PIPING DESIGN BASIS
FOR
HINDUSTAN PETROLEUM CORPORATION LTD.
VISAKH REFINERY

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</table>

TOYO ENGINEERING INDIA LIMITED
MUMBAI INDIA
CONTENTS

1.0 Scope

1.0 Design Philosophy / Criteria-General

2.1 Equipment Layout
2.2 Unit Piping
2.3 Offsite & Yard Piping
2.4 Tank Farm Piping
2.5 Flare Piping
2.6 Under Ground Piping
2.7 Flexibility Analysis & Supporting
2.8 Materials
2.9 Thermal Insulation Of Piping, Equipment And Vessels
2.10 Painting
2.11 Welding
2.12 Miscellaneous

3.0 Referenced Publication

Attachments:

Annexure - A Table of basic span
Annexure - B Accessibility for valves & instruments
Annexure - C Vertical and horizontal guides spacing
Annexure - D Technical requirements of piping material
Annexure - E Clearances
Annexure - F Special requirements for Hydrogen service.
Annexure - G Requirements for PMI testing.
Annexure - H Specification for sour service piping.
Annexure - I General requirements
1.0 Scope

This Design Basis briefly covers the basic requirements for the design of Piping systems for Petrochemicals plants covered by ASME B31.3. These shall be adhered to by Engineering / EPCC Contractor(s) or his subcontractor(s) during the course of engineering, procurement & construction.

2.0 Design Philosophy / Criteria: General

2.1 Equipment Layout

2.1.1 Basis of Equipment Layout

Equipment layout shall be developed based on the following data:
- P&IDs
- Overall Plot Plan
- Wind direction
- Equipment Data Sheets
- Indicative Equipment Layout from Process Licensor
- Process package

2.1.2 Development of Equipment Layout

The following aspects shall be considered during development of equipment layout:
- Process Requirement - i.e. proper interconnection between equipment as per P&IDs to achieve the intended process parameters.
- Economy of Piping material- Minimise the quantity of costly piping.
- Erection & Construction requirement -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 column, approach road for cranes / derrick for lifting the column or reactors and requirement of special foundation / pile etc.
- Safety Requirements-As a minimum, ‘OISD Std. 118’ shall be followed.
- Fire fighting facilities shall be provided as per ‘TAC’ & ‘OISD’ norms. Safety shower location shall be marked in equipment layout. For detailed guidelines refer General Civil-Design basis for fire protection.
- Constructability, Operation and Maintenance Requirement:
  - Overhead and side clearances for exchangers and pumps
  - Provision of exchangers tube bundle pulling area
  - Horizontal & overhead clearances for easy movement of working personnel
  - Crane approaches for air coolers/fired heaters.
  - Provision of catalyst loading / unloading facilities
  - Provision of monorail for pumps and exchangers
  - Provision of EOT/HOT crane for compressors
  - Provision of operator’s cabin
- Similar equipment grouping - All columns, exchangers, pumps etc. should be grouped together for convenience of maintenance and safety wherever feasible.
- The technological structures should be inter-connected for easy movement of operational personnel.
- U/G piping corridors for main headers should be marked in equipment layout for all underground piping.
- All areas requiring crane access for erection or specific maintenance purpose e.g. catalyst loading etc. shall be marked on the equipment layout.

2.1.3 Piperack

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 total width of pipe rack shall include 25% extra space for future expansion/modifications in unit for rack-widths upto 16M and 10% for rack-widths above 16M.

The width of the rack shall be 6M, 8M or 10M for single bay and 12M, 16M or 20M for double bay having 4 tiers maximum. The spacing between pipe rack portals shall be taken as 6M in general. However it can be increased to 8M depending on the size of the pumps to be housed below pipe rack, in which case an intermediate structural member shall be provided in pipe rack for tier.

- For Units, clearance beneath pipe rack shall be 4.0M minimum both in longitudinal and transverse directions.
- For Offsites, clearance beneath pipe rack shall be 2.2M minimum both in longitudinal and transverse directions.
- Road clearance shall be 7M minimum for main road and 5M for secondary road.
- Water lines more than 30" shall not be routed over pipe rack, these shall be routed underground.

2.1.4 Towers and Vertical Vessels

Towers and vertical vessels shall be arranged in a row with common centre line, decided by the largest vessels, placing O.D. of the equipment minimum 4M away from the pipe rack. A minimum clearance of 3M shall be allowed between tower shells, but in any case platforms of adjacent towers shall not overlap (minimum 100 mm horizontal gap shall be provided between platform of adjacent towers) and that a minimum 900mm is left between tower plinths. The gap between vertical vessels shall allow full opening of manhole covers without restriction. Efforts shall be made to provide interconnecting platforms at suitable levels for adjacent towers and/or adjacent technological structures & rack walkways etc. Interconnections, wherever feasible shall be done after taking thermal expansions of towers into considerations. All level switches, LGs etc including their isolation valves shall be accessible from ladders or platforms.

To handle heavy items (like relief valves, blinds etc.) a davit shall be provided. The davit shall be on the side of the vessel away from the piperrack. The area at grade shall be kept clear for a dropout.

Chemical dosing vessels shall be located close to the dosing point to the extent possible, specially ammonia & corrosion inhibitors. These shall be preferably located at one place with escape routes.
2.1.5 Reboiler

Reboilers shall be located next to the tower they serve except fired heater type. The elevation of reboiler shall be as given in the P&IDs. Horizontal thermosiphon exchangers are located at a minimum elevation. Vertical thermosiphon types are usually supported by the tower and are located away from rack so that it is accessible for maintenance. Large vertical types may require an independent supporting structure that cannot be supported from the tower/column. Reboiler piping shall be checked for pressure drop before finalisation. For vertical reboilers adequate space to be kept so that there should be no obstruction for bundle pulling/rodding. Suitable swinging type davit of adequate capacity to be provided for removal/handling of the cover flange of vertical reboiler.

2.1.6 Horizontal Vessels

The horizontal vessels shall be laid perpendicular to pipe rack and shall be placed minimum 4M away from the pipe rack. The clearance between adjacent horizontal vessel shells shall be minimum 2M or 900 mm clear aisle whichever is higher.

2.1.7 Pumps

Wherever practicable pumps shall be arranged in rows with the centre line of the discharge nozzle on a common straight line. Pumps shall be kept outside the pipe rack with pump discharge nozzle kept at a distance of 1metre from pipe-rack and motor towards rack.

Gap between each pump foundation/ and foundation of technical structure should be sufficient for easy removal of equipment after piping.

Clearance between two adjacent pumps shall be such that clear 900 mm aisle is available.
All pumps not open to sky with motor rating >=75 KW shall be provided with monorail. No monorail should normally be provided for pumps open to sky and sufficient space below rack shall be available for pump maintenance.

2.1.8 Exchangers

In most of the cases floating head of exchangers are placed on a line 4M away from pipe rack. Shell and tube type exchangers may have a removable shell cover with flanged head. Tube pulling or rod cleaning area must be allowed at the channel end. This shall be minimum the tube bundle length + 1.5M from the channel head. In case of vertical exchanger suitable platform shall be provided below the top flange of channel or bonnet. For vertical exchanger cover, davit shall be provided for it’s removal. Minimum clearance in between two horizontal exchangers shall be 2M or 900mm clear aisle whichever is higher. Like wise Heat Exchanger train should be suitably spaced such that shell/ tube inlet/ outlet piping do not foul with floating Head Covers creating maintenance problem.
2.1.9 Air coolers

Air coolers shall be located over the main pipe rack or on technological structure. For air coolers located on technological structure/rack, blind floor shall be provided. Blind floor is generally not required if pumps handling hydrocarbons or equipment are not placed below them. The width of the structure from where Air cooler assembly is supported shall be about 2.0m more than the Air cooler tube bundle length so that proper supporting of inlet/outlet piping manifolds can be done from the main members of pipe rack/technological structure to transfer piping load to main structural members. Davit shall be provided for lowering the gear boxes etc. along with mobile trolley with retractable jacking arrangement of suitable load carrying capacity.

2.1.10 Furnaces

Furnaces are located upwind or sidewind of process units to blow any combustible leaks away from the open flame. They are located minimum 90M away from hydrocarbon tanks and 30M away from control room. Distances for equipments handling hydrocarbon from the furnace shall be as per OISD norms. Vessels / reactors directly connected to furnace are exception. Furnaces shall be arranged with centreline of the stacks on a common line in case of circular furnace and wherever a common stack is furnished to cater more than one furnace the stacks shall be located at the end or side, which is away from the unit. In case of individual box furnaces, the edge of the furnaces on the rack side shall be matched. F.D. fans shall be located at one corner of furnace area away from equipments handling hydrocarbons. It shall be ensured that there are no working platforms within an elevation of 6M below the tip of stack and within a 25M radius of stack. However, the stack height is governed by the clearances from statutory authorities like Director General of Civil Aviation and Pollution Control Board. For maintenance, vertical tube furnaces must have access to permit a crane to remove and replace tubing. Horizontal tube furnaces must have horizontal free space equal to tube length plus crane parking space for tube pulling / maintenance / cleaning. In case of bottom floor fired heaters, there shall be adequate headroom clearance underneath the furnace for removal of burners. In case of wall fired furnaces min. 2M wide platform with escape route at each end is necessary.

Pits and trenches are not permitted under furnace or any fired equipment. Underground drain points and manhole covers shall be sealed within furnace vicinity. All OWS points in the vicinity of heater area shall be connected to a common header & in turn the header shall be routed to CRWS system or Storm water drain. In no case they shall be connected to OWS system. Condensate funnels can be connected to condensate header and in case of non feasibility/ non existence of U/G condensate header these can be routed to CRWS/Storm Sewer.

Air Pre-heaters should be located in such a way that the modules can be removed by crane.
2.1.11 Compressors and their Prime Movers

Following types of compressors are used in process plants:

a. Centrifugal compressors
b. Reciprocating compressors.
c. Liquid ring compressors
d. Screw compressors
e. Diaphragm compressors

Compressors shall be located to keep suction lines as short as possible. The gas compressors shall be located downwind side of furnace so that leaks are not blown towards furnace. In general compressors are to be located under shed. When compressors are located under shed, sides to be kept fully open for the low shed or partially closed from top for high shed to avoid accumulation of heavier gases in the shed, however, in case of hydrogen compressors located under the sheds provision for top venting from compressor sheds shall be provided.

In case of a turbine driven compressor, if exhaust steam is condensed, turbine and compressor need to be located at an elevated level and condenser to be located below turbine. A major consideration in centrifugal compressor location is the lube and seal oil console. It must be accessible from a road, must be lower than the compressor to allow gravity drain of oil to the consoles oil tank.

Intercoolers & Knockout pots may be kept within/outside the Compressor house shed, but, shall be kept near compressor house.

For compressors Electrically Operated Travelling Crane to handle heaviest removable piece shall be provided for each compressor house. Maintenance bay for compressors shall be provided. Maintenance bay shall be accessible from road to facilitate unloading & loading on to truck etc. For removal of bundles of exchangers located within building monorail arrangement shall be provided.

Compressor manufacturer may be consulted for recommended layout and additional requirement for maintenance. Licensor’s requirement, if any, shall also be taken into consideration.

2.1.12 Clearance and Accessibility

2.1.12.1 Crane Access & Tube bundle pulling

Equipment, structures shall be arranged to permit crane access to service air coolers, compressors and exchangers. A clear space for tube bundle removal shall be provided. Dropout bay may be considered for exchangers at elevated structures. For high pressure exchangers, shell pulling on rails shall be provided, as required.
2.1.12.2 Access to Pumps

Clear access of 4.0M vertically and 3M horizontally shall be provided centrally under main pipe ways for small mobile equipment to service pumps/motors, wherever these are installed under pipe ways with prior specific approval. Pumps outside rack shall be approachable by mobile equipments etc. from under the pipe rack.

2.1.12.3 Access to lower items to grade (Lowering Area)

Clear access shall be provided at grade on the access side for lowering external & internal fittings, PSVs, Control valves etc from elevated equipment(columns, towers etc) by providing pipe davits.

2.1.12.4 Layout & Access Requirements for Platforms (Ladders and Stairs)

For providing platform ladder & staircase following guidelines shall be followed:
- Two means of access (i.e. two ladders or one ladder and one stair case) shall be provided for any elevated platform, which serves three or more vessels & for battery limit valves operating platforms.
- Platforms, ladders & stairways shall be consistent with access & safety requirements.
- Stairway for tanks to be provided on upstream of predominant wind direction.

(i) Platform at elevated structure

- 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.
- Air coolers shall have platforms with interconnected walk-ways provided to service valving, fan motors and instruments. Access requirements shall be Dual access (i.e. one staircase and one ladder).
- Fired heaters located adjacent to one another shall have inter-connecting platforms at various elevations. Inter-connecting platforms between adjacent towers shall be provided, wherever feasible, taking into consideration expansion of towers.

(ii) Platforms with stair access shall be provided only for:

- Location at which normal monitoring (once a day or more) is required or where samples are taken.
- Locations where vessels or equipment items have operator attention such as compressors, heaters, boilers etc.
- Main piperack at battery limits

(iii) Platforms with ladder access shall be provided for

- Items that require occasional operating access including valves, spectacle blind and motor operated valves, heater stack sampling points.
- Manways above grade on equipment.
(iv) **Ladder Location**

- Wherever practicable, ladder shall be so arranged that users face equipment or platform rather than facing open space.
- Landings shall be staggered. No ladder shall be more than 6M in one flight.

**2.1.12.5 Clearances**

Minimum clearances shall be as indicated in Annexure - E.

**2.2 UNIT PIPING**

**2.2.1 Basis of Unit Piping**

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

The following objective shall be achieved during piping layout:

- Proper access to all operating points including valves and for all orifice - tapping points, instruments in particular (refer Annexure-B).
- Proper access to interrelated operating points for specific purpose and for maintenance.

**2.2.2 Pipe Ways/Rack piping**

- Racks shall be designed to give the piping shortest possible run and to provide clear head rooms over main walkways, secondary walkways and platforms.
- Predominantly process lines are to be kept at lower tier and, utility & hot process lines on upper tier.
- Generally the top tier is to be kept for Electrical cable trays (if not provided in underground trench) and Instrument cable ducts/trays. Cable tray laying to take care of necessary clearances for the fire proofing of structure.
- Generally the hot lines and cold lines shall be kept apart in different groups on a tier.
- Generally the bigger size lines shall be kept nearer to the rack column.
- 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. Even if flange is not appearing the min. spacing shall be based on above basis only.
- 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.
- 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.
- Anchors shall be provided within unit on all hot lines leaving the unit.
- Process lines crossing units (within units or from unit to main pipeway) 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 a platform above the lines shall be provided.
- Stubs in sea water shall be from top of main header.

2.2.3 Column / Vessel Piping / Control Valves

- Piping from column shall drop or rise immediately upon leaving the nozzle and run parallel and close as practicable to vessel. Reboiler outlet piping shall be as short as possible with minimum bends.
- Piping shall be grouped as far as possible for the ease of supports and shall run on the rack side of the column.
- Manholes shall be kept on the road side of the column and shall be approachable from the platform. Platform width shall be such that minimum 1M space is available beyond manhole for movement.
- Piping shall be supported from cleats welded on the vessel as far as possible.
- Proper guides at recommended intervals shall be provided for long vertical lines.
- Access platforms/ladders shall to be provided along the column for valves and instruments. Minimum clear width of platform shall be 750mm.
- For ease of operation and maintenance, column and vessels which are grouped together, shall have their platforms at the same elevation and should be interconnected by walkways. 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.
- Piping at columns/vessel nozzles shall be arranged so that blanks can be easily installed for hydrotesting.
- Unless specifically indicated in P&IDs control valves shall preferably be kept at grade.
- Piping intended for vacuum services shall be routed as short as possible with minimum bends and flanged joints.
- Piping support cleats for safety valves shall be independent meant for safety valves only & shall be designed considering impact loading during popping off.
- Utility Connection nozzles shall be from side/top.

2.2.4 Exchanger Piping

- Exchanger piping shall not run in the way of built in or mobile handling facilities.
- Wrench clearance shall be provided at exchanger flanges.
- Piping shall be arranged so that they do not hinder removal of shell end and channel cover and withdrawal of tube bundle.
2.2.5 Heater / Furnace Piping

- Arrange piping to permit burner removal by providing break-up flanges in the piping.
- Burner valves shall be located close to the peepholes for operation so that adjustment can be made while observing the flame from working level.
- Piping to burners shall be arranged so that there are no pockets & shall distribute equal and sufficient quantity of oil/gas to all burners.
- Only flexible metallic SS (SS316/SS304) hoses shall be used for burner piping if required.
- Block valves for emergency, snuffing steam valve shall be located at the recommended distance from the heater, preferably on the upwind side of the heater.
- Piping from various passes of heater outlet nozzles should preferably be symmetrical. Transfer line from heater to column shall be as short as possible, without pockets, free draining and with minimum bends.
- No piping shall be routed in the tube withdrawal area. If unavoidable, break up flanges shall be provided in the piping for removal.

2.2.6 Pump Piping

- Pump drives shall have clear access.
- Pump suction piping shall be as short as possible and shall be arranged to avoid vapour pockets.
- Reducers immediately connected to the pump suction shall be eccentric type with 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 be provided at the suction nozzle.
- Pump discharge check valve if installed in vertical lines shall be fitted with a drain connection as close as possible downstream of the valve.
- Unless otherwise specified, T-type strainers shall be used on pump suction piping for sizes 2” and above.
- Y-type strainers shall be used for all sizes in steam services and for pump suction lines below 2”.
- All small bore piping connected to pump (drain to OWS & CBD, seat and gland leak drain) shall have break up flanges for removal of pumps.
- Piping shall be so arranged that the forces and moments imposed on the pump nozzle do not exceed double the allowable values of API610.
- Pump discharge should be preferably routed away from the pump rather than towards the motor side.
- Pump cooling water connection shall be taken from the top of circulating cooling water header.
- Suction & discharge valves shall be located at operable height.

2.2.7 Compressor Piping

- Suction lines shall be as short as possible.
- Suction piping shall have adequate flanged joints for ease of erection and maintenance.
- Where the line between knockout drum and the compressor cannot be routed without pocket, low point drain shall be provided to remove accumulation of liquid. The system should be approved by process.
- A minimum straight length of suction pipe shall be provided as per manufacturer's recommendation.
- Lube oil cooler space shall be provided in a way so as to facilitate tube bundle removal.
- All operating valves on main suction and discharge piping shall be lined on one side as far as possible.
- Piping shall be designed so that forces and moments imposed on the compressor do not exceed the manufacturer's recommendation.
- Low points in the discharge line from an air compressor shall be avoided because it is possible for lube oil to be trapped and subsequently ignited. If low points are unavoidable, they shall be provided with drains.
- In case of reciprocating compressor, piping shall be suitably supported to avoid vibrations due to pulsating flow. Unless requirements of no pockets are specified by the licensor, all the piping shall run at 500mm above grade level so that proper supports can be provided to minimise vibrations. Analog study shall be carried out for complete compressor piping including suction / discharge piping as per P&IDs and the study recommendations if any, shall be implemented.
- Reciprocating compressor piping shall be provided independent supports from grade and shall not be supported from compressor platform structure.
- The small bore branches shall be checked for requirement of braced supports.

2.2.8 Relief System / Blowdown System Piping

- Wherever the inlet line size is higher than the safety valve inlet size, reducer shall be installed adjacent to inlet of safety valve.
- Relief valve discharging steam, air or other non-flammable vapour or gas directly to atmosphere shall be equipped with drain and shall be suitably piped to prevent accumulation of liquid at valve outlet.
- Liquid-phase blowdown system piping connected to a closed system shall be self draining to the blowdown drum. Closed blowdown header shall be sloped towards the CBD drum to ensure free drainage.
- Liquid-vapour phase relief valves shall discharge into the flare header at an angle 45 degrees in the direction of header flow, to minimise the effect of kinetic energy and to avoid accumulation of liquid.
- Pockets in the flare header and blowdown system shall be prohibited.
- Relief valve discharge piping shall be taken to safe location as per following:
  
<table>
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<th>Distance</th>
<th>Location</th>
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<tr>
<td>3M</td>
<td>Above top platform of column or structure, within 6M radius for steam and 8M for hydrocarbon/toxic discharge.</td>
</tr>
<tr>
<td>25M</td>
<td>Horizontally away from furnace.</td>
</tr>
<tr>
<td>50M</td>
<td>Horizontally away from furnace, if more than one relief system of different set pressures is discharging into one common riser of vent stack.</td>
</tr>
</tbody>
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- Inlet and outlet piping of pressure relief valve shall be adequately supported to take care of the thrust induced by the relief valve during popping.
Reaction forces including both momentum & static pressure effects due to safety valve popping shall be ascertained in the connected piping according to API RP520 for systems discharging to atmosphere. The effect of these forces on the piping supports and the anchors of the piping system shall be calculated to ascertain that the allowable limits at these locations are not exceeded. The supporting structure also shall be adequately designed so that when subjected to these reaction forces the supporting elements connected to piping as well as the basic supporting structure i.e. platform members etc. are capable of withstanding them. System stresses in the inlet and outlet piping portions at safety valves also shall be kept within the allowable limits, inclusive of the distribution branching points in the inlet portion. These reactive forces shall not lead to any leakage at the flanged joints present in the system. To ascertain this the necessary calculations for checking leakage at the flanged joints shall be performed.

2.2.9 Steam Piping

2.2.9.1 Indian Boiler Regulations (IBR)

Steam lines with conditions listed below fall in the scope of IBR.
- Lines having design pressure (max. working pressure) above 3.5 Kg/cm² (g).
- Line sizes above 10" inside diameter having design pressure 1.0 Kg/cm²(g) & above.
- Lines with design pressure less than 1.0 Kg/cm²(g) are excluded.
- Users of steam like steam tracing lines, jacket of the steam jacketed lines, steam heating coil within the equipment are excluded from IBR scope.
- Boiler feed water lines to steam generator, condensate lines to steam generator and flash drum shall be under purview of IBR.

2.2.9.2 IBR requirements (in brief)

- All materials used on lines falling under IBR must be accompanied with IBR Inspection Certificate in original. Alternatively, photocopy of the original certificate duly countersigned and attested by local boiler inspector is acceptable. Leading inspection authority viz. Lloyds, TEIL etc are authorised inspection authorities for IBR outside India, whereas, for Indian supply only IBR is the inspection authority.
- Drawings like ‘General Arrangement Drawings’ and Isometrics of lines falling under IBR must also be approved by IBR authority of State in which the system is being installed.
- All welders used for fabrication of IBR system must possess IBR welding qualification certificate.
- IBR system shall be designed to comply with IBR regulations as well as ASME B31.3. Design calculations for the same must be approved by IBR authority.
- IBR approval is obtained with requisite fees payable to Indian Boiler Board of the State concerned.
- Steam generators (boilers/heat exchangers) shall require exclusive IBR approval alongwith it’s integral piping upto the final isolation valve.
- The discretion of IBR authority of state is final and binding for the above cases.
2.2.10 Steam Header & Supply Lines

- 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 down stream riser and shall be provided to suit bi-directional flows, if applicable.
- All turbines on automatic control for start up 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 or underground condensate collection system.
- 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.

2.2.11 Steam Tracing

- Tracers for the individual lines shall generally be supplied from manifolds when there are two or more connections.
- Standard module for steam distribution and condensate collection manifolds with glandless integral piston valve shall be used. Number of tracers shall be 4/8/12 and tracer size ½” or ¾” depending upon the detail engineering requirement. 20% or minimum 2 tracer connections shall be kept spare for future use for both steam supply and condensate collection manifolds.
- All manifolds shall be installed in vertical position and manifold size shall be 1½”.
- For steam tracing balanced pressure thermostatic steam trap (5º/ 10ºsubcool) with 40 mesh strainer to be used.
- Steam Manifolds shall be located at upper levels in pipe-rack, accessible from a platform whereas Condensate Manifolds shall be located on grade.
- Pockets in steam tracers shall be avoided as far as possible.
- Heat tracing cement to be used to improve conductivity of heating medium from tracer piping to main piping.
- Tracers shall be limited to the following run length upstream of traps:
Following shall be used for maintaining length of 1/2” tracer in open and closed systems (excluding supply and return lines).

<table>
<thead>
<tr>
<th>Size of Tracer (inch)</th>
<th>Length of tracer pipe (Meters)</th>
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<tbody>
<tr>
<td></td>
<td>Steam operating pressure</td>
</tr>
<tr>
<td></td>
<td>20 Psig</td>
</tr>
<tr>
<td>0.5&quot;</td>
<td>23</td>
</tr>
</tbody>
</table>

- Tracers shall generally be of ½". Tracers shall be of carbon steel material on the steam tracing circuit including steam station block valve shall be **glandless piston type** construction.
- Size of the lead line to manifold shall be 1½".
- The lead line to manifold, manifold to the block valves of individual tracer shall be carbon steel of IBR quality.
- Tracers lines shall be provided with break up flanges for main line flange joints and valves.
- All tracers shall have individual steam traps before condensate manifolds. Condensate manifold including the last valve on individual tracer shall be of carbon steel.
- All steam traps discharging to a closed system shall have a block valve upstream and downstream of the trap. A bypass globe valve shall be installed around the trap. Check valve shall be installed on the downstream of the steam trap near the condensate header in case discharging to a closed system.
- All steam tracer lines shall be welded as per approved Welding Specification followed by hydrotest.

- Number of tracers required on a line shall be as follows:

<table>
<thead>
<tr>
<th>Size of Line</th>
<th>Number of Tracers</th>
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</thead>
<tbody>
<tr>
<td>upto 4&quot;</td>
<td>1</td>
</tr>
<tr>
<td>6&quot; to 16&quot;</td>
<td>2</td>
</tr>
<tr>
<td>18&quot; to 24&quot;</td>
<td>3</td>
</tr>
<tr>
<td>26&quot; &amp; above</td>
<td>To Calculate</td>
</tr>
</tbody>
</table>
2.2.12 Steam Jacketing System

- A steam jacketed pipe consists of a product line which passes through the centre of a larger diameter steam line.
- The nominal size of the inner pipe (CORE) and outer pipe (JACKET) in inches shall be as per table below unless otherwise mentioned in project piping material specification (PMS) or P&ID.

<table>
<thead>
<tr>
<th>Core pipe</th>
<th>Jacket pipe</th>
<th>Steam feeder to jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4&quot;</td>
<td>1-1/2&quot;</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>1&quot;</td>
<td>2&quot;</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>3&quot;</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>2&quot;</td>
<td>3&quot;</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>3&quot;</td>
<td>4&quot;</td>
<td>0.5&quot;</td>
</tr>
<tr>
<td>4&quot;</td>
<td>6&quot;</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>6&quot;</td>
<td>8&quot;</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>8&quot;</td>
<td>10&quot;</td>
<td>0.75&quot;</td>
</tr>
<tr>
<td>10&quot;</td>
<td>12&quot;</td>
<td>0.75&quot;</td>
</tr>
</tbody>
</table>

- For jacketed lines using high pressure steam, actual calculations for core jacket and feeder pipe shall be performed before finalisation of sizing.
- Baffle plates, flanged joints or end caps shall be used to discontinue one feed length from the next. The size of steam feeder to jacket shall be generally 1/2" or as specified in job specification.
- Flanged jumpovers shall be used in case of a flanged joint. In case of discontinuous jacketing simple jumpovers shall be employed. The length of jacket shall be 4 to 5 meters or as mentioned in job specification.
- Intermediate partial baffles shall be provided if a separate branch portion is to be heated from the main line stream.
- Steam inlet to jacket shall generally be provided from top of the pipe in case of horizontal lines. The jumpovers and condensate outlets shall be from the bottom.
- In case of vertical lines steam inlet shall be done at the topmost points and condensate outlet shall be done from the lowest possible points. Two consecutive jumpovers shall be 180 deg. apart.
- Each feed length shall be provided with individual trap before connecting to condensate recovery headers.
- Balanced pressure / bi-metallic type thermostatic steam traps with 40 mesh strainer shall be used in jacketing.
- To keep proper concentricity between core and jacket pipe internal guides (rods or flat bars) shall be provided at intervals depending on the size of the pipe.
- Wherever anchors are provided on jacket lines proper interconnection of jacket pipe and core pipe shall have to be provided with proper jumpovers for steam.
- Steam jacketing inlet and outlet to be as per Jacketing standard.

2.2.13 Utility Stations

Requisite number of utility stations shall be provided throughout the unit to cater to the utility requirement. Utility stations shall have three connections [one for LP steam (SL), one for Plant Air (AP) and one for Service Water (WS)] each of 1"NB unless otherwise specified in P&ID. Air and water lines shall have quick type hose connection and steam line shall have flanged type hose connection and shall be directed downward. All connections shall have globe valve for isolation purpose. Inert gas hose, when required, shall have built in non return valve and quick connection coupling at piping end.

Number of utility stations shall be such that all equipments shall be approachable from atleast one utility station. The approach of utility station shall be considered 15M 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 be accessible from utility station.

2.2.14 Fire Fighting

All fire fighting facilities shall be as per TAC & OISD norms. Sprinkler system shall be provided for all hot pumps as per OISD / TAC norms. For detailed guidelines refer General Civil design basis for fire protection.

2.3 Offsite & Yard Piping

In general, offsites piping (except tankages area), electrical cable and instrumentation cable shall be laid either on pipe rack or on pipe sleepers. Wherever piping is laid on pipe sleepers, hard surfacing/gravel is provided below it, hard surfacing/gravel should be completed before start of pipe laying. Width of hard surfacing/gravel shall be about 1 meter more than the piping corridor on either side. This extra hard surfacing/gravel shall be for movement of operating personnel along the piping corridor. This movement area shall be approachable from the road at a distance of every 500 meters.

Overhead pipe bridges shall be used for pipes at road crossings. Culverts, if required, may be provided but to be minimised. Pipe bridges/culverts shall be adequately designed to take care of future requirements.
Clearances between lines shall be minimum ‘C’ as given below.

\[ C = \frac{(d_o + D_f)}{2} + 25 \text{ mm} + \text{Insulation thickness(es)} \]

where,  
- \(d_o\) - outside diameter of smaller pipe (mm)  
- \(D_f\) - outside diameter of flange (min 300#) 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 expansion.

Adequate clearance shall be provided for every long & high temperature lines to avoid clashing at the bends. See 2.2.2 also for line spacing at ‘L’ bends and loop locations.

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 sleeperway if the same is not accessible and valves shall be put in horizontal only. At all such places where piping is extended to make drain valves accessible - 2 nos. of stiffeners, irrespective of pipe rating, shall be provided as per 2.7.1. Spacing of guides on each line on a pipe bay shall not exceed the value given in clause 2.7.1.

### 2.4 Tank Farm Piping

The number of pipelines in the tank dyke shall be kept minimum and shall be routed in the shortest practicable way to main pipe track outside the tank dyke, with adequate allowance for expansion. Within one tank dyke the piping connected to that tank shall only be routed.

Manifolds shall be located outside the tank dyke & by the side of the roads, easily accessible by the walkway.

Plug valves whenever specified shall be of pressure balance type.

Analysis shall be carried out to prevent damage to lines and tank connection caused by tank settlement.

If exceptionally high settlement is expected, it shall be taken care during stress analysis. For flexibility analysis and supporting refer clause 2.7.

Special consideration shall be given as regards to spacing of nozzles while installing special item like hammer blind, MOV etc.

### 2.5 Flare Piping

Flare header shall be sloped towards flare knock-out drum. Expansion loop shall be provided in horizontal plane 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 minimise 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.

2.6 Underground Piping

For sever piping and Oily process water system please refer Doc.No.

(1) Buried piping shall have a minimum cover of soil as shown below:
   - fire water pipes (main) 0.6m
   - pipes of NPS 24 and smaller 0.6 m
   - pipes over NPS 24 0.9 m
   - pipes crossing beneath railways 1.0 m
   - in areas where only night frost can be expected cover down to below the frost level
   - in areas where daytime freezing can be expected cover down to below the frost level

(2) For buried pipes operating at a temperature of 60 degC and below, there shall be a clear distance of at least 300 mm between the pipe and any electrical or instrument cables.

(3) For buried pipes which have impressed current cathodic protection, there shall be a clear distance of at least 1 metre between the pipe and any parallel-running cables, to prevent stray-current corrosion of the steel wire armouring of those cables.

2.7 Flexibility Analysis and Supporting

2.7.1 Pipe Supporting Criteria & General Guidelines.

Piping system shall be properly supported taking into account the following points:

   a. Sustained Loads
      - Weight of Piping (Bare pipe, service fluid, valves, flanges, jacketting etc)
      - Weight of Insulation (if any)
      - Weight of snow (if any)
      - Weight of online equipments (if any)
      - Weight of instruments (if any)
      - Pressure relief loads due to safety valve operation
      - Dynamic loads due to pulsating flow/two phase with slug flow
      - Pressure-Thrust loads in case of expansion joints

   b. Occasional Loads

      Wind/Seismic loads(as and when required)
c. **Thermal Loads**

Thermal loads due to operating/design/steam out/decoking or any other possible abnormal condition.

Pipe supporting shall preferably follow the basic span as given in Annexure-A except for flare line in offsite on trestles in which case the basic span shall be restricted to max. 18.0 metres. For sizes not covered in Annexure-A, 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. Guides shall be provided on straight run of pipes at intervals as specified in Annexure-C, unless specifically becomes non-viable due to flexibility problems.

Additional supports, guides, anchors, special supports like spring supports and sway braces shall be provided based upon detailed analysis of piping system to restrict the forces on nozzles of critical equipments like pumps, compressors, turbines, exchangers, Air coolers etc.

A permanent support, either resting or spring support shall be provided for lines which do not need any supporting otherwise but require supporting during maintenance.

Bare pipes of size above 12” shall be supported with pad or shoe.

Adequate care shall be taken for small bore (1 1/2 and below) branch from piping. As a rule, for all lines in 600# & above classes, lines having two phase flow and lines having pulsating flow such as discharge of reciprocating compressors & reciprocating pumps, all small bore branches, e.g. vents, drain, orifice taps, pressure tapings, temperature tapings, sample connections, PSV inlet, TSV inlet etc. shall be provided with 2 number stiffeners at 90º to each other from the main pipe to impart adequate stiffness to the branch connection. The stiffeners shall be made of 6mm thick flats of material equivalent to the pipe material. Further, irrespective of line rating, the stiffeners shall be provided for all orifice taps, all small bore tapings from PSV inlet/outlet lines and all small bore tapings from Control Valve manifolds.

For pulsating flow lines, detailed thermal and vibration analysis by analog study shall be done to decide on location of anchor supports and guides etc.

Wherever two phase with slug flow in piping is expected and for Transfer Lines, piping design shall be checked by dynamic stress analysis to prevent vibrations.

Pipe support design shall be such that deflection in piping systems due to sustained loads shall not exceed 15mm, between two adjacent supports.

As far as possible long trunnion types of supports (more than 0.5 mtr.) are to be avoided. In case long trunnion support is unavoidable in straight length of pipe, trunnion height to be restricted to 0.5m 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 such a way that either of the lines should not be in the hanging position when not in operation.
Piping passing through the technology structure or passing near the concrete column etc. should have adequate 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. Wooden blocks may be used for load taking supports on vertical lines or as anchor supports.

All pipes supports shall be so designed that there is no undue tension on equipment flanges.

2.7.2 **Flexibility Analysis Criteria & General Guidelines.**

Piping shall be analysed for expansion, contraction, differential settlement, relief valve reaction and effects mentioned in para 2.7.1.

- 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 so specified in Process document. System where combination of different operating conditions are envisaged, such system shall be analysed for all possible combinations.
- 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 generally 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. In case the same is exceeded, categorical written confirmation of acceptance of the higher loads shall be obtained from the equipment supplier.

2.7.3 **Method Of Analysis**

Analysis shall be done as per stress analysis design basis.

For details refer Doc.no A-6261-480-004.
2.8 MATERIALS

Basic material selection of particular line depending on its service, temperature and corrosivity shall be as spelt out in process package. Detailed material specification shall follow the requirements stated herewith, except wherever specified as per Licensor’s requirement.

2.8.1 Pipe

2.8.1.1 Wall Thickness

- Calculation of pipe thickness and branch reinforcement shall be based on requirements of ASME B31.3 / IBR as applicable. Proper corrosion allowance and mill tolerance shall be considered while selecting nominal thickness.

- For carbon steel and low alloy steel pipes minimum pipe thickness shall be as follows:

  ‘S160’ up to 0.75”NB (for other than steam tracing),
  ‘XS’ up to 0.75”NB (for steam tracing),
  ‘XS’ for 1” to 2”NB,
  ‘STD’ for above 2NB.

- For stainless pipes minimum pipe thickness shall be as follows:

  ‘80S’ up to 0.75”NB,
  ‘40S’ for 1”NB to 2”NB,
  ‘10S’ for above 2”NB

- The philosophy of minimum thickness/schedule is applicable for both seamless and welded pipes.

- The above mentioned minimum thickness/schedule criteria is not applicable to category -D classes (for services in A3A, A3Yspecs etc), firewater service(A33A) and A10A specification where IS pipes or welded API 5L pipes are being used.

- All pipes (seamless & welded) shall have uniform negative wall thickness tolerance of 12.5% for wall thickness calculations purpose.

- For thicknesses exceeding minimum thickness/schedule criteria, schedule XS shall be selected for CS & AS classes (for 2” & above). Intermediate schedules between STD & XS shall be ignored. Similarly for SS classes (2” & above) S10, S20, S30 & 40S may be selected beyond minimum thickness/schedule criteria.

- If, the thicknesses exceed XS in CS & AS classes and 40S in SS classes, only then, the thickness shall be calculated based on actual service conditions subject to a minimum of 80% class rating. Maximum 10% of corrosion allowance may be reduced in special cases, to optimise the pipe schedules.
In general, the pressure-temperature combination to calculate wall thickness shall be as follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Class</th>
<th>Size</th>
<th>Design Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.S. (A106 GR.B, API-5L GR.B, A672)</td>
<td>160</td>
<td>upto 24&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td>LTCS (A333 GR.6), Low Alloys, 1.25% Cr-0.5% Mo, 2.25% Cr-1.0% Mo, 5%Cr-0.5% Mo, 9%Cr-1.0% Mo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>above 24&quot;</td>
<td>Line condition (#)</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>above 14&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>above 8&quot;</td>
<td>Line condition (#)</td>
</tr>
<tr>
<td></td>
<td>1500 &amp; 2500</td>
<td>upto 4&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>above 24&quot;</td>
<td>Line condition ($)</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>above 14&quot;</td>
<td>Line condition ($)</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>above 8&quot;</td>
<td>Line condition ($)</td>
</tr>
<tr>
<td></td>
<td>900, 1500</td>
<td>upto 4&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>above 2&quot;</td>
<td>Line condition</td>
</tr>
<tr>
<td>Higher Alloys</td>
<td>150</td>
<td>upto 6&quot;</td>
<td>Class condition</td>
</tr>
<tr>
<td></td>
<td>300-2500</td>
<td>all sizes</td>
<td>Line condition</td>
</tr>
</tbody>
</table>

# Only If the thickness / schedule as per class condition exceeds XS .

$ Only If the thickness / schedule as per class condition exceeds 40S .

For Cat-D classes, for aboveground applications, 'D/t' ratio shall be taken as 120(max.). For other than Cat-D services, 'D/t' ratio shall be generally restricted to 100. 'D' is nominal dia. and 't' is nominal thickness.
2.8.1.2 Pipe Size


2.8.1.3 Pipe Type

<table>
<thead>
<tr>
<th>Material</th>
<th>Size</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS, LTCS, AS</td>
<td>Upto 14&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td>(except for Cat ‘D’ fluids &amp; LP hydrocarbons in offsites)</td>
<td>16&quot; and Above</td>
<td>E.F.S.W.</td>
</tr>
<tr>
<td>SS (Process lines)</td>
<td>Upto 8&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>10&quot; and Above</td>
<td>E.F.S.W.</td>
</tr>
<tr>
<td>SS (Non process lines)</td>
<td>Upto 1.50&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>2&quot; &amp; Above</td>
<td>Welded</td>
</tr>
<tr>
<td>CS (Cat ‘D’ fluids &amp; Fire water service)</td>
<td>ALL</td>
<td>Welded*</td>
</tr>
<tr>
<td>CS (LP hydrocarbons offsites)</td>
<td>Upto 6&quot;</td>
<td>Seamless</td>
</tr>
<tr>
<td></td>
<td>Above 6&quot;</td>
<td>Welded</td>
</tr>
</tbody>
</table>


2.8.2 Fittings

- Type of fittings shall be equivalent to pipe type.
- Thickness of fittings at ends to match pipe thickness for BW fittings.
- SW fittings shall be 3000#, 6000# or 9000# depending on the pipe thicknesses S80, S160 and above S160 respectively.
- Upto 600# all branch connections shall be as follows, unless specifically mentioned otherwise in PMS:

  Up to 1-1/2” NB          Half couplings/ Tee
  2” and above              Tees/ Pipe to pipe with or without
                           reinforcement pad

- For branch connections above 600# rating, equal tee/unequal tee shall be used for all sizes. In case of non availability of unequal tees, o-lets may be used. Usage of sweep-o-let shall be avoided due to poor availability globally.

- Mitres shall be used in Category ‘D’ service above 6”NB. Elbows(seamless/welded) are acceptable in place of mitres, however, thickness of elbows shall be same as mitres. Seamless elbows are acceptable in place of welded elbows.

- For other than Category ‘D’ fluid in 150# and 300# Class mitres can be permitted for sizes above 48”. Mitres to be designed as per ASME B31.3. However, use of mitres shall be minimum.

- Union shall not to be used in lines other than Cat-D water lines.

2.8.3. Flanges

- Flanges shall be as follows:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Size</th>
<th>Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>Up to 1.50”</td>
<td>SW RF</td>
<td>If used with non metallic gasket</td>
</tr>
<tr>
<td></td>
<td>Up to 1.50”</td>
<td>WN RF</td>
<td>If metallic/spiral wound gasket is used</td>
</tr>
<tr>
<td>2” &amp; above</td>
<td>WN RF</td>
<td>For CS (Other than Cat-D), AS &amp; SS(Cryo)</td>
<td></td>
</tr>
<tr>
<td>2” &amp; above</td>
<td>LJ FF+Stub ends</td>
<td>For SS (Other than Cryo)</td>
<td></td>
</tr>
<tr>
<td>2” &amp; above</td>
<td>SO FF</td>
<td>For CAT-D service</td>
<td></td>
</tr>
<tr>
<td>300,600</td>
<td>Up to 1.50”</td>
<td>SW RF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2” &amp; above</td>
<td>WN RF</td>
<td></td>
</tr>
<tr>
<td>≥900</td>
<td>All</td>
<td>WN RTJ</td>
<td></td>
</tr>
</tbody>
</table>

- All flange joints on piping system including flanges on the equipment, manholes, etc shall be tightened using Hydraulic bolt tensioner as per the requirement given in the following table & the stud bolt length shall be longer by one diameter to facilitate bolt tensioning:
Notes:

1) Hydrogen service is defined as service in contact with hydrogen or gaseous mixtures containing hydrogen in which the partial pressure of hydrogen is 5 bar or more.

2) Joints with leakage potential shall include
   a) Joints involving tapped holes
   b) Items not subjected to hydrotest eg. Joints for equipment manholes, equipment mounted temp, pressure & level instruments, line mounted temp connections, online instrument joints like control valves and safety valves, compressor volume bottles.
   c) Items involving two sets of gaskets with one set of bolt eg orifice flange joint, joints with spectacle blind, spacer, flangeless wafer check valve, wafer type butterfly valves.
   d) Tie-in joints with other Contractors & package vendors
   e) High temperature (above 370deg C) joints in hydrocarbon service.

3) Critical joints with equipments shall include inlet & outlet flanges of pumps, compressors & turbines

For flange assemblies not covered under the requirements of hydraulic bolt tensioning, but falling in the following categories Bolt Torquing using pre-specified torque value shall be employed:

<table>
<thead>
<tr>
<th>Service</th>
<th>Classes (as per ASME B16.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Service</td>
<td>All</td>
</tr>
<tr>
<td>Category-M services as per ASME B31.3</td>
<td>All</td>
</tr>
<tr>
<td>Other Services</td>
<td>600# &amp; above</td>
</tr>
</tbody>
</table>
### 2.8.4 Gaskets

Gaskets shall be as follows:

<table>
<thead>
<tr>
<th>Rating</th>
<th>Material /service</th>
<th>Temperature (°C)</th>
<th>Type</th>
<th>Gasket or Strip material + Filler material/RTJ Gasket Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>CS &amp; SS (utilities)</td>
<td>up to 371 °C</td>
<td>PLAIN</td>
<td>CAF</td>
</tr>
<tr>
<td>150</td>
<td>CS &amp; LTCS (other than utilities)</td>
<td>up to 371 °C</td>
<td>Spiral wound</td>
<td>SS316+CAF</td>
</tr>
<tr>
<td>150</td>
<td>AS (all services)</td>
<td>up to 371 °C</td>
<td>Spiral wound</td>
<td>SS316+CAF</td>
</tr>
<tr>
<td>300 &amp; 600</td>
<td>CS</td>
<td>up to 427 °C</td>
<td>Spiral wound</td>
<td>SS316+CAF</td>
</tr>
<tr>
<td>300 &amp; 600</td>
<td>AS</td>
<td>All</td>
<td>Spiral wound</td>
<td>SS316+Grafoil</td>
</tr>
<tr>
<td>150, 300, 600</td>
<td>SS (other than utilities)</td>
<td>All</td>
<td>Spiral wound</td>
<td>SS316+Grafoil where trim material is SS304/316 SS316L+Grafoil where trim material is SS304L/316L</td>
</tr>
<tr>
<td>300(<em>), 600(</em>), 900, 1500, 2500</td>
<td>CS</td>
<td>All</td>
<td>Octagonal RTJ</td>
<td>Soft Iron</td>
</tr>
<tr>
<td>300(<em>), 600(</em>), 900, 1500, 2500</td>
<td>AS</td>
<td>All</td>
<td>Octagonal RTJ</td>
<td>5Cr-Alloy steel</td>
</tr>
<tr>
<td>300(<em>), 600(</em>), 900, 1500, 2500</td>
<td>SS</td>
<td>All</td>
<td>Octagonal RTJ</td>
<td>SS</td>
</tr>
</tbody>
</table>

* Only if RTJ is specially mentioned in PMS.
2.8.5 Valves

- SW valves - Upto 1½ inch, for 150#, 300#, 600# (except ball & plug valves). Ball & Plug valves shall be flanged for all sizes.

- Flanged valve - Above 1½ inch for 150#, 300#, 600#.

- BW valves - 900# and above

2.8.6 Over and above the requirements specified in clause 2.8.1 through 2.8.5, other technical requirement prescribed in Annexure “D” shall also be adhered to.

2.8.7 NDT Requirements (If not specified in PMS)

Depending upon the severity of application, extent of NDE shall be decided. As a rule, all hydrogen, oxygen, NACE and any other lethal service shall have 100% radiography on weld joints in all class ratings.

For high pressure applications, ie., 900# and upward 100% radiography on butt weld joints shall be employed. In 100% radiography classes any fillet welds employed shall have 100% DP/MP test in CS/AS classes and 100% DP test in SS classes.

Cat. ‘D’ service as per ASME B31.3 does not require radiography.

Butt welds for Class in 150# for normal hydrocarbon service shall be subjected to 10% radiography and fillet welds to 10% DP/MP test for CS&AS and 10% DP test for SS.

Butt welds for Classes 300# & 600# for normal hydrocarbon service shall be subjected to 20% radiography and fillet welds to 20% DP/MP test for CS&AS and 20% DP test for SS.

For firewater service, IBR etc., radiography shall be as per statutory requirement.

2.9 Thermal Insulation of Piping, Equipment & Vessels

2.9.1 Hot Insulation

Insulation materials, application etc. shall be based on recommendations of Standard specification for hot insulation of vessels, piping and equipments (Doc. No. L-101)

Insulation thickness on piping shall be as per ‘Process design basis’.

2.9.2 Cold Insulation

Insulation materials, application etc. shall be based on recommendations of Standard specification for cold insulation of vessels, piping and equipment (Doc. No. L-101)

Insulation thickness on piping shall be as per ‘Process design basis’.
2.10  **Painting**

Painting materials, application etc. shall be based on recommendations of Job specification for shop & field painting for PNCP (Doc. No. O-301-A).

2.11  **WELDING**

2.11.1  **APPLICABLE CODES & STANDARDS**

All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures:

a)  Process Piping - ASME: B31.3

b)  The Indian Boiler Regulations - I.B.R.

In addition, the following codes and specifications referred in the code of fabrication shall be followed for the welding specifications, consumable qualifications and non destructive test procedures.

Welding and Brazing Qualifications ASME BPV Sec. IX.

Non-destructive examination ASME BPV Sec. V.

Material specifications: Welding rods, electrodes and filler metals ASME BPV Sec II Part C.

The additional requirements mentioned in this specification, over and above those obligatory as per codes, shall be followed wherever specified.

2.11.2  **WELDING PROCESSES**

2.11.2.1  Welding of various materials shall be carried out using one or more of the following processes with the approval of the Engineer-in-charge.

- Shielded Metal Arc Welding process (SMAW)
- Gas Tungsten Arc Welding process (GTAW).

2.11.2.2  Automatic and semi-automatic welding processes shall be employed only with the express approval of the Engineer-in-charge. The welding procedure adopted and consumables used shall be specifically approved.

2.11.2.3  A combination of different welding processes could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of engineer-in-Charge.

2.11.2.4  For additional details “Welding Specification for Fabrication of Piping” shall be referred.
2.12 MISCELLANEOUS

2.12.1 **Positive material identification** (PMI) test at construction site shall be done as per ‘Standard Specification for positive material identification PMI at construction site, Annexure - G

2.12.2 Potable water shall be used for testing of Carbon steel & Alloy steel piping. For testing of Stainless Steel piping maximum chlorine content in water shall be 15-20 ppm.

2.12.3 Item codes for surplus & spare materials shall be as per Owner codes at the time of handing over of the Project.

2.12.4 All small bore piping and steam tracer lines, size ¾” and below shall be welded by TIG process for all type of joints, e.g. Butt Weld, Socket Weld, tee etc.

2.12.5 Preheating/Post heating is mandatory for all type of Alloy steel piping welding joints.

2.12.6 All low hydrogen electrodes shall be baked at 350 deg.C in suitable furnace at site by the contractor.

2.12.7 Welding of Alloy steel butt joints should not be left incomplete for long hours, atleast one third of the weld joint shall be completed in continuity.
3.0 Referenced Publications

The following codes and standards shall be followed unless otherwise specified:

- **ASME SEC. I**  
  Rules for Construction of Power Boilers.

- **ASME SEC. II, Part-C**  
  Material Specifications :Welding Rods, Electrodes and filler metals

- **ASME SEC. VIII**  
  Rules for Construction of Pressure Vessels.

- **ASME SEC. IX**  
  Welding and Brazing qualifications

- **ASME B31.1**  
  Power Piping

- **ASME B31.3**  
  Process Piping

- **API RP 520**  
  Sizing, Selection & Installation of Pressure Relieving Devices in Refineries

- **API Std. 610**  
  Centrifugal Pumps for Petroleum, Heavy Duty Chemical and Gas Industry Service

- **ANSI/NEMA SM 23**  
  Steam Turbines for Mechanical Drive Service

- **API Std. 617**  
  Centrifugal Compressors for Petroleum, Chemical and Gas Industry Service

- **API Std.661**  
  Air Cooled Heat Exchanger

- **API Std.560**  
  Fired Heater

- **EJMA**  
  Expansion Joints Manufacturer’s Association

- **TEMA**  
  Tubular Exchangers Manufacturers Association

- **OISD-118**  
  Layouts for Oil and Gas Installations

- **IBR**  
  Indian Boiler Regulations

- **NACE MR0103**  
  Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments

- **NACE MR0175/ISO15156**  
  Materials for use in H2S containing Environments in Oil & Gas Production

- **NACE MR-0284**  
  Evaluation of Pipeline and Pressure Vessel Steel for Resistance to Hydrogen Induced Cracking

- **NACE TM-0177**  
  Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking in H2S Environments
## Annexure - A

### TABLE OF BASIC SPAN

<table>
<thead>
<tr>
<th>Pipe Size NB (inch)</th>
<th>SCH/ TRK (in)</th>
<th>PIPE-VAPOR-INSULATION</th>
<th>PIPE-LIQUID-INSULATION</th>
<th>BARE PIPE EMPTY</th>
<th>BARE PIPE WATER FILLED</th>
<th>Pipe Size NB (inch)</th>
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<td></td>
<td>BASIC SPAN (L) M</td>
<td>BASIC SPAN (L) M</td>
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<tr>
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<td>To 400 °C</td>
<td>Upto 175 °C To 315 °C</td>
<td>To 400 °C</td>
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Annexure-B

Accessibility for Valves & Instruments

<table>
<thead>
<tr>
<th>VALVES, INSTRUMENTS, EQUIPMENT TO BE OPERATED</th>
<th>CENTRELINE OF ITEM TO BE OPERATED, LOCATED LESS THAN 3.6 m ABOVE GRADE, 2.75 m ABOVE FLOOR OR PLATFORM OR 1.8 m ABOVE WING PLATFORM</th>
<th>CENTRELINE OF ITEM TO BE OPERATED, LOCATED MORE THAN 3.6 m ABOVE GRADE, 2.75 m ABOVE FLOOR OR PLATFORM OR 1.8 m ABOVE WING PLATFORM</th>
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<tr>
<td>EXCHANGER HEADS</td>
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<td>PLATFORM</td>
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<tr>
<td>OPER. VALVES 2” &amp; SMALLER</td>
<td>FIXED LADDER</td>
<td>FIXED LADDER</td>
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<tr>
<td>OPER. VALVES 3” &amp; ABOVE</td>
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<tr>
<td>MOTOR OPERATED VALVES</td>
<td>PLATFORM</td>
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<tr>
<td>CONTROL VALVES</td>
<td>PLATFORM</td>
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<td>RELIEF VALVES 2” &amp; SMALLER</td>
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<td>FIXED LADDER</td>
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<td>RELIEF VALVES 3” &amp; ABOVE</td>
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<td>PLATFORM</td>
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<tr>
<td>BLOCK VALVES 2” &amp; SMALLER</td>
<td>PORTABLE LADDER</td>
<td>PLATFORM</td>
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<tr>
<td>BLOCK VALVES 3” &amp; ABOVE</td>
<td>PLATFORM (NOTE-1)</td>
<td>PLATFORM (NOTE-1)</td>
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<td>BATTERY LIMIT VALVES</td>
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<tr>
<td>PRESSURE INSTRUMENT</td>
<td>FIXED LADDER IF ABOVE 2.2 m HEIGHT</td>
<td>FIXED LADDER</td>
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<tr>
<td>TEMPERATURE INSTRUMENT</td>
<td>FIXED LADDER IF ABOVE 2.2 m HEIGHT</td>
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<td>SAMPLE POINTS</td>
<td>PLATFORM</td>
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<tr>
<td>GAUGE GLASSES</td>
<td>FIXED LADDER</td>
<td>FIXED LADDER</td>
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<td>LEVEL CONTROLLERS</td>
<td>PLATFORM</td>
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<tr>
<td>PROCESS BLINDS AND SPACERS 2” &amp; SMALLER</td>
<td>PORTABLE LADDER / PLATFORM</td>
<td>PLATFORM</td>
</tr>
<tr>
<td>PROCESS BLINDS AND SPACERS 3” &amp; ABOVE</td>
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<td>PLATFORM</td>
</tr>
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<td>MANWAYS/ MANHOLES</td>
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</tr>
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<td>HANDHOLES/ INSPECTION HOLES</td>
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<td>NO ACCESS REQD. (NOTE-2)</td>
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<td>VESSEL VENTS</td>
<td>PORTABLE LADDER</td>
<td>FIXED LADDER</td>
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<td>LINE DRAINS &amp; VENTS</td>
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<tr>
<td>ORIFICE FLANGES</td>
<td>PORTABLE LADDER</td>
<td>PORTABLE LADDER</td>
</tr>
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</table>

**NOTE -1 :** BLOCK VALVES WITH CENTRELINES LOCATED ABOVE 2.0 m FROM THE OPERATING FLOOR, WHICH ARE REQUIRED FOR NORMAL OPERATION SHALL BE PROVIDED WITH PORTABLE PLATFORM OR CHAIN FOR OPERATION OF VALVES.

**NOTE-2 :** TEMPORARY ARRANGEMENT FOR ACCESS SHOULD BE FEASIBLE.
## Vertical and Horizontal Guides Spacing

<table>
<thead>
<tr>
<th>NOM PIPE SIZE IN INCHES</th>
<th>VERTICAL SPACING METRES</th>
<th>HORIZONTAL SPACING METRES NOTE-1</th>
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<tr>
<td>1</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>1 ½</td>
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<tr>
<td>26 and above</td>
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<td>18.0</td>
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</tbody>
</table>

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.
Technical Requirements for Piping Material

1.0 General

1.1 Ends

Unless otherwise specified, the ends shall be to the following standard:

- SW/SCRD: ASME B16.11
- BW: ASME B16.25
- FLANGED: ASME B16.5 and ASME B16.47 SERIES 'B'
- THREADING: ASME/ANSI B1.20.1 (NPT, Taper threads)

1.2 Face Finish

This shall be to MSS-SP-6/ASME B46.1/ASME B16.5/ B16.47. The interpretation shall be as follows:

- Stock Finish: 250-1000 µ in AARH
- Serrated Finish /Smooth Finish/125 AARH: 125-250 µ in AARH
- Extra Smooth Finish/63 AARH: 32-63 µ in AARH

1.3 Austenitic Stainless Steel

All items/parts shall be supplied in solution annealed condition.

For all Austenitic Stainless steels, Intergranular Corrosion (IGC) Test shall be conducted as per following:

- ASTM A262 Practice 'B' with acceptance criteria of 60 mils/year (max.) for casting.
- ASTM A262 Practice 'E' with acceptance criteria of 'No cracks as observed from 20Xmagnification' & microscopic structure to be observed from 250 X magnification' for other than casting.

For IGC test, two sets shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and other set corresponding to the highest rating/thickness.

For all items of stabilised SS grades (SS321, SS347), stabilizing heat treatment shall also be done. It shall be carried out subsequent to normal solution annealing. Soaking temperature and holding time shall be 900°C and 4hrs respectively.

1.4 Threads

Threads for threaded Pipes, Fittings, Flanges, Valves etc shall be in accordance with B1.20.1 taper threads, unless otherwise specified. All threaded joints, irrespective of pressure and temperature, for critical services including toxic fluid, hydrogen etc shall be seal welded with a full strength fillet weld.
2.0 ITEM SPECIFIC NOTES:

2.1 Pipes

Unless specifically exempted, welded pipes shall be acceptable only with longitudinal weld made employing automatic welding.

Unless mentioned otherwise in the material code, double seam 180 deg. apart is allowed for sizes 36" and larger only.

Galvanised Pipes shall be only Hot Dip galv. to ASTM A53.

2.2 Fittings

All fittings shall be seamless in construction unless otherwise specified.

For reducing BW fittings having different wall thickness at each end, the greater one shall be employed and the ends shall be matched to suit respective thickness.

All welded fittings shall have maximum negative tolerance equivalent to pipe selected.

All welded fittings shall be double welded. Inside weld projection shall not exceed 1.6mm, and the welds shall be ground smooth at least 25mm from the ends.

For fittings made out of welded pipe, the pipe itself shall be of double welded type, manufactured with the addition of filler material and made employing automatic welding only.

All welded fittings shall be normalised for CS, normalised & tempered for AS; and 100% radiographed by X-ray for all welds made by fitting manufacturer as well as for welds on the parent material.

Bevel ends of all BW fittings shall undergo 100% MP/DP test.

Those used in fire fighting facilities shall be marked.

2.3 Flanges

For Ring Joint Flanges, Blinds and Spacers, the hardness shall be as follows:

<table>
<thead>
<tr>
<th>Flange Material</th>
<th>Min. Hardness of Groove (BHN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Steel</td>
<td>140</td>
</tr>
<tr>
<td>1% Cr to 5% Cr, 1/2 Mo</td>
<td>150</td>
</tr>
<tr>
<td>Type 304,316,347,321</td>
<td>160</td>
</tr>
<tr>
<td>Type 304L. 316L</td>
<td>140</td>
</tr>
</tbody>
</table>
For RTJ flanges, blinds & spacers, the hardness of the groove shall be specified on the test report. Bore of weld neck flange shall correspond to the inside diameter of pipe for specified schedule/thickness. Ends shall be bevelled to suit the specified schedule / thickness. For RTJ flanges, only octagonal section ring joint flanges shall be used.

2.4 Valves

2.4.1 General

Valves of Class 900 & above shall be pressure-seal type. Threaded and seal welded or welded bonnet may be employed upto sizes 1½".

All flanged valves (except forged) shall have flanges integral with the valve body. Weld-on flanges shall be made by full penetration joints and 100% radiographed.

Valve Castings/Forgings purchased from India or Indian vendors shall be from TEIL approved foundries/forging shop.

Yoke material shall be at least equal to body material.

Forgings are acceptable in place of Castings but not vice-versa.

No cast iron valves to be used in firewater or any other service except in drinking water service.

2.4.2 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’s Std.

Valve under cryogenic service (temp. below -45°C) shall meet the requirements of BS-6364 and shall be procured from prequalified vendor.
2.4.3 Operation

Generally the valves are handwheel or lever operated. However, suitable gear operator in enclosed gear box shall be provided for valves as follows:

<table>
<thead>
<tr>
<th>Valve Type</th>
<th>Class</th>
<th>For Sizes ≥</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate/Globe</td>
<td>150</td>
<td>12&quot;</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>12&quot;</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>12&quot;</td>
</tr>
<tr>
<td>Gate/Globe/Y-Globe/Stop-Check</td>
<td>900</td>
<td>6&quot;</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>3&quot;</td>
</tr>
<tr>
<td></td>
<td>2500</td>
<td>3&quot;</td>
</tr>
<tr>
<td>Ball/Plug (other than Pressure balanced Plug)</td>
<td>150</td>
<td>6&quot;</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>6&quot;</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>4&quot;</td>
</tr>
<tr>
<td></td>
<td>900</td>
<td>3&quot;</td>
</tr>
<tr>
<td></td>
<td>1500</td>
<td>3&quot;</td>
</tr>
<tr>
<td>Butterfly</td>
<td>150</td>
<td>6&quot;</td>
</tr>
<tr>
<td></td>
<td>300</td>
<td>6&quot;</td>
</tr>
</tbody>
</table>

Hand wheel diameter shall not exceed 750mm and lever length shall not exceed 500 mm on each side. Effort to operate shall not exceed 35 kgf at handwheel periphery. However, failing to meet the above requirement, vendor shall offer gear operation. Quarter-turn valves shall have "open" position indicators with limit stops.

2.4.4 By Pass

A globe type valve (size as per ASME/ANSI B16.34) shall be provided as by-pass for the following sizes of gate valves:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>26&quot; &amp; above</td>
</tr>
<tr>
<td>300</td>
<td>16&quot; &amp; above</td>
</tr>
<tr>
<td>600</td>
<td>6&quot; &amp; above</td>
</tr>
<tr>
<td>900</td>
<td>4&quot; &amp; above</td>
</tr>
<tr>
<td>1500</td>
<td>4&quot; &amp; above</td>
</tr>
<tr>
<td>2500</td>
<td>3&quot; &amp; above</td>
</tr>
</tbody>
</table>

By-pass Piping, Fitting and Valves shall be of compatible material and design. Complete fillet welds for by-pass installation shall be DP/MP tested. NDT of by-pass valve shall be in line with main valve.
2.4.5 Radiography of Cast Valves

All casting shall be of radiographic quality. This requirement to be ensured by sample radiography before proceeding with the actual production.

Radiography procedure, areas of casting to be radiographed, and the acceptance criteria shall be as per ASME/ANSI B16.34.

a) Radiography requirement for casting of sizes for special/ critical piping classes shall be as follows:

i) For hydrogen / hydrogen bearing hydrocarbons, oxygen, NACE services & stress relieved Piping classes:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>upto 24&quot;</td>
<td>50%</td>
</tr>
<tr>
<td>300</td>
<td>upto 16&quot;</td>
<td>50%</td>
</tr>
</tbody>
</table>

ii) For LT/CYRO services:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>upto 24&quot;</td>
<td>20%</td>
</tr>
<tr>
<td>300</td>
<td>upto 16&quot;</td>
<td>20%</td>
</tr>
</tbody>
</table>

b) Radiography requirement for castings for categories not mentioned in a) above shall be as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Size</th>
<th>Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>upto 24&quot;</td>
<td>5% For Carbon Steel material (Except Cat ‘D’ &amp; Fire water services for which it is NIL )</td>
</tr>
<tr>
<td>150</td>
<td>26&quot; &amp; above</td>
<td>10% For Alloy steels &amp; Stainless Steels</td>
</tr>
<tr>
<td>150</td>
<td>26&quot; &amp; above</td>
<td>100% For all materials (Nil for Cat. ‘D’ &amp; Fire water service)</td>
</tr>
<tr>
<td>300</td>
<td>upto 16&quot;</td>
<td>10% For all materials</td>
</tr>
<tr>
<td>300</td>
<td>18&quot; &amp; above</td>
<td>100% For all materials</td>
</tr>
<tr>
<td>600 &amp; above</td>
<td>All</td>
<td>100% For all materials</td>
</tr>
</tbody>
</table>

Note-1: No radiography is required for castings for ‘Demineralised Water service(Cat-D)’-A3K Spec.

Note-2: For stabilized grades of SS 100% radiography is required for castings irrespective of the category or rating these belong to.
2.4.6 Ball/Plug/Butterfly Valves

Each valve shall be supplied with a lever/wrench except for gear operated/motor operated valves.

Soft-seated Ball, Plug & Butterfly valves shall be supplied with antistatic devices.

The ball of Ball valves shall not protrude outside the end flanges.

Ball valves shall be floating ball type/trunion mounted type as per following:

<table>
<thead>
<tr>
<th>Class</th>
<th>Floating Ball</th>
<th>Trunion Mounted</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>8&quot; &amp; below</td>
<td>10&quot; &amp; above</td>
</tr>
<tr>
<td>300</td>
<td>4&quot; &amp; below</td>
<td>6&quot; &amp; above</td>
</tr>
<tr>
<td>600 &amp; above</td>
<td>11/2&quot; &amp; below</td>
<td>2&quot; &amp; above</td>
</tr>
</tbody>
</table>

Use of soft seated ball/plug/butterfly valves shall be suitably selected based on temperatures handled.

Butterfly valves shall be suitable for throttling application.

Use of Fire safe valves shall be as per Process requirement.

For Process (Hydrocarbon) services butterfly valve shall be triple offset, high performance type.

2.5 Strainer

Allowable pressure drop when specified shall be certified along with the offer. If asked specifically, pressure drop calculations shall be furnished.

All 2" & higher sized Y type strainers shall be provided with 3/4" threaded tap and solid threaded plug as drain connection on the blind flange. For less than 2", this shall be 1/2" size.

Bottom flange of Y-type strainer shall not have tapped hole. Full length standard size studs shall be used for joining blind flange.

For fabricated strainers, all BW joints shall be fully radiographed and fillet welds shall be 100% DP/MP checked.
All the strainers shall be hydrostatically tested at twice the design pressure.
2.6 Traps

Vendor shall 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 function in horizontal as well as in vertical installation.

Traps shall have integral strainers.

All traps shall be hydrostatically tested to twice the design pressure.

2.7 Hoses

Suitability of hoses shall be guaranteed for the service and working conditions specified in the requisition, even if the material is not specified in the Material Requisition for any particular service.

All hoses shall be clearly marked with service and working pressure at both ends.

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.

2.8 Expansion Joints

The applicable codes are ASME B31.3 and EJMA (Expansion Joint Manufacturer's Association).

Bellows shall be formed from solution annealed sheet conforming to the latest ASTM Spec. Any longitudinal weld shall be 100% radiographed. The finished longitudinal weld must be of the same thickness and same surface finish as the parent material. Circumferential welds are not permitted. Bellows are to be hydraulically or expansion (punched) formed. Rolled formed bellows are not acceptable. Noticeable punch or die marks resulting from expansion operation are not acceptable.

No repairs of any kind are allowed on the bellows after forming. Deep scratches and dents are not acceptable.

The out of roundness shall be limited to ± 3mm. This is the max. deviation between the max. & min. diameter.

The actual circumference of the welding end shall be maintained to ± 3mm of the theoretical circumference.
Apart from the usual requirements, the vendor shall also furnish:
- Design calculations to justify stiffness and fatigue life.
- Axial, lateral stiffness, angular stiffness, effective pressure thrust area.
- Installation/maintenance manual.
- Moments & forces due to stiffness & pressure thrust due to expansion joint

### 2.9 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.

### 2.10 Gaskets

Asbestos filler for spiral wound gasket shall not have any colour or dye

Full face gaskets shall have bolt holes punched out.

Non-metallic ring gaskets as per ASME/ANSI B16.21 shall match flanges to ASME/ANSI B16.5 upto 24", and ASME/ANSI B16.47 or AWWA for sizes > 24" unless otherwise specified.

Spiral wound gaskets as per ASME B16.20 shall match flanges to ASME/ANSI B16.5 upto 24", and ASME B16.47 series 'B' for sizes > 24" unless otherwise specified.

Inner and outer rings requirement for spiral wound gaskets shall be as per PMS General notes.

Inner ring shall be provided for the following:

a) As per code (B 16.20) requirement.
b) For sizes 26" & above in all classes.
c) For vacuum, cryo and hydrogen service.
d) For SS321, SS347 and H-grade SS classes.
e) For classes where temperature is higher than 427°C.
f) For 900# rating and above classes.(If PMS specifies spiral wound gasket)

In case of RTJ gaskets, only octagonal section ring gaskets shall be used & shall have proper marking stamped. Material certificate shall be available for the gasket. Hardness of RTJ gaskets shall be 20 BHN(min) less than the corresponding flange groove hardness.

### 2.11 Stud, Bolts, Nuts and Jack Screws

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.

Threads shall be unified (UNC for ≤ 1" dia and 8UN for > 1" dia) as per ANSI B1.1 with class 2A fit for Studs, M/C Bolts and jack screws, and class 2B fit for nuts.
Stud bolts shall be threaded full length with two heavy hex nuts. Length tolerance shall be in accordance with the requirement of table F2 of Annexure F of ASME B16.5

The nuts shall be double chamfered, semi-finished, heavy hexagonal type and shall be made by the hot forged process.

The length of the studs/ bolts should be such that minimum two threads should be out of the nut on either side.

All the stud/ bolt should have metallurgical certificates in case of alloy/ SS metallurgy with identified colour marking at the stud ends/ bolt side face.

Heads of jack screws and M/C bolts shall be heavy hexagonal type. Jack screw end shall be rounded.

Wherever bolt tensioning is specified stud bolt length shall be longer by minimum one diameter to suit bolt tensioner. Excess threads shall be protected by a threaded nut.

3.0 Special Service Requirements:

3.1 IBR

IBR stands for Indian Boiler Regulation. For steam services, it is statutory obligation to meet IBR requirements. For items under IBR, composition restrictions, test reports, painting, etc. shall be as per IBR’s stipulations.

3.2 CRYO & Fire-Safe

For items to be used under cryogenic conditions, temp below - 45 °C and those required to be fire-safe, special designs and tests would be applicable. Pre-qualification criteria need to be specified before execution of job.

3.3 Impact Tests

Welded Pipes and Fittings used below ASME Temp. –29 °C shall be impact tested as per requirement of ASME B31.3.

3.4 Hydrogen & other demanding services

Vendor quality plan shall include the special quality checks and inspection requirements for these services.

For items to be used in Hydrogen service, requirements as mentioned in Annexure-F shall be applicable, except wherever specified otherwise as per Licensor’s requirement.
4.0 Inspection & testing

All items and their parts shall be subjected to all mandatory as well as supplementary (wherever specified) tests and checks called for in the respective codes/standards/data sheets. The examining personnel shall have the requisite qualification and experience.

Client and its authorized representative reserve the right to vet and suggest changes in vendor's procedures.

Vendor's works and facilities shall be accessible to the Client/Representative at all reasonable times.

Test reports for all mandatory as well as supplementary tests wherever specified shall be furnished.

Positive material identification test at vendor’s works shall be done as per ‘Standard specification for positive material identification PMI at vendor’s works, Annexure - H’.

5.0 Marking

All items shall be marked (stamped/etched) in accordance with the applicable code/standard/specification. In addition, the item code, if available, shall also be marked.

For ease of identification, the colour of painted strip (wherever required) shall be as per the applicable standard.

Paint or ink for marking shall not contain any harmful metal or metal salts which can cause corrosive attack either ordinarily or in service. Special items/smaller items shall have attached corrosion resistant tag providing salient features.

6.0 Despatch

All items shall be dry, clean and free from moisture, dirt and loose foreign material of all kinds.

All items shall be protected from rust, corrosion, and mechanical damage during transportation, shipment and storage.

Rust preventive on machined surfaces to be welded shall not be harmful to welding and shall be easily removable with a petroleum solvent.

Ends shall be suitably protected, and the protectors shall be securely and tightly attached.

Each variety and size of item shall be supplied in separate packaging marked with the purchase order no., item code (if available), and the salient specifications.

Carbon steel, LTCS and low alloy steel valves shall be painted with one coat of inorganic zinc silicate primer.
Annexure-E

OVERHEAD CLEARANCES

Equipment, structure, platforms, piping & its supports shall be arranged to provide the following clearances overhead :

- Over rail roads, top of rail to bottom of any obstruction. 7 m
- Over plant roads for major mobile equipment. 7 m
- Over secondary roads (bottom of pipe) and access ways for mobile equipment. 5 m
- Over grade & bottom of pipe (inside battery limit) at pump row access way. 3.5 m
- Over walk-ways, pass-ways & platforms to nearest obstruction and inside building. 2.2 m
- Over exchangers at grade, shell cover channel end. 1.5 m

HORIZONTAL CLEARANCES :

- Between exchangers (aisles between piping). 0.9 m
- Around pumps (aisles between piping). 0.9 m
- Fired heaters to pumps handling flammable stock. 15 m
- Fired heaters to other flammable containing equipment not closely associated with heaters. 15 m
- At driver end of pumps, where truck access reqd 3 m
- At driver end of pumps, where truck access not reqd 1.8 m
- At shell cover end of exchangers at grade, for access way. 1.3 m
- Between shells of adjacent horizontal vessels. 1.2 m
PIPE BERTHING:

Under ground 300 mm minimum clear gap between pipes
Above ground Normal - Flange to bare pipe (or insulation) plus 25 mm

EQUIPMENT SPACING:

Small pumps (3.7 kw & less) Mounted on common foundations with suitable centre to centre distance.

Medium pumps 900 mm clear aisle

Larger pumps (above 22.5 kw) 900 mm clear aisle

Exchangers & other equipment 900 mm minimum clear aisle on structures

PLATFORMS:

Towers, vertical & horizontal vessels:

Distance of platform below centreline of manhole flange - side platform 900-1050 mm
Width of manhole platform from manhole cover to outside edge of platform 900 mm
Platform extension beyond centreline of manhole - side platform 900 mm
Distance of platform below underside of flange - head platform 175 mm
Width of platform from three sides of manhole - head platform 750 mm

HORIZONTAL EXCHANGER:

Clearance in front of channel or bonnet flange 1200 mm
Heat exchanger tube bundle removal space Bundle length + 1m
Min. clearance from edge of flanges 300 mm

VERTICAL EXCHANGER:

Distance of platform below top flange channel or bonnet 1500 mm of
FURNACES:

Width of the platform at side of horizontal and vertical tube furnace: 750 mm min.

Width of platform at ends of horizontal tube furnace: 1000 mm min.
ANNEXUR-F

SPECIAL REQUIREMENTS FOR HYDROGEN SERVICE

1.0 GENERAL

These requirements are applicable in addition to the requirements specified in the Piping Material Specifications.

2.0 PIPES, FLANGES AND FITTINGS

2.1 Method of Manufacture

All carbon steel pipes, fittings and flanges having wall thickness 9.53 mm and above shall be normalised. Cold drawn pipes and fittings shall be normalised after the final cold draw pass for all thicknesses. In addition, fittings made from forgings shall have Carbon - 0.35% max. and Silicon - 0.35% max. The normalising heat treatment shall be a separate heating operation and not a part of the hot forming operation.

All alloy steel (Cr-Mo) pipes, forgings and fittings shall be normalised and tempered. The normalising and tempering shall be a separate heating operation and not a part of the hot forming operation. The maximum room temperature tensile strength shall be 100,000 psi.

2.2 Post Weld Heat Treatment (PWHT)

All carbon steel pipes and fittings having wall thickness 19 mm and above shall be post weld heat treated.

All alloy steel (Cr-Mo) pipes and fittings shall be post weld heat treated irrespective of type or thickness of weld.

All austenitic stainless steel grades shall be solution annealed after welding. 100% radiography of welded joints shall be done both before and after PWHT.

2.3 Ferrite No. Test

For all austenitic stainless steels, the weld deposit shall be checked for ferrite content. A Ferrite No. (FN) not less than 3% and not more than 10% is required to avoid sigma phase embrittlement during heat treatment. FN shall be determined by Ferritescope prior to post weld heat treatment.

2.4 Impact Test

For all carbon steels and alloy steels pipes, flanges and fittings with thickness over 19 mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and in accordance with ASTM A370. Impact energies at 0 C shall average greater than 27J (20 ft-lb) per set of 3 specimens, with a minimum of 19J (15 ft-lb).
If welding is used in manufacture, impact test of Heat Affected Zone (HAZ) and weld metal shall also be carried out.

2.5 **Hardness**

For carbon steel pipes and fittings, hardness of weld and HAZ shall be limited to 200 BHN (max.).

For alloy steel pipes and fittings, hardness of weld and HAZ shall be limited to 225 BHN (max.).

2.6 **Radiography**

All girth welded joints (longitudinal and circumferential) shall be 100% radiographed in accordance with UW-51 of ASME Section VIII, Div-1 and ASME Section V.

3.0 **VALVES**

3.1 All valve castings shall be of radiographic quality.

3.2 All cast valve flanges & bodies with flange rating of Class 900 or greater shall be examined in accordance with paragraphs 7.2 through 7.5 of Appendix-7 of ASME SEC-VIII, DIV.1, regardless of casting quality factor.

3.3 Only Normalized and Tempered material shall be used in the following specifications:

- **Castings:** A217 Gr.WC1, A217 Gr.WC4, A217 Gr.WC5, A217 Gr.WC6, A217 Gr.WC9, A217 Gr.C5, A217 Gr.C12
- **Forgings:** A182 Gr.F11 Cl.2

3.4 Body / bonnet / cover joints & stuffing box of valves shall have low emission. One valve per metallurgy, per rating, per size shall be helium leak tested as per ASME Sec.V, Subsection A, Article 10 (Detector Probe Technique), Appendix IV at a minimum of 25% of the allowable (rated) cold working pressure. Selection of valves for helium leak test shall be at random. Test duration shall be as follows:

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>Pressure Class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upto 300</td>
</tr>
<tr>
<td>Upto 2&quot;</td>
<td>3</td>
</tr>
<tr>
<td>3&quot; to 6&quot;</td>
<td>6</td>
</tr>
<tr>
<td>8&quot; to 16&quot;</td>
<td>9</td>
</tr>
<tr>
<td>18&quot; to 24&quot;</td>
<td>9</td>
</tr>
</tbody>
</table>

The valve shall show no leakage. No leakage is defined as a total leakage rate of less than 0.0001 ml/s of helium.
3.5 **CS & AS Valves**

Bend test and Magnetic Particle inspection of the entire surface of body and bonnet casting shall be in accordance with ASTM A217. Supplementary requirement S3 & S4 evaluation of magnetic particle, inspection shall be in accordance with MSS-SP-53 except that no linear discontinuities shall be allowed.

The Brinell hardness of heat treated casting shall not exceed 200 BHN for carbon steel & 225 for alloy steel.

Repair of defective casting shall be outlined in writing to the purchaser before repair starts. Repair method to be approved prior to welding.

Casting shall be preheated to a minimum of 400ºF prior to welding and all Chromium-Molybdenum alloys shall be postweld heat treated after welding is complete. Stress relieving is essential for welds.

Carbon steel shall be normalised and alloy steels shall be normalised & tempered.

Dye Penetrant test of welds shall be in accordance with ASTM B165 Procedure B-2. Interpretation as per Appendix-8 of ASME-VIII Div.1.

The tensile stress for AS shall be less than 100,000 psi.

Charpy V-notch impact testing is to be done for valve material (average 20 ft-lb for set of 3 [minimum value 15 ft-lb] at 30 F).

For radiography and acceptance criteria for valve castings, refer para 2 of clause3.6.

3.6 **SS Valves**

Casting and test bar shall be heat treated together. Valve casting shall be in solution heat treated and pickled condition.

Critical body and bonnet casing section typically defined by ASME B16.34 shall be radiographed and shall meet ASTM E446 (upto 2" thick) Category A,B & CA Level 2, Category CB, OC & CD Level 3, Category D,B & F Level 0. For wall thickness 2" to 4.5" comparable plates of ASTM E186 shall be used. ASTM E94 and ASTM E142 shall be used for recommended practice & controlling quality of radiography as guide. The entire surface of all castings shall be dye-penetrant inspected after pickling.

Repair welds shall be 100% radiographed and evaluated in accordance with paragraph 344.5 of ASME B31.3 with a minimum casting quality factor of 0.95. Dye Penetration test shall be as per ASTM E165 Procedure B-2, Interpretation as per Appendix-8 of ASME-VIII Div.1.
# CONTENTS

1.0 SCOPE  
2.0 REFERENCE DOCUMENTS  
3.0 DEFINITIONS  
4.0 PMI EXAMINATION  
5.0 ACCEPTABLE METHODS FOR PMI  
6.0 EXTENT OF PMI EXAMINATION  
7.0 RECORDING AND DOCUMENTATION  
8.0 MARKING
1.0 SCOPE

1.1 This specification applies to the requirements for Positive Material Identification (PMI) to be performed at the vendor’s works on Metallic Alloy Materials procured either directly by the Owner/EIL/LSTK contractor or indirectly through the sub-vendors.

1.2 Any post order deviation from this specification must be approved by Owner/EIL in the Deviation/ Waiver Permit format (No. 5-0000-0180-F1) enclosed with Material Requisition.

1.3 This specification covers the procedures and methodology to be adopted to assure that the chemical composition of the alloy material is consistent with the material specifications as specified in purchase documents using ‘Alloy Analyser’ at the time of final inspection before dispatch.

1.4 The scope of this specification shall include but shall not be limited to Positive Material Identification (PMI) to be performed on Alloy Materials listed below:

- Alloy Steel Pipes including Clad Pipes
- Alloy Steel Flanges & Forgings
- Alloy Steel Fittings including Clad Fittings
- Alloy Steel Fasteners
- Alloy Cast & Forged steel valves
- Alloy Steel Instrumentation Items (Control Valves, Safety Valves etc.)
- Longitudinal Pipe & Fittings Welds.
- Gaskets (for Ring Type Joints)

Following items shall be excluded from scope of PMI examination.

- Gaskets other than for Ring Type Joints
- Internal Components of Valves

1.5 All grades of material supplies including Stainless Steels shall be liable for PMI test at site. In case of any defective materials being found at site, the vendor shall be responsible to effect replacement of such defective materials at project site without any delays to the satisfaction of EIL site RCM (Resident Construction Manager).

2.0 REFERENCE DOCUMENTS


3.0 DEFINITIONS

3.1 Vendor: Any Supplier or Manufacturer on whom an order is placed for the supply of referred items. This definition shall also include any sub-vendor or manufacturer on whom a sub-order is placed by the vendor.

3.2 Inspection Lot: A group of items offered for inspection covered under same size, Heat and Heat treatment lot.

3.3 Alloy Material: Any metallic material (including welding filler materials) that contains alloying elements such as chromium, nickel, molybdenum or vanadium, which are intentionally added to enhance mechanical or physical properties and/or corrosion resistance.
4.0 PMI EXAMINATION

4.1 The vendor shall submit a procedure of PMI to comply with the requirements of this Specification Approval of PMI Procedure shall be obtained from Owner/EIL/TPI prior to commencing manufacture/inspection of product.

4.2 PMI examination of alloy materials is independent of any certification, markings or colour coding that may exist and is aimed at verifying that the alloy used are as per specified grades.

4.3 The Vendor shall identify all incoming alloy materials and maintain full traceability of all alloy materials, including all off-cuts. Transfer of identification marks shall be undertaken prior to cutting to ensure maintenance of identification on off-cuts.

4.4 The Vendor shall ensure that all alloy materials are segregated and stored in separately identified locations to prevent the mix up of materials of different alloy specifications or alloy material with carbon steel. Non ferro-magnetic materials shall be segregated at all times from ferro-magnetic materials.

4.5 PMI examination is subject to surveillance inspection by Owner/EIL/TPI.

5.0 ACCEPTABLE METHODS FOR PMI

5.1 The method used for PMI examination shall provide a quantitative determination of the alloying elements like Cr, Mo, Ni, V in Alloy Steel items.

5.2 Instruments or methods used for PMI examination shall be able to provide quantitative, recordable, elemental composition results for positive identification of alloying elements present.

5.3 The acceptable instruments for alloy analyser shall be either “Portable X-Ray fluorescence” or “Optical Emission” type each capable of verifying the percentage of alloy elements within specified range.

5.4 Chemical spot testing, magnets, alloy sorters and other methods using eddy current or triboelectric testing methods are not acceptable for PMI examination.

5.5 The PMI instrument used shall have the sensitivity to detect the alloying elements in the specified range.

5.6 All PMI instruments shall have been serviced within a 6 month period of the time of use to verify the suitability of batteries, sources etc., The data of the last service shall be stated on the PMI Report Form (Sample enclosed).

5.7 Each analyser must be calibrated according to the manufacturer’s specification at the beginning and end of each shift. Instrument must be checked against known standard for each alloy type to be inspected during the shift.

5.8 Certified samples, with full traceability, of a known alloy materials shall be available for use as a random spot check on the instrument calibration.

5.9 The surfaces to be examined shall be prepared by light grinding or abrasive paper and solvent cleaner. Evidence of Arc burn resulting from examination shall be removed by light grinding or abrasive paper.

No permanent marks, which are injurious to the usage of product in service, are acceptable.
5.10 Alloy Steel ring type joint Gaskets shall be inspected by using portable X-Ray fluorescence instrument.

5.11 Testing shall be done as per the procedures outlined by the manufactures of alloy analyser being used. Modification of these procedures if any, must be approved by Owner/EIL.

5.12 The persons performing PMI shall demonstrate their capabilities to the satisfaction of Owner/EIL/TPI visiting engineer. If the vendor has qualified operator on their rolls, he may perform the examination. Otherwise PMI examination shall be sub-contracted to an independent testing agency approved by EIL.

5.13 Whenever material is identified as not meeting requirements by the visiting engineer a rejection note shall be issued.

6.0 EXTENT OF PMI EXAMINATION

Following sampling plans shall be applicable for PMI examination of various alloy items.

A. Flanges, Fittings Valves, RTJ Gaskets - 100%

B. Pipes - 100% (for pipes procured from traders).

2 random samples drawn from each size/Heat/Lot (for pipes procured directly from Mills).

C. Fasteners -

<table>
<thead>
<tr>
<th>Lot Size</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 100</td>
<td>2% (Min 2)</td>
</tr>
<tr>
<td>101 to 500</td>
<td>1% (Min 3)</td>
</tr>
<tr>
<td>501 and above</td>
<td>0.5% (Min 5)</td>
</tr>
</tbody>
</table>

Note:

a. For Welded Pipes and Fittings, PMI shall be performed on Base Metal as well as weldments.

b. Whenever any sample drawn to PMI test on the basis of percentage selection in B & C above, fails to meet specification requirements, 100% of items of lot shall be tested for PMI.

7.0 RECORDING AND DOCUMENTATION

The results of PMI examination shall be recorded in a Report Format as enclosed with this specification.

8.0 MARKING

8.1 All alloy materials tested by PMI shall be identified using either of the following methods by indicating "PMI OK"

a) Bar Code/Hologram Sticker

b) A low stress stamp marking
### POSITIVE MATERIAL IDENTIFICATION REPORT

#### BULK MATERIALS

<table>
<thead>
<tr>
<th>Project:</th>
<th>Client</th>
<th>Job No.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>PMI Report No.</th>
<th>Vendor/Sub-Vendor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purchase Order No.</td>
<td>Testing Agency</td>
</tr>
<tr>
<td>Purchase Requisition No.</td>
<td>PMI Location</td>
</tr>
<tr>
<td>Bulk Item Type (as per Requisition)</td>
<td></td>
</tr>
<tr>
<td>Material Specification/Grade</td>
<td></td>
</tr>
<tr>
<td>Number of items in Lot</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Requisition Item No./Description</th>
<th>Alloy content, Weight Percent</th>
<th>Remarks Accept/Reject</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>Cr</th>
<th>Mo</th>
<th>Ni</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specified Range</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Actual observations

1. 
2. 
3. 
4. 
5. 
6. 
7. 
8. 

| Instrument Type / ID | |
|----------------------| |
| Last Service Date | Inspection Agency |
| Witnessed By | |
ANNEXURE-H

CONTENTS

1.0 SCOPE
2.0 CODES AND STANDARDS
3.0 METALLURGY
4.0 PREQUALIFICATION OF BIDDERS
5.0 ACCREDITED INSPECTION AGENCIES
6.0 TEST CERTIFICATE
7.0 POST ORDER PRODUCTION TESTS
8.0 TESTING PROCEDURES AND ACCEPTANCE CRITERIA
9.0 QUALITY SURVEILLANCE & INSPECTION
10.0 IDENTIFICATION, STAMPING, MARKING, CERTIFICATION
11.0 SPECIFICATIONS & CHEMICAL COMPOSITION OF PRODUCTS
     (TABLE 1 TO TABLE 4)
     ABBREVIATIONS
     APPENDIX - I
     LIST OF PREQUALIFIED VENDORS
STANDARD SPECIFICATIONS FOR SOUR SERVICE PIPING

1.0 SCOPE

1.1 This specification covers the specific requirements for metallurgy, inspection and testing of carbon steel and low alloy carbon steel material to be used for anchor installations wherever sour service conditions are present. This specification shall be read together with the corresponding material specified in the relevant piping material specification intended to be used for sour services.

In case of conflict between this specification and the referred material codes / standards, the requirements of this specification shall govern.

1.2 The NACE standard MR-01-75 defines the sour service and recommends materials which will not fail by SSC in wet sour environment and is solely concerned with the prevention of SSC of metallic materials. However, equipment handling sour streams can fail by other mechanisms when Hydrogen Sulphide is involved. This document has been developed to minimize not only SSC but also HIC or step-wise cracking or hydrogen blistering.

2.0 CODES AND STANDARDS

Latest revision of the following codes and standards form a part of this specification

NACE TM-01-77 Testing of metals for resistance to sulfide stress cracking at ambient temperatures.

NACE TM-02-84 Test method, evaluation of pipeline steels for resistance to stepwise cracking.

NACE MR-01-75 Sulfide stress cracking resistant metallic materials for oil field equipment.

ANSI B 16.34 Steel valves flanged and butt welding ends

API SPEC 5L Specification for line pipe.

ASTM A - 105 Forgings, carbon steel, for piping components.

ASTM A - 106 Seamless carbon steel pipe for high temp. service.
<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM A - 194</td>
<td>Carbon and alloy steel nuts for bolts for high pressure and high temp. service.</td>
</tr>
<tr>
<td>ASTM A - 216</td>
<td>Carbon steel castings, suitable for fusion welding, for high temp. service.</td>
</tr>
<tr>
<td>ASTM A - 234</td>
<td>Piping fittings of wrought carbon steel for moderate and elevated temperatures.</td>
</tr>
<tr>
<td>ASTM A - 320</td>
<td>Alloy steel bolting material for low-temp. service</td>
</tr>
<tr>
<td>ASTM A - 333</td>
<td>Seamless and welded pipes for low-temp. service</td>
</tr>
<tr>
<td>ASTM A - 350</td>
<td>Forgings, carbon and low alloy steel, requiring notch toughness testing for piping components.</td>
</tr>
<tr>
<td>ASTM A - 352</td>
<td>Steel castings, ferritic and martensitic, for pressure containing parts suitable for low temp.service.</td>
</tr>
<tr>
<td>ASTM A - 370</td>
<td>Methods and definitions for mechanical testing of steel products.</td>
</tr>
<tr>
<td>ASTM A - 420</td>
<td>Piping fittings of wrought carbon steel and alloy steel for low-temp. service.</td>
</tr>
<tr>
<td>ASTM A - 671</td>
<td>Specification for electric fusion welded steel pipe for atmospheric and lower temperatures</td>
</tr>
<tr>
<td>ASTM A - 672</td>
<td>Specification for electric fusion welded steel pipe for high pressure service at moderate temperatures</td>
</tr>
<tr>
<td>ASTM A - 694</td>
<td>Specifications for forgings, carbon and alloy steel, for pipe flanges, fittings, Valves and parts for high pressure transmission service</td>
</tr>
<tr>
<td>ASTM E - 10</td>
<td>Test for Brinell hardness of metallic materials</td>
</tr>
<tr>
<td>ASTM E - 18</td>
<td>Rockwell hardness and Rockwell superficial hardness of metallic materials</td>
</tr>
</tbody>
</table>
ASTM E - 45  Determining the inclusion content of steel.
ASTM E - 140  Standard hardness conversion tables for metals.
MSS - SP - 44  Steel pipeline flanges.
MSS - SP - 75  High test wrought butt welding fittings.

3.0 METALLURGY

3.1 All steels shall be killed and fine grained.

3.2 The steel making process shall produce steel with high resistance to hydrogen sulfide attack i.e. HIC & SSC.

3.3 All steels shall be manufactured by either basic oxygen or electric furnace process only.

3.4 The following treatments during steel making are mandatory:

- Steel shall be made by low sulphur and low phosphorus refining process and shall be vacuum degassed while molten.

- Steel shall be calcium treated for inclusion morphology control. To determine the effectiveness of calcium treatment inclusion count check shall be performed as per ASTM E - 45 (microscopic method).

- Steel shall be specifically treated to control non-metallic inclusions like metallic oxide clusters, silicates and magnesium sulphide etc.

3.5 The manufacturer shall take particular care to control the rolling and heat treatment conditions so as to eliminate low temperature transformation microstructures associated with segregation such as bainite band or islets of martensite, in order to reduce the propagation of HIC.

3.6 Carbon equivalent shall be computed as per the following formulae depending upon the carbon content.
3.6.1 If $C < 0.12$:

$$P_{cm} = C + \frac{Si}{30} + \frac{(Mn+Cu+Cr)}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

3.6.2 If $C > 0.12$:

$$CE = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Ni+Cu)}{15}$$

4.0 PREQUALIFICATION OF BIDDERS

To meet the stringent performance requirements, materials used for sour service needs to be closely monitored throughout the manufacturing process. For achieving this, it is proposed to prequalify manufacturers for each sequence of manufacturing process based on prequalification criteria and prequalification documents. Appendix - I gives a list of manufacturers who are already prequalified and need not submit prequalification documents if same combination / sequence is used. It may please be noted that only a specific combination / sequence of manufacturing has been prequalified. Any deviation from this list would necessitate a fresh prequalification approval.

4.1 Prequalification Criteria

It is felt that quality can be ensured only if the product manufacturer obtains raw material from the same reliable source and forging/ casting/ finishing operations are carried out employing the same shop as indicated in the prequalification documentation. Prequalification is made product-wise, material-wise, type of construction-wise (seamless or welded), type of valve-wise (gate/ globe/ check/ ball/ needle) irrespective of thickness/ size/ pressure rating etc.

4.2 Prequalification Documentation:

The following documents shall be furnished to the company for review, to prequalify manufacturers (4.2.1 to 4.2.4) and traders (4.2.5) along with the quotation initially

4.2.1 List of clients where similar materials have been supplied.

4.2.2 The name(s) of manufacturers/ forging source/ raw material source (mill) etc. utilised for manufacturing of the quoted product.

4.2.3 Steel making procedure from raw material supplier including specific details and conformation to requirements indicated in Cl. 3.1 through 3.6.
4.2.4 Test certificates as per Fig.1, duly witnessed and certified by any of the company accredited third party inspection agencies indicated in Cl. 5.0. The test certificates shall be as per Cl. 6.0. The test certificates furnished for chemical composition, mechanical properties hardness, HIC test (as applicable) & SSC test (as applicable) shall be for an earlier manufactured 'NACE' product executed for any client previously. All test certificates shall bear the same heat number.

4.2.5 Traders shall furnish chemical composition, HIC test (irrespective of chemical composition), mechanical properties, hardness test & SSC test (only if S & P % is greater than Table 1 to Table 4 limits or if UTS is greater than 77000 psi) certificates duly witnessed and certified by accredited third party inspection agency (Cl.5.0) per heat of ex-stock products. If the test certificates meet the requirements of this specification then the trader shall be prequalified for ONE time only. The test certificates shall meet all the requirements of Cl.6.0. The relevant test certificates shall be furnished with the quotation.

4.3 It is repeated that for every combination of manufacturing process or vendors (suppliers to manufacturers) required for the finished product separate prequalification is mandatory. A fresh set of prequalification documents need to be submitted everytime there is ANY deviation from the specific manufacturing process and vendor for which the earlier prequalification approval was obtained.

4.4 The manufacturer trader shall be qualified based on the above documents. Company’s decision in this regard shall be final and binding on the bidder.
FIGURE -1
PREQUALIFICATION DOCUMENTATION BY MANUFACTURERS
(For every material)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Certificate</th>
<th>Seamless Pipe</th>
<th>Welded Pipe</th>
<th>Forged Fittings</th>
<th>Wrought Fittings (Stainless)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chemical Composition</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>Mechanical Properties</td>
<td>N</td>
<td>A</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>Hardness</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Test Certificate</th>
<th>Wrought Fittings (Welded)</th>
<th>Flanges</th>
<th>Valves (G/O/Ch/B) Forged</th>
<th>Valves (G/O/Ch/B) Cast</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Raw Material</td>
<td>Finished Product</td>
<td>Raw Material</td>
<td>Finished Product</td>
</tr>
<tr>
<td>1</td>
<td>Chemical Composition</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>Mechanical Properties</td>
<td>N</td>
<td>A</td>
<td>N</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>Hardness</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
</tbody>
</table>

Legend for Figure 1:

Y : Yes, required
N : Not required
A : Yes reqd., only if chemical composition % exceeds Table 1 to Table 4 limits, as applicable.
B : Yes, reqd., only if S & P % is greater than Table 1 to Table 4 limits or if UTS is greater than 77000 psi

Raw Material: Previously used input steel to manufacture products supplied to any client earlier

Finished Product: Previously manufactured NACE product from the same raw material (as defined above), executed for any client earlier

Note 1: Seamless pipe / fittings are acceptable in lieu of welded pipe / fittings.

Note 2: Forged valves are acceptable in lieu of cast valves.
5.0 ACCREDITED INSPECTION AGENCIES

Prequalification / post-order production tests shall be duly witnessed and certified by any of the accredited third party inspection agencies. The accredited inspection agencies are

- LLOYDS
- BV
- DNV
- ABS TECH
- SGS
- TUV
- EIL

6.0 TEST CERTIFICATE

The test certificate furnished shall bear the following details

- Product name
- Heat number
- Raw material source
- Forge shop / casting foundry / manufacturer
- Chemical composition (with carbon eqvt.)
- Mechanical properties i.e. UTS, hardness, YS, ratio of yield to UTS, impact properties etc.
- Material designation (ASTM, BS, MSS-SP etc)
- Test results
Witnessed and certified with proper seal and signature of accredited inspection agency

Any certificate not meeting these requirements shall be rejected

7.0 POST ORDER PRODUCTION TESTS

On placement of the order, the manufacturer shall carry out all the tests as listed henceforth under each product and furnish test certificates for the same duly ‘Witnessed and Certified’ by any of the company accredited third party inspection agency referred in Cl.5.0. The test certificates shall meet all the requirements of Cl.6.0.

7.1 Pipe

7.1.1 American specifications as per Table-1 specified against each product are permitted.

7.1.2 Chemical Composition

This shall be carried out on heat as well as on finished product as per relevant product material specifications and shall meet the requirements of Table-1

7.1.3 Mechanical Properties

The following mechanical properties shall only be acceptable over and above that specified in the relevant product material specification:

- Ultimate Tensile Strength = 77,000 psi (max) on finished product
- Ratio of yield to tensile strength shall not exceed 0.8 on finished product

7.1.4 Hardness Test

Hardness (max) shall be RC22 on finished product and shall be as per Cl.8.1

7.1.5 Non Destructive Examination
The inside and outside surfaces of all pipes shall be visually examined. The longitudinal seam of the welded pipe shall be subjected to 100% radiography. Repair welds are not permitted on any size.

7.1.6 HIC Test

This shall be carried out on one pipe (material-wise & type of construction-wise i.e. seamless & welded separately) per heat irrespective of size / thickness as per Cl 8.2.2. HIC test requirement is as follows.

7.1.6.1 Seamless Pipe

Seamless pipe shall contain max. 0.010% sulphur and max. 0.02% phosphorus, otherwise HIC testing is required. If the bidder is unable to offer seamless pipe with a sulphur content less than or equal to 0.010% and phosphorus content less than or equal to 0.02%, then HIC testing shall be carried out on pipe where the check analysis exceeds the above value.

7.1.6.2 Welded Pipe

HIC testing shall be carried out for welded pipes irrespective of S & P % values.

7.1.7 SSC test is not required. But in case of deviation of S & P % from Table-1 on the chemical analysis of the finished product or UTS being greater than 77000 psi the manufacturer shall either conduct SSC test on every heat (as per Cl. 8.2.3.) Successfully OR reject all the finished products made from that heat.

7.2 Fittings (Elbows, Tees, Reducers, Caps, Half cplgs., Swages, Weldolets & Sockolets)

7.2.1 American specifications as per Table 2 as specified against each product are permitted.

7.2.2 Chemical Composition

This shall be carried out on heat as well as on finished product as per relevant product material specifications and shall meet the requirements of Table-2.
7.2.3 Mechanical Properties

These shall be as per specified product material specification & Cl. 7.1.3

7.2.5 Hardness Test

This shall be as per Cl. 7.1.4 & 8.1

7.2.5 HIC Test

This shall be carried out on one finished product (materialwise & type of construction wise i.e., seamless and welded separately) per heat irrespective of size/ thickness / type of fittings as per Cl. 8.2.2. HIC test requirement is as follows.

Forged : HIC testing is not required if chemical composition does not exceed Table-2 limits. Otherwise HIC test shall be carried out.

Wrought : The requirements for wrought fittings are the same as for the Seamless or welded pipe from which the fittings are wrought

7.2.6 SSC test is not required. But in case of deviation of S & P % from Table-1 on the chemical analysis of the finished product or UTS being greater than 77000 psi the manufacturer shall either conduct SSC test on every heat (as per Cl. 8.2.3) successfully OR reject all the finished products made from that heat.

7.3 Flanges (all types)

7.3.1 American specifications as per Table 3 as specified against each product are permitted.

7.3.2 Chemical Composition

This shall be carried out on heat as well on the finished product as per relevant product material specification and shall meet requirements of Table-3

7.3.3 Mechanical Properties
This shall be as per specified product material specification & Cl.7.1.3

7.3.4 Hardness Test

This shall be as per Cl.7.1.4 & 8.1

7.3.5 HIC Test

This shall be carried out on one finished product each materialwise per heat irrespective of size / rating / type of flange as per Cl.8.2.2 HIC test is required only if chemical composition exceeds Table-3 limits.

7.3.6 SSC test is not required. But in case of deviation of S & P % from Table-1 on the chemical analysis of the finished product or UTS being greater than 77000 psi the manufacturer shall either conduct SSC test on every heat (as per Cl.8.2.3.) successfully OR reject all the finished products made from that heat.

7.4 Gate / Globe / Check / Ball / Needle Valves

7.4.1 Valve body shall be of forged construction or cast construction as per Table-4. Forged construction valves offered in lieu of cast construction are also acceptable.

Other components & trim materials & other requirements shall be as per valve specification sheets. Generally SS 316 with max hardness of RC22 is used. If hardfaced with stellite hardness upto max RC43 is allowed.

7.4.2 Chemical Composition

This shall be carried out on heat / cast, as well as on finished product as per relevant product material specification and shall be as per Table-4

7.4.3 Mechanical Properties

This shall be as per specified product material specification & Cl.7.1.3

7.4.4 Hardness Test

All valve bodies, bonnets, liquid level chambers & and all parts having contact with sour gas / liquid, shall be stress relieved after final machining & hardness tested as per Cl.8.1
7.4.5 Non Destructive Testing

All valve castings shall be 100% radiographed irrespective of rating. The procedure, areas to be radiographed and acceptance limits shall be as per ANSI B16.34 Annexure-B.

Dye Penetrant or Magnetic Particle testing shall also be done on all castings. Procedure and acceptance criteria shall be as per ANSI B16.34.

7.4.6 HIC Test

This shall be carried out on one finished product (material-wise & type of construction-wise i.e. cast & forged separately) per heat irrespective of size / rating / type of valve as per Cl.8.2.2. HIC test is required only if chemical composition exceeds Table-4 limits.

7.4.7 SSC test is not required. But in case of deviation of S & P % from Table-1 on the chemical analysis of the finished product or UTS being greater than 77000 psi the manufacturer shall either conduct SSC test on every heat (as per Cl.8.2.3 ) successfully OR reject all the finished products made from that heat.

7.5 Bolting

7.5.1 Bolts and nuts shall conform to the following American specifications:

Studs : ASTM A193 Gr B7M / ASTM A320 Gr L7M

Nuts : ASTM A194 Gr 2HM / ASTM A194 Gr 7M

Studs shall be fully threaded with two nuts.

7.5.2 Chemical Composition

This shall be as per the relevant ASTM specification

7.5.3 Mechanical Properties

These shall be as per the relevant ASTM specifications.

7.5.4 Hardness Test
This shall be as per Cl.8.1

7.5.5 HIC test is not required

7.5.6 SSC test is not required

7.6 Gaskets

7.6.1 Spiral wound gaskets of SS 316L + CA filler shall be used for RF flanges. In case of RTJ flanges the gasket shall be soft iron.

7.6.2 Chemical Composition

The composition for soft iron gasket shall be as follows

\[
\begin{align*}
C &= < 0.24\% \\
Mn &= < 1.35\% \\
P &= < 0.02\% \\
S &= < 0.01\% \\
Ni &= < 0.25\% \\
Si &= < 0.35\%
\end{align*}
\]

7.6.3 Mechanical Properties

These shall be as per relevant ASTM specification.

7.6.4 Hardness Test

For soft iron gasket the hardness shall be 90 BHN max.

7.6.5 HIC test is not required

7.6.6 SSC test is not required

7.7 Quality Assurance manual shall be furnished for company's review which should include the schemes for the raw material quality assurance, product quality assurance, storage & traceability of products & quality control procedures for each product (i.e. pipes, fittings, flanges, valves etc.)

8.0 TESTING PROCEDURES AND ACCEPTANCE CRITERIAS

8.1 Hardness Test

8.1.1 Max. hardness shall be limited to HRC-22 or 248 HV5 or 237 BHN & measurement shall be as per ASTM E-18 or ASTM E-92 or ASTM E-10.
8.1.2 Hardness test shall be conducted on sample of each heat and on each finished product. Waiver may be given only for those products which can get damaged due to hardness test. For small products which can not be hardness tested individually the manufacturer shall conduct test on a random basis by selecting components from production run or stores batches to ensure that the product complies fully with hardness requirements. The products for which hardness values are found in excess of specified value shall be rejected. If the hardness on the sample of heat is more than the acceptable value, then the entire raw material from the heat shall be rejected.

8.2 Corrosion Tests

8.2.1 Selection of test samples

A. Test specimen shall be taken from per heat of the finished product. Where the test specimen cannot be taken from the finished product, a representative test specimen shall be taken from the same heat, heat treated in the same batch or charge as the product and shall undergo the same amount of working as the most worked section of the finished product.

B. In case the finished product is of welded type, the test piece shall include the parent metal, weld metal and HAZ.

8.2.2 HIC Test

A. The test shall be performed on a set of three test specimens of the finished product. The test shall be performed as per NACE–TM–02-84 and the acceptance criteria shall be as follows:

1. CSR = < 0.00%
2. CLR = < 10.00%

Both the above conditions must be met by all the samples. Samples shall be as per Cl 8 2 1.

B. In case any one of the above samples fails to meet the acceptance criteria, three more additional specimen from the product from which the first set of specimens were taken, shall be retested and results reported.
C. In case of failure of any of the samples in 'B' above, two additional products shall be selected from the same heat and six specimens shall be tested (three from each product). In case of failure of any one of the six samples, that particular heat will be rejected.

8.2.3 SSC Test

The test shall be carried out as per NACE-TM-01-77. Samples shall be as per Cl.8.2.1

8.2.4 Reporting of Test Results

Curves shall be reported as per NACE-TM-01-77 for various stress levels between 72% & 90% of SMYS.

8.2.5 Acceptance Criteria

At 72% of SMYS, 'Time to failure' shall not be less than 720 hrs

9.0 QUALITY SURVEILLANCE & INSPECTION

9.1 The manufacturer shall perform all tests and inspection mentioned above to ensure that the materials conform to the requirements of this specification. The manufacturer / supplier shall provide all testing and inspection facilities to meet the requirements of this specification. The company's duly authorised representative shall have access to the material subject to inspection and / or witnessing the selection of samples, preparation of the test specimens, and performance of tests. For such tests the company's representative shall have the right to indicate the pieces from which the specimens are to be drawn. In case of any doubts regarding the quality of the product, company shall have the option to ask for requalification of the mill at contractor's cost. Inspection by the company or its authorised representative shall not relieve the supplier of his responsibility for ensuring compliance of the materials supplied with this specification.

10.0 IDENTIFICATION, STAMPING, MARKING, CERTIFICATION

10.1 Identification Stamping

Identification stamping shall be done by using low stress stamping methods (dot, vibratory and round "V"). For thin sections =< 10 mm thick use only stencilling.
Conventional "V" stamping is acceptable in low stress areas such as the outside diameter of flanges. Sharp "V" stamping is not permitted in high stress areas unless subsequently stress relieved at 1100°F (595°C) min.

10.2 Marking Paints, Crayons etc.

Conventional paints, crayons and adhesive tapes (frequently used for temporary marking during fabrication etc.) May contain significant amount of chloride and heavy metals. Unless approved by the owner, these marking materials must not be used on any stainless steel, and if used on carbon and low alloy steels they must be removed before heat treatment (if applied), and before shipment if heat treatment is not required.

10.3 Marking

In addition to all other marking, reference to this specification shall also appear on the finished products i.e. 6-44-0060

10.4 Certificates

In addition to all other information, reference to this specification shall also appear on the final certificates i.e. 6-44-0060

11.0 SPECIFICATIONS & CHEMICAL COMPOSITION OF PRODUCTS

See Table 1 to Table 4
Table-1
Chemical Composition for Pipes

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.23 % max</td>
</tr>
<tr>
<td>Mn</td>
<td>1.35 % max</td>
</tr>
<tr>
<td>Si</td>
<td>0.10 % to 0.35 % max</td>
</tr>
<tr>
<td>P</td>
<td>0.02 % max</td>
</tr>
<tr>
<td>Ni</td>
<td>0.20 % max</td>
</tr>
<tr>
<td>S</td>
<td>0.010 % max for seamless</td>
</tr>
<tr>
<td></td>
<td>0.003 % max for welded</td>
</tr>
<tr>
<td>Other elements</td>
<td>As per specification</td>
</tr>
<tr>
<td>Pcm</td>
<td>0.21 % max</td>
</tr>
<tr>
<td>CE</td>
<td>0.40 % max</td>
</tr>
</tbody>
</table>

1.0 The following material designations are applicable with restriction of chemical composition as above.

1.1 ASTM A106 Gr.B  Seamless
1.2 ASTM A333 Gr.6  Seamless
1.3 API 5l Gr.B     Seamless & SAW (longitudinal)
1.4 API 5l Gr.X52   SAW (longitudinal)
1.5 API 5l Gr.X60   SAW (longitudinal)
1.6 ASTM A671 Gr CC70 Cl.32  SAW (longitudinal)
1.7 ASTM A672 Gr.CC70 Cl.32  SAW (longitudinal)

2.0 Pipes may be supplied in quenched and tempered or normalised condition.
Table-2
Chemical Composition for Fittings

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.23 % max</td>
</tr>
<tr>
<td>Mn</td>
<td>1.35 % max</td>
</tr>
<tr>
<td>Si</td>
<td>0.10 % to 0.35 % max</td>
</tr>
<tr>
<td>P</td>
<td>0.02 % max</td>
</tr>
<tr>
<td>Ni</td>
<td>0.20 % max</td>
</tr>
<tr>
<td>S</td>
<td>0.010 % max for seamless</td>
</tr>
<tr>
<td></td>
<td>0.003 % max for welded</td>
</tr>
<tr>
<td>Other elements</td>
<td>As per specification</td>
</tr>
<tr>
<td>Pcm</td>
<td>0.21 % max</td>
</tr>
<tr>
<td>CE</td>
<td>0.40 % max</td>
</tr>
</tbody>
</table>

1.0 The following material designations are applicable with restriction of chemical composition as above.

1.1 ASTM A105 Forged

1.2 ASTM A234 Gr.WPB Seamless

1.3 ASTM A234 Gr.WPBW/WPCW Welded

1.4 ASTM A350 Gr.LF2 Forged

1.5 ASTM A420 Gr.WPL6 Seamless

1.6 MSS-SP-75 Gr.WPHY52 Welded

1.7 MSS-SP-75 Gr.WPHY60 Welded

2.0 Fittings may be supplied in quenched and tempered or normalised, or normalised and tempered condition. However all bends formed by induction heating shall be tempered afterwards to meet hardness requirements.
Table-3
Chemical Composition for Flanges

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.23 % max</td>
</tr>
<tr>
<td>Mn</td>
<td>1.35 % max</td>
</tr>
<tr>
<td>Si</td>
<td>0.10 % to 0.35 % max</td>
</tr>
<tr>
<td>P</td>
<td>0.02 % max</td>
</tr>
<tr>
<td>Ni</td>
<td>0.20 % max</td>
</tr>
<tr>
<td>S</td>
<td>0.010 % max</td>
</tr>
<tr>
<td>Other elements</td>
<td>As per specification</td>
</tr>
<tr>
<td>Pcm</td>
<td>0.21 % max</td>
</tr>
<tr>
<td>CE</td>
<td>0.40 % max</td>
</tr>
</tbody>
</table>

1.0 The following material designations are applicable with restriction of chemical composition as above.

1.1 ASTM A105

1.2 ASTM A350 Gr.LF2

1.3 ASTM A694 Gr.L52

1.4 MSS-SP-44 Gr.F60

2.0 Flanges may be supplied in quenched and tempered or normalised, or normalised and tempered condition.
Table-4
Chemical Composition for Valves
Gate / Globe / Check / Ball / Needle

<table>
<thead>
<tr>
<th>Element</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.23 % max</td>
</tr>
<tr>
<td>Mn</td>
<td>1.35 % max</td>
</tr>
<tr>
<td>Si</td>
<td>0.10 % to 0.35 % max</td>
</tr>
<tr>
<td>P</td>
<td>0.02 % max</td>
</tr>
<tr>
<td>Ni</td>
<td>0.20 % max</td>
</tr>
<tr>
<td>S</td>
<td>0.010 % max</td>
</tr>
<tr>
<td>Other elements</td>
<td>As per specification</td>
</tr>
<tr>
<td>Pcm</td>
<td>0.21 % max</td>
</tr>
<tr>
<td>CE</td>
<td>0.40 % max</td>
</tr>
</tbody>
</table>

1.0 The following material designations are applicable with restriction of chemical composition as above.

1.1 ASTM A105 Forged
1.2 ASTM A216 Gr.WCB Casting
1.3 ASTM A350 Gr.LF2 Forged
1.4 ASTM A352 Gr.LCB Casting

2.0 Forgings may be supplied in quenched and tempered or normalised, or normalised and tempered condition.
ABBREVIATIONS

NACE    National Association of Corrosion Engineers
SSC     Sulfide Stress Cracking
HIC     Hydrogen Induced Cracking
Temp    Temperature
Std     Standard
MSS–SP  Manufacturers Standardisation Society-standard Practice
ANSI    American National Standards Institute
ASTM    American Society for Testing and Materials
CE      Carbon Equivalent
CLR     Crack Length Ratio
CSR     Crack Sensitivity Ratio
HAZ     Heat Affected Zone
SMLS    Seamless
SAW     Submerged Arc Welded
LLOYDS  Lloyds Register of Industrial Service
BV      Bureau Veritas
DNV     DNV Veritas
ABSTECH ABS Worldwide Technical Service
SGS     SGS Inspection Service
TUV     Technisches Untersuchungs und Vorschungszentrum
EIL Engineers India Limited

= < Equal to or less than

> Greater than

GLOSSARY

Within the context of this specification the following words shall have the meaning stated.

Product - Refers to pipe, fitting, flange, or type of valve or plate
Appendix - 1
List of Prequalified Manufacturers for Pipe
(as on 1.07.1998)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Material</th>
<th>Manufacturer</th>
<th>Remarks / Job No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mannessmann Rohrenwerke, Germany</td>
<td>OED</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Dalmine, Italy</td>
<td>OED</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Thyssen Stahlunion GMBH, Germany</td>
<td>OED</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Coprosider (M/s Dalmine), Italy</td>
<td></td>
<td>2917</td>
</tr>
<tr>
<td>5</td>
<td>ASTM A333 Gr.6 - Seamless</td>
<td>Dalmine, Italy</td>
<td>2917</td>
</tr>
<tr>
<td>6</td>
<td>API 5LX Gr.60/65</td>
<td>Europipe GMBH, Germany</td>
<td>2917</td>
</tr>
<tr>
<td>7</td>
<td>ASTM A106 Gr.B - Seamless</td>
<td>NKK, Japan</td>
<td>2917</td>
</tr>
</tbody>
</table>
Appendix - I  
List of Prequalified Manufacturers for Fittings  
(as on 1.07.1998)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IBF</td>
<td></td>
<td></td>
<td>Dalmine (Pipe Source)</td>
<td>OED</td>
</tr>
<tr>
<td>2</td>
<td>ASTM A234 Gr. WPB</td>
<td>Shulz Asia</td>
<td></td>
<td>Mannessmann Rohrenwerke</td>
<td>OED</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Pipe Source)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Trauway &amp; Cauvin, France</td>
<td></td>
<td></td>
<td>Dalmine (Pipe Source)</td>
<td>OED</td>
</tr>
<tr>
<td>4</td>
<td>MSS-SP-75 Gr. WPHY60</td>
<td>Coprosider</td>
<td>IBF</td>
<td>Flick</td>
<td>2917</td>
</tr>
<tr>
<td></td>
<td>Welded</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>MSS-SP-75 Gr. WPHY60</td>
<td></td>
<td></td>
<td>Dalmine</td>
<td>2917</td>
</tr>
<tr>
<td></td>
<td>Seamless</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ASTM A420 Gr. WPL6</td>
<td></td>
<td></td>
<td></td>
<td>2917</td>
</tr>
<tr>
<td>7</td>
<td>ASTM A105</td>
<td></td>
<td></td>
<td></td>
<td>2917</td>
</tr>
<tr>
<td>8</td>
<td>ASTM A350 Gr. LF2</td>
<td></td>
<td></td>
<td></td>
<td>2917</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>Nicola Galperti</td>
<td>Nicola Galperti</td>
<td></td>
<td>2917</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>Shulz Export (Shulz</td>
<td>Melesi</td>
<td>Safau</td>
<td>2917</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Asia)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Marubeni</td>
<td>Benkan</td>
<td>NKK Corp.</td>
<td>2917</td>
</tr>
</tbody>
</table>
Appendix - 1

List of Prequalified Manufacturers for Flanges
(as on 1.07.1998)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ASTM A105</td>
<td></td>
<td>Nicola Galperti</td>
<td>Acclaiera Di Rubiera</td>
<td>OED</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>Thyssen / Safau</td>
<td>OED</td>
</tr>
<tr>
<td>3</td>
<td>ASTM A350 Gr.LF2</td>
<td>Nicola Galperti</td>
<td>Thyssen / Safau</td>
<td>2917</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ASTM A105</td>
<td>Shulz Export</td>
<td>Orficine Ambrogio Melesi</td>
<td>Acclaiera Di Rubiera</td>
<td>2917</td>
</tr>
<tr>
<td>5</td>
<td>ASTM A694 Gr.F60</td>
<td>Shulz Asia)</td>
<td></td>
<td>OED</td>
<td>2917</td>
</tr>
<tr>
<td>6</td>
<td>MSS-SP-44 Gr.F60</td>
<td></td>
<td></td>
<td>OED</td>
<td>2917</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix - 1

List of Prequalified Manufacturers for Ball Valves
(as on 1.07.1998)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ASTM A105</td>
<td>TK Valves, Abu Dhabi, U.A.E.</td>
<td>SCH Miederverk Stoos, AG Zurich</td>
<td>ASO 25035 Ospitalet</td>
<td>OED</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>OMB S.P.A</td>
<td>FEAT</td>
<td>Rubiera</td>
<td>OED</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Grove Italia</td>
<td>Ringmill</td>
<td>Thyssen Stahl</td>
<td>OED</td>
</tr>
<tr>
<td>S.NO.</td>
<td>ITEM</td>
<td>BID REQUIREMENT</td>
<td>CLIENT’ COMMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------</td>
<td>------------------------------------------------------</td>
<td>----------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Equipments spacing (ISBL)</td>
<td>Generally OISD norms/ Licensor requirements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Minimum pipe rack width (Main Pipe rack)</td>
<td>6m, 8m, or 10m for single bay 12m, 16m or 20m for double bay</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Spare capacity on Rack/ Sleeper</td>
<td>25% (For New Unit)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Cooling water lines</td>
<td>• On rack upto 30”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Underground above 30”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Minimum height of sleeper</td>
<td>300mm For Paved area 500 mm For Unpaved area</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Fin-fan cooler location</td>
<td>On Pipe rack/ Tech structure top</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Location of pumps:</td>
<td>• In Units</td>
<td>• Pump discharge 1m outside rack with motor towards rack.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In offsites</td>
<td>• Open area (no shed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Requirements of monorail on pumps:</td>
<td>• Under Pipe rack/ shed</td>
<td>• In Motor rating 75KW and above for all pumps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In Open area</td>
<td>• None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Means for exchanger bundle removal:</td>
<td>• In open area at grade and on tech structures top floor open to sky</td>
<td>• None</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• On Tech Structures except top floor open to sky</td>
<td>• Hydroextractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Battery limit valves operation:</td>
<td>• OSBL Piping on sleepers</td>
<td>• Operatable from ground/platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• OSB/ISBL Piping on piperack</td>
<td>• Operatable from platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Pipe way road crossing</td>
<td>Culvert for sleepers &amp; Overhead pipe bridges for rack.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Electrical cable routing underground/above ground</td>
<td>As per Electrical Design Basis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Instrument Cable Routing:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– ISBL</td>
<td>– On rack (Refer Instrument Design Basis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>– OSBL</td>
<td>– On Sleeper/Rack (Refer Instrumentation Design Basis)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Any reaquirement of statutory approval</td>
<td>IBR regulations for projects in India</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Safety shower/eye wash</td>
<td>As per P &amp; ID</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Requirements of elevators</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Connectivity of all platforms at higher elevations for tall columns &amp; technological structures</td>
<td>Wherever feasible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Compressor house for ISBL &amp; OSBL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Location</td>
<td>● Under shed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Maintenance requirement</td>
<td>● E.O.T (ISBL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>* E.O.T. Crane shall be used only for those cases where availability of H.O.T</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Instrument Air Drier Shed</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Insulation material:</td>
<td>As per Process Design Basis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Hot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Cold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Electrical heat tracing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Type of environment for selection of painting system: Normal corrosive/Corrosive/Highly corrosive</td>
<td>Highly corrosive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Method of surface preparation:</td>
<td>Blast cleaning (Grit blasting)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Mechanical tools</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Power tool cleaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>● Blast cleaning</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Corrosion protection below insulation:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• CS Pipe (upto 125°C operating temperature) • As per TEIL Painting spec</td>
<td></td>
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<td></td>
<td>• SS Pipe • Aluminium Foil</td>
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<tr>
<td>a) Cold Insulated</td>
<td>• As per TEIL Painting Spec</td>
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<tr>
<td>24</td>
<td>Specific colour coding requirement</td>
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<td></td>
<td>HPCL’s Colour Coding</td>
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<tr>
<td>25</td>
<td>Usage of IS grade material</td>
<td></td>
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<td></td>
<td>Limited to CAT-D services as per ASME B31.3 &amp; Fire water service</td>
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<tr>
<td>26</td>
<td>Usage of asbestos sheet gasket</td>
<td></td>
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<tr>
<td></td>
<td>No</td>
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<tr>
<td>27</td>
<td>Provision for high settlement in tank farm:</td>
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<tr>
<td></td>
<td>• Usage of dresser coupling in tank farms</td>
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<td></td>
<td>• Flexibility of piping</td>
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<td>28</td>
<td>Steam tracing</td>
<td></td>
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<td></td>
<td>Standard modules with integral glandless piston valves</td>
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<tr>
<td>29</td>
<td>Bulk Material Supplier</td>
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<td></td>
<td>TEIL vendor list (duly approved by HPCL)</td>
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<td>30</td>
<td>Engineering Drawing mode</td>
<td></td>
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<td></td>
<td>Electronic - ISBL/OSBL</td>
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<td></td>
<td>Specific software package for engineering drawing:</td>
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<tr>
<td>31</td>
<td>• Autocad, AP-ISO &amp; Isketch</td>
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<td></td>
<td>• For revamp jobs in Units &amp; Offsites</td>
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<td></td>
<td>• PDS/PDMS with Isogen</td>
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<td>• For units</td>
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<tr>
<td></td>
<td>• AutoPlant Designer/Autocad</td>
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<td></td>
<td>• Offsites</td>
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<tr>
<td>32</td>
<td>Material Constrol System</td>
<td></td>
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<td></td>
<td>TEIL-In-House software package (For jobs for which detail engineering is done by TEIL). LSTK - Contactor software package (for LSTK jobs)</td>
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<td>33</td>
<td>Item Coding System</td>
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<td>TEIL practice (For jobs for which detail engineering is done by TEIL)</td>
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<td></td>
<td>• LSTK - Contactor's practic (for LSTK jobs)</td>
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<tr>
<td></td>
<td>Description</td>
<td>Details</td>
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<td>34</td>
<td>Stress analysis package</td>
<td>CAESAR-II</td>
<td></td>
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<tr>
<td>35</td>
<td>Access to nozzles of columns</td>
<td>Platform for all manholes, and nozzles. However ladder access may be provided for instrument connections</td>
<td></td>
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<tr>
<td>36</td>
<td>Staircase / Ladders for all columns</td>
<td>Ladder</td>
<td></td>
<td></td>
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<tr>
<td>37</td>
<td>Provision of breakup flanges for removal of tube bundles of heat exchangers</td>
<td>Nil</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>38</td>
<td>Height of pipe support pedestals</td>
<td>150 mm</td>
<td></td>
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</tbody>
</table>
| 39 | Mandatory Bulk Material Escalation                                          | • TEIL Standard (For Jobs for which detail engineering is done by TEIL)  
• As per LSTK Contractor (For LSTK jobs) |
| 40 | Cathodic Protection of Tankage and U/G Piping                               | Required / Not Required                                                  |
| 41 | Cast iron valves                                                           | None                                                                    |
| 42 | Strainers:                                                                  | • Upto 1½” irrespective of service                                      
• 2” & above in services other than steam |
| 43 | Dynamic stress analysis                                                     | Required for:                                                           
• Two phase flow lines with slug /plug flow      
• Transfer lines                                  |
| 44 | Pump discharge piping layout                                               | Pump discharge to be routed away from motor side                        |
| 45 | Piping isolation valve for instruments/Stand Pipes                          | As per P & ID / Process Design Basis                                    |