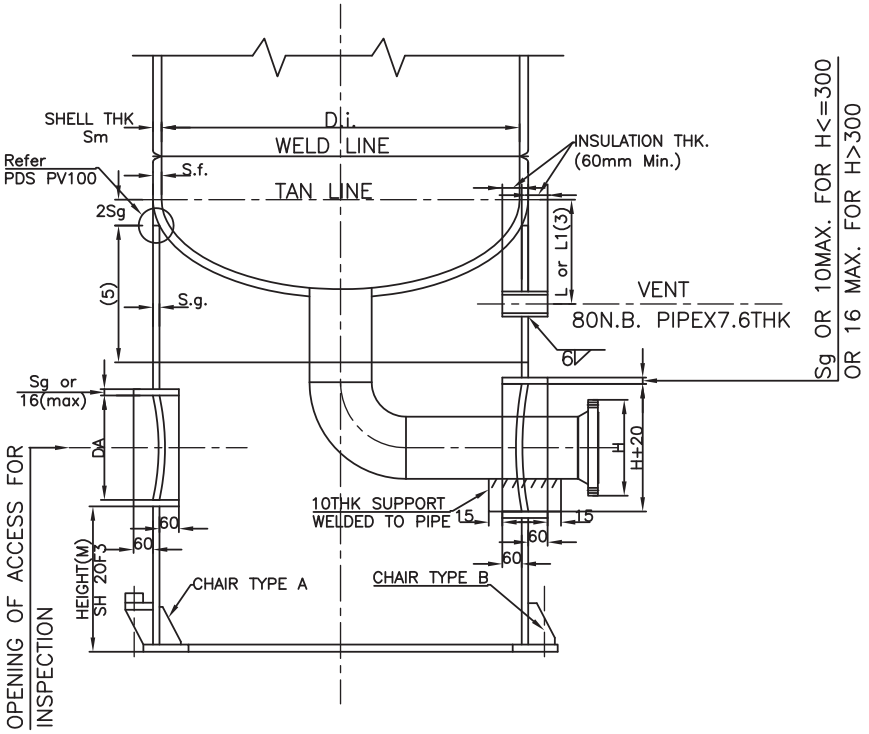
BRACKET (1) IS 2062 Gr.A
SCREWS (2) S.S.304
NAME PLATE(3) S.S.304

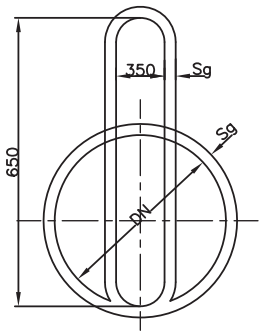
2 PAD PLATE OF SIMILAR COMPOSITION AS THAT OF SHELL SHALL BE WELDED ON VESSELS OF MATERIALS OTHER THAN CARBON STEEL AND THOSE UNDER LOW TEMPERATURE SERVICE

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

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

FILE NAME :STD/RCP/PV003H2





OPENING OF ACCESS

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

NOTES :−

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

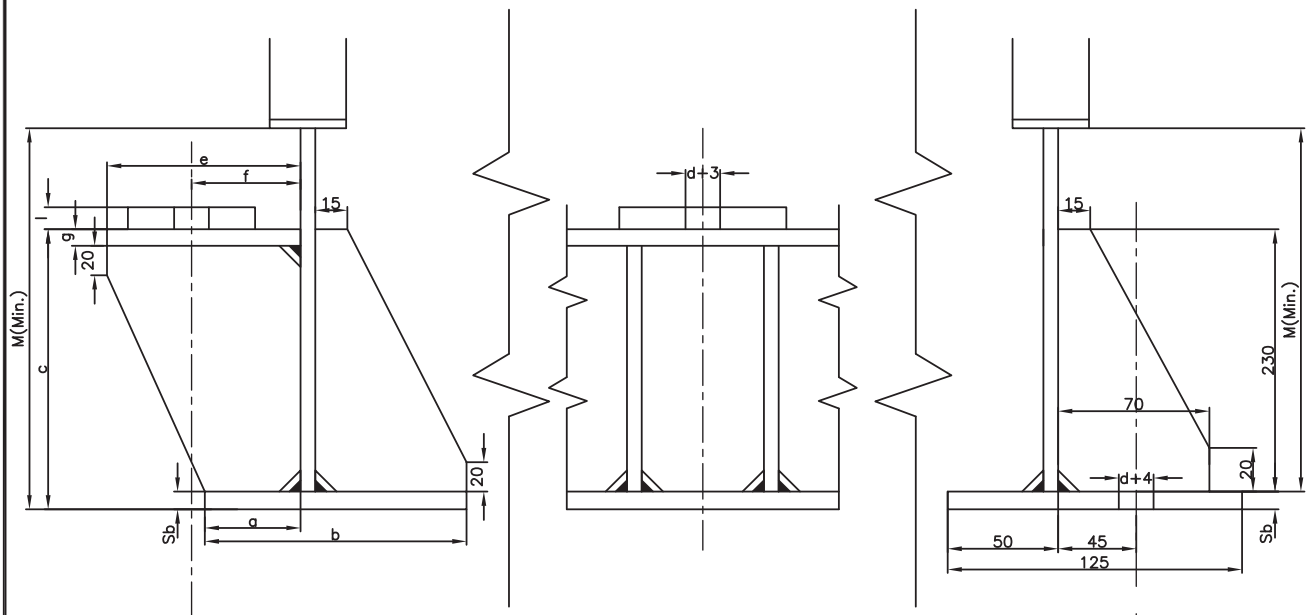
2. For the skirt of conical(lapered) construction, the type and the no. of access opening and vent to be decided according to the dia. of skirt at corresponding elevation of centre line of opening.

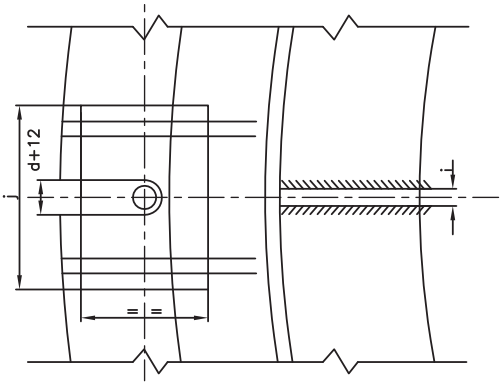
3. The values of 'L' & 'L1' are adopted for insulation thickness<= 90mm. L for semielliptical head and 'L1' for torispherical head with r/D = 0.1. For other types of head and insulation thickness > 90mm. 'L' & 'L1' shall be decided case by case.

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

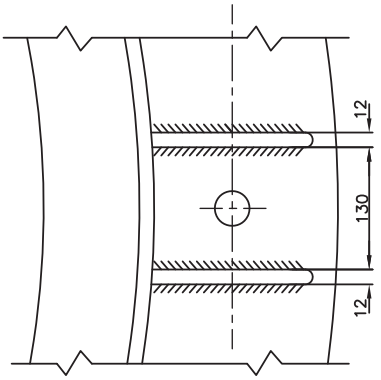
5. In case the head is made of S.S. or of special material and skirt in C.S., unless otherwise specified provide the skirt length ot the same material as that of head with minimum length of 250mm. For high temperature service, the length and the material of the skirt shall be decided according to design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

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





CHAIR TYPE"A"(HEAVY)

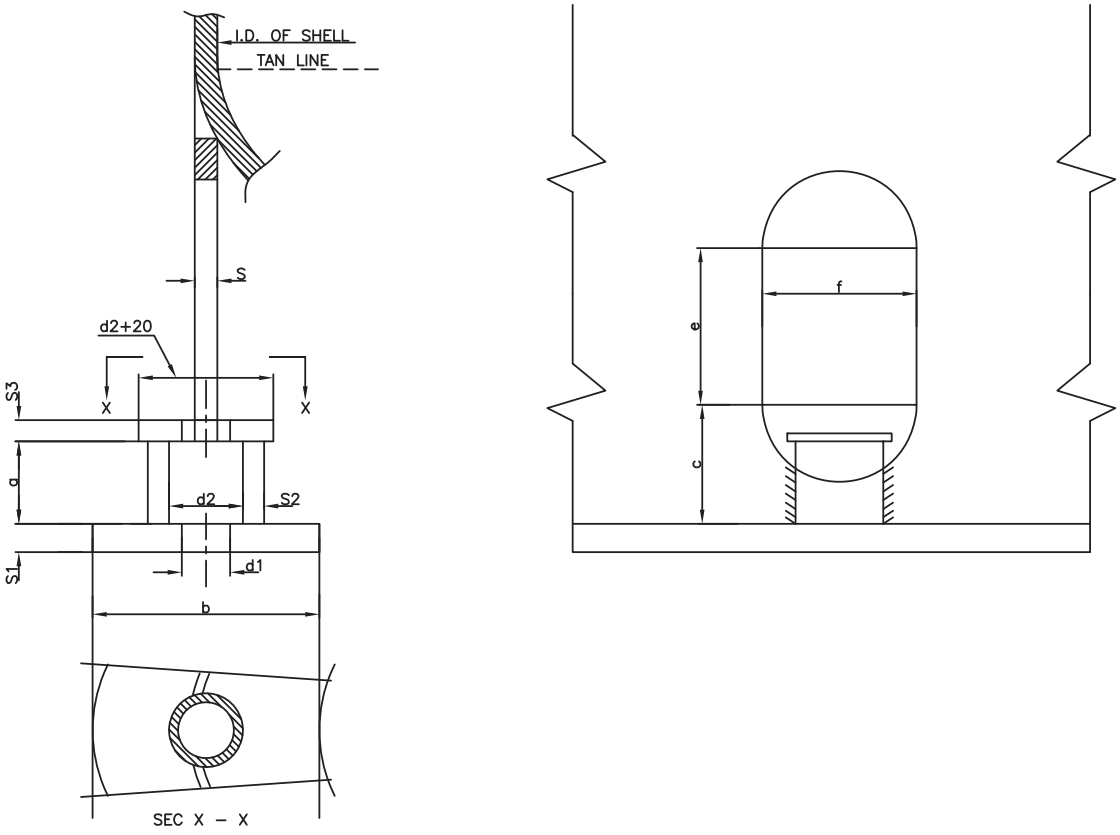


CHAIR TYPE"B"(LIGHT)

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

NOTES :–

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



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

NOTES :–

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

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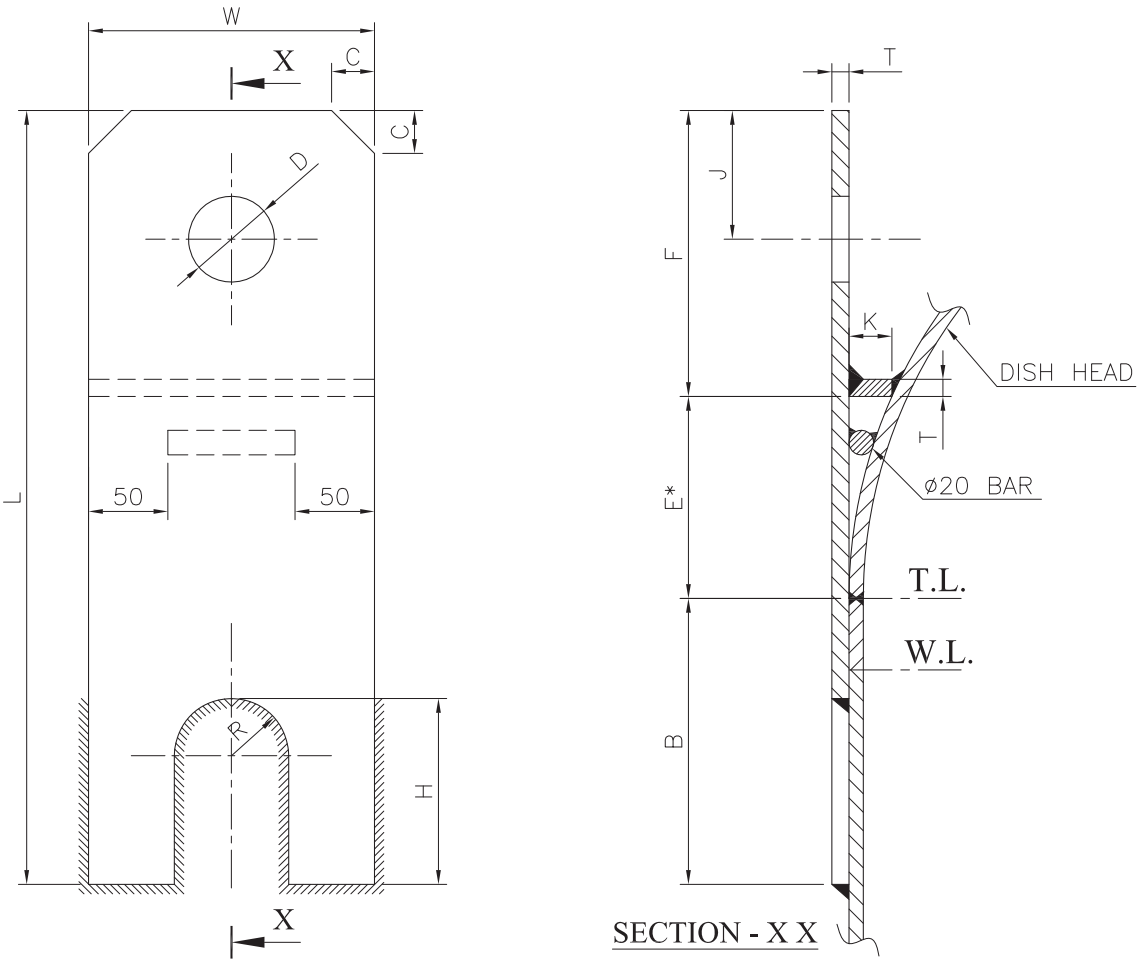
LIFTING LUG

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

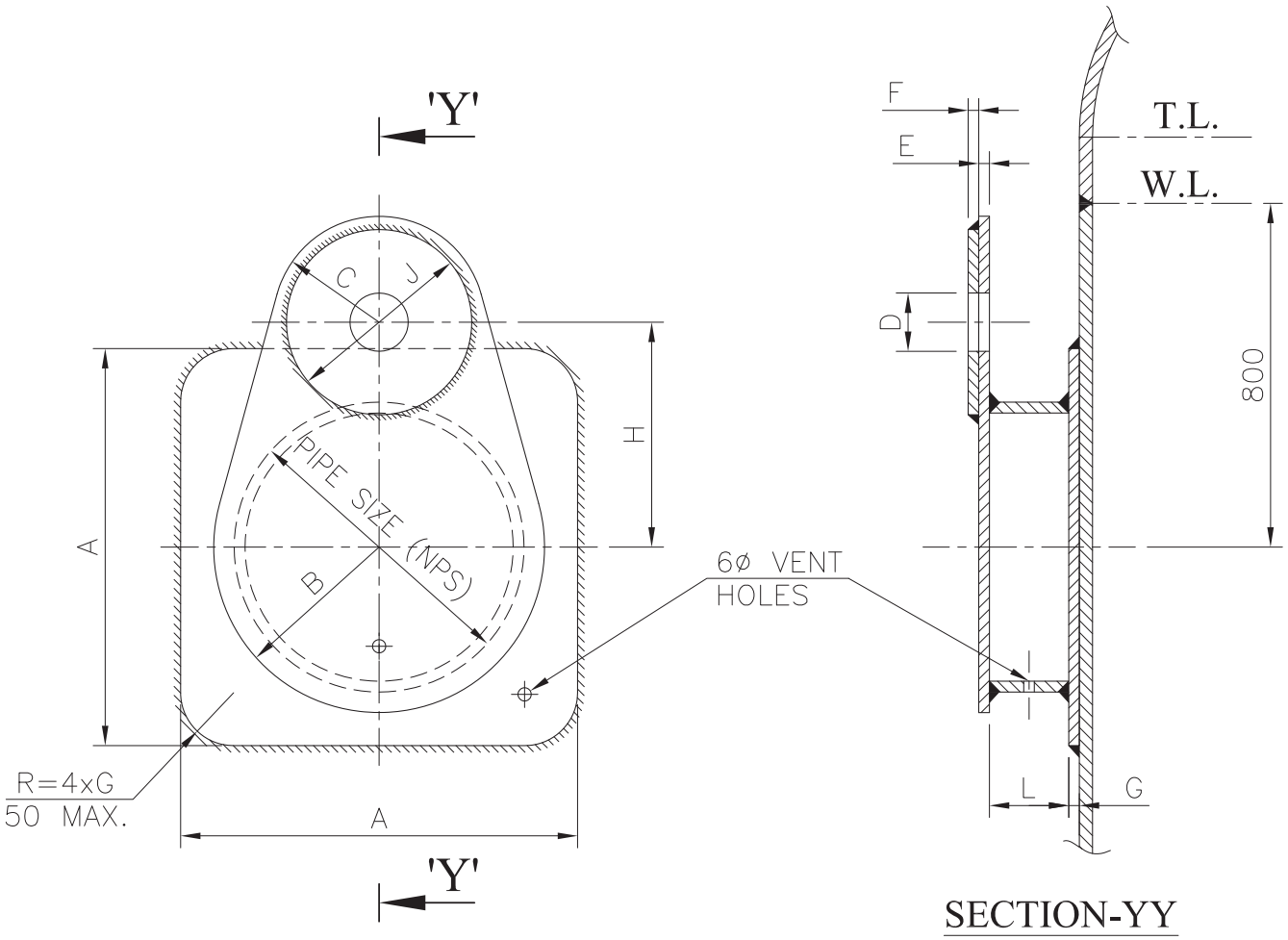


MAX. ERECTION WT OF VESSEL (M TON)	10	25	45	90	140	180
THICKNESS OF PLATE (T)	12	28	40	50	70	80
WIDTH (W)	200	230	300	400	500	615
LENGTH (L)	400+E	460+E	580+E	750+E	900+E	1080+E
DIAMETER OF HOLE (D)	60	75	75	100	130	150
HEIGHT OF NOTCH & SIDE WELD (H)	130	130	150	200	250	300
RADIUS OF NOTCH (R)	40	40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

NOTES :

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

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



SECTION-YY

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

NOTES :

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

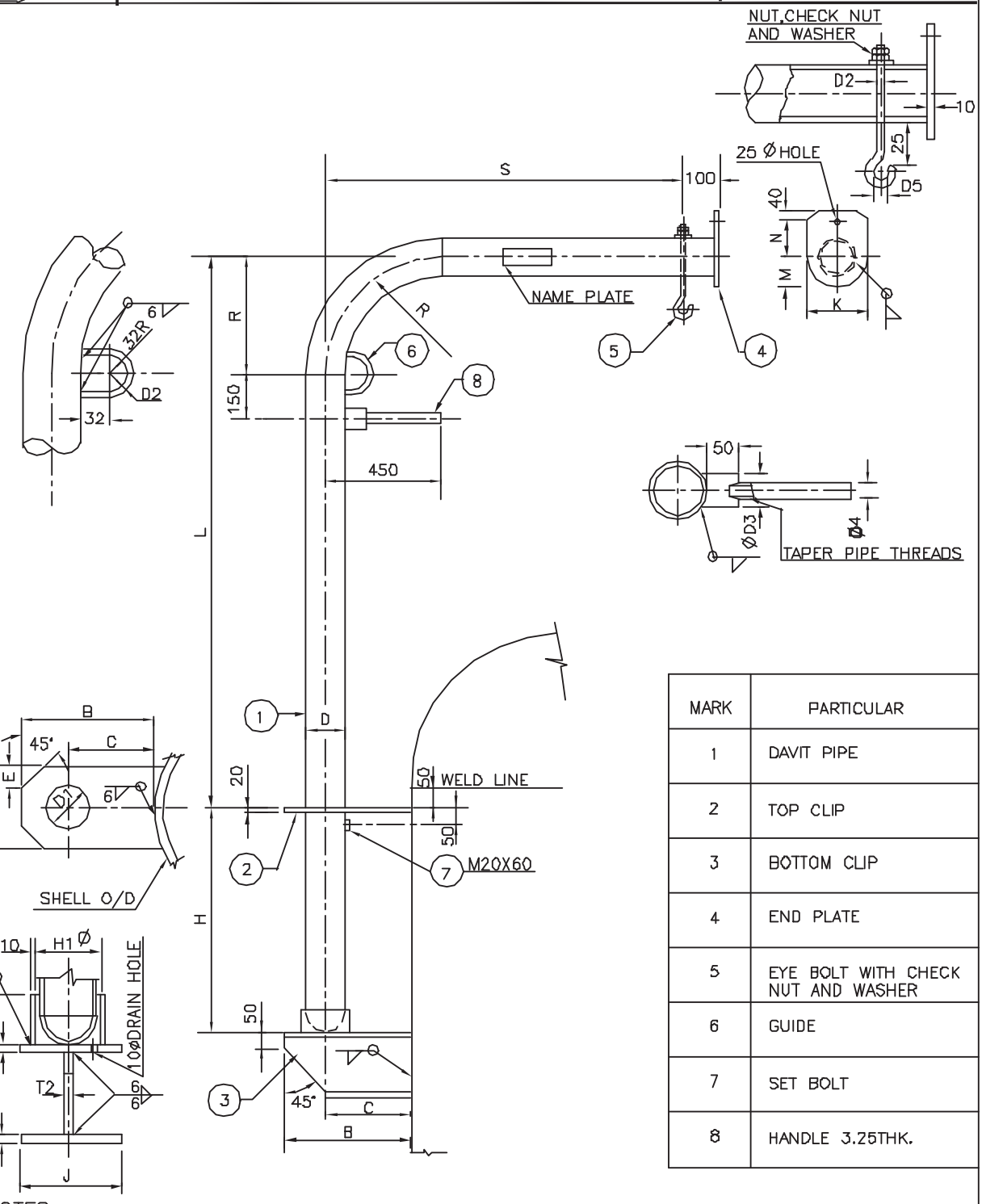
PDIL

PIPE DAVIT

PDS:PV 303

ISSUE: AUG. 1999

SHEET 1 OF 2



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

NOTES:

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

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

SH.2 FILE DKM/DAYTODAY/STANDARD/MECH/PDS PV303-F3

FILE NAME :STD/PPS/PV303

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

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

Controlled Copy

Copy Serial No. 01

Issued by: S. K. Upadhyay

Dated: Upadhyay

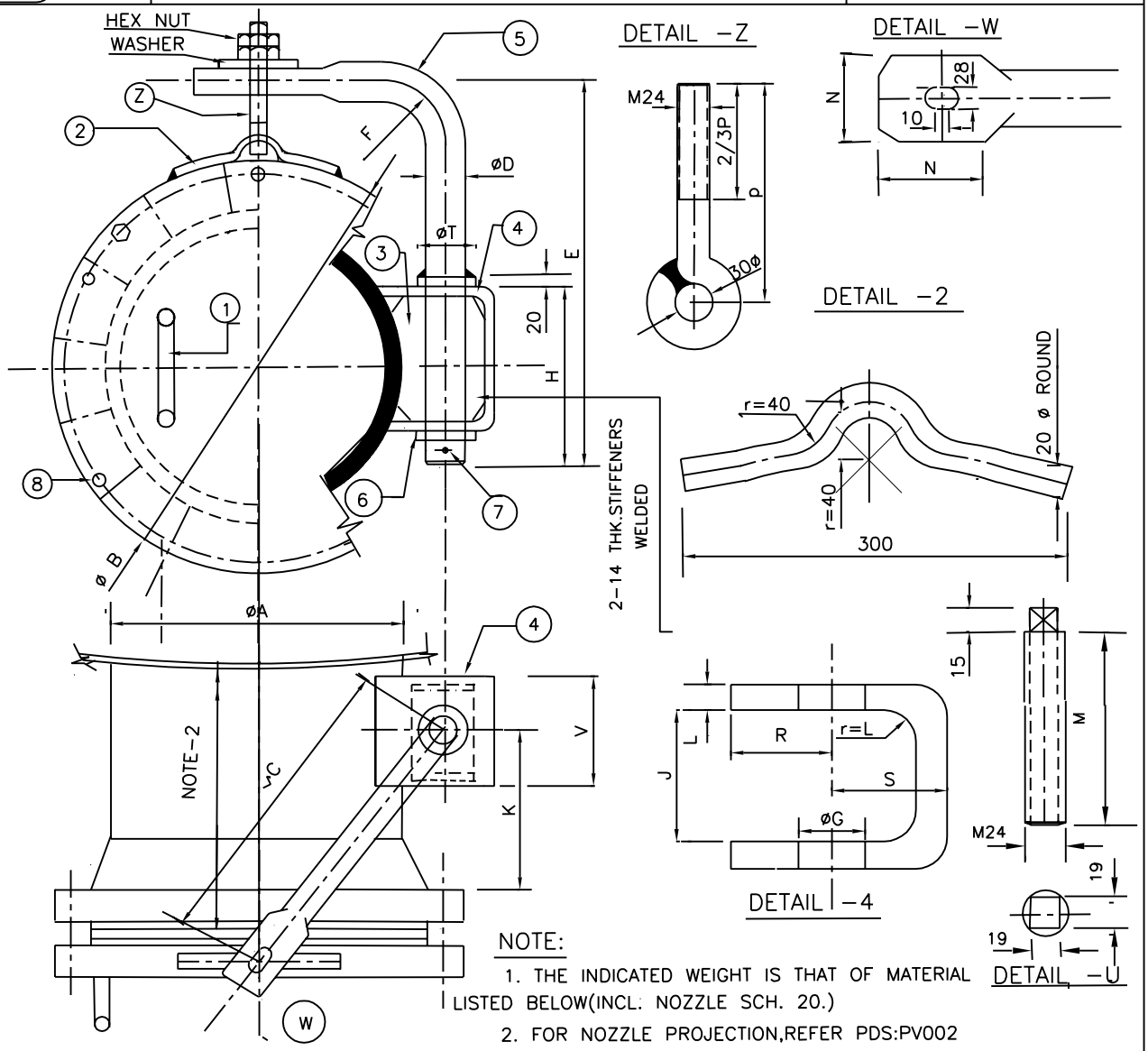
09.09.99 (Signature & Name)

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

PDIL

DAVIT FOR MANHOLE WITH ASME FLANGE FOR HORIZONTAL NOZZLE

PDS: PV 304
ISSUE: OCT. 1999
SHEET 1 OF 2



NOTE:
1. THE INDICATED WEIGHT IS THAT OF MATERIAL LISTED BELOW(INCL. NOZZLE SCH. 20.)
2. FOR NOZZLE PROJECTION,REFER PDS:PV002

SIZE DN	RTG PSI	A	B	C	NPS	E	F	G	H	J	K	L	M	N	P	R	S	T	V	WT KG
18"	150	457	635	370	2"SCH80	600	260	62	280	200	220	20	80	80	180	70	100	100	140	205
	300	457	711	390	2"SCH80	650	290	62	280	200	239	20	100	80	180	70	100	100	140	365
	600	457	743	440	3"SCH160	650	310	92	280	200	284	20	130	100	180	85	120	130	180	595
	900	457	787	485	3"SCH160	700	350	92	280	200	328	25	150	100	180	85	130	130	180	785
20"	150	508	698	395	2"SCH80	650	300	62	280	200	225	20	85	80	200	70	100	100	140	265
	300	508	775	435	3"SCH160	700	300	92	280	200	282	20	105	100	200	85	120	130	180	465
	600	508	813	465	3"SCH160	700	300	92	280	200	291	25	135	100	200	85	130	130	180	695
24"	150	610	813	445	2"SCH80	700	340	62	280	200	233	20	90	80	200	70	100	100	140	365
	300	610	914	485	3"SCH160	750	360	92	280	200	269	20	110	100	200	85	120	130	180	675
	600	610	940	520	3"SCH160	750	400	92	280	200	303	25	150	100	200	85	130	130	180	1095

PART NO.	DESCRIPTION	MATERIAL	QUANTITY	OBSERVATIONS
8	JACK SCREW SEE DETAIL U	IS:2062 GRA/B	3	
7	COTTER PIN	IS:2062 GRA/B	1	
6	WASHER	IS:2062 GRA/B	1	
5	DAVIT PIPE	SA:106 GR B	1	
4	DAVIT BRACKET	SAME AS NOZZLE	1	
3	BRACKET STIFFENERS	SAME AS NOZZLE	2	
2	HOLDING ROD/HOOK	SAME AS NOZZLE	1	
1	HANDLE	SAME AS COVER	1	

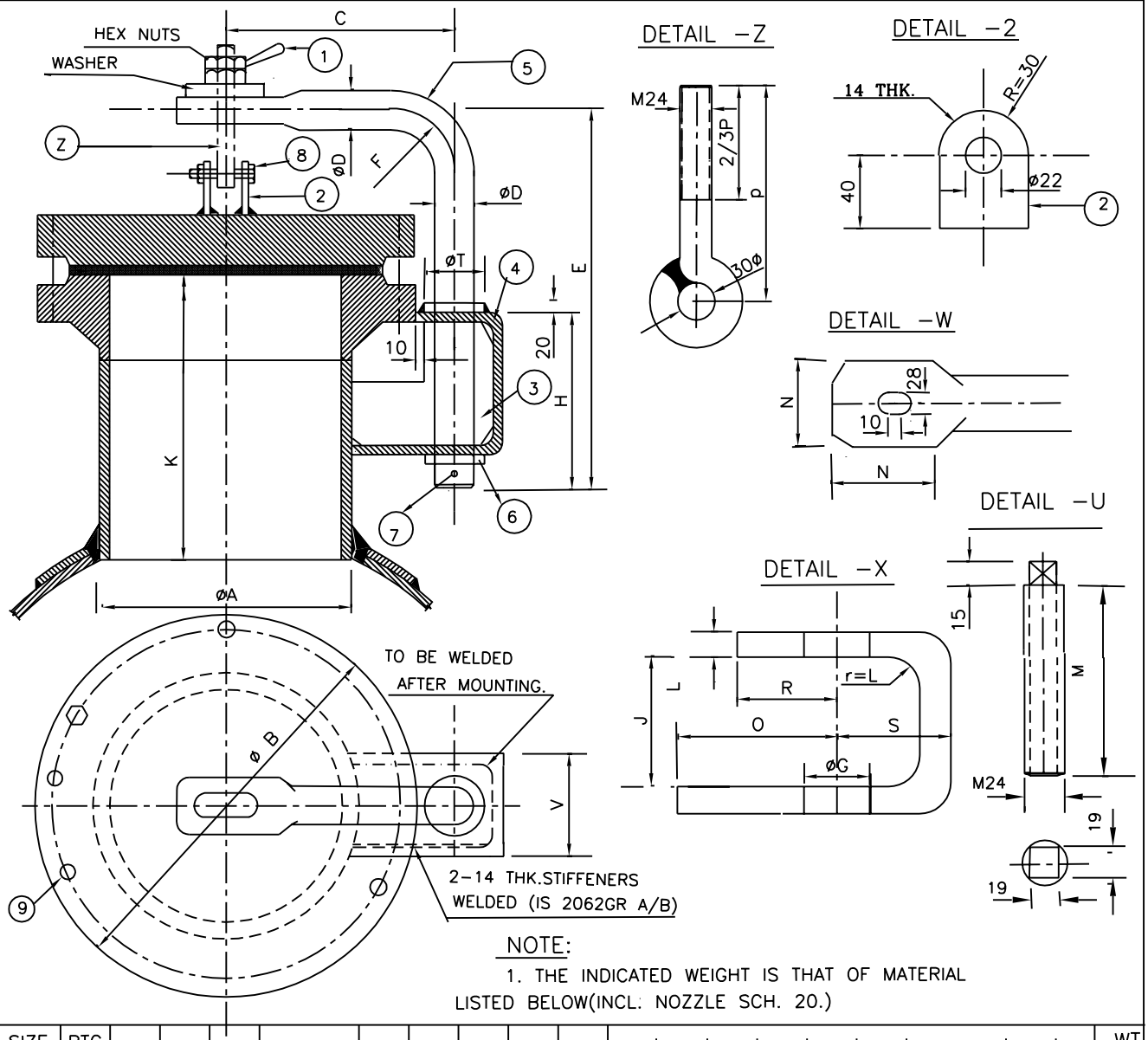
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
04.10.99	ISSUED FOR IMPLEMENTATION			

FILE NAME :STD/RPAL/PV304

PDIL

DAVIT FOR MANHOLE WITH ASME FLANGE FOR VERTICAL NOZZLE

PDS: PV 304
ISSUE: OCT. 1999
SHEET 2 OF 2



NOTE:
1. THE INDICATED WEIGHT IS THAT OF MATERIAL LISTED BELOW(INCL. NOZZLE SCH. 20.)

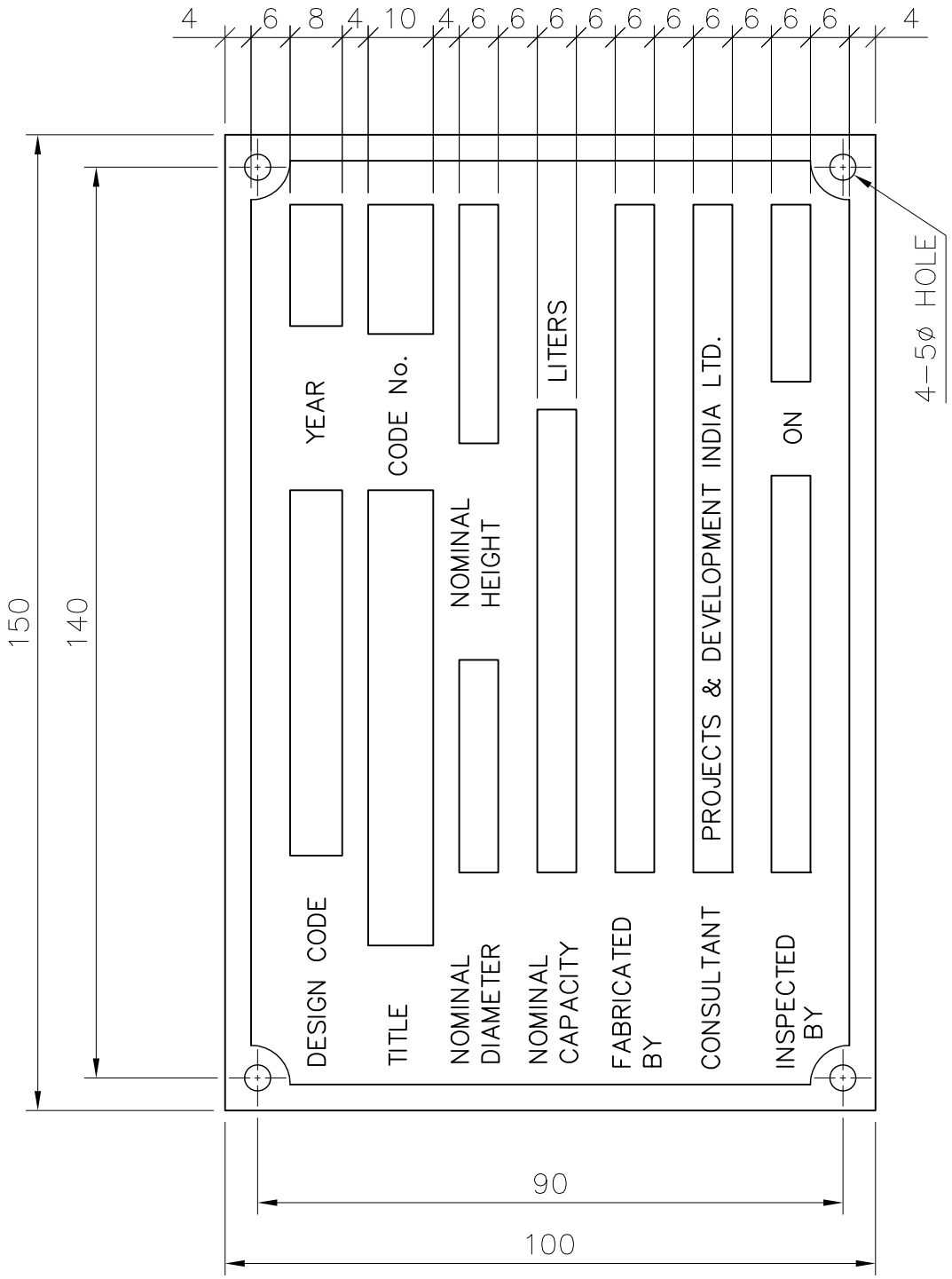
SIZE DN	RTG PSI	A	B	C	NPS	E	F	G	H	J	K	L	M	N	O	P	R	S	T	V	WT KG
18"	150	457	635	390	2"SCH80	550	300	62	220	150	REFER PDS:PV 002	20	80	80	159	300	70	100	100	140	205
	300	457	711	430	2"SCH80	600	340	62	220	150		20	100	80	197	300	70	100	100	140	370
	600	457	743	460	3"SCH160	750	340	92	280	200		20	130	100	228	350	85	120	130	180	615
	900	457	787	480	3"SCH160	800	360	92	280	200		25	150	100	250	350	85	130	130	180	800
20"	150	508	698	420	2"SCH80	550	300	62	220	150		20	85	80	165	300	70	100	100	140	260
	300	508	775	465	3"SCH160	650	340	92	220	150		20	105	100	206	300	70	100	100	180	450
	600	508	813	480	3"SCH160	700	340	92	280	200		25	135	100	238	350	85	120	120	180	665
24"	150	610	813	480	2"SCH80	600	360	62	220	150		20	90	80	172	350	70	100	100	140	365
	300	610	914	545	3"SCH160	650	410	92	220	150		20	110	100	237	350	85	120	130	180	675
	600	610	940	560	3"SCH160	850	440	92	280	200		25	150	100	250	450	85	130	130	180	1095

PART NO.	DESCRIPTION	MATERIAL	QUANTITY	OBSERVATIONS
9	JACK SCREW SEE DETAIL U	IS:2062 GRA/B	3	
8	BOLTS&HEX NUTS	–	AS REQUIRED	
7	COTTER PIN	IS:2062 GRA/B	1	
6	WASHER	IS:2062 GRA/B	1	
5	DAVIT PIPE	SA:106 GR B	1	
4	DAVIT BRACKET	SAME AS NOZZLE	1	
3	BRACKET STIFFENERS	SAME AS NOZZLE	2	
2	HOLDING PLATE	SAME AS NOZZLE	2	
1	HANDLE	IS:2062 GRA/B	1	

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

FILE NAME :STD/RPAL/PV304

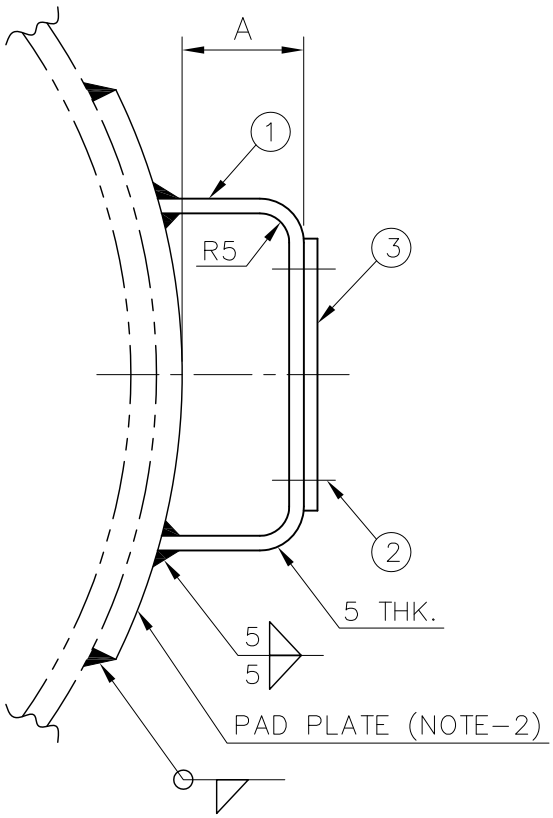
NAME PLATE FOR STORAGE TANK



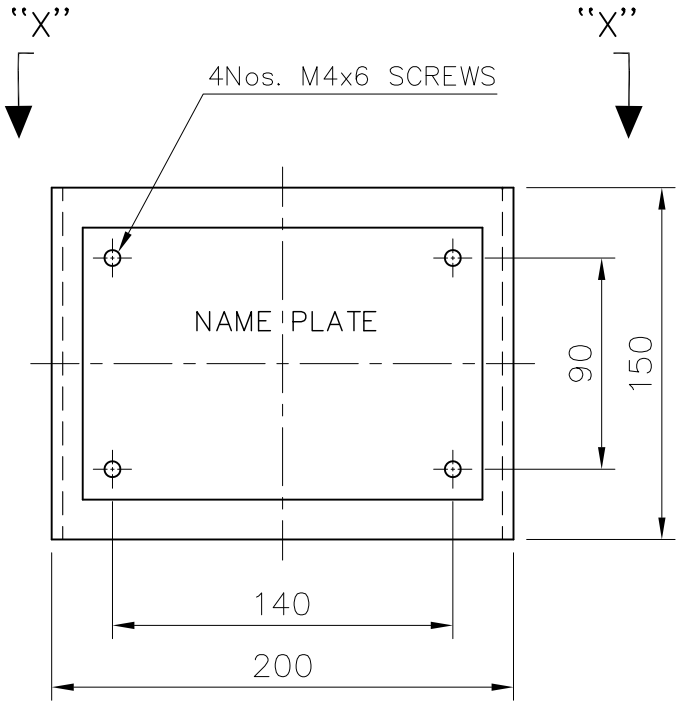
2 THK PLATE, MATERIAL:18/8 STAINLESS STEEL.

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

NAME PLATE BRACKET



VIEW "X-X"



ELEVATION

DIMENSION "A"

a) VESSELS WITHOUT INSULATION = 25 mm

b) VESSELS WITH INSULATION = INSULATION THK + 25 mm

NOTES :

1 MATERIALS :

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

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

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

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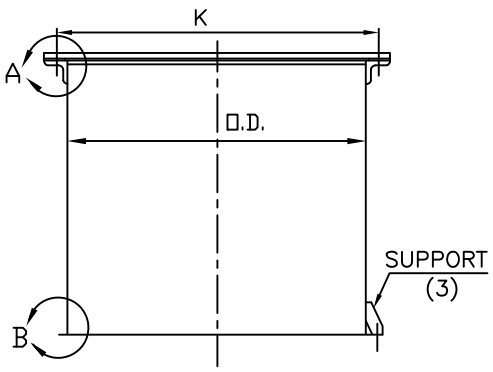
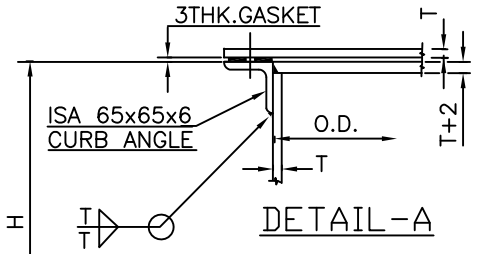
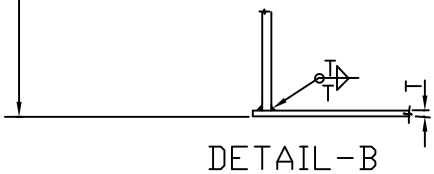
PDIL

STORAGE TANKS WITH FLAT COVER
CARBON STEEL



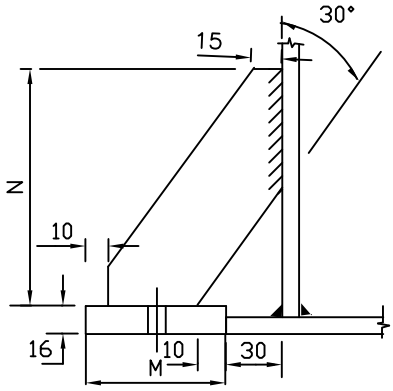




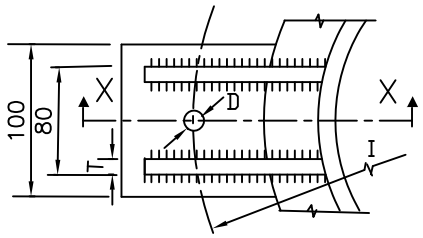
TANK DIMENSIONS

CAPACITY M3	SHELL OD. MM	HEIGHT M.M.	T(1) MM	K.MM	NO.OF BOLTS	SIZE OF BOLTS	WEIGHT K.G.	STIFFENERS FOR TOP COVER * (2)
0.4	800	800	5	860	24	M 12	148	
0.63	900	1000	5	960	28	M 12	196	
1.0	1000	1300	5	1070	28	M 16	265	
1.60	1200	1450	5	1270	32	M 16	358	
2.0	1400	1350	5	1470	36	M 16	434	2-65x65x6L
3.20	1600	1600	5	1670	36	M 16	570	-DO-
4.00	1800	1600	5	1870	40	M 16	675	2-65x65x8L
6.30	2000	2050	5	2070	44	M 16	892	-DO-
8.00	2200	2150	5	2270	48	M 16	1044	2-75x75x8L
10.00	2400	2200	5	2470	56	M 16	1198	-DO-
12.50	2600	2400	5	2670	64	M 20	1390	-DO-
16.00	2800	2600	5	2870	72	M 20	1645	4-65x65x8L
20.00	3000	2850	5	3070	72	M 20	1901	-DO-
25.00	3200	3150	5	3270	80	M 20	2197	-DO-

* STIFFENER SIZE SHALL BE CHECKED FOR ANY EXTERNAL LOADING ON TOP OF TANK.



SEC-XX



SUPPORT

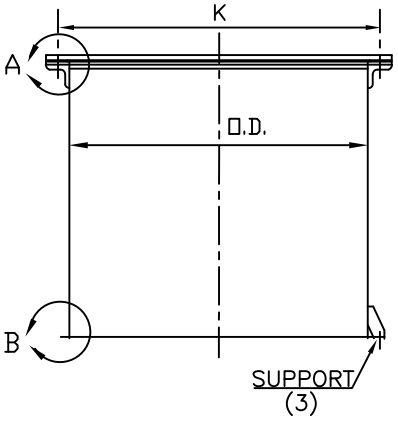
SUPPORT DIMENSIONS

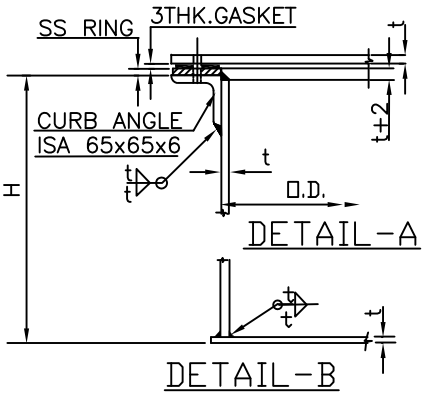
OD	H	I	M	N	D	SIZE OF BOLTS
800	800	950	70	170	20	M 16
900	1000	1050	70	170	20	M 16
1000	1300	1150	70	170	20	M 16
1200	1450	1350	70	170	20	M 16
1400	1350	1550	100	220	20	M 16
1600	1600	1810	100	220	20	M 16
1800	1600	2010	100	220	20	M 16
2000	2050	2210	150	310	20	M 16
2200	2150	2510	150	310	20	M 16
2400	2250	2710	150	310	20	M 16
2600	2400	2910	150	310	20	M 16
2800	2600	3110	150	310	20	M 16

NOTE: 1. MINIMUM THICKNESS OF TANKS WITH AGITATOR/LINING SHALL BE 1 MM HIGHER THAN SPECIFIED
2. STIFFENERS ON TOP COVER SHALL BE WELDED AT 90° TO EACH OTHER STIFFENER SPACING FOR SHELL DIA >= 2800 SHALL BE 1/3rd O.D.
3. IF REQUIRED, 4 NO. OF SUPPORTS MAY BE PROVIDED AS SHOWN IN FIGURE WITH DIMENSIONS AS GIVEN IN ABOVE TABLE
4. THESE TANKS ARE DESIGNED FOR ATOMOSPHERIC PRESURE AND TEMPERATURE LESS THAN 100°C, THICKNESS INCLUDES 1MM CORROSION ALLOWANCE
5. LINED TANKS SHALL BE PROVIDED WITH AT LEAST TWO MANHOLES.
6. TANKS >2800 O.D.NEED NOT BE ANCHORED.

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

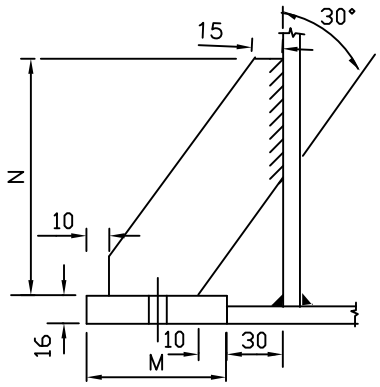
FILE NAME :VGK/SR005SH1



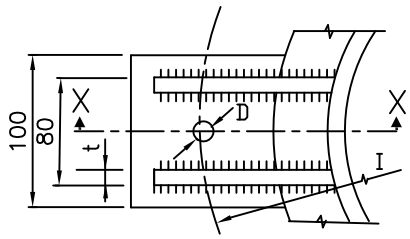


DETAIL-A

DETAIL-B



SEC-XX



SUPPORT

TANK DIMENSIONS

CAPACITY M3	SHELL OD MM	HEIGHT M.M.	t(1) MM	SS.RING	K MM	NO.OF BOLTS	SIZE BOLTS	WEIGHT K.G.	STIFFENER FOR TOP COVER * (2)
0.4	800	800	5	65x3THK	860	24	M 12	143	
0.63	900	1000	5		960	28	M 12	201	
1.0	1000	1300	5		1070	28	M 16	272	
1.60	1200	1450	5		1270	32	M 16	366	
2.0	1400	1350	5		1470	36	M 16	443	2-65x65x6L
3.20	1600	1600	5		1670	36	M 16	578	-DO-
4.00	1800	1600	5		1870	40	M 16	684	2-65x65x8L
6.30	2000	2050	5		2070	44	M 16	992	-DO-
8.00	2200	2150	5		2270	48	M 16	1055	2-75x75x8L
10.00	2400	2250	5		2470	56	M 16	1210	-DO-
12.50	2600	2400	5		2670	64	M 20	1403	-DO-
16.00	2800	2600	5		2870	72	M 20	1659	4-65x65x8L
20.00	3000	2850	5		3070	72	M 20	1916	-DO-
25.00	3200	3150	5		3270	80	M 20	2213	-DO-

* STIFFENER SIZE SHALL BE CHECKED FOR ANY EXTERNAL LOADING ON TOP OF TANK.

MATERIAL FOR CURB ANGLE, STIFFENER AND SUPPORT SHALL BE TO IS:2062 Gr.B. STIFFENER SHALL BE WELDED OVER TOP COVER WITH SS. PAD PLATE

SUPPORT DIMENSIONS

OD	H	I	M	N	D	SIZE OF BOLTS
800	800	950	70	170	20	M 16
900	1000	1050	70	170	20	M 16
1000	1300	1150	70	170	20	M 16
1200	1450	1350	70	170	20	M 16
1400	1350	1550	100	170	20	M 16
1600	1600	1810	100	220	20	M 16
1800	1600	2010	100	220	20	M 16
2000	2050	2210	150	310	20	M 16
2200	2150	2510	150	310	20	M 16
2400	2250	2710	150	310	20	M 16
2600	2400	2910	150	310	20	M 16
2800	2600	3110	150	310	20	M 16

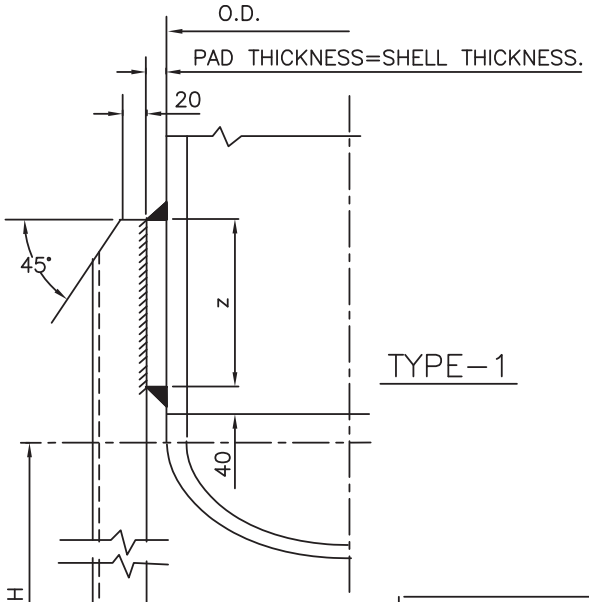
NOTE:

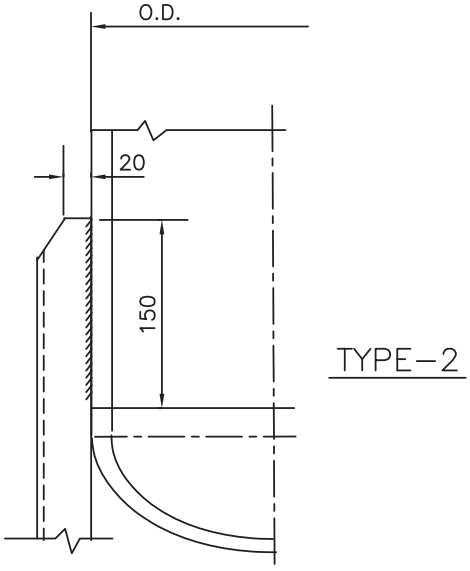
1. MINIMUM THICKNESS OF TANKS WITH AGITATOR SHALL BE 1 MM HIGHER THAN SPECIFIED ABOVE
2. STIFFENERS ON TOP COVER SHALL BE WELDED AT 90 TO EACH OTHER STIFFENER SPACING FOR SHELL DIA >=2000 SHALL BE 1/3rd O.D.
3. IF REQUIRED 4 NO. OF SUPPORTS MAY BE PROVIDED AS SHOWN IN FIGURE WITH DIMENSIONS AS GIVEN IN ABOVE TABLE
4. THESE TANKS ARE DESIGNED FOR ATOMOSPHERIC PRESURE AND TEMPERATURE LESS THAN 100°C
5. TANKS > 2800 O.D. NEED NOT BE ANCHORED.

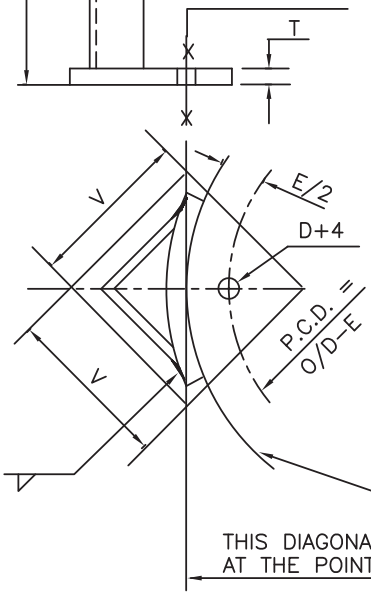
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
AUG. 99	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		

FILE NAME :VGK/SR005SH2

LEG SUPPORT FOR VERTICAL VESSELS







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

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

VESSEL O/D.

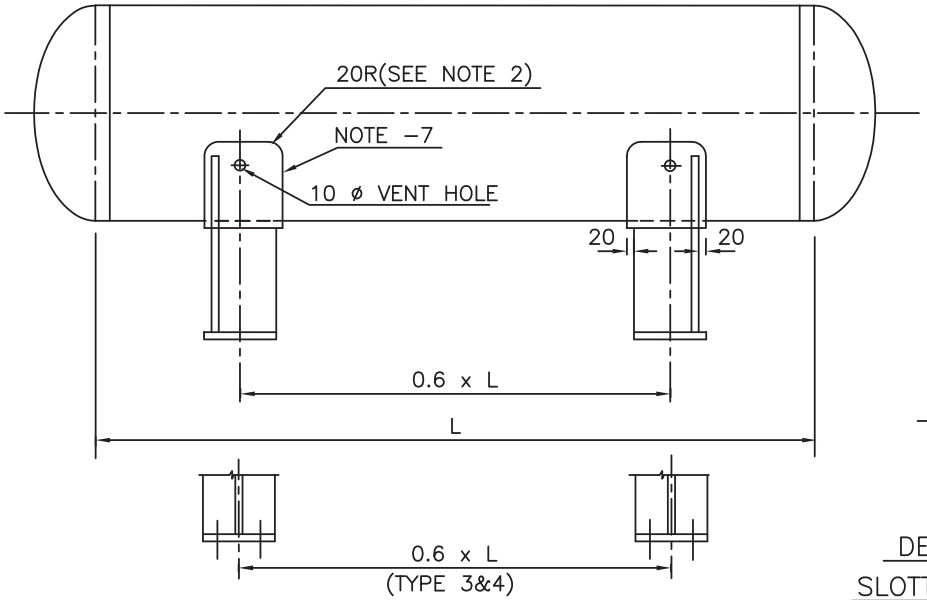
THIS DIAGONAL SHALL BE TANGENT TO O/D OF VESSEL AT THE POINT OF INTERSECTION OF DIAGONALS OF BASE PLATE.

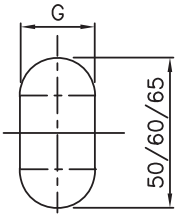
NOTES

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

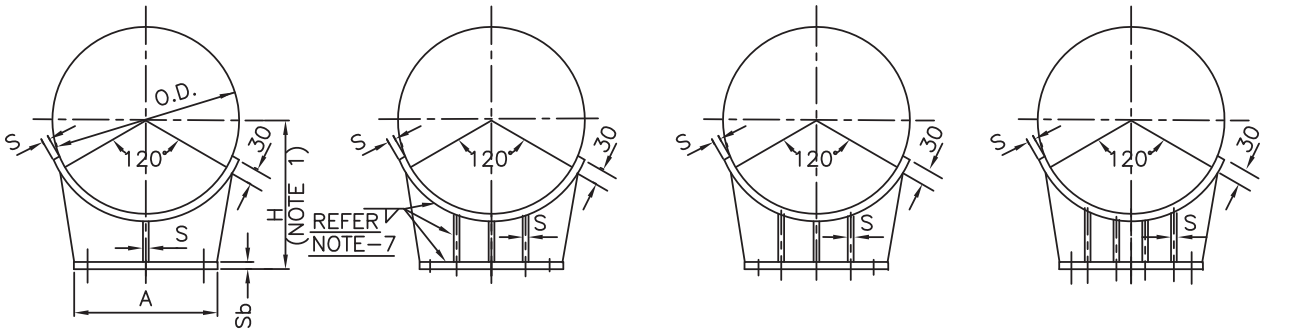
SEP. 2014	ISSUED FOR IMPLEMENTATION	ENGG. COMM.		
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:

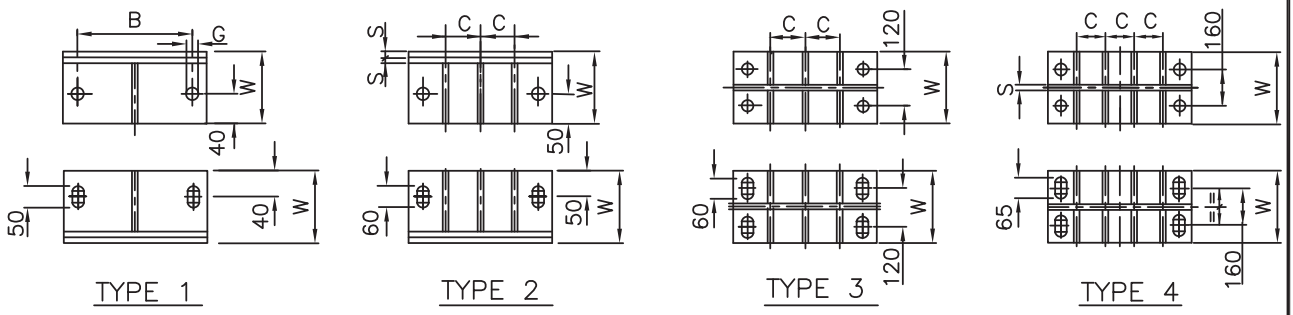
FILE NAME :STD/NCR/SR300





DETAIL OF SLOTTED HOLES





NOTES:

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

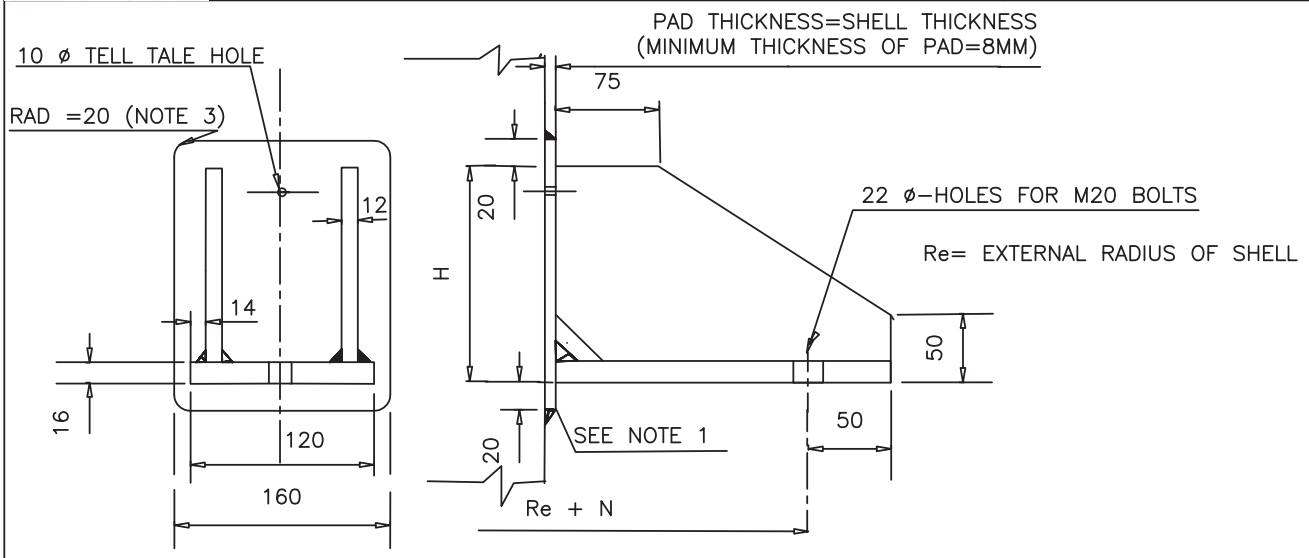
DATE	PURPOSE	PREPARED	REVIEWED	APP'D.BY:
SEP. 2014	ISSUED FOR IMPLEMENTATION			

FILE NAME :STD/PPS/SR302

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

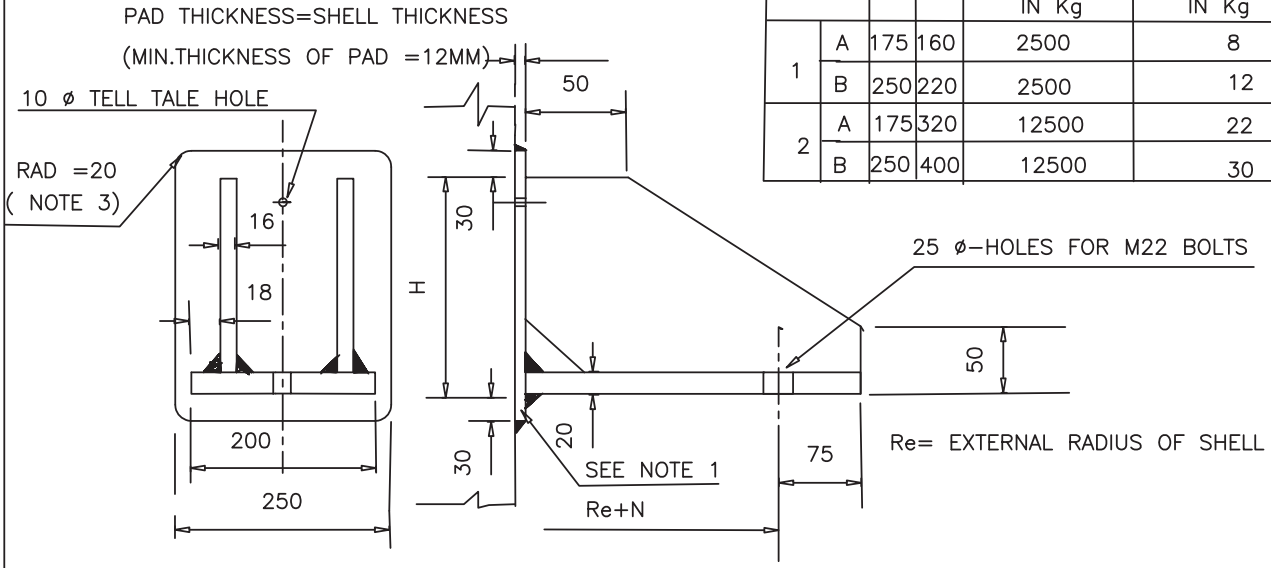
BRACKET SUPPORT FOR VERTICAL VESSEL

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



TYPE–1

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



TYPE–2

NOTES

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

RECOMENDATION FOR USE

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

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

FILE NAME :STD/RPAL/SR304

PART II: TECHNICAL

Section – 5.2.2

DESIGN SPECIFICATION – ROTATING EQUIPMENTS

IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

TABLE OF CONTENTS

1.0 SCOPE

1.1 General

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 Plant of prescribed capacity for **M/s RFCL, Ramagundam.**

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

2.0 DESIGN SPECIFICATION FOR MACHINERY

2.1 Codes and Standards

Latest Edition of National / international codes and standards shall be followed for design and manufacturing of different machinery items.

2.2 Design Life

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

2.3 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.

2.4 Site Conditions

Site conditions shall be as defined elsewhere.

3.0 DESIGN REQUIREMENT FOR CENTRIFUGAL PUMPS

3.1.1 This standard shall be followed in establishing the minimum engineering requirements for centrifugal pumps for non-critical services / water handling services.

3.1.2 The pumps shall be designed, manufactured and supplied as per Hydraulic Institute Standard / DIN 24256 / ISO-2858 /IS-1520/ IS-13518/ IS-5120 / API Standard

3.1.3 The pump shall be designed to develop the specified differential head at rated capacity, suction pressure and specific gravity while running at the rated speed. Rated speed of pump shall be full load speed of the drive motor.

3.1.4 The pump characteristics shall be guaranteed / tested with reference to the full load speed of motor.

3.1.5 Guarantee point shall refer to the differential head, rated capacity, specific gravity, and full load speed of the driver.

3.1.6 The pump and accessories shall be suitable for outdoor, unsheltered installation and continuous duty unless otherwise specified in the respective specification sheets.

3.1.7 The pumps shall be supplied complete with all the accessories as specified in the respective specification sheets inclusive of necessary appurtenances, auxiliary piping, special tools, spares etc.

3.1.8 Accessories required / recommended by pump vendor other than those specified in the pump specification sheet for safe and efficient operation of the pump unit shall be included in the pump vendor's scope of supply

3.1.9 All safety provisions shall be taken in to consideration while manufacturing of equipment.

3.1.10 Pumps shall have SI dimensions, comply with applicable ISO standards except for piping connections which shall be as per ANSI/ASME standard.

3.1.11 Reference list of pumps which are in operation for similar service conditions shall be furnished with the offer indicating broad specifications, purchase order number, date and name & address of user.

3.1.12 All continuously running pumps shall have a stand-by pump.

3.1.13 Maximum allowable noise level shall be within 85 dBA measured at a distance of 1.0 meter.

3.1.14 The shut off head of the pump shall be 105% to 120% of the head at rated capacity.

3.1.15 It should be possible to increase the head minimum by 5% by installing higher size impeller.

3.1.16 In addition to static balancing, impellers shall be dynamically balanced as per G6.3 of ISO-1940.

3.1.17 Pump inlet, outlet and auxiliary connections shall be flanged. All connections shall be provided with slip-on type companion flanges, nuts, bolts and gaskets. However, piping design philosophy enclosed with NIT to be followed.

3.1.18 Non-Standard Connections of 1 1/4, 2 1/2, 3 1/2, 5, 7 nominal pipe sizes shall not be used.

3.1.19 When specified, pump shall be provided with drip tray under the stuffing box and leak-off line with flange, companion flange, nuts, bolts and gaskets. Material composition shall be same as that of pump casing. Leak - off piping shall be arranged upto the edge of the base plate and shall be suitably terminated by bidder to hook-up point.

3.1.20 Pump inlet, outlet and auxiliary flanged connections shall confirm to the facing and drilling requirements of ANSI / ASME B 16.1 or ANSI / ASME B16.5.

3.1.21 All equipment shall be designed to permit rapid and economical maintenance.

3.1.22 Impeller shall be keyed to the pump shaft. Impeller nut shall be used to secure the impeller and a positive mechanical locking method shall be adopted.

3.1.23 The pump shaft shall be one piece for horizontal pumps. For vertical pumps number of shafts shall be minimum.

3.1.24 Shafts for horizontal pumps shall be fitted with deflectors. Deflectors shall be made of non-sparking material (corrosion resistant material for corrosive service).

3.1.25 Renewable wear ring surfaces shall be furnished on impeller and casing. Mating wear surfaces of hardenable materials shall have a difference in Brinell hardness number of at least 50.

3.1.26 Radial and thrust bearings shall be rolling element type. These shall be designed for minimum 24,000 hours bearing life.

3.1.27 For between bearing pumps arrangement, bearing housing shall be cast integral with the lower half of the pump casing or bolted to it. Bearing housing should be provided with stiffening brackets and be sufficiently rigid to resist the dynamic loads during operation.

3.1.28 Castings shall be sound and free from shrink holes, blow holes, cracks, scale, blisters and other similar injurious defects. Ferrous pressure casting shall not be repaired by peening, plugging, burning in or impregnating. When weld repairs to castings are authorized by ASTM specification for the material, repair welding shall be carried out in accordance with that specification. Unless otherwise specified, weld repairs shall be inspected according to the same quality standards used to inspect the casting.

3.1.29 Effluent transfer pumps MOC should be able to withstand to the effluent fluid as per process parameters.

3.1.30 Material of construction of various pump parts shall be as per pump specification sheet, if any. Materials not specified in the specification sheet shall be selected by the vendor in accordance with the service conditions and based on relevant codes & standards. Chemical composition and physical properties of the materials (MOC),

wherever used by bidder, must be proven ones and furnished along with the offer.

3.1.31 A name plate of 18 Cr - 8 Ni Stainless Steel or Monel, securely attached by stainless steel pins at an easily accessible point on the pump body shall be furnished. The name plate shall be stamped with following information:

- Purchaser's item number
- Pump serial number
- Capacity in m^3/h
- Differential head in meters
- Revolution per minute
- Casing hydrostatic test pressure in kg / cm^2g
- Absorbed power in kW

3.1.32 In addition to above an arrow shall be cast / attached at a reasonably observable point on the pump to indicate direction of rotation.

3.1.33 Motor shall have power ratings including service factor at least equal to following percentage of pump rated absorbed power :

Pump absorbed power (in kW)	Motor rating percentage of absorbed power
< 22	125
22 - 55	115
> 55	110

3.1.34 Vendor shall indicate for vertical pumps, minimum liquid level for pump operation / startup in the offer.

3.1.35 For vertical pumps, a hole shall be provided in the column pipe above the maximum liquid level to relieve pressure on stuffing box.

3.1.36 For vertical pumps, the specified head shall be measured at the discharge flange, at pump mounting level. Pumps shall be suitable to develop specified discharge head in addition to column losses and vertical distance, between minimum level in the sump tank and center line of the discharge flange. Pump vendor shall indicate total head to be developed by the pump in the offer.

3.1.37 Vertical pumps taking suction from sump / vessel shall be furnished with corrosion resistant suction strainer. Perforation / mesh size shall be suitable for proper operation of pump. Sufficient free flow area of the strainer shall be provided.

3.1.38 Pumps shall be provided with shaft sleeve under mechanical seal.

3.1.39 Shaft sleeves shall be hard chrome oxide coated under flexible member of mechanical seal.

3.1.40 Gland Packed pumps shall not be prefered.

3.1.41 When pumps are specified with mechanical seals: Make of mechanical seal shall be Flowserve, Eagle Burgmann, John Crane make.

3.1.42 Suitable flushing plan shall be provided.

3.2 DESIGN REQUIREMENTS FOR METERING PUMPS

3.2.1 This standard shall be followed in establishing the minimum requirements for design and construction of positive displacement pumps (controlled volume) and their auxiliaries. Both packed plunger and diaphragm type pumps are included in the scope of this specification.

3.2.2 Positive displacement pumps (controlled volume) shall conform to relevant API / IS/ ISO / Equivalent national & international standards.

3.2.3 The metering pumps model shall be preferred as mechanically actuated type.

3.2.4 Accessories required / recommended by pump vendor other than those specified in the pump specification sheet for safe and efficient operation of the pump unit shall be included in the pump vendor's scope of supply

3.2.5 The metering pumps shall be suitable for continuous capacity variation preferably from 0 to 100%.

3.2.6 All continuously running pumps shall have a stand-by pump.

3.2.7 All threads and fastners shall preferably be of ISO metric sizes.

3.2.8 Maximum noise level shall not exceed 85 db (A) at one meter distance.

3.2.9 Arrangement of equipment including piping and auxiliaries shall be developed by the vendor and submitted to the purchaser for review.

3.2.10 Any water or steam jackets for liquid ends shall envelop liquid cylinders, stuffing boxes and preferably valve chambers.

3.2.11 NPSH(R) shall be indicated by the vendor taking into account acceleration head. For pumps handling volatile liquids, the NPSH required shall be determined and guaranteed after taking into account the heat generated in the glands.

3.2.12 Valves and sets shall have a minimum hardness of 150 BHN if constructed of carbon or low alloy steel and 225 BHN for 13% Cr steel. The difference in hardness between valves and seats shall be 50 BHN minimum.

3.2.13 Hollow plungers are prohibited. Repacking should be possible without removing plunger from the cylinder.

3.2.14 Enclosed crank cases, gear units and similar mechanisms shall be sealed. Removable covers shall be provided for inspection, cleaning and minor adjustments of parts.

3.2.15 For liquid end pressure containing parts like cylinders, valve chambers and suction and discharge manifolds, corrosion allowance shall not be less than 1.0 mm for carbon and low alloy steels.

3.2.16 The enclosure shall be suitable for mounting on base frame and shall be weatherproof and dust tight.

3.2.17 Welding of piping and pressure containing parts upto 40 kg/cm2 pressure shall be spot radiographed. For pressure above 40 kg/cm2 100% radiography, magnetic particle test or dye penetrant test of welds is required.

3.2.18 Reference list of pumps which are in operation for similar service conditions shall be furnished with the offer indicating broad specifications, purchase order number, date and name & address of user.

3.3 DESIGN REQUITRERMENTS FOR SCREW PUMPS

3.3.1 This standard shall be followed in establishing the minimum engineering requirements for rotary pumps (screw type) and their auxiliaries for service.

3.3.2 The pumps shall be designed, manufactured and supplied as per Hydraulic Institute Standard / DIN 24256 / ISO-2858 /IS-1520/ IS-13518/ IS-5120 Standard / API codes & standards

3.3.3 Pumps shall have SI dimensions and comply with applicable ISO standards, except for piping connections which shall be as per ANSI standards.

3.3.4 Accessories required / recommended by pump vendor other than those specified in the pump specification sheet for safe and efficient operation of the pump unit, shall be included in the pump vendor's scope of supply

3.3.5 Pump shall be designed as per this technical specification, data sheet, operating conditions, process variation, fluid properties and start up condition.

3.3.6 Noise level shall be limited to 85 dBA @ 1 mtr distance from the equipment.

3.3.7 All electrical components, enclosures and installations shall be in accordance with Electrical Specification and suitable for the area classification and environmental conditions specified in the Material Requisition.

3.3.8 All continuously running pumps shall have a standby pumps

3.3.9 Reference list Reference list of pumps which are in operation for similar service conditions shall be furnished with the offer indicating broad specifications, purchase order number, date and name & address of user.

3.4 CENTRIFUGAL FANS / BLOWERS

3.4.1 Centrifugal fans/ blower shall be designed as per AMCA standard or equivalent relevant national/ international codes, latest edition.

3.4.2 First critical speed of the rotor shall be higher than 120% of rated speed. Rotor assembly shall be dynamically balanced.

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

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

3.4.5 The drive motors of the fans/ blower 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.

3.4.6 Bearing shall be preferably oil lubricated.

3.4.7 All continuously running fan / blower shall have a standby equipment

3.5 AGITATOR

3.5.1 Agitators shall be manufacturer as per relevant national / international codes & standards.

3.5.2 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.

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

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

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

3.5.6 Flexible coupling shall be provided between the power drives and agitator shaft or gear.

3.5.7 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.

3.6 HVAC System

Air conditioning system & air flow ventilation rate should be sufficient to satisfy not only air removal specification, but also to maintain over pressure and temperature specification. It should be also capable to avoid wind penetration in order to meet the requirements of a conditioned space, simultaneous control of temperature, humidity, cleanliness, contamination and air distribution should be considered in design & selection of HVAC equipment. Eco-friendly refrigerant to be used in HVAC equipment. All civil buildings / facility, Control room, substation, labs etc to be equipped with suitable HVAC system with 100 % redundancy. In case of 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. 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.

4.0 INSPECTION & TESTING

4.1 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.

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

4.3 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
- Helium leak test
- Mechanical running test
- NPSHR test for pumps
- Performance Test
- Disassembly Test

5.0 INSPECTION & TESTING OF PUMPS

5.1 All pumps shall be subjected to inspection by Owner / inspector of owner/ purchaser or authorized inspecting agency as defined in the purchase order. Test and inspection plan shall be submitted to the inspector for approval. The inspector shall indicate additional test to be witnessed over and above the once specified in the pump specifications.

5.2 Inspector shall have free access at all reasonable times to the vendor's / sub vendor's shops. Vendor shall furnish to the inspector all necessary information and assistance to verify that the requirements of the order specifications have been met. The vendor shall give 2 weeks' notice regarding readiness of material for inspection to the inspector.

5.3 Acceptance of shop test shall not relieve the vendor of this responsibility in any way.

5.4 Inspector shall witness / inspect the following:

5.5 Review of material test certificate for casing, impeller, shaft, shaft sleeve, wearing rings etc., and for spare parts.

5.6 Dynamic balancing of impeller as per ISO-1940

5.7 Hydrostatic test.

5.8 NPSHR test, when specified.

5.9 Performance test including vibration check.

5.10 Disassembly / strip down test.

5.11 Visual inspection and dimensional check.

5.12 Manufacturer's standard shall be applied with respect to the tolerances of each dimension.

5.13 All casting shall be visually inspected before machining for surface defects and irregularities.

5.14 All repairs of defects found on inspection shall be subjected to prior approval of purchaser's inspector.

5.15 **PERFORMANCE TEST**

5.16 Performance test of each pump in the manufacturer's shop shall be carried out, unless specified otherwise.

5.17 Pumps shall be operated in shop for a period sufficient to obtain complete test data. Unless otherwise agreed, the test speed shall be the rated speed of the pump.

5.18 Test procedure shall be as per Hydraulic Institute Standard / IS – 5120/ Equivalent standards.

5.19 During performance test, pump shall operate without undue heating of bearings, excessive vibration, noise or other mechanical faults. Such defects if noticed shall be promptly rectified to the satisfaction of the inspector.

5.20 Instruments (if any) measurement tolerance shall be as per accuracy class I of IS-1520.

5.21 When operating fluid has viscosity appreciably higher than test fluid, test values of capacity, head, efficiency and power input shall be corrected to specified viscosity of operating fluid as per IS - 5120 / Hydraulic Institute Standard/ equivalent standards. Characteristic curves shall be plotted accordingly.

5.22 Job driver shall be used during performance test.

5.23 **HYDROSTATIC TEST**

5.24 Each pressure casing shall be hydrostatically tested to 1.5 times the maximum allowable casing pressure. Multistage pumps may be segmentaly tested at appropriate section pressure.

5.25 Test pressure shall be maintained for a minimum period of 30 minutes during hydrostatic test.

5.26 Vendor shall compile all the tests & inspection reports relevant to purchase order scope of supply in folder(s). Following reports must be included:

- Material certificates (chemical analysis, chemical test & impact test)
- Results of non destructive inspection
- Results of hydrostatic test
- Records of performance test
- Records of NPSH test
- Records of dimensions
- Other test conducted by vendor as per specification
- Guarantee certificates

6.0 PREPARATION FOR SHIPMENT FOR PUMPS

6.1 Pumps shall be despatched only after the shop test data and performance test curves are approved by the inspector.

6.2 The un-machined exterior surfaces shall be sand blasted, de-scaled and cleaned. The surface must be free from foreign material before paint is applied.

6.3 The external surface subject to atmospheric corrosion shall be painted with two coats of primer and two coats of epoxy based finish paint.

6.4 All the internal parts and machined unpainted exterior surfaces shall be protected with suitable rust preventive.

6.5 When driver is supplied with pump, the same shall be duly mounted on a common base frame.

6.6 Both halves of the coupling shall be supplied by vendor in machined condition.

6.7 Each unit shall be suitably packed for outdoor storage for at least six months.

7.0 PAINTING

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

8.0 VENDOR 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 approval during detail engg.

9.0 SPARE PARTS

9.1 Spare parts shall be as per NIT and shall be quoted in the proforma enclosed with enquiry.

10.0 LSTK CONTRACTOR / VENDOR DOCUMENTATION

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

SECTION – 5.2.3

DESIGN SPECIFICATION – PIPING

PLANT: RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED

PROJECT: IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

CONTENTS

LIST OF ATTACHMENTS

SL NO.	DOC.NO.	DESCRIPTION	NO.OF SHEETS
1	PC211-PNMP-TS951	DESIGN PHILOSOPHY- PIPING	50
2	A747-6-44-0005	PIPING MATERIAL SPECIFICATION	91
3	PC211-7611-0001_Rev P	PLOT PLAN (OVERALL)	1

1.0 GENERAL PIPING SCOPE OF WORK

1.1 The detail scope of work includes such as, but not limited to, complete project management, Design, Detailed Engineering, 3D modelling, Stress Analysis, to provide all the necessary data, drawings, documents required as per the project requirements, Procurement, Supply, Transportation of all materials to the work site & storage at site, shop & site Fabrication, assembly, Erection, Installation, Supporting, Non-Destructive Testing (NDT) & required Inspection, pre-heating, dye-penetrant test, Magnetic Particle Test, post weld heat treatment, radiography, Ultrasonic test, Testing, Flushing, Air drying, blowing, cardboard-blasting, seal/leak-testing, Pre-Commissioning, Trial run, Commissioning and Guarantee of all the associated works pertaining to complete piping system and related facilities for implementation of Zero Liquid Discharge package at RFCL, TELANGANA.

1.2 Design, material, fabrication and erection shall be in accordance with latest edition of ASME B31.3 chemical plant and petroleum refinery piping code. The dimensions, manufacturing tolerances shall conform to applicable standards.

1.3 All works described in this package shall be performed in accordance with the design-basis, specifications, drawings, and other requirements of NIT and shall be subject to Owner's review and approval.

1.4 There are few utility lines (Service water, Fire water & Instrument air) inside the proposed plot location which are to be re-routed; same shall be in the scope of LSTK contractor.

1.5 New effluent transfer pumps (of the required capacity) for ZLD are to be installed in place of existing treated effluent transfer pumps with tag nos. 307-PA-005 A&B (presently using for toilet flushing). Required piping modification for new effluent transfer pumps for ZLD to retain the existing scheme has to be done. These works shall be in the scope of LSTK Contractor. However, new piping from new effluent transfer pumps to ZLD as marked in Plot Plan shall also be in the scope of LSTK Contractor.

1.6 MATERIAL OF CONSTRUCTION

Materials as per internationally acceptable code shall be used for piping based on service requirement. All materials for piping Components shall conform to ASTM or API Specifications as per enclosed piping specifications. All piping materials and valves shall be procured from the approved suppliers/vendors (as per attached vendor list).

1.7 Cost of piping job shall also include the cost of supervision, Labour, overheads / profits, materials, consumables, scaffolding and all other associated arrangements required to execute the related activities of this package.

1.8 PIPING INTER - CONNECTION

Piping lines as per P&ID shall be provided at battery limit which shall be indicated later by Owner. Bidder shall provide valve at battery limit for respective piping system of the package unit.

Necessary Tie-in points shall be identified and included in the scope of work of Contractor (For details of Tie-in points, refer attached Plot Plan).

All utilities lines which are required in the plant shall be extended from, the nearest tie-in point from battery limit, and shall be in Contractor's scope (For details of Tie-in points, refer attached Plot Plan).

Fire water Tie-in shall be taken from the nearest point on the existing Fire water ring.

The RO/ZLD permeate water can be used as cooling water make-up, transferred by pumping into cooling tower sumps of existing UCT & ACT with individual isolation valve i.e., ammonia cooling tower & urea cooling tower. There will be provision to divert the RO/ZLD permeate water to Fire water reservoir/pump sump in case main plants are under shut down. Provisions for transferring RO/ZLD permeate to existing cooling water sump and fire water reservoir sump including laying of piping will be under scope of supply of LSTK contractor.

1.9 SPARES

Mandatory spares shall be quoted by bidder as per spares section of NIT.

2.0 DESIGN AND DETAILED ENGINEERING BY BIDDER

2.1 Collection of all data/ information furnished in the NIT and additionally collected/ generated by Bidder.

2.2 Finalization of design data/ basis for carrying out design, detailed Engineering for complete scope of work as per project specifications, contained in the NIT.

2.3 Performing design and detailed engineering of the following:

a) Complete piping system for the package unit.

b) Carry Out all necessary calculations in accordance with approved design basis, drawings / documents and requirements of the NIT.

c) Finalization of layouts for the unit and preparation of construction drawing, preparation of piping drawings, equipment layouts, piping general layout drawings (GAD's), pipe supports, piping isometrics. Typical indicative sketches/drawings included in NIT document shall be taken as broad basis for developing the layouts. Since, the availability of free space is limited, bidder shall plan its piping layouts in such a way so as to minimize the area requirement while giving due importance to ease of access, operation and maintenance of the facilities installed by the Bidder. The fabrication/erection & all other piping jobs shall be carried out as per drawings/documents approved by Owner.

d) Carrying out Material Take Off for the entire piping system for the package unit.

e) The detail design shall take into consideration of local Statutory Regulation, if any, for the package unit.

3.0 PROCUREMENT & SUPPLY BY BIDDER

3.1 Bidder shall procure and supply all materials whatsoever required for temporary/permanent installation of piping system in sequence and at appropriate time. All equipments, materials, components etc shall be suitable for the service and the design life of the system.

3.2 Bidder shall procure all materials, components, equipments, consumables etc required for successful completion of the piping system. Bidder shall also procure spares required for pre-commissioning and commissioning/start-up as recommended for all the items supplied by him as per specifications provided in the NIT. Where no specifications are available in the contract, the same shall be prepared by the Bidder, and shall be subject to Owner's approval.

3.3 Material take-off (linewise and consolidated) with complete description of size, rating, material, thickness and specifications.

3.4 Preparation and finalization of data sheets for all piping materials e.g. all valves etc. All data-sheets shall be subject to review and approval by Owner.

3.5 Preparation of material requisitions, request for quotation & its evaluation and recommend bidders for owner's approval. Preparation of purchase requisitions, review of Bidder's drawings and calculations, approval of manufacturing procedures wherever necessary, and the party inspection at manufacturer's works of the materials by reputed agencies as required. Quality control and expediting of all procured items at bidder's shop or at fabrication yard.

3.6 Bidder shall procure materials as per specifications and list of approved Vendors/Suppliers (for major Items) included in the bid document.

3.7 Carry out proper documentation of inspection and quality assurance programs for all equipment and bulk materials duly approved by Owner. Bidder shall maintain an accurate and traceable listing of procurement records for the location, quality and character of all permanent materials in the Project.

3.8 Bidder shall immediately report to the Owner of all changes which will affect material quality, and take necessary corrective actions. Purchase requisitions including Purchase Orders of all major items shall be approved by Owner. For balance items, records shall be furnished for information only.

3.9 Compliance with Bidders and supplier's instructions and recommendations for transportation, handling, installation and commissioning.

4.0 INSPECTION

4.1 Inspection authority means the Third Party Inspection Agencies (TPIA) as per owner approved TPIA list (attached elsewhere in NIT) to carryout inspection of materials.

4.2 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.

4.3 All the items shall be inspected and tested in the presence of one or more representatives of the purchaser during various stages of manufacturing. Material shall be considered acceptable for dispatch only after final certificate of acceptance is issued by the Inspector.

4.4 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.

4.5 Quality Assurance plan (QAP) / Inspection Test Plan (ITP) shall be submitted by bidder for approval by Third Party Inspection Agency (TPIA).

4.6 Scope of Inspection by TPIA:

- Review of Chemical composition report, MTC (all batches)
- Positive Material Identification (PMI) for Alloy/Stainless steels (10% random witness)
- Hydrostatic test (10% random witness)
- Non Destructive Examination- Report review
- Dimensional check, Marking, Visual check for surfaces, external appearance (10% random witness)
- Packing: Report review.

5.0 PAINTING

Painting shall be as per specification attached elsewhere in NIT.

6.0 CONSTRUCTION

All construction works be carried out as per "Approved for Construction" drawings, procedures, specifications and applicable codes and standards. Any changes at site shall also need prior approval from the Owner/PMC and revision of drawings.

Bidder shall procure and supply all materials whatsoever required for temporary/permanent installations of piping system in required and at appropriate time. All equipment, materials, components etc. shall be suitable for the intended service and the design life of the system. Wherever no specification is available in the contract, the same shall be prepared by the Bidder and shall be subject to Owner approval.

After completion of erection jobs, all piping system will be suitably hydraulically tested as per the test pressure indicated in the line list / relevant document approved by owner.

7.0 BIDDER'S RESPONSIBILITY

All works shall be carried out by Bidder in accordance with the drawings / documents / specifications indicated in the subsequent paragraphs.

7.1 Specifications

7.2 Standards

7.3 Piping Support Standards

7.4 Drawings

7.5 Design Review

7.6 Bidder shall submit all proposal designs, analysis, drawings, installation and testing procedure for review & approval by Owner as mentioned in the scope of work. Bidder shall as a minimum, provide above deliverables for Owner's information / records & review / approval.

7.7 Typical Plot Plan drawing of package unit is attached in the NIT. This drawing is INDICATIVE only and is furnished for Bidder's information. Issued for construction (IFC) drawings shall be prepared by Bidder after detailed engineering being done by him and shall be subject to approval by the Owner.

7.8 The Bidder shall submit separately, the material take off for piping, valves, fittings and all other accessories as per requirements.

7.9 Bidder shall obtain statutory approval from various authorities having jurisdiction over the area, as necessary, for construction of the unit package.

8.0 DRAWINGS/ DOCUMENTATION SCHEDULE

Bidder shall furnish all the drawings/ documents to Owner for comments/ approval. He shall incorporate all comments/modification suggested by Owner. The drawings/documents should be properly organised, supplied & submitted as per documentation schedule of NIT.

Number of sets shall be as stipulated elsewhere in the tender document. Final documentation shall be supplied in hard copies (4nos.) as well as soft copies.

9.0 PACKAGING

9.1 Items shall be thoroughly dried, cleaned and shall be free from moisture, dirt & loose foreign materials, with ends protected from mechanical damage during transportation, shipment & storage.

9.2 For transportation overseas, protection and packing shall be adequate to prevent damage from sea atmosphere.

10.0 DOCUMENTATION WITH BID

Following drawings/documents must be submitted along with the bid.

i) Proposed equipment layout drawing.

DESIGN PHILOSOPHY – PIPING

PACKAGE UNITS

PROJECT: IMPLEMENTATION OF ZERO LIQUID DISCHARGE (ZLD) UNIT

AT

RAMAGUNDAM FERTILIZERS AND CHEMICALS LIMITED (RFCL),

TELANGANA, INDIA

CONTENTS

LIST OF ATTACHMENTS

DOCUMENT/ANNEXURE NUMBER	DESCRIPTION
1	TABLE OF BASIC SPAN
2	ACCESSIBILITY FOR VALVES AND INSTRUMENTS
3	MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES
4	CLEARANCES
5	DESIGN PHILOSOPHY FOR STRESS ANALYSIS
5A	CRITERIA FOR IDENTIFING EXTREMELY CRITICAL LINES (LEVEL I)
5B	CRITERIA FOR IDENTIFYING MODERATELY CRITICAL LINES (LEVEL II)
5C	MINIMUM ALLOWABLE NOZZLE LOADINGS- VESSELS AND S/T HEAT EXCHANGERS
6	DESIGN PHILOSOPHY FOR STRESS ANALYSIS

1.0 SCOPE

The scope of this document is pertaining to the design philosophy, norms and specific requirements which shall be adhered to by contractor or his associates and representatives during the course of the project in designing, procurement & construction of piping material.

1.1 APPLICABLE STANDARD & CODES

Standard No.	Title
ASME/ANSI B16.5	Steel Pipe Flanges and Flanged Fittings
ASME/ANSI B16.9	Steel Butt-Welding Fittings
ASME/ANSI B16.10	Face to Face and End to End Dimensions of Valves
ASME/ANSI B16.11	Forged Fittings Socket Welded and Threaded -
ASME/ANSI B16.20	Metallic Gaskets for Pipe Flanges – Ring Joint, Spiral Wound, and Jacketed.
ASME/ANSI B16.21	Non-Metallic Flat Gaskets for Pipe Flanges
ASME/ANSI B16.25	Butt-Welding Ends
ASME/ANSI B16.34	Valves – Flanged, Threaded Welding End.
ASME/ANSI B16.47	Large Diameter Steel Flanges
ASME/ANSI B31.1	Power Piping
ASME/ANSI B31.3	Process Piping
ASME/ANSI B31.5	Refrigeration Piping
ASME/ANSI B36.10M	Welded and Seamless Wrought Steel Pipe.
ASME/ANSI B36.19M	Stainless Steel Pipe
API 6D	Specification for Pipe Line Valves (Gate, Plug, Ball and Check Valves).
API 6FA	Fire Test for Valves
API 501	Specifications for Metallic Gaskets for Refinery Piping
API 594	Check Valves: Wafer-Lug and double flanged type
API 598	Valve Inspections and Testing
API 599	Steel Plug Valves, Flanged and Butt-weld ends
API 600	Steel Gate Valves, Flanged and Butt-welding ends, Bolted Bonnets
API 602	Gate, Globe, and Check Valves for Sizes DN 100 (NPS 4) and Smaller for the Petroleum and Natural Gas Industries
API 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 623	Steel Globe Valves—Flanged and Butt-welding Ends, Bolted Bonnets
IBR	Indian Boiler Regulations
AWWA C207-D	Large Dia. Steel Flanges (Ring Type).
EJMA	Expansion Joints Manufacture Association

MSS SP 6	Standard Finishes for Contact Faces of Pipe Flanges and Connecting End Flanges of Valves and Fittings
MSS SP 25	Standard Marking System for Valves, Fittings, Flanges & Unions
MSS SP 43	Wrought Stainless Steel Butt-weld Fitting
MSS SP 45	By-pass and Drain Connection
NACE MR0175-94	Sulphide Stress Cracking resistant Metallic Material
NFPA	National Fire Protection Association
EN 10204	Metallic Products - Types of Inspection documents
ASTM D3035	Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

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
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 the approval of the owner and include any changes resulting from HAZOP studies and taking into consideration the following :

i) General site layout taking into account the topographical geo-technical aspect of the site.
ii) Access for maintenance and fire appliances.
iii) The interdependency of units and buildings with each other within the complex.
iv) Safety escape routes for personnel based on emergency or disaster management plans in the event of environmental upset or fire.
v) Suitable drainage system of Project site.

2.3 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.

3.0 CODES, STANDARDS AND SUPPLEMENTARY SPECIFICATIONS

3.1 The latest edition of codes 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:

a) Statutory Regulations

b) National, International and Industry Standards and Codes of Practice.

c) Technical Specifications

3.3 Standards, Codes and Supplementary Specifications for piping design shall be applied as follows:

i) Process and utility piping to ASME B31.3 Process Piping

ii) Power Plant piping to ASME B 31.1

Fire protection system shall be designed and installed in accordance with applicable NFPA (National Fire Protections Associations) Codes.

4.0 GENERAL DESIGN

4.1 Flanges for process and utility piping shall be in accordance with ANSI B16.5 and ANSI B16.47.

4.2 Wherever possible all purchased equipment shall be supplied with flanges that comply with ANSI B16.5/B16.47.

4.3 The minimum size of piping to be used in pipe-racks shall be 2" NB.

4.4 With the exception of equipment connections the minimum size of piping shall be ½" NPS.

4.5 Pipe sizes 1 ¼", 2 ½", 3 ½", 5" and 22" NPS shall not be used except as connections to purchased equipment.

4.6 Threaded pipe nipples between headers and vent, drain and instrument isolation valves shall be Schedule 160 for CS and Schedule 80S for SS in the size range ½" to 2" NPS.

4.7 Piping 2" NPS and above shall be butt-welded. All weld joints in piping 1½" NPS and below shall be socket welded using socket weld fittings.

4.8 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.

4.9 When a line of one material specification is connected to a line of higher material specification, the connecting line shall be constructed of the higher material specification or pressure rating up to & including the first block valve.

4.10 As a minimum, piping systems shall have isolation facilities as follows:

ASME B31.3 Category 'M' service and Normal service (Class 900 and above) shall have double block isolation valves with a downstream drop-out spool.

ASME B31.3 Normal service (upto Class 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.

5.0 DESIGN PHILOSOPHY / GENERAL CRITERIA

5.1 Equipment Layout

5.1.1 Basis of Equipment Layout

Equipment Layout shall be finalised based on the following data:

a) Overall Plot Plan
b) P&I Ds
c) Equipment Data Sheets
d) Wind Direction
e) Safety Distance and Specific Distance mentioned in Piping Design Basis and as per statutory requirements.

5.1.2 Development of Equipment Layout

The following aspects shall be considered during development of equipment layout:

a) Process Requirement - Proper interconnection between equipment as per P&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.
- Horizontal & overhead clearances for easy movement of working personnel.
- Crane approaches for air coolers/fired heaters.
- Provision of monorail for pumps and exchangers.

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 under ground piping.

5.1.3 Plant Layout & Design guidelines

5.1.3.1 General

The plant layout shall be based on ensuring adequate access, to allow construction, inspection, maintenance and operation to be performed in a safe and efficient manner. The

alignment of equipment and pipe shall offer an organised appearance. The layout shall be in accordance with, but not limited to the design practices described in this criteria.

Where dynamic loading, limited pressure drop or other severe service condition applies, particular care shall be taken in routing pipe lines.

Flushing connections shall be provided on all lines containing flammable or toxic material, slurries, and materials which solidify– when the line is dead. Sufficient Nitrogen purging points shall also be provided. Supply piping of fuel gas shall be arranged for equal flow distribution.

Trolley beams, pipe davits, shall be provided with appropriate removable hoists mechanism for charging and discharging catalysts, chemicals, packing rings etc.

Piping and all other services shall be arranged so as to permit ready access of Cranes for removal of Equipment for inspection and servicing.

All utility and process piping shall be located above ground, and major lines shall be located in overhead pipe ways.

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.

Drip legs and dead ends shall be avoided, especially for piping where solids or fluids may congeal from corrosive condensate.

Where sleeper ways are used the elevations shall be staggered to permit ease of crossing or change of direction at intersections. Flat turns may be used when entire sleeper ways change direction. Flat turns must not be used within pipe racks.

Spacing and routing of piping shall be such that expanding/contracting lines (including insulation) will not clash with adjacent lines, structures, instruments and electrical equipment during warm up and cool down.

Piping to be sloped shall be indicated on the P&ID's.

5.1.3.2 **Pipe-Rack/T-Post/Small Portals**

In general, equipment layout shall be prepared considering straight pipe rack, however other shapes like L / T / U / H / Z etc can also be considered based on area available.

The width of the rack shall be 4M, 6M, 8M, 10M or 12M for single bay having four (4) tiers maximum. In general, the spacing between pipe rack portals (span) shall be taken as 8 M for main rack. However it can be decreased to 6 M depending on the size/number of the pumps to be housed below pipe rack. Intermediate Beams between two portals shall be provided to support smaller pipes <= 2". 20% extra space shall be provided on the pipe rack and portals on each tier for future expansion/modifications.

-Clearance beneath pipe rack shall be 3.8 M minimum.

-Height between two pipe rack tiers shall be 2.0M minimum.

-Road clearance shall be 9 M minimum wherever heavy duty crane movement is required during construction and future maintenance.

-Road clearance shall be 7.5 M minimum for main roads.

-Road clearance shall be 5 M minimum for secondary roads.

-T-Portal's width shall not be more than 2.5 M and height shall not be less than 3.0 M.

5.1.3.3 **Pumps**

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 applicable.

Pump foundation height shall be 300 mm above H.P.P.

Gap between each pump foundation / and foundation of technical structure should be sufficient for easy removal of equipment after piping. Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.

All pumps not open to sky with motor rating >= 45 KW shall be provided with monorail. No monorail should normally be provided for pumps outside rack and sufficient space below rack shall be available for pump maintenance.

5.1.3.4 **Clearance and Accessibility**

5.1.3.4.1 **Access to Pumps**

Clear access of 3.8M vertically and 4.5M horizontally shall be provided centrally under main pipe rack for small mobile equipment to service pumps, wherever these are put under pipe ways with prior specific approval. Pumps outside rack shall be approachable by small cranes etc. from under the pipe rack.

5.1.3.4.2 **Access to lower items to grade (Lowering Area)**

Clear access shall be provided at grade on the access side for lowering external and internal fittings from tall elevated equipment by providing pipe davits.

5.1.3.4.3 **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.

ii) Platforms with stair access shall be provided for:

a) Location at which normal monitoring (once a day or more) is required or where samples are taken.

b) Locations where vessels or equipment items need operator attention "such as compressors, heaters, boilers etc.

iii) Platforms with ladder access shall be provided for:

a) Points which require occasional operating access including valves, spectacle blind and motor operated valves, heater stack sampling points.

b) Man ways above grade on equipment.

iv) Ladder location

a) Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.

b) Landings shall be staggered. No ladder shall be more than 6 M in one flight.

5.1.3.5 **Clearances**

Minimum clearances shall be as indicated in Annexure.

5.2 Unit Piping

5.2.1 Basis of Unit Piping

- Piping & Instrument Diagram
- Equipment layout
- Equipment Data sheet & Setting plan
- Line list
- Instrument Data sheet
- Structural & building drawings
- Topography of the plant
- Piping material specification
- Overall plot plan
- Tie in point drawing.

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.
- Proper access to interrelated operating points for specific purpose and for maintenance.

5.2.2 Pipe Ways/Rack piping

5.2.2.1 Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.

5.2.2.2 Predominantly process lines are to be kept at lower tier and, utility & hot process lines on upper tier.

5.2.2.3 Generally the top tier is to' be kept for Electrical (if not provided in underground trench as per electrical design basis) and Instrument cable trays. Cable tray laying to take care of necessary clearances for the fire proofing of structure.

5.2.2.4 Generally the hot lines and cold lines shall be kept apart in different groups on a tier.

5.2.2.5 Generally the bigger size lines shall be kept nearer to the column.

5.2.2.6 Minimum spacing between adjacent lines shall be decided based on O.D of bigger size flange'(minimum rating 300# to be considered), O.D of the smaller pipe, individual insulation

thickness and additional 25 mm clearance, preferably. Wherever even if flange is not appearing the minimum spacing shall be based on above basis only. '

5.2.2.7 Actual line spacing, especially at 'L' bend and loop locations, shall take care of thermal expansion / thermal contraction / non expansion of adjacent line. Non expansion / thermal contraction may stop the free expansion of the adjacent line at "L' bend location.

5.2.2.8 Anchors on the racks are to be provided on the anchor bay, if the concept of anchor bay is adopted. Otherwise anchors shall be distributed over two to three consecutive bays.

5.2.2.9 Anchors shall be provided within unit on all hot lines leaving the unit.

5.2.2.10 Process lines crossing units (within units or from unit to main pipe way) are normally provided with a block valve, spectacle blind and drain valve. Block valves are to be grouped and locations of block valves in vertical run of pipe are preferred. If the block valves have to be located in an overhead pipe way, staircase access to platform above the lines shall have to be provided.

5.2.2.11 Provision of block valves, blinds etc. shall be as per Process Design Basis and P&IDs.

5.2.2.12 All small bore piping shall be designed in a way so as to ensure adequate space for maintenance and operation. For small bore piping intermediate support shall be provided in between portals.

5.2.2.13 Stubs on saline water (if applicable) service shall be from top of main header.

Minimum branch size for tapping including for instruments e.g. PG/PTI TE etc. shall be of 3" NPD and 150 mm height on internal cement lined pipes.

5.2.2.14 Aboveground lines shall be grouped to run on pipe racks or sleepers in so far as practicable.

5.2.2.15 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.

5.2.2.16 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.

5.2.2.17 All process and utility piping will be located aboveground within the plant battery limit, except water mains.

5.2.2.18 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.

5.2.2.19 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.

5.2.2.20 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.

5.2.2.21 Lines carrying molten solids, slurries or highly viscous liquids shall have a sufficient slope for each gravity flow.

5.2.2.22 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.

5.2.2.23 Piping shall be arranged to facilitate handling of equipment for inspection or maintenance.

5.2.2.24 Vapor collecting system shall be routed so that the vapor rises continuously from the vessel being vented to a higher point without pocketing.

5.2.2.25 Pockets shall be avoided in lines, particularly those carrying corrosive chemicals, slurries, vents, blow down lines, etc.

5.2.3 Column / Vessel Piping Control Valves

5.2.3.1 Piping shall be supported from cleats welded on the vessel as far as possible.

5.2.3.2 Proper guides at intervals shall be provided for long vertical lines.

5.2.3.3 Access platforms/ladders shall be provided along the column for valves and instruments.

5.2.3.4 For ease of operation and maintenance, column and vessels which are grouped together, shall have their platforms at the same elevation interconnected by walkways wherever feasible. However each column \ vessel shall have an independent access also. Column vessel platforms should be designed in such a way so that all the nozzles should be approachable from platforms.

5.2.3.5 Unless specifically indicated in P&ID's, control valves shall preferably be kept at grade instead of platform.

5.2.3.6 Piping intended for vacuum services shall be routed as short as possible, with minimum bends and flanged joints.

5.2.3.7 Piping support cleats shall be designed for safety valves considering impact loading during popping off.

5.2.4 Pump Piping

5.2.4.1 Pump drives shall have clear access.

5.2.4.2 Pump suction piping shall be as short as possible and shall be arranged with particular care to avoid vapor pockets.

5.2.4.3 Reducers immediately connected to the pump suction shall be eccentric type flat side up to avoid the accumulation of gas pocket. For end suction pumps, elbows shall not be directly connected to the suction flange. A straight piece minimum 3 times the line size shall have to be provided at the suction nozzle.

5.2.4.4 Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.

When a suction vessel operates under vacuum, the vent connection of the pump has to be permanently connected to vapour space of the suction vessel to allow possible filling of the pump with liquid before it is started.

5.2.4.5 Unless otherwise specified T-type strainers shall be used on pump suction piping for sizes 2" and above.

5.2.4.6 Y-type strainers to be used for all sizes in steam services and for pump suction lines 1½ and below.

5.2.4.7 All small bore piping connected to pump (drain to OWS & CBD, seat and gland leak drain) shall have provision for break up flanges for removal of pumps.

5.2.4.8 Piping shall be so arranged that forces and moments imposed on the pump nozzle do not exceed the allowable values as per API 610.

5.2.4.9 Pump discharge should preferably be routed away from the pump rather than towards the motor side.

5.2.4.10 Pump cooling water connection shall be taken from the top of circulating cooling water header.

5.2.5 **Steam Header & Supply Lines / Steam and Condensate Systems**

5.2.5.1 Steam piping shall be designed to have complete condensate removal. Drip legs shall be provided with steam traps at low points in the system.

5.2.5.2 All steam branch connections shall be taken from the top of the header.

5.2.5.3 Return exhaust steam / condensate lines shall connect to the top of the exhaust steam Condensate header.

5.2.5.4 Where block valves have been installed in the main steam header such that condensate can collect either side of the valve when closed, a safe means of draining the condensate prior to opening the valve shall be provided.

- Steam header shall be located generally on the upper tier and at one end of the rack adjacent to columns.
- Branch lines from horizontal steam header, except condensate collection points, shall be connected to the top of the pipe header.
- Isolation valves (if provided) on the branch line shall preferably be provided on the horizontal run and outside the pipe rack.
- All branch lines shall be drainable.
- Drip legs & steam traps shall be provided at all low points and dead ends of steam header. Drip legs at low points shall be closer to downstream riser and shall be provided to suit bidirectional flows, if applicable.
- All turbines on automatic control for startup shall be provided with a steam trap in the steam inlet line.
- All traps shall be provided with strainers if integral strainers are not provided.
- Steam traps discharging to atmosphere shall be connected to storm water drain/storm sewer, in case of open system. In case of condensate recovery, traps shall discharge into condensate header.
- Expansion loops are to be provided to take care of the expansions within units.
- Wherever condensate is to be drained, proper condensate draining facility shall be provided.

5.2.6 **Water Piping**

5.2.6.1 Water piping shall be designed to minimize the possibility of water hammer.

5.2.6.2 Water main headers may run underground to prevent freezing.

5.2.6.3 Unless local code or regulation prohibits, firewater lines shall be underground to prevent freezing. Firewater piping system shall conform to egulations of the competent governmental authorities.

5.2.7 **Instrument Air Piping**

5.2.7.1 Instrument air lines shall not be connected to process lines, service lines and other equipment.

5.2.7.2 Instrument air shall not be used as plant air or service air.

5.2.7.3 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.

5.2.8 **Supports and Anchors**

5.2.8 1 Supports and/or anchors shall be provided close to changes in direction of lines, branch lines and, particularly, close to valves to prevent excessive sagging, vibration and strain.

5.2.8 2 Allowable spans between pipe supports shall be determined to keep the maximum deflection within 16 mm.

5.2.8 3 In cases where periodic maintenance requires removal of equipment, such as pumps and relief valves, and where lines must be dismantled for cleaning, piping shall be supported to minimize the necessity of temporary supports.

5.2.8.4 Spring-loaded hangers may be used on piping subject to thermal expansion or contraction. In cases where the movement is very large, or the limitation of reaction and stress are very severe, constant support spring hangers shall be used.

5.2.8.5 Suction and discharge lines of rotating equipment shall be supported as close as possible to equipment nozzles, and shall be relieved of excessive strains by using proper pipe supports.

5.2.8.6 Supports shall not be directly welded to pipes. Where welding is unavoidable, supports having the same chemical composition as pipe shall be carefully welded.

5.2.8.7 All piping shall be properly supported to minimize vibration.

5.2.8.8 Outlet piping of safety and relief valves shall be supported so that the inlet piping is capable of withstanding the reaction caused by operation of safety and relief valves. Furthermore, the supports shall be designed to minimize the stresses due to thermal expansion and the stresses in the valve body due to the weight of piping.

5.2.8.9 Expansion joints shall be guided and anchored to the extent necessary for their proper operation and alignment.

5.2.8.10 Anchors shall provide sufficient fixation to substantially transmit all load effects into the foundations.

5.2.8.11 Underground piping shall be given special anchoring consideration for differential settlement.

5.2.9 **Utility Stations**

Requisite number of utility stations shall be provided throughout the unit to cater for the utility requirement. Utility stations shall have four connections one for LP steam (SL), one for Plant Air (AP), one for Service Water (WS) and one for nitrogen each of 1.0" with isolation valves unless otherwise specified in P&ID.

Utility connection with nitrogen shall be provided with NRV along with isolation valve kept at a separate location other than this cluster @ 15 M.

Air and water lines shall have quick type hose connection and steam line shall have flanged type hose connection. All connections shall be directed downward. All connections shall have globe valve for isolation purpose. An inter connection with valve shall be provided between steam and service water lines shall be provided. Inert gas hose, when required, shall have built in non return valve in quick connection coupling of piping end.

Number of utility stations shall be such that all equipments shall be approachable from at least one utility station. The approach of utility station shall be considered 15 M all around the station location.

The Utility stations shall generally be located adjacent to pipe-rack column.

The utility stations shall also be provided on elevated structures like - technological structure, operating platforms of vertical equipments etc.

Operating platforms having manholes must have a utility station. Utility station locations shall be limited to a height of 35 M from H.P.P.

5.3 Offsite & Yard Piping

In general, offsite piping (except tank ages area), electrical cable and instrumentation cable shall also be laid either on pipe rack or pipe sleepers.

Wherever piping is laid on pipe sleepers, it shall have hard surfacing below it keeping a gap of 300 mm from the bottom of the pipes. Hard surfacing should be completed before start of pipe laying. Width of hard surfacing shall be about 1.0 meter more than the piping corridor. This extra hard surfacing shall be for movement of operating personnel along the piping corridor.

Pipes at road crossing shall be under culverts in general. Overhead pipe bridges may be used for areas where pipe racks are provided. Where culverts are not provided, pipe sleeves shall be used for underground road crossing. Culverts / overhead pipe bridges shall be adequately designed to take care of future requirements. Minimum 20% extra width shall be provided in all such structures.

Clearances between lines shall be minimum "C" as given below:

$C = (Do + D_f)/2 + 25\ mm + Insulation\ thickness(es)$ where,

Do - outside diameter of smaller pipe (mm)

D_f - outside diameter of flange of bigger pipe (mm)

However this 'C' spacing between the offsite piping on the rack/sleeper can be suitably increased so that the lines should not touch each other after insulation / lateral thermal expansion.

Adequate clearance shall be provided for every long & high temperature lines to avoid clashing at the bends. See 5.2.2 also for line spacing at 'L' bends and loops.

Expansion loops for all lines shall generally be kept at the same location.

Vents shall be provided on all high points & drains shall be provided at all low points. Drain valves at sleeper piping shall be kept outside the sleeper way if the same is not accessible and valves shall be put in horizontal only.

Places where piping is extended to make drain valves accessible - 2 nos. of stiffeners, irrespective of pipe rating, shall be provided as per 5.12.1. Spacing of guides on each line on a pipe bay shall not exceed the value given in clause 5.12.1

5.4 Flare Piping

Flare header shall be sloped towards flare knock-out drum. Only horizontal loop shall be provided as per requirement to accommodate thermal expansion. The desired slope shall be ensured throughout including flat loop. Flare header shall be supported on shoe of height ranging from 100mm to 300mm.

Proper thermal analysis temperature shall be established including the possibility of temperature gradient along the line before providing expansion loops. Efforts shall be made to minimize the number of loops. Flare line between knock out drum and water seal drum shall be designed for pressure fluctuations and adequately supported to avoid vibrations.

5.5 Underground Piping

5.5.1 Underground steel piping shall be protected from electric corrosion.

5.5.2 Underground piping passing under loaded areas, such as main roads in the plant, shall be protected from heavy traffic by casing pipes or covers extending at least 1 m on either side of the area or having the wall thickness sufficient to bear earth pressure.

5.5.3 Underground piping shall be sloped to all drain points with a downward slope of not less than 1 m in 150 m.

5.5.4 Expansion elbows or joints of underground piping for hot fluids, such as steam or heated heavy oil, shall be enclosed in a conduit from which they are separated to allow free longitudinal expansion.

5.5.5 Where it is impossible to run pipe aboveground or underground, trenches may be used.

5.5.6 Trenches for piping close to process equipment should be avoided, whenever possible.

5.5.7 All underground pipe work shall be provided with following protection:

a) At location where Underground Piping becomes above ground, INSULATING GASKET with material Glass Filled Teflon or equivalent shall be provided.

b) CATHODIC PROTECTION (CP) shall be provided to all underground piping. Specification shall be submitted by the CONTRACTOR & shall be approved by the OWNER.

c) Underground piping shall be wrapped & coated by “PYP KOTE” or equivalent tapes / sheets, 4.00 mm thick & shall be “HOLIDAY TESTED” before Hydro Test.

d) All underground pipes shall have Sand Bed, at least 150 MM all around the pipe.

e) All road crossings by Underground piping shall be through Hume Pipe Sleeves.

5.5.8 **Buried Pipes**

The following points to be considered in designing of buried pipes:

i) All underground metallic piping shall be coated and wrapped and provided with cathodic protection system. If sacrificial metal is used, permanent testing arrangement shall be provided.

ii) All cooling water distribution headers 18" and higher shall be laid underground.

iii) All Sewage lines (oily and chemical) from catch basin to mains and manholes shall be laid underground.

iv) Underground pipe crossing roads, access ways and rails shall have casing pipe (R.C.C or C.S).

v) Valve chamber wherever required shall be made of brick or concrete. Valve chamber should be spacious to attend valves during operation/Maintenance.

vi) All U.G. headers shall clear equipment foundations as far as possible. Under special cases, the C.W. header may be laid over the footing of foundations.

vii) Provide break flange at + 500 MM from floor level connection with cathodic protection to isolate underground pipe from above ground piping with insulating gasket KIT.

viii) Pipes shall be laid below electrical cables if any.

ix) 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.

5.5.9 Piping in Trenches

The following points to be considered in designing of trench pipes:

i) Piping located below grade, requiring inspection, servicing or provided with protective heating.

ii) Fire water lines/Process lines.

iii) Drain lines requiring gravity flow trenches.

iv) Sump for valves and trenches shall be provided.

v) Suitable draining scheme for trenches shall be provided.

5.6 **Air Systems**

5.6.1 Branch connections shall be taken from the top of the header.

5.6.2 Low points shall be fitted with drains.

5.7 **In-Line Instruments**

5.7.1 Liquid level controllers and level glasses shall be located so as to be accessible from grade, platform or permanent ladder. The level glass shall be readable from grade wherever possible.

5.7.2 Relief valves shall be accessible. Relief valves with a centre line elevation over 4.5 M above grade (expect in pipe racks) shall be accessible from a platform or permanent ladder.

5.7.3 Relief valves that discharge to a closed system shall be installed higher than the collection header, with no pockets in the discharge line.

5.7.4 Relief valves that discharge to atmosphere shall have tail-pipes extended to a minimum of 3.0 M above the nearest operating platform that is within a radius of 8 M.

5.7.5 Provide steam traps at pocketed low points and at dead ends of steam headers. Provide steam traps on excessively long runs of steam piping to ensure dry quality steam at destination. Steam traps located more than 4.5 M above grade, except in pipe racks, shall be accessible from a platform.

5.7.6 Control valves shall be accessible from grade or platforms. In general, the instruments or indicators showing the process variables shall be visible from the control valve.

5.7.7 Orifice runs shall be located in the horizontal. Orifice flanges with a centre line elevation over 4.5m above grade, except in pipe racks, shall be accessible from a platform or permanent ladder.

5.7.8 Orifice taps shall be located as follows:

i) Air, Gas and steam
Top vertical centreline (preferred)
45 degrees above horizontal centreline (alternate)

ii) Liquid
Horizontal centreline (preferred)
45 degrees below horizontal centreline (alternate)

iii) Tap orientation shall be shown on piping isometrics.

5.8 Sample Connections

Sample connections shall be accessible from grade or platforms. In general, where liquid samples are taken in a bottle, locate the sample outlet above a drain funnel to permit free running of the liquid before sampling.

5.9 Vents and Drains

5.9.1 The minimum size of vent and drain connections shall be as follows:

For process & utilities lines:

4” & Below	NPS ¾”
6” & 10”	NPS 1”
12” & above	NPS 11/2”

Vent & Drain shall be provided with the valve & blind flange. For all vents / drains of process lines / utilities lines, double valves shall be required for 600 # & more rating.

Process vents and drains shall be indicated on the P&ID’s.

5.9.2 Vent, drain and sampling valves on process lines, not connected to a piping system, shall be provided with appropriate end closures.

5.9.3 Vents shall be located at high points of pipelines when necessary.

5.9.4 Drains shall be located at low points to empty pipelines or equipment after testing or during maintenance (i.e for every loop).

5.9.5 All drains and vents shall be provided with valve, except that vents for test purpose for flare lines (header), may be plugged. Exposed threads shall generally be seal welded.

Low-point hydrostatic drains and high-point hydrostatic vents shall be added as required; locations to be determined during the design review.

5.9.6 Vent valves shall be the globe or gate type and drain valves the gate type.

5.9.7 Valved bleeds shall be provided at control valve stations, level switches, level controllers, and gauge glasses.

5.10 Line Strainers

5.10.1 Provide temporary conical type strainers in 2” NB and above butt weld pump suction lines for use during start-up. Arrange piping to facilitate removal.

5.10.2 Provide permanent Y-type strainers for pump suction piping below 2” NB Thd or SW.

5.10.3 Provide temporary basket type strainers located at the suction pulsation device inlet for start-up of reciprocating compressors. Arrange piping to facilitate removal of the filter.

5.10.4 Provide temporary basket type strainers and locate them as close as possible to the compressor inlet flange for start-up of centrifugal compressors. Arrange piping to facilitate removal of the filter.

5.10.5 Allowable pressure drop when specified shall be certified by vendor along with the offer. If asked specifically, vendor shall furnish pressure drop calculations

5.10.6 All 2" & higher sized Y type strainers shall be provided with 3/4" threaded, tap and solid threaded plug as drain connection. For less than 2", this shall be ½ " size.

5.10.7 Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.

5.10.8 For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.

5.10.9 All the strainers shall be hydrostatically tested at twice the design pressure.

5.11 Spectacle Blinds

5.11.1 Spectacle blinds shall be provided to isolate equipment. In hazardous service flanged drop-out spools shall be provided for safety purposes. Both shall be shown on the P&ID’s.

5.11.2 Spectacle blinds shall be accessible from grade or platforms. Blinds located in a pipe-rack are considered to be accessible. Blinds that weigh over 40kg shall be accessible by mobile equipment. Where this is not possible davits or hitching points shall be provided.

5.12 Flexibility Analysis and Supporting

5.12.1 Pipe Supporting Criteria & General Guidelines.

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.

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.

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.

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.

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.

Pads shall be provided for insulated pipes before welding the shoes for sizes 8" & above.

Adequate stiffening shall be provided for the following:

a) Lines in above 600#,

b) Lines having two phase flow,

c) Lines having Pulsating flow such as discharge of reciprocating compressors & reciprocating pumps,

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 licensor/owner.

Wherever two phase flow in piping is expected, piping design shall be checked by dynamic analysis to prevent vibrations.

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.

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.

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.

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.

High density PUF blocks shall be considered for cold piping supports. Use of wood blocks shall be avoided.

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.

5.12.2 **Flexibility Analysis Criteria & General Guidelines**

5.12.2.1 Formal flexibility analysis by computer program of piping system shall be performed on latest version of CAESAR-II software as per Annexure 5, 5A & 5B.

5.12.2.2 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.

5.12.2.3 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.

5.12.2.4 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.

5.12.2.5 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.

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.

Other Horizontal Centrifugal Pumps

The allowable nozzle loads shall meet the load criteria specified by the manufacturer.

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.

5.12.2.6 For piping design purposes, differential settlement between items of major equipment on separate foundations shall be taken as 10 mm.

5.12.2.7 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 Cl. 5.12.1.

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.

5.12.3 **Method of Analysis**

Formal computer analysis shall be performed on piping systems as per design philosophy for stress analysis

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.

All lines shall be analyzed at design / analysis temperature. In the absence of analysis temperature lines shall be analyzed at design temperature.

However in case of wide difference in design and operating temperature, temperature for analysis shall be established in process documents. (e.g. flare line)

All non-critical lines may be analyzed using other methods.

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.

Seismic analysis shall be done for line sizes 12” and above.

5.13 **Personnel Protection**

5.13.1 Eyewash and emergency safety showers shall be provided in areas where operating personnel are subject to hazardous sprays, emissions or spills.

5.13.2 Personnel protection shall be provided on un-insulated lines and equipment operating above 70 deg C when they constitute a hazard to the operators during normal operation of the facility.

5.13.3 Leakage indicating tape and spray impingement shrouds shall be provided at flanged joints in hazardous service.

5.14 **Mechanical Handling**

5.14.1 Handling facilities such as davits and monorails shall be provided on vessels over 10m in height where the weight of removable internal and/or external equipment is greater than 35 Kg.

6.0 MATERIALS

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 per process parameters & attached PMS / VMS.

6.1.2 Only piping materials listed in ASME B31.3 shall be used for Category 'M' and Normal Service piping. Unless otherwise specified in PMS, For Category 'D' utility piping, where scaling and impurities are to be avoided (such as instrument air, potable water and deluge water) hot dipped galvanised and threaded fittings may be used in sizes up to and including 4" NB. Galvanised piping shall not be used in environments containing acids or other corrosive commodities. In corrosive environments stainless steel piping material shall be used for such utility systems.

6.1.3 All items/parts of Austenitic Stainless Steel shall be supplied in solution annealed condition.

6.1.4 In absence of specific requirement, Natural Rubber shall be used for lining in rubber lined piping items, wherever applicable. The Vendor shall confirm the suitability of Rubber Material for specified service. Unless otherwise specified, rubber lining shall be in accordance with IS4682 Part-I.

6.1.5 Unless otherwise specified, HDPE pipes & fittings shall be in accordance to ASTM D3035/ ASTM D3261/ASTM D3350 or equivalent.

6.1.6 **Specification for FRP material**

6.1.6.1 Anticorrosion Barrier of Polymer veil having minimum thickness 2.5 mm shall be provided for chemical resistance. Mechanical resistance to be sustained by FRP.

6.1.6.2 The selected nominal pipe wall thickness will include manufacturers full under tolerance, and the specified corrosion and/or erosion allowance. The pipe thickness will be adequate to resist all external loads from thermal, mechanical and other sources in addition to the process pressure-temperature requirements. However the pipe thickness will be according to vendor's norms and standard calculations but not be lower than indicated in DIN 16965

Part 4. External FRP layer shall be protected against ultra-violet light.

6.1.7 Cast Iron shall not be used as Material of Construction for any piping items like Pipes, fittings, flanges, valves, fasteners, gaskets, etc.

6.2 Pipe

6.2.1 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.

6.2.2 Unless specifically exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding. 100% radiography for all welds except for pipes for category D service.

6.2.3 Double seam 180˚ apart is allowed for sizes 36" and larger only.

6.2.4 Galvanized Pipes shall be only Hot Dip galv. to ASTM A53.

6.2.5 Hydrostatic tests shall be applied to each length of pipe and be in accordance with the requirements of ASTM A530/A530M, unless otherwise specified.

6.3 **Fittings**

6.3.1 Type of fittings shall be equivalent to pipe type in construction.

6.3.2 Thickness of fittings at ends to match pipe thickness for BW fittings. For reducing BW fittings having different wall thicknesses at each end, the greater one shall be employed and the ends shall be matched to suit respective thickness.

6.3.3 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.

6.3.4 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 B31.3. Manufacturer shall submit drawings/catalogues of these items along with the offer & also shall be submitted for approval before manufacturing.

6.3.5 All pipes employed for manufacturing of fittings shall be required to have undergone Hydro test to ASTM A530.

6.3.6 All welded fittings shall be 100% Radio-graphed by X-Ray on all welds.

6.4 **Flanges**

6.4.1 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 All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Torque wrench / hydraulic bolt tensioner depending upon service criticality.

6.5 **Gaskets**

Gaskets shall be as per piping material specification/ applicable standard.

6.6 **Stud, Bolts, Nuts and Jack Screws**

6.6.1 All bolting shall be as per ASME/ANSI B18.2.1 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 Screw threads of bolting shall be unified coarse threads in accordance with ANSI / ASME B1.1 having Class 2A for bolts and Class 2B for nuts. Screw threads in size l-1/8 and larger shall be 8 threads per inch.

6.7 Valves

6.7.1 General

All flanged valves (except forged) shall have flanges integral with the valve body.

Yoke material shall be at least equal to body material.

Forgings are acceptable in place of Castings but not vice-versa.

No cast iron material valves to be used in any service.

Valves in saline water (if applicable) service shall be with non ferrous trims and all wetted parts other than trims shall be epoxy coated.

Valve body basic MOC shall be equivalent or above basic MOC of connecting pipe.

6.7.2 Ball/Plug/Butterfly Valves

Use of soft seated ball/plug/butterfly valves shall be suitably selected based on temperatures handled.

Butterfly valves shall be suitable for throttling application.

Lug type Butterfly valves shall be with threaded lugs only. Each butterfly valve shall be provided with the Bolts to be installed from both sides separately.

PN equivalent rating for Class150# valves shall be minimum PN16.

Ball valves may be used in place of gate or plug valves with the following limitations:

i) Operating conditions are within the permissible pressure - temperature range of seat materials.

ii) Fire safe type to be used for hydrocarbon services.

6.7.3 Valve Dimensions

Face-to-Face/End-to-End dimension shall be as per ANSI B16.10. In case the same is not covered under B16.10, the dimension shall be as per BS 2080/manufacturer standard.

Hand wheel diameter shall not exceed 750 mm and lever length shall not exceed 500 mm on each side. Effort to operate shall not exceed 35 kgf at hand wheel periphery. However, failing to meet the above requirement, vendor shall offer gear operation.

Quarter-turn valves shall have "open" position indicators with limit stops.

6.7.4 Non Destructive Testing of Valves

6.7.4.1 Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME/ANSI B16.34.

All valve castings shall be of radiographic quality.

The minimum requirement of radiography shall be as under:

Class	Size	Qty
150	Up to 24”	5%
150	26” & above	100%
300	Up to 16”	10%
300	18” & above	100%
600 & above	All	100%

6.7.4.2 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.

6.7.4.3 Beveled ends on each butt welding end valve shall be subjected 100% magnetic particle or liquid penetrant examination.

6.7.4.4 Each valve shall be pressure tested in accordance with API 598.

6.7.5 **Criteria for Isolation Valves**

Installation	Process Isolation	Drain/ Vent	Pressure Taping	Level Taping	Flow Element	Safety Valve	Control Valve
150 / 300#	Single	Single	Single	Single	Single	Single	Single
600 #	Single	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.

6.8 **Traps**

Vendor shall also furnish the performance curve indicating the capacity in mass/hour at various differential pressures across the trap.

Parts subject to wear and tear shall be suitably hardened. Traps shall have integral strainers.

All traps shall be hydrostatically tested to twice the design pressure.

6.9 **Hoses**

Manufacturer shall guarantee suitability of hoses for the service and working conditions specified in the requisition, if the material is not specified in the Material Requisition for any particular service.

All hoses shall be marked with service and working pressure at minimum two ends clearly.

Hoses shall be resistant to ageing, abrasion and suitable for outdoor installations.

Complete Hose assembly shall be tested at two times the design pressure.

Steam hoses shall be subject to steam resistance test.

6.10 **Expansion Joints (Metallic)**

The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).

Bellows shall be formed from solution annealed sheet conforming to the latest ASTM Spec. Any longitudinal weld shall be 100% radiographed. The finished longitudinal weld must be of the same thickness and same surface finish as the parent material.

Circumferential welds are not permitted. Bellows are to be hydraulically or expansion (punched) formed. Rolled formed bellows are not acceptable. Noticeable punch or die marks resulting from expansion operation are not acceptable.

No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable.

The out of roundness shall be limited to ± 3mm. This is the max deviation between the max & min diameter.

The actual circumference of the welding end shall be maintained to ± 3mm of the theoretical circumference.

Apart from the usual requirements, the vendor shall also furnish

a) Design calculations to justify stiffness and fatigue life.

b) Axial, lateral stiffness, angular stiffness, effective pressure thrust area.

c) Installation/maintenance manual.

6.11 Supports & Spring Assemblies

The Material, Design, Manufacture and Fabrication shall be generally as per MSS-SP-58/ MSS-SP-89 and/or BS 3974.

Testing of springs shall be as per BS1726.

6.12 Non Destructive Examination

10% radiography of butt welds and 10%DP/ MP test of fillet welds shall be done for pipe Classes in 150# & 300#.

100% radiography on butt weld joints and 100% DP/MP for fillet welds test shall be done for Pipe Classes in 600# & above.

7.0 PAINTING

Painting shall be as per attachment provided elsewhere in NIT.

8.0 WELDING

Welding shall be as per ASME BPV- Sec. IX

ANNEXURE – 1

TABLE OF BASIC SPAN

Pipe Size In.	SCH/Thk (in)	PIPE- VAPOR INSULATION BASIC SPAN (L)M			PIPE- LIQUID INSULATION BASIC SPAN (L)M			BARE PIPE EMPTY		BARE PIPE WATER FILLED		Pipe size in.
		UPTO 175^{0}C	176^{0}C TO 315^{0}C	316^{0}C TO 400^{0}C	UPTO 175^{0}C	176^{0}C TO 315^{0}C	316^{0}C TO 400^{0}C	SPAN(L) M	WEIGHT KG/M	SPAN(L) M	WEIGHT KG/M	
3/4"	SCH 40	3.5	3.5	2.5	3.5	3.0	2.0	4.5	1.68	4.0	2.04	*3/4"*
1"	SCH 40	4.5	4.0	3.0	4.5	3.5	3.0	5.0	2.52	4.5	'3.07	1"
1-1/2"	SCH 40	5.0	5.0	4.5	5.0	4.5	3.5	6.0	4.08	5.0	.5.4	*1-1/2"*
2"	SCH 40	5.5	5.0	4.5	5.0	4.5	3.5	8.5	5.47	5.5	7.65	2"
2-112"	SCH 40	6.5	6.0	5.0	6.0	5.5	4.5	7.5	8.7	6.5	11.79	*2-112"*
3"	SCH 40	7.5	6.5	5.5	6.5	6.0	5.0	8.0	11.35	6.5	16.15	3"
4"	SCH 40	8.0	7.5	6.5	7.5	7.0	6.0	9.0	16.2	7.5	24.45	4"
6"	SCH 40	10.0	9.5	8.5	9.0	8.0	7.5	10.5	28.3	9.0	46.7	6"
8"	SCH 40	12.0	11.0	10.0	10.0	10.0	9.0	12.0	42.84	10.0	75.22	8"
10"	SCH 40	13.5	13.0	12.0	11.5	10.5	10.5	14.0	60.74	11.5	111.9	10"
12"	*3/8"* w	14.5	13.5	13.0	12.0	11.5	11.0	15.0	74.40	12.0	147.5	12"
14"	*318"*w	15.0-	14.5	13.5	12.0	12.0	11.5	16.0	82.5	12.5	172.05	14"
16"	*318"*w	16.0	15.5	14.5	13.0	12.5	12.0	17.0	94.5	13.0	213.15	16"
18"	*3/8"* w	17.0	16.5	15.0	13..5	13.0	12.0	18.0	106.5	13.5	258.3	18"
20"	*318"* w	18.0	17.5	16.0	14.0	13.5	12.5	19.0	118.5	14.0	307.5	20"
24"	*3/8"*w	20.0	19.0	17.5	14.5	14.5	13.0	21.0	1425	15.0	418.2	24"
3/4"	SCH 80	3.5	3.5	2.5	3.5	3.0	2.0	4..5	2.20	4.0	2.49	*3/4"*
1"	SCH 80	4.5	4.0	3.0	4.5	3.5	3.0	5.0	3.25	4.5	3.72	1"
1-112"	SCH 80	5.0	5.0	4.5	5.0	4.5	4.0	6.0	5.45	5.0	6.60	*1-112"*
2"	SCH 80	6.0	5.0	4.5	5.5	5.0	4.0	6.5	7.53	6.0	9.45	2"
2-112"	SCH 80	6.5	6.0	5.5	6.0	6.0	5.0	7.5	11.49	6.5	14.25	*2-1/2"*
3"	SCH 80	7.5	6.5	6.0	6.5	6.5	6.0	8.0	15.37	7.0	19.66	3"
4"	SCH 80	8.0	8.0	7.0	7.5	7.5	6.5	9.0	22.47	8.0	29.94	4"
6"	SCH 80	10.5	10.0	9.0	9.5	9.0	8.5	10.5	42.90	9.5	59.85	6"
8"	**½" w**	12.0	11.5	10.5	10.5	10.0	10.0	12.0	65.10	11.0	94.8	8"
10"	**½" w**	13.5	13.0	12.0	11.5	11.5	10.5	14.0	82.20	12.0	130.69	10"
12"	**½" w**	14.5	13.5	./, 3.0	12.5	12.0	11.5	15.0	98.13	13.0	168.64	12"
14"	**½" w**	15.0	14.5	13.5	13.0	12.5	12.0	16.0	108.15	13.5	194.4	14"
16"	**½" w**	16.0	15.5	15.0	13.5	13.0	13.0	17.0	124.2	14.0	240.0	16"
18"	**½" w**	17.5	17.0	.16.0	14.5	14.0	13.5	18.0	140.25	14.5	286.64	18"

Pipe Size In.	SCH/Thk (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 175^0 C	176^0 C TO 315^{0}C	316^{0}C TO 400^{0}C	UPTO 175^0 C	176^0 C TO 315^{0}C	316^{0}C TO 400^{0}C	SPAN(L) M	WEIGHT KG/M	SPAN(L) M	WEIGHT KG/M	
20"	½" w	18.0	17.5	..:.17. 0.	15.0	14.5	14.0	19.0.	157.5	15.0	341.8	20"
24"	½" w	20.0	19.0	. 18.5	16.0	15.0	15.0	21.0	188.25	16.0	458.44	24"
1"	10S	4.0	3.5	3.0	4.0	3.0	2.5	4.5	2.08	4.0	2.7	1"
1-112"	10S	5.0	4.5	3.5	4.5	4.0	3.0	5.5	3.12	5.0	4.57	*1-112"*
2"	10S	5.0	4.5	3.5	4.5	4.0	3.0	6.0	3.94	5.5	6.33	2"
2-112"	10S	6.5	5.5	4.5	5.5	5.0	4.5	7.0	5.26	6.0	8.85	*2-1/2"*
3"	10S	7.0	6.0	5.0	6.0	5.5	5.0	7.5	6.45	6.0	11.91	3"
4"	10S	7.5	7.0	6.0	*6.p*	6.0	6.0	8.0	8.34	7.0	17.87	4"
6"	10S	9.5	9.0	8.0	8.0	7.5	7.5	10.0	13.82	8.5	34.54	6"
8"	10S	11.0	10.5	10.0	9.5	9.5	8.5	11.5	19.94	10.0	55.5	8"
10"	10S	12.5	12.0	11.0	10.5	10.0	9.5	13.0	27.S3	11.0	83.4	10"
12"	10S	14.0	13.0	12.0	11.0	11.0	10.0	14.5	36.00	11.5	114.6	12"
14"	105	14.5	14.0	13.0	11.5	11.0	11.0	15.5	41.18	11.5	132.6	14"
16"	10S	16.5	14.5	14.0	12.0	11.5	11.5	16.5	47.33	12.5	172.2	16"
IS"	10 S	16.5	15.5	14.5	12.5	12.5	11.5	17.5	53.18	13.0	212.1	18"
20"	10 S	17.5	16.5	15.5	13.0	13.0	12.0	18.5	68.50	13.0	264.5	20"
24"	10 S	19.0	18.0	17.0	14.0	13.5	12.5	20.5	94.37	14.0	376.8	24"

ANNEXURE – 2

ACCESSIBILITY FOR VALVES AND INSTRUMENTS

VALVES, INSTRUMENTS, EQUIPMENT TO BE OPERATED	CENTRELINE OF ITEM TO BE OPERATED, LOCATED LESS THAN 3.6m ABOVE GRADE, 2.75 m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM	CENTRELINE OF ITEM TO BE OPERATED, LOCATED MORE THAN 3.6m ABOVE GRADE, 2.75m ABOVE FLOOR OR PLATFORM OR 1.8m ABOVE WING PLATFORM
EXCHANGER HEADS	NIL	PLATFORM
OPER.VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
OPER. VALVES 3" & ABOVE	PLATFORM	PLATFORM
MOTOR OPERATED VALVES	PLATFORM	PLATFORM
CONTROL VALVES	PLATFORM	PLATFORM
RELIEF VALVES 2" & SMALLER	FIXED LADDER	FIXED LADDER
RELIEF VALVES 3" & ABOVE	PLATFORM	PLATFORM
BLOCK VALVES 2" & SMALLER	PORTABLE LADDER	PLATFORM
BLOCK VALVES 3" & ABOVE	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)
BATTERY LIMIT VALVES	PLATFORM	PLATFORM
PRESSURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2m HEIGHT	FIXED LADDER
TEMPERATURE INSTRUMENT	FIXED LADDER IF ABOVE 2.2 M Ht	FIXED LADDER
SAMPLE POINTS	PLATFORM	PLATFORM
GAUGE GLASSES	FIXED LADDER	FIXED LADDER
LEVEL CONTROLLERS	PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 2" & SMALLER	PORTABLE LADDER / PLATFORM	PLATFORM
PROCESS BLINDS AND SPACERS 3" & ABOVE	PLATFORM	PLATFORM
MANWAYS/MANHOLES	PLATFORM	PLATFORM
HANDHOLES/INSPECTION HOLES	PLATFORM	PLATFORM
NOZZLES (process}	PLATFORM	PLATFORM
VESSEL VENTS	PORTABLE LADDER	FIXED LADDER
LINE DRAINS & VENTS	PORTABLE LADDER	PORTABLE LADDER
ORIFICE FLANGES	PLATFORM (NOTE-1)	PLATFORM (NOTE-1)

NOTE -1:-BLOCK VALVES / ORIFICE FLANGES, IF LOCATED, WITH CENTRE LINES GREATER THAN 2 METER FROM THE OPERATING FLOOR / OPERATING PLATFORM, SHALL BE PROVIDED WITH PORTABLE PLATFORM OR CHAIN FOR OPERATION.

NOTE -2 : PLATFORM SHALL BE PROVIDED FOR THE ORIFICE FLANGES ON PIPE RACK.

ANNEXURE-3

MAXIMUM SPACING OF GUIDES FOR VERTICAL & HORIZONTAL PIPES

NOM PIPE SIZE IN INCHES	VERTICALSPACING METRES	HORIZONTAL SPACING METRES
1	6.0	6.0
1 ½	6.0	6.0
2	6.0	6.0
3	8.0	12.0
4	8.0	12.0
6	8.0	12.0
8	8.0	12.0
10	12.0	18.0
12	12.0	18.0
14	12.0	18.0
16	12.0	18.0
18	12.0	18.0
20	16.0	18.0
24	16.0	18.0
26 & ABOVE	16.0	18.0

NOTES:-

1. These spacings may be varied to suit column spacing of rack. The above spacing is for straight runs of pipe & does not include guides which are used for control of thermal movements, as decided by stress group.

2. The guide spacings given in the above table are indicative only.

ANNEXURE – 4

CLEARANCES

Minimum clearances for piping, equipment, structures, platforms, and supports shall be in accordance with the following table:

Item	Description	
Roads	Headroom for primary access roads wherever heavy duty crane movement is required.	9 M
	Headroom for primary access roads	7.5 M
	Width of primary access roads excluding shoulders.	Refer Civil
	Headroom for secondary roads	5 M
	Width of secondary roads excluding shoulders.	Refer Civil
	Clearance from edge of road shoulders to platforms, equipment, pipe associated with equipment, or similar features.	1.5 M**
Maintenance Aisles at Grade	Horizontal clearances for equipment maintenance by hydraulic crane (12t capacity)	3 M
	Vertical clearance for equipment maintenance by hydraulic crane (12t capacity)	3.6 M
	Horizontal clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Vertical clearance for fork lift and similar equipment (2500 kgs capacity)	2.4 M
	Horizontal clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	1 M
	Vertical clearances for equipment maintenance by portable manual equipment (A-frames, hand trucks, dollies or similar equipment)	2.4 M
Walkways	Horizontal clearance (not necessarily in a straight line)	750 mm
	Headroom (except for hand wheels)	2.2 M
Platforms	Minimum width	1200mm
	Headroom from stairwell treads.	2.2 M

Item	Description	
Platforms	Minimum clearance around any obstruction on the platform.	500 mm
	Headroom	2.2 M
	Maximum vertical distance between platforms	6 M
	Minimum toe clearance behind a ladder.	210 mm
	Minimum handrail clearance.	100 mm
Equipment	Minimum maintenance space required between flanges of exchangers or other equipment arranged in pairs.	500 mm
	Minimum maintenance space required for structural members or pipe.	300 mm
	Clearance from edge of road shoulder (the extreme projection)	1.5 M
Fired Equipment	Horizontal clearance from hydrocarbon equipment (shell to shell)	15 M
	Exception: Reactors or equipment in alloy systems shall be located for the most economical piping arrangement.	
	Clearance from edge of road to heater shell.	3 M
Valve Hand wheels	Clearance between the outside of the hand wheel and any obstruction.	25 mm*
Pipe (aboveground)	Clearance between the outside diameter of the flange and the outside diameter of pipe insulation.	25 mm*
	Clearance between the outside diameter of the pipe, flange or insulation and a structural member.	50 mm*
	Clearance between the outside diameter of the flange and the outside diameter of bare pipe.	25 mm*
	Minimum distance from underside of pipe to grade or platform.	300 mm
Control Valve Arrangement	Centreline of control valve above grade or platform.	450 mm
	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,	

Item	Description	
	the tail pipe shall terminate as below:	
	Distance above nearest operating platform.	3 M
	Within radius of nearest operating platform.	7.5 M
** Verify conformance with local regulations. * With full consideration of thermal movements		

ANNEXURE – 5

DESIGN PHILOSOPHY FOR STRESS ANALYSIS

1.0 PURPOSE

This design basis deals with the subject of Identification of Stress Critical pipelines and preparation of Critical line list. This procedure also defines the minimum requirements for performing stress analysis, design and location of spring, support and level of system

Analysis with the extent of documentation required for flexibility analysis.

Purpose of piping stress analysis is to ensure:

Safety of piping and piping components

Safety of connected equipment and supporting structure

Piping deflections are within the limits

2.0 SCOPE

This specification covers the supply of engineering services to perform a complete piping and pipe support analysis for piping systems.

3.0 DEFINITIONS

3.1 Critical Lines / Critical Line List

Critical lines or Critical Line List as referred to in this procedure relates to Piping Stress Critical Lines and does not include or refer to process critical lines.

3.2 Stress Analysis Temperature

Stress Analysis Temperature refers to either “Maximum Operating Temperature” or “Steam-out temperature / hot nitrogen purging temperature” of the lines under review whichever is higher. In absence of the above values, it refers to the Design Temperature of the line under review. The Line List should be strictly followed in obtaining the above temperature values.

3.3 Design Pressure

Design Pressure refers to the “Design Pressure” of the line under review as indicated on the Line List. Design Pressure is as defined in clause 301.2 of ASME B 31.3.

3.4 Temperature for Flexibility Analysis

The temperature to be used for the flexibility analysis shall be taken as the maximum / minimum temperature which the pipe will see under any combination of different normal / abnormal operating conditions, as defined in clause 301.3 of ASME B 31.3. Where piping is exposed to direct sunlight, solar radiation temperature of 70 ^{0}C is considered in establishing the maximum temperature of piping. Even, for non-critical piping exposed to direct sunlight on pipe rack or elsewhere, expansion loops, wherever essential, are provided to take care of pipe movements resulting from piping skin temperature due to solar radiation.

In general, unless there is a difference of more than 50 ^{0}C between working Temperature and the design temperature, the design temperature should be taken as Flexibility temperature. Ambient Temperature shall be considered as 21ºC the assumed piping installation temperature. The displacement stress range from this installation temperature to the minimum recorded ambient temperature of 0^{0} C being less than the same from installation temperature

to the maximum operating temperature of hot piping in most cases, the later governs as per clause 319.2.3 of ASME B 31.3

The temperature under fire condition is normally not considered for flexibility analysis.

4.0 SELECTION

A line is selected and listed as a Critical Line provided it falls under any one of the categories defined below and is intended to include the special requirements of Piping Stress Engineer. It is hence defined as any line for which a flexibility review is required or where pipe supporting is deemed to be critical and needs review by a Stress Engineer. Line DN 50 and smaller is inherently flexible and is not normally considered critical unless built from non-metallic or non-ferrous materials. In case of more than one applicable line size, larger line size governs. Lines are classified as Level I, Level II & Level III according to the criteria listed below.

4.1 Level I [Extensive Analysis]

Piping systems or lines that meet Annexure 5A criteria are deemed to be extremely critical. These lines are categorized as Level I and require careful study to ensure that the code compliance is met and the accurate determination of nozzle and support loads have been made. The routing of these lines is very important. They must be analyzed in the early stages of the project during routing studies so that the impact on the location of less critical lines is minimized. Normally, these systems require computer analysis. The general intent of the Level I analysis criteria is to study lines size DN 80 & larger that are affected by thermal expansion and / or a dynamic response, and that can't be evaluated by a weight-only analysis (as per the general intent of Level II analysis). Consideration has to be given to other special situations that augment the Level I general intent guidelines such as for lines that are excessively large and stiff.

4.2 Level II [Normal Analysis]

Piping systems or lines that meet Annexure 5B criteria are moderately critical lines and often do not require such rigorous study to ensure code compliance or accurate determination of nozzle and support loads. These lines are smaller in size and operate at lower temperatures (in general) than the lines to be analyzed using Level I Criteria. Normally, only manual calculations, by use of appropriate monographs are required for analysis of these systems.

4.3 Level III [Minimum Analysis]

All lines that are outside the purview of Level I or Level II criteria will be classified as level III and shall be reviewed by the Piping Engineer during the squad check of the piping drawings and or fabrication Iso's. If more detailed analysis is required, the Piping Engineer may change the level of analysis during the squad check as applicable. Normally, only visual analysis is required for these systems.

4.4 Lines Deemed To Be Support Critical

Lines subjected to two-phase flow.

Cross country pipelines.

Lines with pipe thickness Sch 160 or greater.

Lines DN 400 and above with pipe thickness less than 8 mm.

Lines DN 250 and above with corrosion allowance 3 mm and above.

Lines with high concentrated loads such as heavy valves or fittings etc.

Lines downstream of Relief Valve / letdown Control Valves / bursting (rupture) discs.

Connecting to vent or flare systems or discharging to atmosphere

Liquid Blow down Lines.

Lined pipes

Non-metallic pipes

4.5 **Lines Needing Dynamic Analysis**

There are instances where in the frequency of the applied load is comparable to the natural frequency of the piping system. Such systems tend to store the energy and release it according to certain scientific laws. Such a system is dynamic in nature and the study of the response of such a system is referred to as “Dynamic Analysis”. Examples of such kind of systems are Relief Valve discharge lines, water hammer and surge in pipe lines, two phase flow in pipelines, reciprocating pumps and compressor piping, submarine piping etc.

4.6 **Special Piping**

Special piping forming part of reformer tubes, heater internal piping, etc. are treated as proprietary piping and nozzle loading at the Interface connections are to be co-ordinate 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).

The equivalent horizontal static force method shall apply in general .The contractor shall also carry out special designs and provisions as necessary for piping which is considered to be dynamically sensitive to earthquake.

Seismic analysis to be performed for lines equal to and above 12".Seismic load case shall ALGEBRIC combination with operating cases.

Heavy rigid masses like valves shall be restrained in their vicinity to avoid large seismic movements. Guides or snubbers as the case may be used for this purpose.

Horizontal seismic coefficient (Ah) to be considered as 0.26 and Vertical (Av) to be considered as 0.173.

6.4 Wind loads shall be calculated in accordance with IS-875 code of practice for structural safety of building – Loading Standards for Indian code requirement using basic wind speed as mentioned in project design basis. For American standard, wind load in accordance to ASCE 07 shall be calculated. Reduction in velocity pressure due to apparent shielding afforded by buildings and structure or terrain shall not be permitted.

Wind loading shall only be considered for lines larger than 20" OD at elevation higher than 10m above grade. Displacements due to wind and earthquake should be limited to 50 mm.

Both the horizontal directions shall be analyzed independently in two cases

+X, -X, +Z, -Z

Wind and seismic loading will not occur simultaneously.

6.5 Analysis of all nozzles loading on vessels within the piping boundaries is covered in this specification. Nozzle analysis shall follow the guidelines of ASME Section VIII, Division 1, and WRC 297 & 107 (latest editions). Nozzle stresses shall fall within the allowable per ASME.

6.6 Piping system shall have sufficient flexibility to avoid leakage at joints. Flanged joints imposed by external moments may be analyzed and the stresses evaluated by using the methods of equivalent pressure given in the ASME boiler and pressure code section III. Flange leakage shall be assessed as per "Pressure Equivalent Method". In case of Failure in Pressure Equivalent Method, the Flanges shall be checked for leakage using Caesar Flange leakage Module. Flange leakage shall be assessed for all PSV flanges, Control valve flanges, High Pressure lines, all steam lines and also for equipment flanges where loads are high.

6.7 All forces on connections to equipment shall not exceed maximum allowable as specified by equipment vendor.

6.8 Pipe supports loads shall be based on the maximum loads determined by the piping analysis. Adjustments shall be made to the piping system and model such that the pipe supports loads are within a reasonable uniformity throughout the piping system.

6.9 Various Load cases built in Caesar II to check stress in piping system are listed below.

1	WW+HP	HYD	
2	W+T1+P1	OPE	
3	W+T2+P1	OPE	
4	W+T1+P1+U1	OPE	
5	W+T1+P1+U2	OPE	
6	W+T1+P1+U3	OPE	
7	W+T1+P1-U1	OPE	
8	W+T1+P1-U2	OPE	
9	W+T1+P1-U3	OPE	
10	W+T1+P1+WIN1	OPE	
11	W+T1+P1+WIN2	OPE	
12	W+P1	SUS	
13	W+P2	SUS	
14	L2-L12	EXP	
15	L3-L12	EXP	
16	L4-L2	OCC	
17	L5-L2	OCC	
18	L6-L2	OCC	
19	L7-L2	OCC	
20	L8-L2	OCC	
21	L9-L2	OCC	
22	L10-L2	OCC	
23	L11-L2	OCC	
24	L12+L16	OCC	
25	L12+L17	OCC	
26	L12+L18	OCC	
27	L12+L19	OCC	
28	L12+L20	OCC	
29	L12+21	OCC	
30	L12+L22	OCC	
31	L12+L23	OCC	

P1- Maximum Operating Pressure 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

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 7 – 98

8.0 SOFTWARE USED

The package used shall be latest version of CEASER-II 5.2. Only one of these packages shall be used for the project & not a combination of the above packages.

9.0 DOCUMENT REQUIREMENT

9.1 A written report shall be submitted on the piping and equipment analysis. The report shall include all pertinent information that shall include but not be limited to the following.

Location and type of pipe supports with loads and movements.

Location of expansion joints and movements.

Vertical and horizontal loads including moments at all support points.

Vertical and horizontal loads including moments on all equipment and

Vessel connections.

Caesar II analysis report, which shall include as a minimum, restraint forces, movements and stresses for all load cases. For flange connection, loaded with high bending moments and/or tensile forces in piping or at equipment connections, Caesar II flange leakage report will be provided. For piping analyzed, if subjected to hydro test, hydro test load case will be made in Caesar II to check for loading under hydro test & the requirement of any additional temporary supports for hydro test.

Detailed nodal model used for the stress analysis

All assumptions and limitations applied to the analysis

9.2 All dimensions and analysis shall be performed using metric and SI units.

9.3 The final report / stress package folder shall be submitted as follows:

1. Front sheet with Approval status
2. Isometrics with following information
   - Node numbers
   - Type of supports selected by stress engineer
   - Springs / Bellows data required for procurement like spring rate, loads, tide/untied information and SM (special material) identification.
   - Maximum Expansion and sustain stress values with node number
   - Nozzle/Anchors initial movements and piping imposed forces and moments on the same
   - Support loads (anchors, guides or rest) only they are above limit (The limit is defined in the beginning of the project in consultation with civil)

- Design and maximum operating conditions
- Coordinate axis system considered for inputs
- Dimensional details for piping designer to locate supports in piping model/layout.

3. Checklist as per Work instructions.
4. Following outputs
   - Load Cases
   - Restraint summary
   - Spring hanger report, if any
5. Stress critical line list extract for the lines analysed
6. Piping material specifications
7. Equipment drawings with allowable loads, if available
8. PID

ANNEXURE-5A

CRITERIA FOR IDENTIFING EXTREMELY CRITICAL LINES (LEVEL I)

Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	All	All	Piping which will undergo hydraulic shock, auto-ignition or is in service.
All	DN≥80	All	Category M (Lethal) fluid service per ASME B31.3 (No cyclic service).
All	DN≥80	All	Piping which is openly exposed to winds> 75 mph.
T<-29	DN≥80	Carbon Steel	All Services.
T<-45	DN≥80	All	All Services
T≥65	DN≥80	Non-Metallic	All Services
T≥65	DN≥80	All	Lines with pressure≥900 psig.
T≥150	DN≥80	All	All Services
ALL	DN≥400	All	All Services.
T≥260	ALL	ALL	ALL Services.
-29≥T≥65 OR -7≥T≥50	DN≥80 DN≥100	All	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1).
ALL	ALL	All	Lines requiring expansion joints or flexible connectors.
DELTA T≥27 (NOTE 2)	DN≥80	All	Jacketed piping.
-29≥T≥65	DN≥100	All	Internally lined pipe (except glass).
All	ALL	All	Glass lined piping.
All	DN≥80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
-40≥T≥80 -29≥T≥70	DN≥100 DN≥200	Metallic Metallic	Underground Piping

NOTES:

1) Load sensitive equipment include fired heaters, reformers, lined vessels with lining of brittle material, non-ferrous equipments, graphite heat exchangers, plate & frame heat exchangers, etc.
2) This criterion is not to be applied to auxiliary piping such as seal flush; bearing cooling, etc. delta T refers to the differential temperature between the process piping and jacket.

ANNEXURE-5B

CRITERIA FOR IDENTIFYING MODERATELY CRITICAL LINES (LEVEL II)

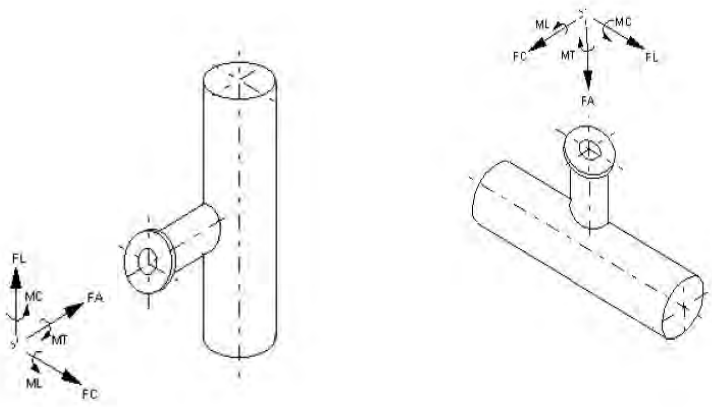
Temperature T, Degree C	Pipe Diameter DN (mm)	Piping Material	Service and Description
All	DN<80	All	Lethal fluid service.
T<-29	DN<80	Carbon Steel	All Services.
T<-46	DN<80	All	All Services
95<T<150	80<DN<200	All	All Services
T≥65	DN<80	Non-Metallic	All Services
T≥65	DN<80	All	All Services
T≥65	DN<80	All	Lines with pressure≥900 psig.
T≥150	DN<80	All	All Services
ALL	200<DN<400	All	All Services.
T≥260	ALL	ALL	ALL Services.
ALL	ALL	ALL	Piping connected to nozzle load sensitive equipment, air-cooled exchangers and rotating equipment (see note 1 of Table-1).
DELTA≥27(NOTE 2 of Table-1)	DN<80	All	Jacketed piping.
All	ALL	All	Internally lined pipe (except glass).
All	DN<80	All	Differential Tank Settlement (Upto 3 supports from nozzle).
All	ALL	All	Underground Piping
All	ALL	All	Piping connected to pressure relief
All	ALL	All	Close coupled interconnecting piping between equipment with differential movement greater than 6.0mm.

ANNEXURE-5C

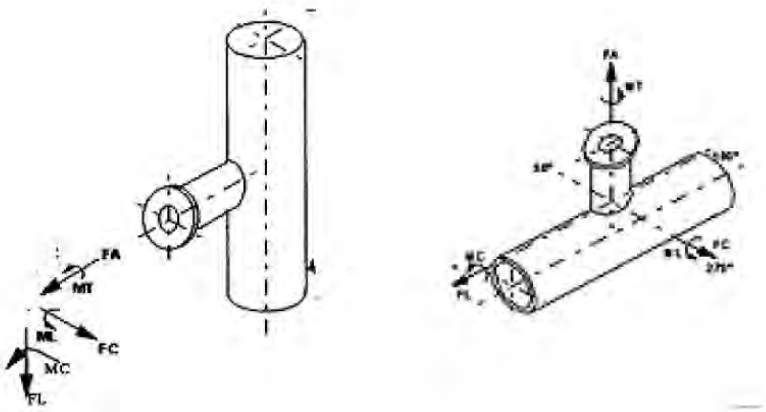
MINIMUM ALLOWABLE NOZZLE LOADINGS- VESSELS AND S/T HEAT EXCHANGERS

NOZZ. SIZE	FLANGE RATING	NOZZLE FORCES (N)				NOZZLE MOMENTS (Nm)			
(in)	(lbs)	FL	FA	FC	F	MT	ML	MC	M
1.5	150#	2250	2250	1688	2385	253	219	169	238
1.5	300#	2250	2250	1688	2385	253	219	169	238
1.5	600#	3750	3750	2813	3975	422	366	281	397
1.5	900#	4500	4500	3375	4770	506	439	338	476
1.5	1500#	6000	6000	4500	6360	675	585	450	635
2	150#	3000	3000	2250	3180	450	390	300	423
2	300#	3000	3000	2250	3180	450	390	300	423
2	600#	5000	5000	3750	5300	750	650	500	705
2	900#	6000	6000	4500	6360	900	780	600	846
2	1500#	8000	8000	6000	8480	1200	1040	800	1128
3	150#	4500	4500	3375	4770	1013	878	675	952
3	300#	4500	4500	3375	4770	1013	878	675	952
3	600#	7500	7500	5625	7950	1688	1463	1125	1586
3	900#	9000	9000	6750	9540	2025	1755	1350	1904
3	1500#	12000	12000	9000	12720	2700	2340	1800	2538
4	150#	6000	6000	4500	6360	1800	1560	1200	1692
4	300#	6000	6000	4500	6360	1800	1560	1200	1692
4	600#	10000	10000	7500	10600	3000	2600	2000	2820
4	900#	12000	12000	9000	12720	3600	3120	2400	3384
4	1500#	16000	16000	12000	16960	4800	4160	3200	4512
6	150#	9000	9000	6750	9540	4050	3510	2700	3807
6	300#	9000	9000	6750	9540	4050	3510	2700	3807
6	600#	15000	15000	11250	15900	6750	5850	4500	6345
6	900#	18000	18000	13500	19080	8100	7020	5400	7614
6	1500#	24000	24000	18000	25440	10800	9360	7200	10152
8	150#	12000	12000	9000	12720	7200	6240	4800	6768
8	300#	12000	12000	9000	12720	7200	6240	4800	6768
8	600#	20000	20000	15000	21200	12000	10400	8000	11280
8	900#	24000	24000	18000	25440	14400	12480	9600	13536
8	1500#	32000	32000	24000	33920	19200	16640	12800	18048
10	150#	15000	15000	11250	15900	11250	9750	7500	10575
10	300#	15000	15000	11250	15900	11250	9750	7500	10575
10	600#	25000	25000	18750	26500	18750	16250	12500	17625
10	900#	30000	30000	22500	31800	22500	19500	15000	21150
10	1500#	40000	40000	30000	42400	30000	26000	20000	28200
12	150#	18000	18000	13500	19080	16200	14040	10800	15228
12	300#	18000	18000	13500	19080	16200	14040	10800	15228
12	600#	30000	30000	22500	31800	27000	23400	18000	25380
12	900#	36000	36000	27000	38160	32400	28080	21600	30456
12	1500#	48000	48000	36000	50880	43200	37440	28800	40608
14	150#	21000	21000	15750	22260	22050	19110	14700	20727
14	300#	21000	21000	15750	22260	22050	19110	14700	20727
14	600#	35000	35000	26250	37100	36750	31850	24500	34545
14	900#	42000	42000	31500	44520	44100	38220	29400	41454
14	1500#	56000	56000	42000	59360	58800	50960	39200	55272

NOZZ. SIZE	FLANGE RATING	NOZZLE FORCES (N)				NOZZLE MOMENTS (Nm)			
(in)	(lbs)	FL	FA	FC	F	MT	ML	MC	M
16	150#	24000	24000	18000	25440	28800	24960	19200	27072
16	300#	24000	24000	18000	25440	28800	24960	19200	27072
16	600#	40000	40000	30000	42400	48000	41600	32000	45120
16	900#	48000	48000	36000	50880	57600	49920	38400	54144
16	1500#	64000	64000	48000	67840	76800	66560	51200	72192
18	150#	27000	27000	20250	28620	36450	31590	24300	34263
18	300#	27000	27000	20250	28620	36450	31590	24300	34263
18	600#	45000	45000	33750	47700	60750	52650	40500	57105
18	900#	54000	54000	40500	57240	72900	63180	48600	68526
18	1500#	72000	72000	54000	76320	97200	84240	64800	91368
20	150#	30000	30000	22500	31800	45000	39000	30000	42300
20	300#	30000	30000	22500	31800	45000	39000	30000	42300
20	600#	50000	50000	37500	53000	75000	65000	50000	70500
20	900#	60000	60000	45000	63600	90000	78000	60000	84600
20	1500#	80000	80000	60000	84800	120000	104000	80000	112800
22	150#	33000	33000	24750	34980	54450	47190	36300	51183
22	300#	33000	33000	24750	34980	54450	47190	36300	51183
22	600#	55000	55000	41250	58300	90750	78650	60500	85305
22	900#	66000	66000	49500	69960	108900	94380	72600	102366
22	1500#	88000	88000	66000	93280	145200	125840	96800	136488
24	150#	36000	36000	27000	38160	64800	56160	43200	60912
24	300#	36000	36000	27000	38160	64800	56160	43200	60912
24	600#	60000	60000	45000	63600	108000	93600	72000	101520
24	900#	72000	72000	54000	76320	129600	112320	86400	121824
24	1500#	96000	96000	72000	101760	172800	149760	115200	162432
26	150#	39000	39000	29250	41340	76050	65910	50700	71487
26	300#	39000	39000	29250	41340	76050	65910	50700	71487
26	600#	65000	65000	48750	68900	126750	109850	84500	119145
26	900#	78000	78000	58500	82680	152100	131820	101400	142974
26	1500#	104000	104000	78000	110240	202800	175760	135200	190632
28	150#	42000	42000	31500	44520	88200	76440	58800	82908
28	300#	42000	42000	31500	44520	88200	76440	58800	82908
28	600#	70000	70000	52500	74200	147000	127400	98000	138180
28	900#	84000	84000	63000	89040	176400	152880	117600	165816
28	1500#	112000	112000	84000	118720	235200	203840	156800	221088
30	150#	45000	45000	33750	47700	101250	87750	67500	95175
30	300#	45000	45000	33750	47700	101250	87750	67500	95175
30	600#	75000	75000	56250	79500	168750	146250	112500	158625
30	900#	90000	90000	67500	95400	202500	175500	135000	190350
30	1500#	120000	120000	90000	127200	270000	234000	180000	253800
32	150#	48000	48000	36000	50880	115200	99840	76800	108288
32	300#	48000	48000	36000	50880	115200	99840	76800	108288
32	600#	80000	80000	60000	84800	192000	166400	128000	180480
32	900#	96000	96000	72000	101760	230400	199680	153600	216576
32	1500#	128000	128000	96000	135680	307200	266240	204800	288768



ORIENTATION OF THE FORCES AND MOMENTS AS PER WRC BULETTIN107



ORIENTATION OF THE FORCES AND MOMENTS AS PER PD 5500

ANNEXURE-6

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% 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. 5.1.3.3
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. b) At elevated Platform.	Elevated platform provided at Battery limit.	
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 (i.e. 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 b) Blast cleaning	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	Stress Analysis Package	CEASER II (Latest Version)	
34	Access to Nozzles of columns	Platforms for all Nozzles.	
35	Staircase / Ladders for tall column/reactors.	Ladders for columns/staircases "for reactors''	
36	Provision of breakup flanges for removal of tube bundles of heat exchangers.	Wherever necessary.	
37	Height of pipe support	150 mm from FGL	

	pedestals		
38	Mandatory Bulk Material Escalation	As per mandatory spares.	
39	Cathodic Protection of Tankage and U/G Piping	Required (Refer Electrical Design Basis)	
40	Cast iron valves	Cast Iron Valves not to be used.	
41	Pump Suction strainers	As per Cl. 5.2.4.5 & 5.2.4.6	However, licensor's requirements, if any, may be considered with approval from owner / PMC.
42	Two phase flow line analysis	Both static and dynamic analysis required.	
43	Connectivity of the technological structure	Technological structure to be Interconnected.	
44	Usage of check valves.	Wafer dual plate and swing check valves	Unless specifically required by process
45	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.