









 	<b>PROJECT</b>		<b>Standby SRU &amp; Additional Tanks</b>		
	<b>CLIENT</b>		<b>INDIAN OIL CORPORATION LIMITED</b>		
<b>STANDARD SPECIFICATION FOR FABRICATION &amp; ERECTION OF PIPING</b>	<b>Project No.</b> 080557C001	<b>Document No.</b> 080557C-000-JSC-1300-001		<b>Rev. No.</b> A	Page 1 of 23

## STANDARD SPECIFICATION FOR FABRICATION & ERECTION OF PIPING

			 <small>Written By</small>  <small>Mayappan Somasundaram</small> <small>2019.10.11 17:29:26</small> <small>+05'30'</small>	 <small>Checked By</small>  <small>Loganathan Sudarsan</small> <small>2019.10.11 17:29:26</small> <small>+05'30'</small>	 <small>Approved By</small>  <small>Rango Thottakal</small> <small>2019.10.11 18:01:19</small> <small>+05'30'</small>	 <small>Authorized By</small>  <small>Jeyaraman</small> <small>2019.10.15 21:03:47</small> <small>+05'30'</small>
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REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	AUTHORIZED



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## 1. Introduction:

**INDIAN OIL CORPORATION LIMITED (IOCL)** has awarded Fax of Acceptance (FOA) dated 29<sup>th</sup> August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

## 2. Definitions & Abbreviations

Wherever used in this procedure, the following words shall have the meaning as given hereunder

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit
IBR	Indian Boiler Regulations
PMI	Positive Material Identification
A.S	Alloy Steel

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C.I	Cast Iron
S.S	Stainless Steel
C.S	Carbon Steel
LTCS	Low Temperature Carbon Steel
NDT	Non-Destructive Testing
NACE	National Association of Corrosion Engineers
OISD	Oil Industry Safety Directorate
ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
P&ID	Piping and Instrumentation Diagram
A/G	Above Ground
U/G	Under Ground

### 3. Scope

This specification covers general requirements of fabrication and erection of above ground and in-trench piping systems at fabrication shop & site. The specification covers the scope of work of Contractor, basis of work to be carried out by Contractor and standards, specifications and normal practice to be followed during fabrication and erection by the Contractor.



### 4. Conflicts, Deviations and Clarifications:

Any conflicts between this specification and other applicable Engineering Standards, Material Specifications, Standard Drawings, Engineering Procedures, Company Forms or Industry standards, specifications, Codes and forms shall be brought to the attention of Authorised Representative by the Contractor for resolution.

Until the resolution is officially made by the Authorized Representative, the most stringent requirement shall govern.

Where a licensor specification is more stringent than those of this standard, the Licensor's specific requirement shall apply.

Where applicable Codes or Standards are not called by this standard or its requirements

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are not clear, it shall be brought to attention of Authorised Representative by Contractor for resolution.

Direct all requests for deviations or clarifications in writing to the Authorised Representative for final resolution.



## 5. Scope of Work of Contractor

Generally, the scope of work of Contractor regarding “Fabrication & Erection of Piping” shall include the following:

- 5.1 Transportation of required piping materials (as described in 5.1.1), pipe support (material as described in 5.3) and all other necessary piping material from Contractor’s storage point (Contractor’s scope of supply) & Owner’s storage point (Owner’s scope of supply if any) to work site/shop including raising store requisitions for issue of materials in the prescribed format & maintaining an account of the materials received from Contractor’s/Owner’s stores

- 5.1.1 Piping materials include the following but not limited to the same.

- a. Pipes (All sizes and schedule)
- b. Flanges (All sizes, types & Pressure ratings).
- c. Fittings (All sizes, types and schedule)
- d. Valves (All sizes, types and Ratings)
- e. Gaskets (All sizes, types & Ratings)
- f. Bolts, Nuts or M/C Bolts (All types)
- g. Expansion Joint/Bellows (All types)
- h. Specialty items like online filters, ejectors, sample coolers, steam traps, strainers, air traps, springs, silencers, snubbers, steam and condensate manifolds, injection nozzles, MOVs, sight glass, hoses, hose couplings, etc.
- i. On line instruments like control valve, on-off valves, orifice flange, all types of flow measuring instruments, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, Pressure Measuring Instruments, ejectors, static mixers, flame arrestors, thermal flow switches, pre- fabricated hook-ups etc.

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- j. Shut Down Valves with and without fire-proofing box
- k. Safety/Firefighting items connected with piping like Deluge Valves, Spray Nozzles, Hoses, Hydrants, Monitors, Hose reels etc.,
- l. Any other item required for piping fabrication & erection, testing, inspection, cleaning, flushing, marking and painting etc.,
- m. All pipe support materials, structural, hangers, prefabricated items, brackets, sliding plates, or any other material used for supporting purpose.



5.2 Shop & field fabrication and erection of piping in accordance with documents listed under 6.1 i.e. 'BASIS OF WORK' including erection of all piping materials enumerated above.

5.3 Fabrication and erection of pipe supports like shoe, saddle, guide, stops, anchors, clips, cradles, hangers, turn-buckles, supporting fixtures, bracket cantilevers, struts, tee-posts including erection of spring supports, sway braces, trunnions (dummy pipes), corrosion pads/protection shields, low friction pads, clamps, special supports, stiffeners and stiffening rings.



#### 5.4 Fabrication of Piping items

Fabrication of Piping items shall include but not be limited to the following

- 5.4.1 Fabrication of piping specials like special radius bends, reducers, mitres etc.
- 5.4.2 Fabrication of plain and threaded nipples from pipes as required during erection.
- 5.4.3 Fabrication of swage nipples as and when required.
- 5.4.4 Fabrication of odd angle elbow like 60°, 30° or any other angle from 90°/45° elbows as and when required.
- 5.4.5 Fabrication of flange, reducing flange, blind flange, spectacle blinds as and when required.
- 5.4.6 Fabrication of stub-in connection with or without reinforcement. External reinforcing pads shall have a minimum of one ¼" vent hole. Pads for branch connections greater than 16 inch shall have minimum of 2 vent holes. Pads installed in sections shall have at least one vent per section. Vents shall remain open until the completion of pressure testing. Plug material shall be adequate for the operating temperature but shall not be capable of sustaining pressure between the reinforcing plate and pipe.
- 5.4.7 Grinding of edges of pipes, fittings, flanges etc. to match mating edges of uneven/different thickness wherever required.



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- 5.4.8 Fabrication of circular pipe for steam rings, fire water lines, utility lines.
- 5.4.9 Threading of all small-bore piping as per piping material specifications.
- 5.4.10 Drilling on blind flange for inserting/joining small bore lines.
- 5.4.11 Fabrication and welding of reinforcement pads at branch pipe locations wherever required.
- 5.4.12 Equipment nozzle reinforcement with pads, jacket & stiffeners wherever required.
- 5.4.13 Fabrication of injection nozzles as per details provided wherever required.
- 5.4.14 Fabrication of chain operation arrangement for valves, wherever required. All material required for this modification shall be supplied by Contractor.
- 5.4.15 Fabrication and erection in position of funnels required for OWS/ SS/ Condensate blow down system.
- 5.4.16 Grinding/ finishing of uneven surfaces/ joints after welding. Internal grinding of welds of orifice flanges to render smooth surface.
- 5.4.17 Tapping and drilling of holes in flanges, blind flanges, piping connections for jack screw, if required.
- 5.4.18 Providing bird screens at the outlet of lines open to atmosphere.
- 5.4.19 Weep hole to be provided in the PSV exit line if its open to Atmosphere.
- 5.5 Modifications like providing additional cleats, extension of stem of valve, locking arrangement of valves etc. as and when required.
- 5.6 Preparation of miscellaneous small bore isometrics (where engineering Isometrics are not available) with bill of materials for process and utility lines (up to 1.5" size) like instruments & pump flushing / cooling, sample connection, purging, pump casing vents & drains, pump base plate drains, control valve drains / vent to flare, instrument drains & vents, steam tracing (non-IBR) from steam supply stations up to condensate recovery station, and lines specified as field routed within the Unit battery limit as and when required are in Contractor's scope of work. Approval for these isometrics prepared by the Contractor shall be taken from Engineer-In charge before erection.
- 5.7 Obtaining approval for drawings prepared by Contractor from statutory authority, if required like IBR etc.

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- 5.8 Rubber lining inside pipes, fittings, flanges as and when required, in accordance with specification.
- 5.9 Radiography, stress relieving, dye penetration, magnetic particle test etc. as required in specification.
- 5.10 Performing PMI using alloy analyzers as per 'Standard specification for Positive Material Identification at Construction Sites
- 5.11 Casting of concrete pedestals and Fabrication and erection of small structures/ platforms for pipe supports and valve operation / instruments, spectacle blinds etc., providing brackets, modification / extension of platforms, providing additional platforms / ladders for improving accessibility.
- 5.12 Providing insert plates with anchor fasteners in concrete structures/ paved floors and repair of platform gratings around pipe openings and providing suitable members for support under the platform grating.
- 5.13 Preparing material reconciliation statement and return of Owner's supply left over materials to Owner's storage if any.
- 5.14 Flushing and testing of all piping systems as per standard specification for inspection, flushing and testing of piping systems. The accessories required for blinding the line like flange, blind flange, gasket (all sizes, type and rating), stud-bolts, flexible hoses etc. are to be arranged by the Contractor. During flushing the discharged water / air shall be drained / routed as directed by Engineer-In Charge at site.
- 5.15 Contractor shall prepare welding specifications for all weld joints where dissimilar welding will be performed, and obtain approval from Engineer-In Charge at site.
- 5.16 Contractor to ensure meeting all requirements for carrying out work in shutdown/running plant.
- 5.17 Pickling (as and when applicable) as per Job specification(s) for chemical cleaning of suction piping of compressors, SS Piping, Weldments etc., as applicable.
- 5.18 Chemical Cleaning/ Hydro jet cleaning as per marked-up P&IDs with supply of chemicals, consumables, DM water, equipment, boilers, coupons, tools & tackles and other testing equipment as applicable required for the same.



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5.19 Site clearing of piping leftovers and other debris and making the site free and clean thoroughly of any waste and or unused materials.

5.20 Providing steam/electrical tracing wherever specified as per specification.

5.21 Ceramic / refractory or any other inner lining of pipes as specified.

## 6 Basis For Work

6.1 The complete piping work shall be carried out in accordance with the following:

6.1.1 "Approved for Construction" drawings, GADs, Layout plans, Isometrics and other sketches issued by Contractor.



6.1.2 "Approved for Construction" drawings, GADs, Layout plans, Isometrics and other sketches supplied by package vendor.

6.1.3 Approved Process Licensor's standards and specification

6.1.4 Approved construction job procedures prepared by Contractor as stipulated.

6.1.5 Following drawings/documents/specifications prepared by Contractor duly approved by Authorised Representative:

- a) P & ID
- b) Line List
- c) Piping Material Specification
- d) Piping Support & Construction Standards
- e) Standard Specification for Hot Insulation of Vessels, Piping and Equipment
- f) Standard Specification for Cold Insulation of Vessels, Piping and Equipment
- g) Standard Specification for Painting & Coating
- h) Job Specification for Steam Tracing & Jacketed Piping
- i) Job Specification for Piping Support Design
- j) Standard Specification for Non-Destructive Testing Requirement of Piping
- k) Standard Specification for application of torque & hydraulic bolt tension for flange joints

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- l) Welding specification for the fabrication of Piping including Welding specification chart for piping
- m) Standard specification for pressure testing of erected piping system
- n) Procedure for storage, preservation and positive identification of materials (PMI) at Contractors work / stores
- o) Inspection & Test Plan for Piping
- p) Instrument installation sketches
- q) Structural drawings wherever required



#### 6.1.6 Following codes, standards and regulations

- a) ASME B 31.3 : Process Piping
- b) ASME B 31.1 : Power Piping
- c) ASME Sec. VIII & IX : ASME Boiler and Pressure Vessel Code
- d) IS: 823 : Code of procedure for Manual Metal Arc Welding of Mild Steel
- e) IBR Regulations

Note: All codes referred shall be latest edition, at the time of award of contract.

## 7 Storage & Handling Materials

- 7.1 All materials, whether loose or prefabricated shall be stored above ground on a flat surface, on platforms or pallets, in a manner that will prevent any deterioration from debris, grease, salts, sea water, paint spray or any other foreign matter.
- 7.2 Stainless steel and duplex stainless steel piping shall be stored on wooden blocks, in segregated areas from carbon, alloy and galvanized carbon steel, to prevent any possibility of cross contamination during cutting and welding.
- 7.3 Stainless steel and duplex stainless steel materials shall not be loaded, unloaded or handled with hoisting devices (e.g. steel ropes and forklift trucks) containing zinc or other harmful materials.

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- 7.4 Materials destined for Indian Boiler Regulation coded systems shall be separated from other materials of equivalent chemistry.

## 8 FABRICATION

### 8.1 General

Fabricated metal piping shall meet local authority requirements like IBR, etc for all piping requiring inspection and approval by local authorities.

All other fabricated metal piping shall meet the requirements of ASME B31.1 / B31.3

To prevent corrosion of stainless steel, duplex stainless steel and other high-alloy steels, fabrication of carbon steel, galvanized carbon steel and low-alloy steel shall be done in a separate area. Area means different shops or two areas in one shop separated by suitable (temporary) walls

For the same reason as above, tools used for fabrication of carbon steel, galvanized steel and low-alloy steel may not be used for fabrication of stainless steel, duplex stainless steel and other high-alloy steel. Only tools made of stainless steel are allowed for grinding, brushing, clamping, etc.

These requirements apply to shop and field fabrication.

### 8.2 Shop Fabrication



Shop fabrication under this specification shall include all the components of the pipeline or parts thereof entering into fabricated assemblies (spools), but shall exclude all piping specialties other than those with welding end constructions such as bolting, gaskets, flanged valves and fittings, blind flanges, orifice plates and similar items.

CONTRACTOR is responsible for selection of piping to be shop fabricated on site or off site.

### 8.3 Shop Detail Drawings

The CONTRACTOR can use authorized software tools to make shop detail spool drawings for piping fabrication.

Spool piece mark number shall be assigned and shall follow in sequential order, the fabricated spools in a line, ascending in direction of flow.

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Lines covered by several sequential isometric sheets, shall have piece mark numbers following the same sequence for the entire pipe line.

A number, consisting of the plant or unit number, commodity symbol, line number, and spool piece number, shall identify each pipe spool.

Piece mark numbers and location of field welds between shop fabricated spool pieces shall be shown on the CONTRACTOR's spool drawings.

#### 8.4 Spool Identification

Spools shall be identified by a detail number comprising of their line number and spool suffix which must be weather proof and painted or marked in characters at least 50 mm high and bar code identification also to be done.

Numbers must be located, and repeated as necessary, in such a manner that any spool may be easily identified without turning or lifting it.

#### 8.5 Location of Field Welds

The size of spools and location of field welds shall be determined by CONTRACTOR.

Lengths of spools shall not be limited by "match lines" that appear on drawings. A line and its branches which appear on more than one drawing is not intended to mean that a field weld is desired at the continuation point from one drawing to another.



Where piping is shown passing through a wall or floor, the first weld point on either side of the wall or floor shall be made a field weld, provided it is located at least 150 mm away from the end of the pipe sleeve.

Erection conditions shall be considered in determining the size of spool.

#### 8.6 Field Fabrication

Field fabrication under this specification covers, but is not necessarily limited to the following operations:

- 8.6.1 Erection of shop-fabricated piping.
- 8.6.2 Fabrication and erection of all field-fabricated piping.
- 8.6.3 Design, routing, fabrication and erection of all field-fabricated piping for which no piping drawings are available.

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8.6.4 Fabrication and erection of all pipe supports and auxiliary steel as detailed in the pipe support drawings.

8.6.5 Design, fabrication and erection of all pipe supports for small bore piping, which shall be executed in line with the available drawings for supports.

## 8.7 Verification of Field Dimensions

Fabrication of piping and pipe supports shall be in accordance with the drawings. However, due to equipment location and fabrication tolerances, field verification of overall dimensions shall be made by CONTRACTOR prior to erection, to ensure a proper fit up at all connections to equipment and other piping.

## 8.8 Longitudinal welding Joints



The longitudinal welds of two (2) adjacent rings or tubes shall be staggered approximately 90°. Longitudinal welds shall not be situated at the bottom of the pipe and positioned at least 45° upwards.

## 8.9 Piping Material

Pipe, pipe fittings, flanges, valves, gaskets, studs bolts etc. used in a given piping system shall be strictly as per the "Piping Material Specification" for the "Pipe Class" specified for that system. To ensure the above requirement, all piping material supplied by the Contractor / Owner (if any) shall have proper identification marks as per relevant standards / PMC specifications / Licensors specification. Contractor shall provide identification marks on left over pipe lengths wherever marked up pipe lengths have been fabricated/erected. Material-traceability is to be maintained for A.S., S.S., NACE, LTCS, IBR, material for Hydrogen service and other exotic materials by way of transferring heat number, etc. (hard punching) as per approved procedure. This shall be in addition to color coding for all piping materials to avoid mix-up.

Betterment of common understanding, the construction job procedure to be submitted by the Contractor, shall include proposal for

- Maximizing prefabrication, inspection and testing at fabrication shop with minimum field joints.
- Positive material identification, handling, storage & preservation.
- Shop fabrication of piping supports to the maximum extent feasible. All sharp corners of base plate and other plates shall be rounded and ground smooth.

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## 8.10 Dimensional Tolerances



The Contractor shall be responsible for working to the dimensions shown on the drawings. However, the Contractor shall bear in mind that there may be variations between the dimensions shown in the drawing and those actually existing at site due to minor variations in the location of equipment, inserts, structures etc. To take care of these variations "Field Welds" shall be provided during piping fabrication. An extra pipe length of 100 mm over and above the dimensions indicated in the drawing may be left on one side of the pipe at each of the field welds. During erection, the pipe end with extra length at each field weld, shall be cut to obtain the actual dimension occurring at site. Fabrication tolerances shall be governed by the relevant code and IOCL standard for fabrication tolerances, whichever is more stringent.

## 8.11 IBR Piping

Contractor shall obtain approval for the piping systems falling under purview of IBR from the statutory Indian Boiler Regulations (IBR) authority of the state where the plant is situated. The Contractor shall carry out the fabrication, erection and testing of this piping as per requirements of Indian Boiler Regulations and to the entire satisfaction of the local Boiler Inspector. The Contractor shall also get the approval of IBR inspector for all fabrication and testing done by him at his own cost. All certificates of approval shall be in proper IBR forms. All IBR approved drawings and certificates to be handed over to Owner through PMC.

Contractor shall perform all the approval related activities which are listed below but not limited to;

- Piping Isometric Dossier Submission to IBR Authority
- Receipt of Drawing Approval from IBR Authority
- Construction Contractor approval from IBR Authority
- IBR Welders Qualification
- Line Registration
- Material Inspection by IBR
- Submission of reports (like Form-III A, III B, III C) to IBR Authority
- Submission of Test Package Dossiers / As-built drawings along with Original IBR Certificates to IBR and obtaining clearance for Pressure Test from IBR Authority
- Obtaining Final Acceptance from IBR Certificate

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IBR Package for residual, field routed and site modified steam lines shall be prepared by the Contractor. IBR approval for the same shall be in Contractor's scope, at his own cost.

## 8.12 Pipe Joints

The piping class of each line specifies the type of pipe joints to be adopted. In general, joining of lines 2" and above in process and utility piping shall be accomplished by butt-welds.

Joining of lines 1-1/2" and below shall be by socket welding/butt welding/threaded joints as specified in "Piping Material Specifications".

However, in piping 1-1/2" and below where socket welding/ threaded joints are specified butt-welds may be used with the approval of Engineer-In Charge for pipe to pipe joining in long runs of piping. This is only applicable for non-galvanized piping without lining.

Flange joints shall be used at connections to Vessels, Equipment, Valves and where required for ease of erection and maintenance as indicated in drawings.

## 8.13 Butt Welded and Socket Welded Piping

End preparation, alignment and fit-up of pipe pieces to be welded, welding, pre-heating, post-heating and heat treatment shall be as described in the Job welding specification and NDT specification.



## 8.14 Screwed Piping

In general, Galvanized piping shall have threads as per IS:554 or ANSI B2.1 NPT as required to match threads on fittings, valves etc. All other piping shall have threads as per ANSI B2.1, tapered unless specified otherwise.

Threads shall be clean cut, without any burrs or stripping and the ends shall be reamed. Threading of pipes shall be done preferably after bending, forging or heat treating operations. If this is not possible, threads shall be gauge checked and chased after welding heat treatment etc.

During assembly of threaded joints, all threads of pipes and fittings shall be thoroughly cleaned of cuttings, dirt, oil or any other foreign matter. The male threads shall be coated with thread sealant and the joint tightened sufficiently for the threads to seal and give a leakproof joint. Threaded joints to be seal-welded shall be cleaned of all foreign matter, including sealant and made up to full thread engagement before seal welding.



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### 8.15 Flange Connections

All flange facings shall be true and perpendicular to the axis of pipe to which they are attached. Flanged bolt holes shall straddle the normal centerlines unless different orientation is shown in the drawing.

Wherever jack screws are to be provided, drilling and tapping for the jack screws in the flange, shall be done as per Specification/Standard before welding it to the pipe.

### 8.16 Branch Connections

Branch connections shall be as indicated in the piping material specifications. For end preparation, alignment, spacing, fit-up and welding of branch connections refer welding specifications. Templates shall be used wherever required to ensure accurate cutting and proper fit-up.

Reinforcement pads shall be provided wherever indicated in drawings/ specifications etc. Reinforcing pads shall be the same material as the pipe.

Prior to welding, saddles or rings shall be drilled with one number of 1/4" NPT threaded hole for testing and venting. Threaded hole shall be sealed with compound after testing. No gap larger than 3 mm shall exist between the OD of the pipe and ID of the ring or saddle.

### 8.17 Bending

Bending shall be as per ASME B31.3 except that corrugated or creased bends shall not be used. Hot bending is not permitted in the field.



Cold bends for lines 1-1/2" and below, with a bend radius of 5 times the nominal diameter shall be used as required in place of elbows wherever allowed by piping specifications. Bending of pipes 2" and above may be required in some cases like that for headers around heaters, reactors etc.

The completed bend shall have a smooth surface, free from cracks, buckles, wrinkles, bulges, flat spots and other serious defects. They shall be true to dimensions. The flattening of a bend, as measured by the difference between the maximum and minimum diameters at any cross-section, shall not exceed 8% and 3% of the nominal outside diameter, for internal and external pressure respectively.

### 8.18 Forging and Forming

Forging and forming of small bore fittings, like reducing nipples for piping 1-1/2" and below, shall be as per ASME B 31.3.



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### 8.19 Mitre Bends and Fabricated Reducers

The specific application of welded mitre bends and fabricated reducers shall be governed by the Piping Material Specifications. Reducers shall be fabricated as per directions of Engineer-In charge. The radiographic requirements shall be as per Material Specifications for process and utility systems and NDT Specification for steam piping under IBR, radiographic requirements of IBR shall be complied with.

### 8.20 Cutting and Trimming of Standard Fittings & Pipes

Components like pipes, elbows, couplings, half-couplings etc. shall be cut / trimmed / edge prepared wherever required to meet fabrication and erection requirements, as per drawings and instructions of Engineer-In charge. Nipples as required shall be prepared from straight length piping.

### 8.21 Galvanized Piping

Galvanized carbon steel piping shall be completely cold worked, so as not to damage galvanized surfaces. This piping involves only threaded joints and additional external threading on pipes may be required to be done as per requirement.



### 8.22 Jacketed Piping & Tracing

The Jacketing & Steam Tracing shall be done in accordance with PMC/Licensors' job specification.

Pre-assembly of jacketed elements to the maximum extent possible shall be accomplished at shop by Contractor. Position of jump-over and nozzles on the jacket pipes, fittings etc. shall be marked according to pipe disposition and those shall be prefabricated to avoid damaging of inner pipe and obstruction of jacket space. However, valves, flow glasses, in line instruments or even fittings shall be supplied as jacketed.

### 8.23 Shop Fabrication /Prefabrication

The purpose of shop fabrication or pre-fabrication is to minimize work during erection to the extent possible. Piping spool, after fabrication, shall be stacked with proper identification marks, so as facilitate their withdrawal at any time during erection. During this period, all flange (gasket contact faces) and threads shall be adequately fabricated

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by coating with removable rust preventive & all openings are to be covered to prevent entry of foreign materials. Care shall also be taken to avoid any physical damage to flange faces and threads.

## 8.24 Miscellaneous

Contractor shall fabricate miscellaneous elements like flash pot, seal pot, sample cooler, supporting elements like turn buckles, extension of spindles and interlocking arrangement of valves, operating platforms as required by Engineer-In charge at Site.

## 9.0 ERECTION

### 9.1 Cleaning of Piping before Erection

Before erection all pre-fabricated spool pieces, pipes, fittings etc. shall be cleaned inside and outside by suitable means. The cleaning process shall include removal of all foreign matter such as scale, sand, weld spatter chips etc. by wire brushes, cleaning tools etc. and blowing with compressed air/or flushing out with water. Special cleaning requirements for some services, if any, shall be as specified in the piping material specification or isometric or line list. S.S jacketed piping requiring pickling shall be pickled to remove oxidation and discoloring due to welding.

### 9.2 Piping Routing



No deviations from the piping route indicated in drawings shall be permitted without the consent of Engineer-In charge or Authorised Representative.

Pipe to pipe, pipe to structure / equipment's distances / clearances as shown in the drawings shall be strictly followed as these clearances may be required for the free expansion of piping /equipment. No deviations from these clearances shall be permissible without the approval of Engineer-In charge or Authorised Representative.

In case of fouling of a line with other piping, structure, equipment etc. the matter shall be brought to the notice of Engineer-In charge or Authorised Representative and corrective action shall be taken as per his instructions.

### 9.3 Slopes

Slopes specified for various lines in the drawings / P&ID shall be maintained by the Contractor. Corrective action shall be taken by the Contractor in consultation with



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Engineer-In charge or Authorised Representative wherever the Contractor is not able to maintain the specified slope.

#### 9.4 Expansion Joints / Bellows

Installation of Expansion Joints/Bellows shall be as follows:

- 9.4.1 All Expansion joints / Bellows shall be installed in accordance with the specification and installation drawings.
- 9.4.2 a. Upon receipt, the Contractor shall remove the Expansion Joints/ Bellows from the case(s) and check for any damage occurred during transit.
- b. The Contractor shall bring to the notice of the Engineer-In charge any damage one to the bellows / corrugations, hinges, tie-rods, flanges/ weld ends etc.
- c. Each Expansion Joint / Bellow shall be blown free of dust / foreign matter with compressed air or cleaned with a piece of cloth.
- 9.4.3 a. For handling and installation of Expansion Joints, great care shall be taken while aligning. An Expansion Joint shall never be slinged from bellows corrugations/ external shrouds, tie / rods, angles.
- b. An Expansion Joint / Bellow shall preferably be slinged from the end pipes / flanges or on the middle pipe.
- 9.4.4 a. All Expansion Joints shall be delivered at "Installation length", maintained by means of shipping rods, angles welded to the flanges or weld ends or by wooden or metallic stops.
- b. Expansion Joints stop blocks shall be carefully removed after hydrostatic testing. Angles welded to the flanges or weld ends shall be trimmed by saw as per manufacturer's instructions and the flanges or weld ends shall be ground smooth.
- 9.4.5 a. The pipe ends in which the Expansion Joint is to be installed shall be perfectly aligned or shall have specified lateral deflection as noted on the relevant drawings.
- b. The pipe ends / flanges shall be spaced at a distance specified in the drawings.

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- 9.4.6 The Expansion Joint shall be placed between the mating pipe ends / flanges and shall be tack welded/bolted. The mating pipes shall again be checked for correct alignment.
- 9.4.7 Butt-welding shall be carried out at each end of the expansion joint. For flanged Expansion Joint, the mating flanges shall be bolted.
- 9.4.8 After the Expansion Joint is installed the Contractor shall ensure that the mating pipes and Expansion Joint are in correct alignment and that the pipes are well supported and guided.
- 9.4.9 The Expansion Joint shall not have any lateral deflection. The Contractor shall maintain parallelism of restraining rings or bellows convolutions.
- 9.4.10 Precautions
- For carrying out welding, earthing lead shall not be attached with the Expansion Joint.
  - The Expansion bellow shall be protected from arc weld spot and welding spatter.
  - Hydrostatic Testing of the system having Expansion Joint shall be performed with shipping lugs in position. These lugs shall be removed after testing and certification is over.



## 9.5 Flange Connections

While fitting up mating flanges, care shall be exercised to properly align the pipes and to check the flanges for trueness, so that faces of the flanges can be pulled together, without inducing any stresses in the pipes and the equipment nozzles. Extra care shall be taken for flange connections to pumps, turbines, compressors, cold boxes, air coolers etc. The flange connections to these equipment shall be checked for misalignment, excessive gap etc. after the final alignment of the equipment is over. The joint shall be made up after obtaining approval of Engineer-In charge.

Hydraulic bolt tensioning & torque tensioning shall be performed on flange joints as per the requirements specified in "Standard Specification for application of Torque Bolt Tension for flange joints"

Temporary protective covers shall be retained on all flange connections of pumps, turbines, compressors and other similar equipment until the piping is finally connected, so as to avoid any foreign material from entering these equipment.

The assembly of a flange joint shall be done in such a way that the gasket between these flange faces is uniformly compressed. To achieve this, the bolts shall be tightened in a proper sequence. All bolts shall extend completely through their nuts but

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not more than 1/4".

Steel to C.I. flange joints, if any, shall be made up with extreme care, tightening the bolts uniformly after bringing flange flush with gaskets with accurate pattern and lateral alignment.

## 9.6 Vents and Drains

High point vents and low point drains shall be provided as per drawings and in case if not shown in the drawings, Vents & Drains shall be added by contractor at site as per piping material specifications / design / construction standards.

## 9.7 Valves

Valves shall be installed with spindle / actuator orientation / position as shown in the layout/isometric drawings. In case of any difficulty in doing this or if the spindle orientation \ position is not shown in the drawings, the Engineer-In charge shall be consulted and work done as per his instructions. Care shall be exercised to ensure that globe valves, check valves, and other uni-directional valves are installed with the "Flow direction arrow" on the valve body pointing in the correct direction. If the direction of the arrow is not marked on such valves, this shall be done in the presence of Engineer-In charge before installation.



Fabrication of stem extensions, locking arrangements and interlocking arrangements of valves (if called for), shall be carried out as per drawings/ instructions of Engineer-In charge.

## 9.8 Instruments

Installation of in-line instruments as per 5.1(i) and (j) shall form a part of piping erection work.

Fabrication and erection of piping up to first block valve / nozzle / flange for installation of offline Instruments for measurement of level, pressure, temperature, flow etc. shall also form part of piping construction work. The limits of piping and instrumentation work will be shown in drawings/standards/specifications. Orientations/locations of take-offs for temperature, pressure, flow, level connections etc. shown in drawings shall be maintained.

Flushing and testing of piping systems which include instruments mentioned above and the precautions to be taken are covered in flushing, testing and inspection of piping. Care shall be exercised and adequate precautions to be taken to avoid any damage and entry of foreign matter into instruments during transportation, installation, testing etc.

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## 9.9 Line Mounted Equipment / Items

Installation of line mounted items like filters, strainers, steam traps, air traps, de-super heaters, ejectors, samples coolers, mixers, flame arrestors, sight glasses etc including their supporting arrangements shall form part of piping erection work.

## 9.10 Bolts and Nuts

The Contractor shall apply moly coat grease mixed with graphite powder (unless otherwise specified in piping classes) to all bolts and nuts during storage, after erection and wherever flange connections are broken and made-up for any purpose whatsoever.

## 9.11 Pipe Supports

Contractor shall follow layout/isometric drawings to locate & provide the pipe supports as per piping support standards. In case, when the supports are not shown in the drawing for small bore Isometrics, then contractor shall suitably design and provide the supports at site. Any additional supports & temporary supports also shall be provided by the contractor if requested by the Engineer-In charge or Authorised Representative. For 1" & below sizes of low point drains & high point vents, stiffeners shall be provided in all pumps & compressors suction & discharge lines.

No pipe shoe / cradle shall be offset unless specifically shown in the drawings. Hanger rods shall be installed inclined in a direction opposite to the direction in which the pipe move during expansion.



Preset pins of all spring supports shall be removed only after hydrostatic testing and insulation is over. Springs shall be checked for the range of movement and adjusted if necessary to obtain the correct positioning in cold condition. These shall be subsequently adjusted to hot setting in operating condition. The following points shall be checked after installation, with the Engineer-in-Charge and necessary confirmation in writing obtained certifying that:

- All restraints have been installed correctly.
- Clearances have been maintained as per support drawings.
- Insulation does not restrict thermal expansion.
- All temporary tack welds provided during erection have been fully removed.
- All welded supports have been fully welded.





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- Lines are completely free for movement except where anchored. All tack welds are removed and grounded smooth. All lines resting/sliding supports shall be checked thoroughly by contractor for free movement before hydro testing.

Insulation support ring to be provided on the pipes as per Insulation specifications.

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## STANDARD SPECIFICATION FOR BOLT TENSIONING

			 <small>Written By</small> <small>Karthikeyan Chokkalingam</small> <small>2019.10.14 20:39:29 +05'30'</small>	 <small>Checked By</small> <small>Subramanian Arumugam</small> <small>2019.10.15 10:20:33 +05'30'</small>	 <small>Approved By</small> <small>Vaidyanathan V</small> <small>2019.10.15 12:21:21 +05'30'</small>	 <small>Authorized By</small> <small>Manojkrispna Jeyaraj</small> <small>2019.10.15 21:07:42 +05'30'</small>
A	14-OCT-2019	ISSUED FOR DESIGN	CK	AS	VV	JM
REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	AUTHORIZED

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## 1. INTRODUCTION

**INDIAN OIL CORPORATION LIMITED (IOCL)** has awarded Fax of Acceptance (FOA) dated 29<sup>th</sup> August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India

## 2. DEFINITIONS & ABBREVIATIONS



<b>Abbreviation</b>	<b>Definition /Expanded form</b>
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit

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OISD	Oil Industry Safety Directorate
ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
P&ID	Piping and Instrumentation Diagram
A/G	Above Ground
U/G	Under Ground
B/L	Battery Limit
ISBL	Inside Battery Limit
EOT	Electrically-operated Overhead Travelling
MTO	Material Take Off

### 3. **SCOPE**



This specification covers the minimum requirements to define the extension for use of “Bolt Tensioning” to be installed on IOCL Paradip Project.

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#### 4. REFERENCE CODES & STANDARDS

This specification conforms to the requirements of, and shall be read in conjunction with, the following codes and standards (most recent edition or revision):.

<b>Code /Std. No</b>	<b>Description</b>
ASME B31.1	Power piping
ASME B31.3	Process Piping
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.21	Nonmetallic Flat gaskets for Pipe Flanges
ASME B16.47	Large Diameter Steel Flanges
ASME B18.2.1	Square, Hex, Heavy Hex, and Askew Head Bolts and Hex, Heavy Hex, Hex Flange, Lobed Head, and Lag Screws (Inch Series)
ASME B18.2.2	Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
ASME PCC-1	Guidelines for Pressure Boundary Bolted Flange Joint Assembly
ASME VIII Div. 1 & 2	Boiler and Pressure Vessel Code
ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
ASTM A307	Standard Specification for Carbon Steel Bolts, Studs, and Threaded 60 000 PSI Tensile Strength
ASTM A320	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
ASTM A453	Standard Specification for High-Temperature Bolting Materials, with Expansion Coefficients Comparable to Austenitic Stainless Steels
ASTM A593	Specification for Charpy V-Notch Testing Requirements for Steel Plates for Pressure Vessel
080557C-000-JSS-1370-001	Job Supply Specification for Fasteners

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## 5. **GENERAL REQUIREMENTS**

### 5.1 **General**

- Use of right type of Gasket, Fasteners etc. conforming to the specifications as per Design and drawings should be ensured.
- For special case (i.e. insulation kits) vendor recommendations should be implemented.

### 5.2 **Examination of Working Surface**

According to ASME PCC-1.

- They shall be free from dirt, scale, remnant gasket and protrusion. Faces with pitting, indentations or radial tool marks, or scratches are not desirable. Surface finish should conform to specifications.
- Visual examination of gaskets should be carried out prior to installation to ensure that these are free of any defects such as bends, crease or loose spiral windings etc.

### 5.3 **Alignment of Mating Surface**

According to ASME PCC-1.

- Flanges should be aligned properly. Flange faces shall be parallel and bolt holes shall match so that studs can be inserted freely.
- No external load shall be used to align the flanges.

### 5.4 **Installation of Gaskets**


According to ASME PCC-1.

- The ring joint gaskets should have 30 to 40 Vickers hardness less than that of the mating face of the flange.
- Gasket position should be checked.
- All non-ring joint gaskets shall be replaced with new ones whenever an opened joint is to be re-closed during construction and commissioning stage. Ring joint gaskets normally can be re-used provided they are inspected and are free from any damage.

### 5.5 **Installation of Bolts**

According to ASME PCC-1.

- Flange connection with bolting of nominal diameter 25 mm and above shall have sufficient clearances and access to allow the use of hydraulic tensioning equipment (wherever hydraulic bolt tensioning is being used).
- Stud bolts shall be longer by one diameter to suit the bolt tensioners for hydraulic bolt tensioning. Excess threads shall be protected by a threaded cap.

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## 5.6 Corrective measures

- Faces with pitting, indentations or radial tool marks, or scratches that form leakage paths or with the surface finish not in accordance with design requirements shall be replaced or re-machined to specified surface finish.
- If necessary, gasket-seating face should be cleaned using wire brush (SS bristles on alloy components) and /or suitable solvent.
- Damages gaskets shall be replaced.
- If holding gasket in place after installation is a problem, a thin adhesive tape should be used along the outside edge of gasket.



## 6. METHODLOGIES AND CONTROL

### 6.1 Identification of Joints for controlled bolt tightening

Controlled bolt tightening can be done by application of calculated bolt tension with hydraulic tensioner or by application of calculated bolt torque with calibrated torque wrenches. The criteria for selection of joints for these two-application procedure are given below.

#### 6.1.1 Hydraulic Bolt tensioning



Hydraulic bolt tensioning shall be applied for all joints where the bolt sizes match the criteria outlined in Table -1, except those in category "D" services, defined in ASME B31.3.

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**Table- 1: Criteria for Bolt Tensioning –**

**Not applicable for flange joints in category “D” services**

Nominal Bolt diameter	Condition	Remarks
All	When specified by the process licensor / vendor / project specifications	
50 mm and above	All joints	
38 mm and above but less than 50 mm	Class 600 and above	
	Hydrogen Service	(See Note-1 below)
	Category "M" fluid services	Refer ASME B31.3
	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipment's	(See Note-3 below)
25 mm and above but less than 38 mm	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipment's	(See Note-3 below)
<p>Note-1: Hydrogen Service</p> <p>Hydrogen service is defined as service in contact with Hydrogen or gaseous mixtures containing Hydrogen in which the partial pressure of Hydrogen is 7 bar absolute (100 psi) or more</p> <p>Note-2: Joints with leakage potential shall include</p> <p>a) Joints involving tapped holes.</p> <p>b) Joints not subjected to hydrotest e.g. joints for equipment manholes, equipment mounted temperature, pressure and level instruments, line mounted temperature connections, on line instruments joints like control valves and safety valves, compressor volume bottles.</p> <p>c) Items involving two sets of gaskets with one set of bolt e.g. orifice flange joint, joints with spectacle blind, spacer, flangeless wafer check valve, wafer type butterfly valves.</p> <p>d) Tie-in joints with other contractors and package vendors.</p> <p>e) High temperature (above 371°C) joints in hydrocarbon services.</p> <p>Note-3: Critical joints with the equipment's shall include the inlet and the outlet flanges of pumps, compressors and turbines.</p>		

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### 6.1.2 Application of torque

Controlled bolt torque, with calculated torque values, shall be applied using calibrated torque wrench. Joints those qualify for hydraulic bolt tensioning per 6.1.1 shall not be considered for torque application. Controlled bolt torque should be applied for the joints meeting the criteria given in Table-2. Joints fulfilling the criteria for Hydraulic bolt tensioning need not be checked for these criteria.

**Table- 2: Criteria for Bolt Torque application**

Service	Joints
Hydrogen Service	All Joints (Note-1)
Category "M" services	All Joints (Note-1)
Other services	Class 600 and above
Note-1: Joints, those qualify for hydraulic bolt tensioning as per cl.6.1.1 shall not be considered for torque calculation.	

## 7. EXTENSION OF SUPPLY FOR BOLTS FOR TENSIONING

Taking into account the paragraph 5.2 and 5.3, The bolts for bolt tensioning shall be purchased with an extra-length equal to 1 bolt diameter in order to permit the getting hold of the bolt tensioner.



The nuts shall be furnished with N. 6 Holes for Tensioning Machine.

Contractor shall submit the following documents to PMC / OWNER's approval.

- Bolt torque calculation
- Bolt tensioning procedure
- Catalogue of bolt tensioning machine to be used.

Operators of manual and hydraulic bolt tensioner machines shall be qualified for and on the actual equipment to be used. Certification of competency and also control and certification of all flanges to be tensioned shall be mandatory.



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## 8. BOLTS PRESTRESS

To cover the minimum bolt load on most of cases, depending of the material the following bolt prestress shall be applied:

- ASTM A193 Gr. B7		50 ksi
- ASTM A193 Gr. B7M		40 ksi
- ASTM A193 Gr. B8 / B8M Cl.1		15 ksi
- ASTM A193 Gr. B8 / B8M Cl.2	≤1"	40 ksi
- ASTM A193 Gr. B8 / B8M Cl.2	>1"	30 ksi
- ASTM A193 Gr. B16		50 ksi
- ASTM A307 Gr.B		15 ksi
- ASTM A320 Gr. L7		50 ksi
- ASTM A453 Gr. 660 Cl.A		40 ksi

## 9. TORQUE/TENSION CALCULATION

The calculation shall follow the procedure outlined in ASME Section VIII Division 1/Division 2. Torque calculation shall care of friction between bolt threads and nut threads as well as that between nut and back face of flange. Torque/tension employed should be sufficient to withstand hydrotest pressure safely. The approximate  $\mu$  values of some of the lubricants are as follows:

Type of Lubricant	Co-efficient of friction ( $\mu$ )
Molybdenum lead oxide + graphite based	0.085
Molykote G-n plus	0.09
Molykote P37	0.10
Molykote HSC Plus / Never Seez nickel special	0.11
API SA2	0.117
Molykote 1000	0.13
Graphite grease / Machine oil	0.15



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## 10. **DESIGN**





The design calculations for minimum bolt load shall be based on ASME Boiler and Pressure Vessel Code Section VIII (Division I), Pressure Vessels: Appendix - S Design considerations for bolted flange connections and Appendix - 2 Rules for bolted flange connections with ring type gaskets.

Bolt Stresses shall be compared against the design stress value for bolting materials found in ASME B31.3.



If necessary, in accordance with ASME section VIII Div.2 article 4-141, it is possible to apply a factor 2 to the allowable

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## Job Specification for Steam Tracing and Jacketed Piping

			 <small>Written By</small> <small>Mageshwar Samundaram</small> <small>2020.06.11 20:23:18 +05'30'</small>	 <small>Checked By</small> <small>Loganathan Sudarsan</small> <small>2020.06.11 20:34:25</small> <small>+05'30'</small>	 <small>Approved By</small> <small>Ranga Thottakalai</small> <small>2020.06.12 12:21:36</small> <small>+05'30'</small>	 <small>Authorized By</small> <small>Mokundalingam Anantharam</small> <small>2020.06.14 06:38:56 +05'30'</small>
B	11-06-2020	ISSUED FOR DESIGN	SMM	SL	TI	JMC
A	16-10-2019	ISSUED FOR DESIGN	SMM	SL	TI	JMC
REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	AUTHORIZED

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**APPENDIX - A: Typical Installation Drawings Steam Tracing Sketches**

**APPENDIX - B: Typical Installation Drawings for Steam Jacketed Piping**



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## 1. Introduction:

**INDIAN OIL CORPORATION LIMITED (IOCL)** has awarded Fax of Acceptance (FOA) dated 29<sup>th</sup> August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

## 2. Definitions & Abbreviations:

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages
EPCM	Engineering, Procurement & Construction Management Services
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit
OISD	Oil Industry Safety Directorate
ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
P&ID	Piping and Instrumentation Diagram

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### 3. **Scope:**

This Specification provides the requirements for heat tracing and Jacketing of piping, piping components and valves for “Standby SRU and Additional tanks Project”, IOCL Paradip Refinery, Odisha, India.

This Standard also covers the design, installation and construction criteria as well as the technical requirements for the heating of piping by means of Steam tracing and external jacketing fed with steam.

### 4. **Conflicts, Deviations and Clarifications:**

- 4.1 Any conflicts between this standard and other applicable Engineering Standards , Material Specifications , Standard Drawings, Engineering Procedures , Company Forms or Industry standards, specifications, Codes and forms shall be brought to the attention of Authorized Representative by the Contractor for resolution.

Until the resolution is officially made by the Authorized Representative, the most stringent requirement shall govern.



- 4.2 Where a licensor specification is more stringent than those of this standard, the Licensor’s specific requirement shall apply.
- 4.3 Where applicable Codes or Standards are not called by this standard or its requirements are not clear, it shall be brought to attention of Authorized Representative by Contractor for resolution.
- 4.4 Direct all requests for deviations or clarifications in writing to the Authorized Representative for final resolution.

### 5. **Design Codes & Standards:**



The latest issue of the following major Codes and Standards shall be referred to as a part of the Piping Design Basis. Other codes and standards not listed herein may also be used for any other design purpose.

The design, materials, equipment and related items in all the systems (i.e. gas, oil, steam, water, air etc.) shall be in accordance with the latest edition of ASME B 31.3 and ASME B 31.1, where the provisions of these standards are applicable. American standards and recommended practices, along with other internationally recognised codes as guidelines, shall be used for the design activity.

Govt. / state / Local rules, regulation, OISD Rules and other industry practice shall be complied with and shall govern the piping systems, in addition to these Piping Design Basis.

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ASME B 31.3	Process Piping
ASME B 31.1	Power Piping
ASME Vol. VIII & IX	ASME Boiler and Pressure Vessel Code
ASME B16.5	Pipe Flanges and Flanged Fittings
ASME B16.9	Factory Made Wrought Steel Butt welding Fittings
ASME B16.34	Valves – Flanged, Threaded, and welding End
ASME B16.47	Large Diameter Steel Flanges
ASME B1.20.1	Pipe threads, General Purpose, Inch
ASME B16.10	Dimensions of Ferrous Valves
ASME B16.11	Forged Steel Fittings, Socket welding and Threaded
ASME B16.20	Metallic Gaskets for Pipe Flanges – Ring Joints, Spiral Wound and Jacketed
ASME B16.21	Non-metallic Flat Gaskets for Pipe Flanges
ASME B16.25	Buttwelding Ends
ASME B18.2.1	Square & Hexagonal Bolts & Screws (Inch Series)
ASME B18.2.2	Square & Hexagonal Nuts (Inch Series)
ASME B36.10	Welded and Seamless Wrought Steel Pipe
ASME B36.19M	Stainless steel pipe
ASME B 46.1	Surface texture
API 594	Wafer and Wafer-lug Check Valve
API 598	Valves inspection and testing
API 599	Metal Plug Valves – Flanged, Threaded and Welded Ends
API 600	Steel Gate Valves, Flanged or Buttwelding Ends
API 602	Compact CS gate valves flanged threaded, welded & extended body ends
API 607	Fire test for soft seated quarter turn valves
API 609	Lug and Wafer type Butterfly valves
BS 1868	Spec. for steel check valves (flanged and butt welding ends) for petroleum, petrochemical and allied industries
BS 1873	Steel globe and globe stop and check valves (flanged and butt welding ends) for the petroleum petrochemical and allied
BS 5351	Steel ball valves for petroleum, petrochemical and allied industries

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BS 5352	Steel wedge gate, globe and check valves, 50mm and smaller for petroleum, petrochemical and allied industries
MSS-SP-6	Standard finishes for contact faces of pipe flanges and connected end flanges of valves and fittings
MSS-SP-25	Standard marking system for valves, fittings, flanges and unions
MSS SP43	Wrought Stainless Steel Butt Welding Fittings
MSS SP44	Steel Pipe Line Flanges
MSS SP48	Steel Butt Welding Fittings (26" and larger)
MSS SP75	High Test Wrought Butt Weld Fittings
MSS SP83	Carbon Steel Pipe Unions, Socket Welding and Threaded
NACE MR0103 / ISO17945	Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments
TM 0284	Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
OISD-118	Layouts for Oil and Gas Installations
IBR	Indian Boiler Regulation

## 6. Design Rules for Steam Tracing

### 6.1 General Requirements

The steam tracing system shall be suitable to perform the following tasks:



- To maintain the fluidity of highly viscous products
- To avoid fluid components separation due to low temperature
- To prevent freezing
- To prevent corrosive compounds forming if condensation occurs.

6.2 As regards the steam tracing system, the size, number and length of each tracer shall be calculated and the output data finalized. The tracer pipe size resulting from the calculation can be optimized with the aim to minimize and standardize the tracer sizes for the whole system. The calculation take into consideration the following parameters:

- ambient conditions (external air temperature and velocity)
- diameter of the process pipe to be traced
- temperature to be maintained in the process pipe
- thermodynamic properties of the tracing steam
- insulation material characteristics (thickness, thermal conductivity)

The above reference parameters, together with economic considerations and any special



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project requirements, univocally establish the tracing pipe diameter, number and maximum length, as well as the insulation thickness for the pipe to be traced.

### 6.3 System Definition

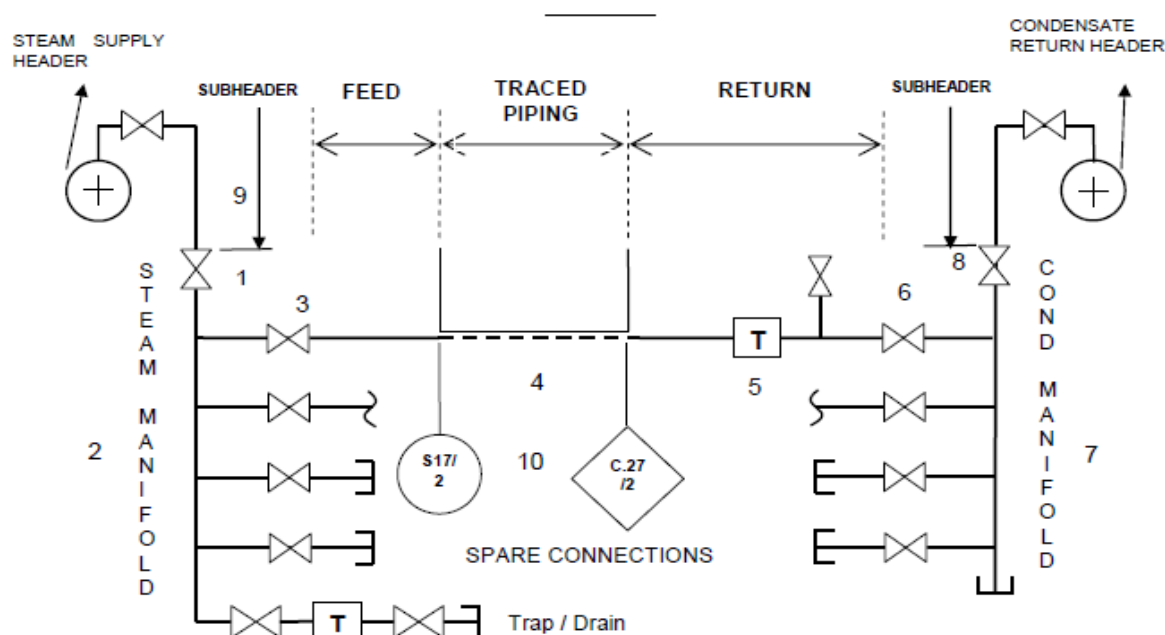
The piping system for steam tracing is defined below:



- Traced lines: the pipeline carrying process or utility fluids which requires steam tracing.
- Steam supply line or condensate recovery line: the pipe connecting the steam supply header with the steam tracing manifold or the pipe connecting the condensate header with the condensate recovery manifold
- Steam, or condensate manifold: typical steam supply or condensate recovery "station".
- Lead tracer or Tail line: the pipe which starts at the "Steam Manifold" or terminates to condensate manifold, from/to tracer line.
- Tracer line: the pipe, or tubing, carrying steam, fastened to the traced line. (Tracer line diameter as indicated on line list or equivalent).

### 6.4 To define the steam tracing system, the following have to be identified:

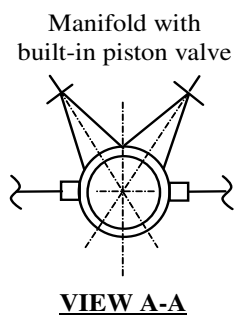
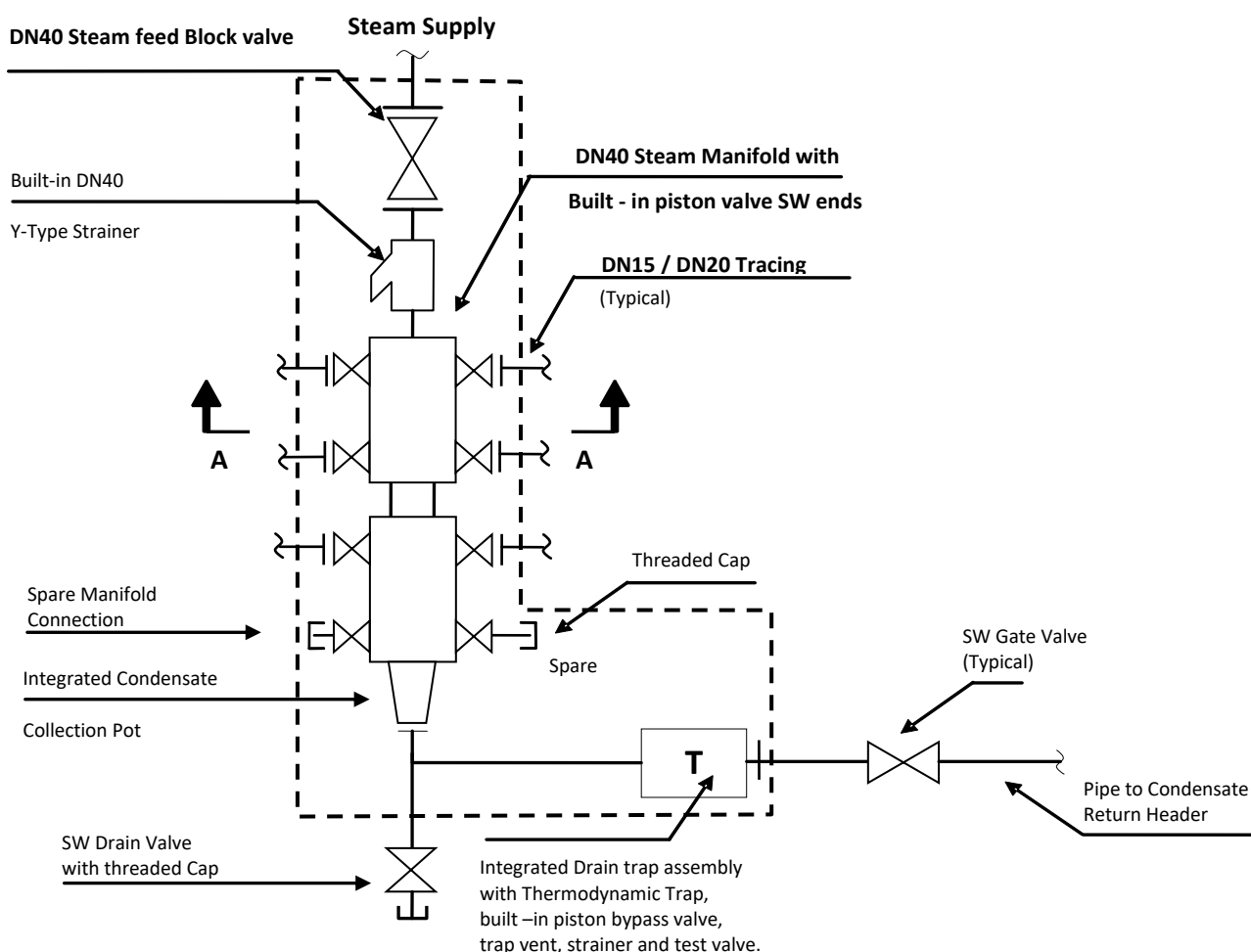
- All feed points on steam-traced pipes
- All recovery points on steam-traced pipes
- Routing of Lead tracer or Tail lines from/to manifolds to define their correct position
- Total number of tracers to define manifold size
- Steam supply and condensate recovery lines from manifolds to headers or sub-headers
- Sub-header size verification according to manifold number.

### 6.5 Schematic arrangement of Steam Tracing System:





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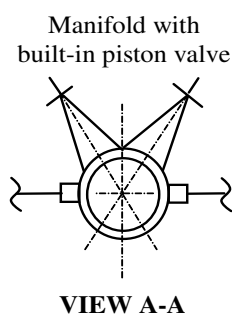
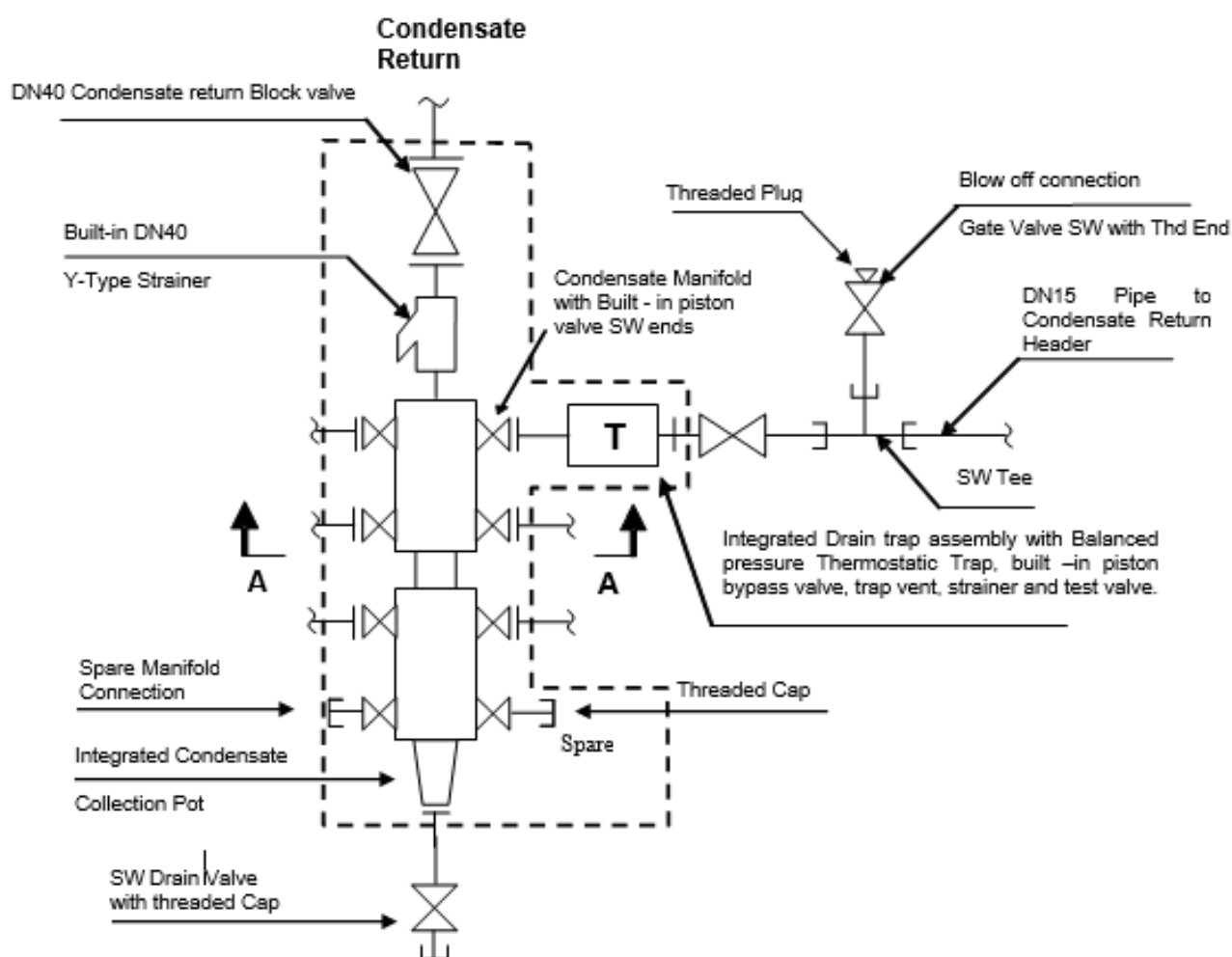
## 6.6 Typical Steam Supply Manifold Hookups:





NOTE: Where the manifold is located at a higher elevation than the header feeding it, the connection will be at the bottom of the manifold. The block valve will therefore be at the bottom and the SW capped will be relocated to the top to act as a vent. The trap will in this case not be required.

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## 6.7 Typical Condensate Return Manifold Hookups:



NOTE: Where the manifold is located at a higher elevation than the header it feeds, the connection will be at the bottom of the manifold. The block valve will therefore be at the bottom and the SW capped will be relocated to the top to act as a vent.

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#### 6.8 Number of Tracers & Length:

The minimum number of tracers with a heating chamber is a function of the diameter of the piping system to be traced as shown in Table-1:

**Table-1: Minimum Number of Tracer per Pipe Size**

<b>Nominal Pipe Size to be traced (in)</b>	<b>Minimum number of tracers</b>
Less than or equal to 4"	1
6" to 16"	2
18" to 24"	3
26" & above	To calculate

- a) Maximum tracer run length & No. of tracers shall be determined using the following specific tracer requirements:
  - The number of tracers per line depends predominantly on Minimum Maintained temperature (MMT) of the process fluid extracted from Line list.
  - Line size from line list
  - Steam supply /Condensate return conditions – Normal operating Pressure & Temperature
  - Wind speed
  - Ambient temperature
  - Tracer size DN15 / DN 20
  - Thickness of insulation surrounding the pipe.
  - Spacing of tracers (if applicable).
- b) The number of tracers shown in Table-1 above is minimum quantity only. The MMT vs. No. of tracers w.r.t specific insulation thickness required per process line shall be determined during detail engineering by CONTRACTOR.
- c) Wherever possible LP steam should be used for tracing to maintain process fluid temperature. However if the required temperature cannot be achieved using LP steam tracers, MP steam may be used.
- d) The steam feed and condensate return pipe size shall be sufficient to carry the maximum throughput from all the tracers on the manifold or sub-header. The size shall be determined according to the steam pressure, insulation thickness/type, maximum length of tracer and normal operating temperature.

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- e) The feed line to manifold, manifold to the block valves of individual tracer shall be carbon steel or stainless steel of IBR quality.

#### 6.8.1 Length of the tracers

The length of a tracer is limited by the loss of pressure in the tracer.

The maximum lengths of the tracers, in meters, which are a function of the minimum steam pressure available, are defined in the table below.

**Table-2 : Maximum Length for Tracer (excluding lead & tail lines)**



<b>Minimum steam operating pressure Kg/cm<sup>2</sup></b>	<b>For 0.5" Maximum Tracer Length (meters)</b>
1.5	23
3.5	38
7.0	46
10.5	53
14.0	61

#### 6.9 Design Criteria

The design of the tracing system shall satisfy the following requirements:

##### Manifolds



- Lead tracer or Tail lines starts from a manifold. For isolated lines or users, the tracer feed line may be fed directly from the header and the condensate discharged from steam trap to the ground.
- Steam feed and condensate recovery manifolds, shall be installed in easily accessible areas (grade or on a platform).
- Depending on the distribution of instruments throughout the various areas of the plant, dedicated manifolds for instruments only, may be installed.
- Number of tracer port shall be 4/8/12 and tracer size DN 15 / DN 20, 20% or minimum 2 nos tracer connections shall be kept spare for future use for both steam supply and condensate collection manifolds.

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- e) Steam & Condensate Manifold size shall be as 40mm unless stated otherwise. Size of the Lead line to steam manifold & tail line from condensate manifold shall be 1.5' unless otherwise specified in the P&ID.
- f) All Manifolds shall be with Compact Type (Complete vendor supplied manifold with insulation jacket) which includes, root isolation glandless piston valve, multiple way steam distribution manifold with built-in piston valves, strainer, spare connections, integrated compact steam trap assembly etc., (as shown in typical sketches / Section 6.6 & 6.7)
- g) Steam manifold at an elevation lower than the feed header shall be provided with a steam trap. Steam manifolds placed highest than the feed header, shall be designed having a free draining toward header and require only a drain valve.
- h) Condensate recovery manifolds shall in all cases be provided with a drain valve.
- i) All manifolds shall be installed in vertical position only.

#### 6.10 Tracers Configuration

- a) As a general rule, the tracer routing shall permit gravity flow of condensate to steam traps. Pockets in steam tracers shall be avoided as far as possible.
- b) Tracers on horizontal pipe shall run parallel to the pipe and be located near bottom center line (to avoid clashing with supports). Tracer loops around flanges and appurtenances shall be in the horizontal plane. Tracer on vertical pipes shall be positioned where they offer the least interference to supports and adjacent piping.
- c) Spiral tracing shall not be used except where continuous free draining is possible, eg., vertical pipes and when specified on PID/line list.
- d) All steam tracer lines shall be TIG welded with minimum of 2 weld runs. Lead and tail Tracer shall be pre-insulated tubing supplied with intermediate patch kit, end patch Kit and bending kit to avoid tubing & insulation damage.
- e) Tracers for single users (e.g. instruments on columns) can be fed from the nearest steam line.
- f) Never flanged and/or threaded joints shall be installed on tracers inside insulation.
- g) Tracer lines shall be provided with break up flanges for main line flange joints and valves.
- h) Differential expansion between pipe and tracer shall be allowed for as follows:  
Tracer expansion loops shall be provided on straight runs of pipe over 7.5 metres long. Loop spacing shall not exceed 30 metres. Loops shall be installed in the horizontal plane.

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On straight pipe shorter than 7.5 metres, expansion may be allowed for within the insulation at the bends, for this purpose where piping changes direction from horizontal to vertical the tracer shall be routed to the side of the elbow to prevent breakout and damage to the insulating system, tracer bands shall be prohibited within 1 metre of the bend.

#### 6.10.1 Max allowable pockets height

Sum of tracer risers may not exceed 4 times the differential pressure value, between the steam and the condensate system. In meters the said value is defined as in the following example:

- Steam system pressure = 6.5 Kg/cm<sup>2</sup>
- Condensate system pressure = 5.0 Kg/cm<sup>2</sup>
- $\Delta P$  = 1.5 Kg/cm<sup>2</sup>
- H (height) = 4 x 1.5 = 6 meters

#### 6.10.2 Pockets drainage

When the tracer rises vertically 1.5 m or more, a steam trap must also be provided before the vertical rise also. If the rise is less than 1.5 m the additional steam trap is not required.

Tracers for single users (e.g. instruments on columns) can be fed from the nearest steam line.

#### 6.11 Materials

##### Tracers:



The following materials should be used for steam tracing (as per project piping material specification)

- a) Carbon Steel Pipe / Tubing
- b) Stainless Steel Pipe / Tubing

Material of the steam tracing tubing or piping shall be compatible with the material of the traced equipment or piping. As an example stainless steel piping shall be traced with stainless steel tubing or piping.

Tracer sizes to be used shall be DN15 and DN20 depending on heat transfer duty required. Unless specifically indicated, carbon steel pipe for tracers shall be schedule 40.



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## Valves

Steam feed /condensate return block valves, Socket welded Glandless Piston type, Carbon steel body as per ASTM A105N with SS Internals.

Manifold block valves for individual tracers shall be Built-in Glandless Piston type valves, Carbon steel body as per ASTM A105N with SS Internals.

## Headers

Materials shall be as specified for the main steam and condensate lines.

## Manifolds

### General

Forged compact 4Way/8way/12way manifold, Socket welded ends with minimum 2 spare connections, DN40 Inlet & DN20 drain. Manifold Body Carbon steel ASTM A105N.

### Steam Supply Manifolds:

Complete proprietary vendor supplied steam supply manifold. Package includes multiple way steam distribution manifold with built-in block valves, strainers, spare connections, integral glandless piston valve for bypass, and integrated Thermodynamic Steam Trap assembly.

### Condensate Return Manifolds:

Complete proprietary vendor supplied condensate return manifold. Package includes multiple way steam distribution manifold with built-in block valves, strainers, spare connections, integral glandless piston valve for bypass, and integrated Balanced pressure Thermostatic Steam Trap assembly.

## Banding

Stainless Steel AISI 201 or equal 12mm wide x 0.76 mm thick band and compatible buckles.

## Tie Wire

Austenitic stainless steel 1.6 mm dia (16 SWG) fully annealed.

## Tags



Austenitic stainless steel strip 75mm long 25mm wide 1.0 mm thick.

## Spacers

The use of spacers is required where hot spots caused by direct contact of the hot tracer tube with the pipe are to be avoided. Hot spots in the process pipe approaching the temperature of the tracing steam may lead to process fluid degradation for instance polymerising or thermally degrading chemicals or to accelerated corrosion.

Heavy density mineral fibre insulation blocks 40 x 25 x 12 mm thick or glass cloth tape 25 mm wide x 6mm thick (2 thicknesses required).



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#### **Drain trap assembly in Steam supply Manifold**

Forged Carbon steel compact drain trapping assembly, SW ends, Assembly complete with Universal Stainless steel thermodynamic steam traps with integral strainer connected to assembly by universal flange with built-in piston valves.

#### **Drain trap assembly in Condensate collection manifold**

Forged Carbon steel compact drain trapping assembly, SW ends, Assembly complete with Stainless steel Universal Balanced pressure thermostatic steam traps with integral strainer connected to assembly by universal flange with built-in piston valves.

Heat tracing cement to be used to improve conductivity of heating medium from tracer piping to main piping.

### **6.12 Project Documentation**

#### **6.12.1 Input documentation to define the system:**

- the present Project Job Specification.
- the "Line List" identifying the lines to be traced and relative number and diameter of tracers
- the "List of Instruments" to be traced
- the "Equipment List", identifying all equipment to be traced, and relative numbers and diameter of tracers
- the "P&I Diagram", identifying all systems to be traced (piping, instruments, equipment).

#### **6.12.2 Output documentation (Detailed Engineering):**



- General Arrangement Drawing: with the installation of manifold and relative connecting pipes with the headers.
- Steam-traced lines isometric sketches with all reference connections from/to manifolds.
- Tracer list (excel) with detail of manifolds, port nos, Tracing line numbers from/To etc

6.12.3 The tracer lead and tail lines arrangement will be defined in field. The lines may be grouped as much as possible and tubing shall be pre-insulated.

### **7. Installation Rules for Steam Tracing**

#### **7.1 Manifold and Steam-trap Installation Arrangements**

Typical arrangements schematically define various possibilities for the installation of manifolds

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and steam traps included in a steam tracing system as described in Figures 13 through 16 of Appendix A.

## 7.2 Typical Tracing Installation Assembly

The typical installations of steam tracing components are described in figure 1 through figure 12 of Appendix – A.

## 7.3 Fixing of Tracers on Traced Piping

- Fixing of tracers on steam traced lines shall be carried out using metallic bands/straps.
- The following table defines distances for tracer support spacing.

Tracer Diameter	Max. spacing between straps in mm
1/2"	1000

- Any anchor point for thermal expansion required on tracers shall be realized by installing two adjacent fastening straps.
- The installation of single fastening strap shall be considered as a guide for thermal expansion purpose.

## 8. Jacketed piping system

### 8.1 General Technical Requirements

Standard jacketed piping provides the most uniform application of heat to the process and maintains the most uniform process temperatures. The core pipe is welded to the front and back of a slip-on flange, and the jacket pipe is welded to the back of the flange.



To meet the above requirements, the system has to be designed taking into account the following parameters:

- Partial or integral jacketing.
- Maintenance temperature of process fluid.
- Temperature of service fluid.
- Thermal exchange capacity between process fluid and service fluid.
- Ambient conditions.
- Type and thickness of thermal insulation.

### 8.2 System Definition

For system definition, the following is necessary:

- Identification of process lines and/or instruments to be jacketed.

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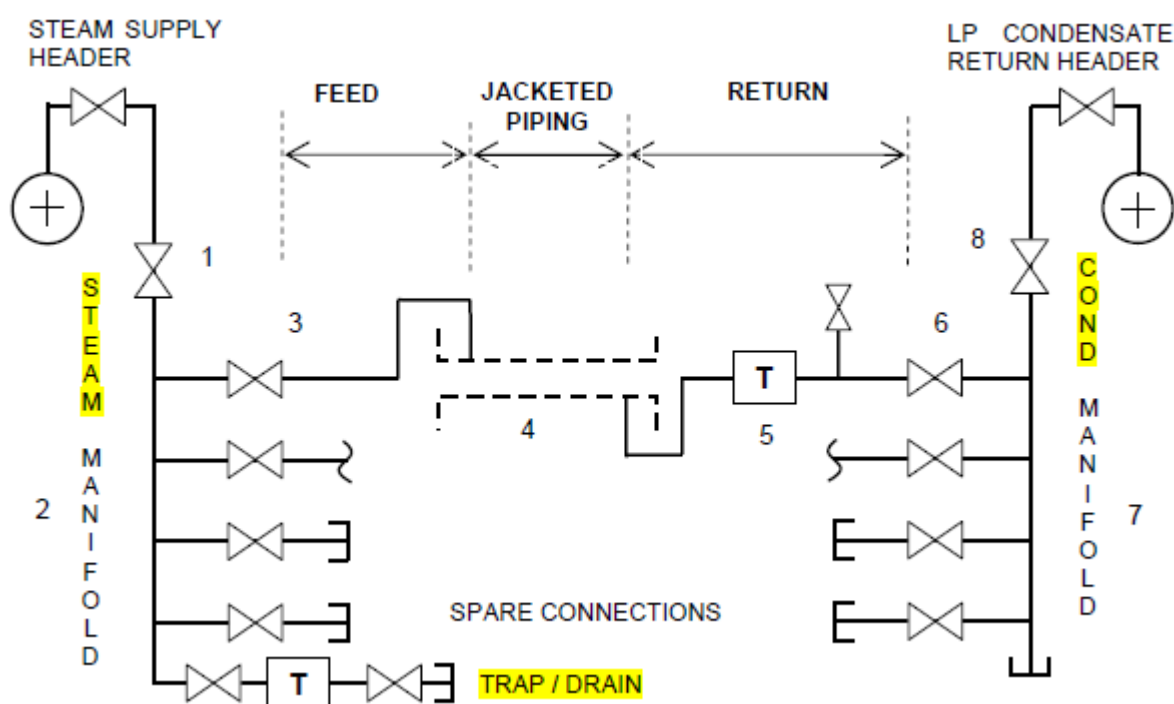
- b) Calculation of max. distance between inlet and outlet of service fluid on Jacketing.
- c) Identification of service fluid inlets and outlets on jacketing for each line.
- d) Location of service fluid feeding and recovery manifolds.
- e) Piping material qualification for process line, jacketing and service line.
- f) Calculation of max. length of straight jacketed piping to be installed without expansion joints.



The above activities shall allow:

- g) Checking of standard size of jacketing in relation to the process line.
- h) Drawing-up of a planimetric flow scheme for all lines relevant to all service fluids included in the system.
- i) Sizing of all service fluid lines.
- j) Sizing of all feeding and recovery manifolds.
- k) Selection of feeding and recovery line routings between manifolds and inlets/outlets on jacketing.
- l) Definition of expansion joints.
- m) Definition of steam trap typology for steam jacketing lines.
- n) Definition of temperature instrument control (thermoregulator valves), on jacketed lines using fluid heating mediums.
- o) Definition of number of jumpers (1 or 2) according to steam condensate flowrate, in horizontal jacketed lines.

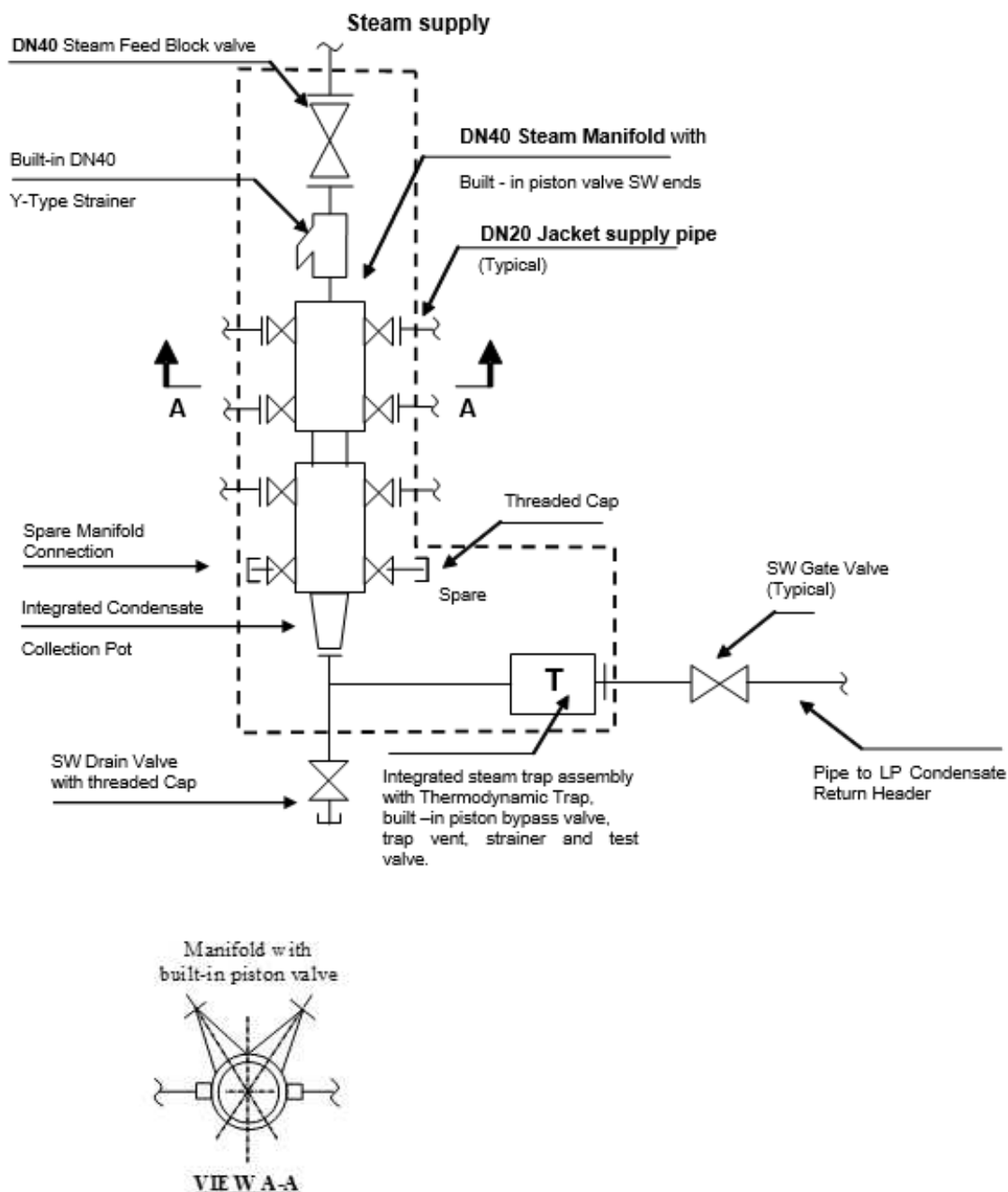
### 8.3

#### **Schematic Arrangement of Steam Jacketing System:**





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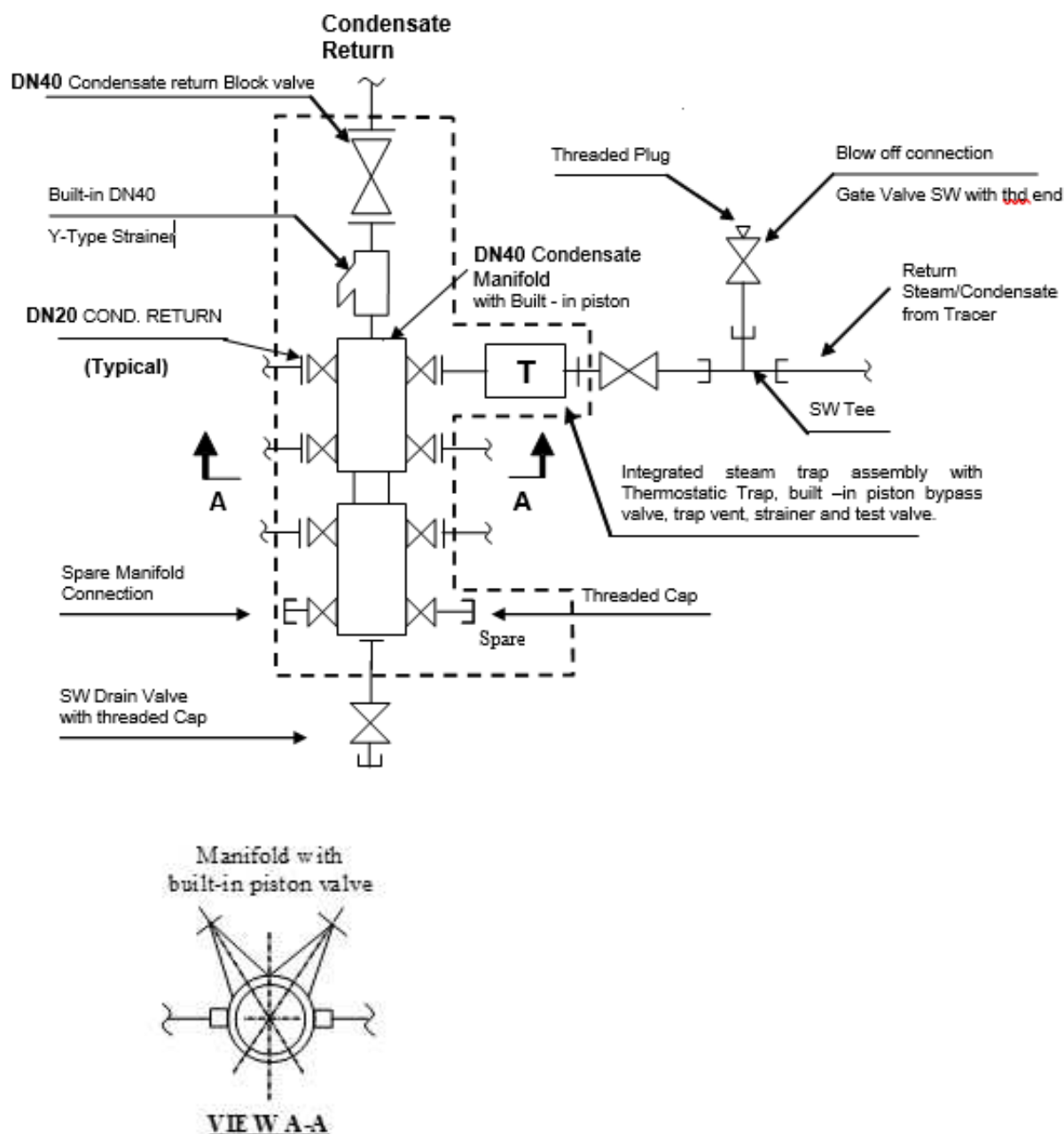
#### 8.4 Typical Steam Supply Manifold Arrangement and Hookup:





NOTE: Where the manifold is located at a higher elevation than the header feeding it, the connection will be at the bottom of the manifold. The block valve will therefore be at the bottom and the SW capped will be relocated to the top to act as a vent. The trap will in this case not be required.

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## 8.5 Typical Condensate Return Manifold Arrangement and Hookup:



NOTE: Where the manifold is located at a higher elevation than the header it feeds, the connection will be at the bottom of the manifold. The block valve will therefore be at the bottom and the SW capped will be relocated to the top to act as a vent.

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## 8.6 Steam Supply & Condensate Distribution

Steam jacket block valves shall be manifolded together where practicable, otherwise separate supplies shall be taken direct from the steam supply lines, or from the steam feed line to a jacketing manifold.

Steam Supply / Sub header size shall be DN40 unless stated otherwise. Manifolds and headers supplying jackets shall be positioned such that the feeds and returns are kept as short as practicable.

Manifolds shall have sufficient capacity for instruments and foreseeable future additions to the plant.

Steam manifolds shall preferably be located above the lines and components being jacketed. They shall be positioned on existing platforms or at grade whenever practicable. All jacket block valves shall be accessible without the use of auxiliary equipment. All jacket steam feed lines from manifolds shall be banded together.

Condensate return connections shall be installed at low points.

Steam and condensate manifolds shall be DN40 unless stated otherwise. The steam supply, condensate return and jump-over connections shall be ¾" (DN 20).

Manifolds shall be with Compact Type (Complete vendor supplied manifold with insulation blanket) which includes, multiple way steam distribution manifold with built-in piston valves, strainers, spare connections, glandless piston valve for bypass, integrated compact steam trap assembly etc., (as shown in typical sketches / Section 8.4 & 8.5). Compact Steam trap assemblies shall be with integral glandless piston valve and in-built strainer.

## 8.7 General Rules



The feeding and discharge lines for jacketing shall be provided with an interception valve.

The jacket shall be provided with non-valved vents and drains for hydraulic testing and operation purposes.

The jackets of line sections in discontinuous service or with removable components for maintenance shall be fed to ensure that the service fluid circulate in the rest of in operation line. 45° elbows shall not be employed due to correct installation difficulties.

Flanged-end cross-branches, shall be utilized instead of jacketed elbows on process fluids subject to solidification that require the mechanical cleaning of lines during maintenance (eg. SULPHUR).

Dead legs and pockets shall be avoided as far as possible on process lines to be jacketed.

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The employment of eccentric reducers shall be avoided as far as possible due to correct installation difficulties.

On horizontal sections with reducers, the jacketing fluid should be fed into the smallest diameter jacketed section.

In case of branches with a change of diameter, the feeding of service fluid should be foreseen on the jacketing run with the smallest diameter.

Process line fittings shall be exclusively B.W. type. (The only exception is the execution of piping branches by means of S.W. half coupling, having verified that this is allowed from a process point of view).

Dismantling joints located on feeding and recovery service fluid lines as well as on jumpers shall be positioned outside the thermal insulation of the jacketed line.

Due consideration shall be given to thermal expansion in order to avoid interference between process lines and jacketing.

In order to permit the welding of the inside process line as well as its inspection during the test phase, the fittings and straight length of jacketed piping shall be provided in two halves.

Internal pipe/jacket spacers shall preferably be placed at piping supports points and should not interfere with feed discharges and jacket vents and drains.

Gate valves on feeding and discharging lines shall be positioned at a minimum distance from manifolds, in an accessible position.

Steam shall be fed into the upper part of the line and, in horizontal sections, in the upper part of the jacket. Jacket steam shall preferably run in counter-flow to the process flow. The discharge shall be provided in the lowest part of the line and, in horizontal sections, at the lowest part of the jacket.

Jumpers on horizontal line sections shall be oriented downward and shall provide a non-valved drain. When two jumpers are foreseen, their orientation shall be one upward and one downward with one vent and one non-valved drain respectively.

Jumpers on vertical line sections shall be alternately oriented one opposite the other in order to avoid preferential circulation areas.



Jacketed carbon steel piping shall be protected with a reinforcing stainless steel plate at steam inlets.

Each condensate discharge line shall have its own steam trap at the outlet from jacket.

Each steam trap shall be dismountable for maintenance or replacement purposes with the steam feed recovery system (if any) in operation. The steam traps shall be compact type.

Steam traps with relative block valves and by-pass shall be preferably positioned as close as possible to the recovery manifold. In any case, the recovery condensate line upstream the steam trap cannot affect any remounts more than two meters.



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On totally jacketed lines, a pad-type flange shall be provided on equipment to which the jacket lines are connected.

## 8.8 Jacket Piping Size (Outer Pipe Size)

The nominal size of the inner pipe (core) and outer pipe (jacket) in inches shall be as per table below unless otherwise mentioned in P&ID.

<b>Process line (in inches)</b>	<b>Jacket line (in inches)</b>
1 (a)	2
1 1/2 (a)	3
2	3
3	4
4	6
6	8
8	10
10	12
12	16

(a) Process line sizes smaller than DN50 shall not be used. Such sizes shall therefore only be used where required to connect to equipment, Instruments, vent/drain or in-line items.

## 8.9 Layout



Where slopes are specified on the P&IDs, the centreline elevation of pipe spools shall decrease by at least one hundredth of the developed length of the pipe. All jacketed pipework should drain in the process direction (unless specifically noted) without pockets.

Straight runs of pipe shall be laid out using standard spool pieces as detailed in Appendix-B, Figure 1. The maximum permitted spool length is 6 meters, the minimum varying according to NB as per Fig.1 Table 1. The construction of spool pieces is illustrated in Appendix-B, Figures 1 and 2.

All changes of direction and branching of process flow shall be achieved by using jacketed crosses with rodding points, except where project data indicates otherwise. This enables lines to be steamed or rodded out if they become blocked with solid Sulphur. Line routings shall ensure that adequate clearance is available at rodding points to enable the use of steam hoses and lances.

The construction of a jacketed cross and tee are illustrated in Appendix B, Figures 3, 4 and 5.



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Tees may only be used for the provision of instrument connections as detailed in Appendix B, Figure 6 except where indicated otherwise.

Standardized crosses complying with the dimensions specified in Appendix B, Fig.4 shall be used wherever possible. Shorter leg lengths shall not be used. Longer legs shall be used only where the layout would otherwise require the use of a pipe spool shorter than the minimum specified in Appendix B, Table 1 Fig.1. Note that there is no provision for the fabrication of crosses and tees with flanges set at any angle other than perpendicular to the fitting centreline. Slopes shall not be achieved by adjusting the flange angle on a fitting, but by using a 'field fit spool' as shown in Appendix B, Fig.8.

The presence of small dead legs is a characteristic of the design of a cross, but they shall be avoided elsewhere and shall not be used to support pipe.

Steam and condensate is transferred between jacketed spools using 'jump overs'. These are fabricated from pipe and fittings and shall be flanged adjacent to the jacket flanges to enable the jacketed spools to be taken out of the system if required. For horizontal legs, steam and condensate connections onto the jacket shall be located on the jacket Top Dead Centre and Bottom Dead Centre respectively, hence being evenly straddled by the flange bolt holes. (See Appendix B, Figure 2). The exception to this rule is where a jumpover is made from a vertical cross to a horizontal (or sloping) spool. In this case a single connection is taken from the lowest practical point on the cross to the top of the connecting spool in order to minimize the build-up of condensate in the bottom leg of the cross.

Each steam jacket feed line is to have a dedicated shut-off valve located near the Steam header or Steam manifold, whichever is applicable.

The arrangement of steam feeds, condensate returns, and jumpovers which constitute a steam supply circuit for jacketed pipe work shall be as specified in Appendix B, Figure 7. Special attention shall be given to the additional clearance required between jacketed pipework and other items, particularly in piperacks, to allow space for the jumpovers.



## 8.10 Detail Design

Valves, fittings, and any in-line devices shall be fully jacketed.

All nozzles should be jacketed to the flange back face where shown on P&IDs. Fresh steam is to be supplied to the nozzle if it is located at the high point in a circuit. The nozzle is to be fed with steam from the pipe if it is located at the low level of a circuit. The condensate can then be drained.

The detail design of standard jacketed system components shall be as specified in the assembly details and sketches in Appendix B.

Information regarding the MMT (minimum maintained temperature), operating and design conditions for jacketed lines is to be taken from the Project Line List.

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Spools shall have continuous jackets which extend to the back faces of the spool flanges except when connecting to equipment nozzles or in-line items with non-jacket size flanges (Appendix B, See Fig.11). The extent of such non-jacketed sections shall be minimized, in order to avoid the need for them to be steam traced. Steam tracing shall be a last resort and subject to agreement with OWNER/PMC.

Detail design shall be such that at all connections, flanges, and reducers, inspection of the process piping shall be possible before installation of the jacket. This is ensured by following the fabrication methods shown in Fig.s 1 to 6, 8, 9 & 11 Appendix B.

Jacket connections for steam & condensate and for jumpovers shall be positioned such that there is a minimum spacing of 75mm between the centre point of the sockolet and any jacket fabrication welds. (See Appendix B, Fig. 2).

The detail design of steam feeds, condensate returns and jumpover connections shall be as specified in Appendix B, Figure 7.

For all flanged connections between jacketed spools, reducing flanges shall be used, sized for the jacket piping with a bore suitable for attachment to the process pipe.

All spades, spacers and Figure 8 blinds shall be specified for the size of the jacket flange but bored to suit the process pipe.

All reducers shall be concentric, as it is not possible to accommodate the offsets generated by eccentric reducers within the spacing between the jacket and inner pipe.

All process and instrument connections to inner pipes shall be fully jacketed up to the Piping/Instrument break as shown on the P&ID. Typically, instrument connections will consist of pre-fabricated flanged units to be bolted directly to a cross or tee. Such units may be removed to accommodate rodding out.



#### 8.10.1 Method of Showing Jacketed Pipework and its services on Drawings

- Piping Isometrics for Process Core Piping
- Piping Isometrics for Jacket piping

Isometrics shall have spool details, support details and with all relevant bill of materials.

The source of steam feeds, destination of condensate returns and type of jumpovers, as per the Steam Jacketing Schedule, will be indicated on the relevant isometric for the jacketed piping by manifold and pin number.

Isometric for Jacket piping shall have separate line number, comprising of jacket size, service and insulation but with the same 4 digit designation as that of process core line shall be used.

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c) Jacketing Schedule including:

- i. Steam Manifold & pin no.
- ii. Condensate Manifold & pin no.
- iii. Relevant Isometric Drawing No. and sheet no.
- iv. Approx. lengths of feed and return pipe to and from jacketed line
- v. Locations of manifolds as co-ordinates and by construction area
- vi. Layout Study: Sketch produced to show location of manifolds

d) General Arrangement Drawings (Erection drawing)

- i. The process line on piping layouts is shown with the same symbol for all plant lines.
- ii. The jacket symbol is shown only at jacket feed and discharge points. Other details are not shown (eg. jumpers, baffles etc.).
- iii. The feed and recovery lines for service fluid between distribution manifold and jacket are not represented on the General Arrangement Drawings. Line routing shall be defined in field by the mechanical contractor with the assistance of the piping supervisor.
- iv. The feed and recovery manifolds for service fluid are represented on layouts using the same symbol for all plant lines.

## 8.11 FABRICATION, ERECTION, AND TESTING

As much pipework as possible will be shop fabricated on site.

The slope of the rundown pipework will be achieved through the use of Field Fit Spools (see Section 'Fabrication Procedure'), not by adjusting the angle of flanges on shop fabricated fittings. Inaccuracies in fabrication may otherwise result in excessively sloping, or wayward runs which cannot be recovered in the field.



### 8.11.1 Fabrication Procedure

Welding details and procedures shall conform project specifications. The geometry for standard weld details shall be as specified in Appendix B, Figure 10.

Shop fabricated items shall have flanges set square to the centreline and correctly aligned. Field fit spools shall be fabricated as shown in Appendix B, Figure 8. Note that any pipe run of less than 6m in length should be treated as a field fit spool, in that the required slope is achieved by setting the flanges at an angle to the pipe. Fabrication tolerances are as specified. The use of standard fittings, such as crosses, should be maximized.

The process pipe for all welded assemblies shall be completely fabricated, inspected, hydrotested and radiographically inspected before any welded connection between the jacket pipe and the assembly is made.

The jacket shall then be welded to the assembly, the welds inspected, and the jacket

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hydrotested before erection. All butt welds shall be full penetration, and longitudinal welds shall be completed before circumferential welds.

To accommodate the inspection and testing requirements for the process pipe, the jacket should be fabricated incorporating split sections. This technique is shown in Appendix B, Figures 1 and 3, which illustrates fabrication methods for jacketed spools and crosses.

### 8.11.2 Erection Procedure

Rundown lines of the jacketed system will achieve a general downward slope by use of field fit spools as shown in Appendix B, Figure 8. The slope will be specified on the Piping isometric drawing.

Adequate compliance with the elevations specified on the isometrics shall subsequently be confirmed by surveying methods to ensure that the minimum required slope has been achieved throughout the system.

### 8.11.3 Hydraulic Testing

The process pipe and the jacket shall be hydraulically tested in accordance with the project line list and the project specifications.

The process pipe shall be designed such that full hydrostatic test pressure can be applied to the jacket whilst the process pipe is at atmospheric pressure without the line collapsing.

## 8.12 Jacket Circuit Configuration

A jacket circuit is an arrangement of continuous spools fed from a single steam feed, with steam and condensate passing to subsequent spool jackets via jumpover connections, with condensate return via a single low point.

The following guidance applies to fully jacketed lines with rodding crosses, upstream and downstream of the sulphur pit. Upstream of the pit the sulphur liquid may contain solid particles which can impair drainage of sulphur and increase blockage potential. Downstream of the sulphur pit, sulphur liquid contains far less solid. For these reasons the guidance is more onerous in the sulphur rundown piping.



### 8.12.1 Maximum jacket Circuit Length

The maximum length of jacket circuits as defined above shall be:

Upstream of the pit:	6m
Downstream of the Pit:	18m

In addition to the limits on jacket circuit length above, the number of fresh steam feeds and condensate return points may be further increased.

Each jumpover type, see Appendix B, Figure 14, provides a location at which condensate flow

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may be restricted and jacket drainage compromised, reducing the jacket heating capability. Within any jacket circuit the number of various types of jumpovers shall be restricted to maximize reliability.

### 8.12.2 Non-Spool Items

Non-spool elements within a jacket circuit include jacketed control valves, block valves, check valves, equipment nozzles, etc., where steam and condensate feeds connect to jackets designed and/ or fabricated by others do not follow the standard and may not have good jacket clearances or drainage. If possible, the non-spool item should be the first or early item in the jacket circuit order, which especially applies to jacketed items in which there is a pocket of un-drained condensate.

### 8.12.3 Jacket Circuit Criteria

The following table is a table summarizing the guidance on length and complexity of jacket circuits

Jacket Circuit Criteria	Upstream of Sulphur Pit	Downstream of Sulphur Pit
Maximum number of jumpovers:		
Type 4 (Horizontal)	3	5
Type 4 (vertical)	4	8
Type 3**	1	3
Total	4	8
Max jacket circuit length (m)	6	18
Max non-spool element	1	5 with bottom drain 2 with side drain



\*\* If Type 3 jumpovers are used, the sum of all the lower to upper invert vertical dimensions shall not be more than 3m, to limit potential condensate lift backpressure.

### 8.12.4 Number of Steam Feeds

Steam from one distribution manifold connection may feed two adjacent circuits if arrangement of the feed points are convenient and economical and the combined length of the two circuits is less than the max jacket circuit length.

## 8.13 Materials

Jacketed piping materials shall be in accordance with the project Piping Material Specifications. Diaphragm and baffle materials shall be the same as or equivalent to the piping materials to which shall be welded. In any case, if the jacket and process line materials are different, the material plates shall be equivalent to the higher quality material.

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Supply specifications shall be as specified in **Section 6.11** for steam supply and condensate return manifolds with integrated compact drain trap assemblies.

## 9 **Installation Rules for Jacketed Piping**

9.1 The installation and construction rules define the shape, size and installation of piping elements in line heating and cooling systems using external jacketing, fed with fluids and/or steam.

### 9.2 Standard Construction Drawings

The installation and construction rules are shown in Appendix B.

#### Notes to the Standard Construction Drawings



- All dimensions are in mm. unless otherwise indicated.
- Each weld of inner pipe shall be accessible for x-raying and shall be visible during hydro testing. Therefore, split jackets shall be used to enable inspection of each inner pipe weld (see jacketed piping details)
- When tees are required, the jacket tee shall be split across the horizontal axis. A split at the crotch of tee is not allowed.
- Longitudinal welds from split pipe jackets and split tees or reducers shall be staggered to avoid crossing welds.
- When a jump over or condensate return connection is required on a split jacket, first the connection shall be welded before splitting the jacket pipe or reducer (to avoid deformation of jacket).
- Only external jacket surface of jacketed piping shall be applied with protective paint.

### 9.3 Pipe Stress and Supports

The annular space between the process and jacket line shall be maintained by centering guides welded to the inner pipe.

Following items shall be checked:

- Stresses caused by thermal expansion and temperature differences between process line and jacket line.
- Position and locations of centering guides or anchors in fully jacketed piping near elbows and branches
- Type of centering guide or anchor shall be specified on isometric drawings.



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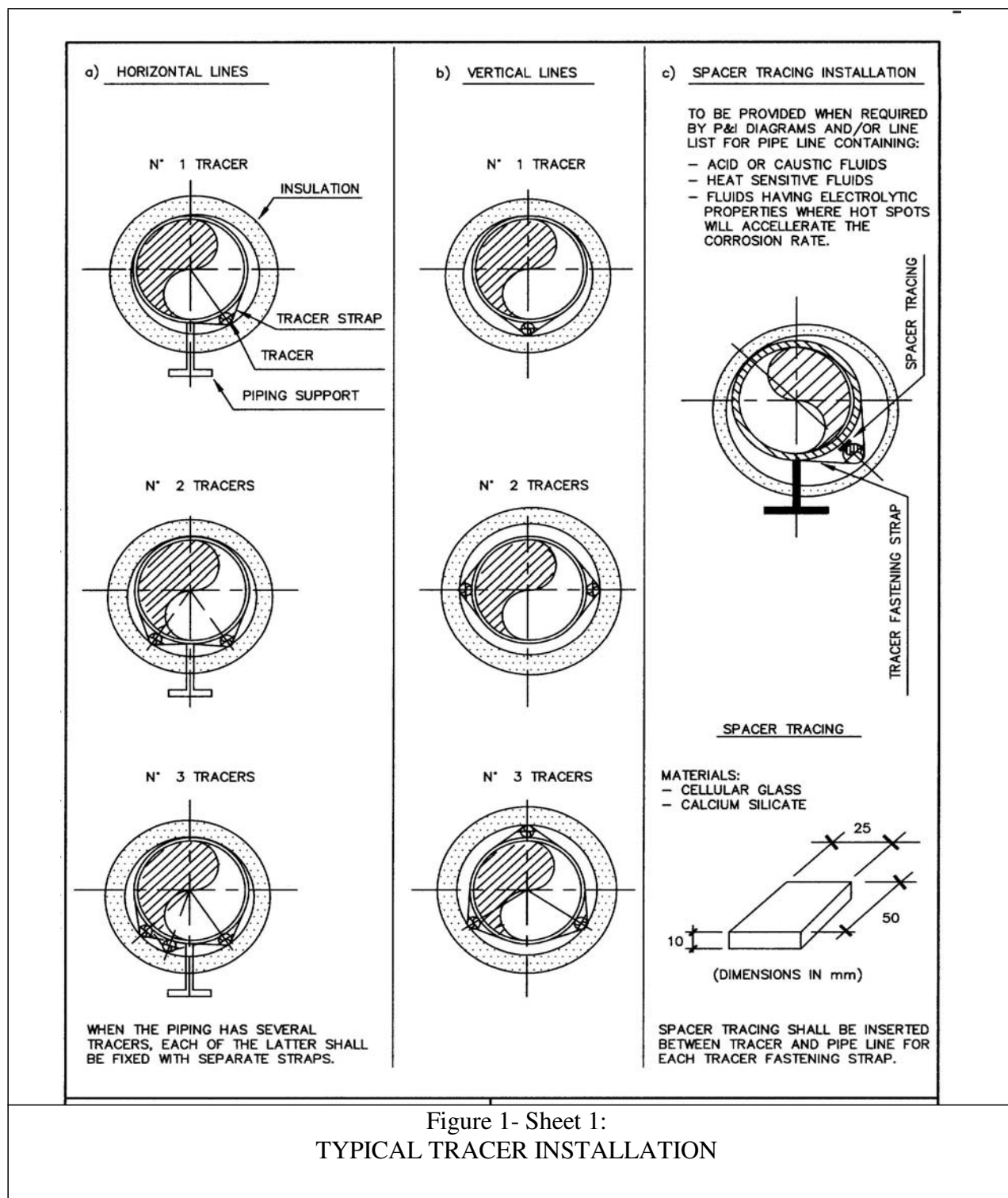
## APPENDIX A: Typical Installation Drawings Steam Tracing Sketches

General Notes:

1. Figures 1 through 16 are applicable for steam tracing.
2. These figures shall be used as general guideline to detail the Issue for Construction Drawings.





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**Figure 1- Sheet 1:**  
**TYPICAL TRACER INSTALLATION**



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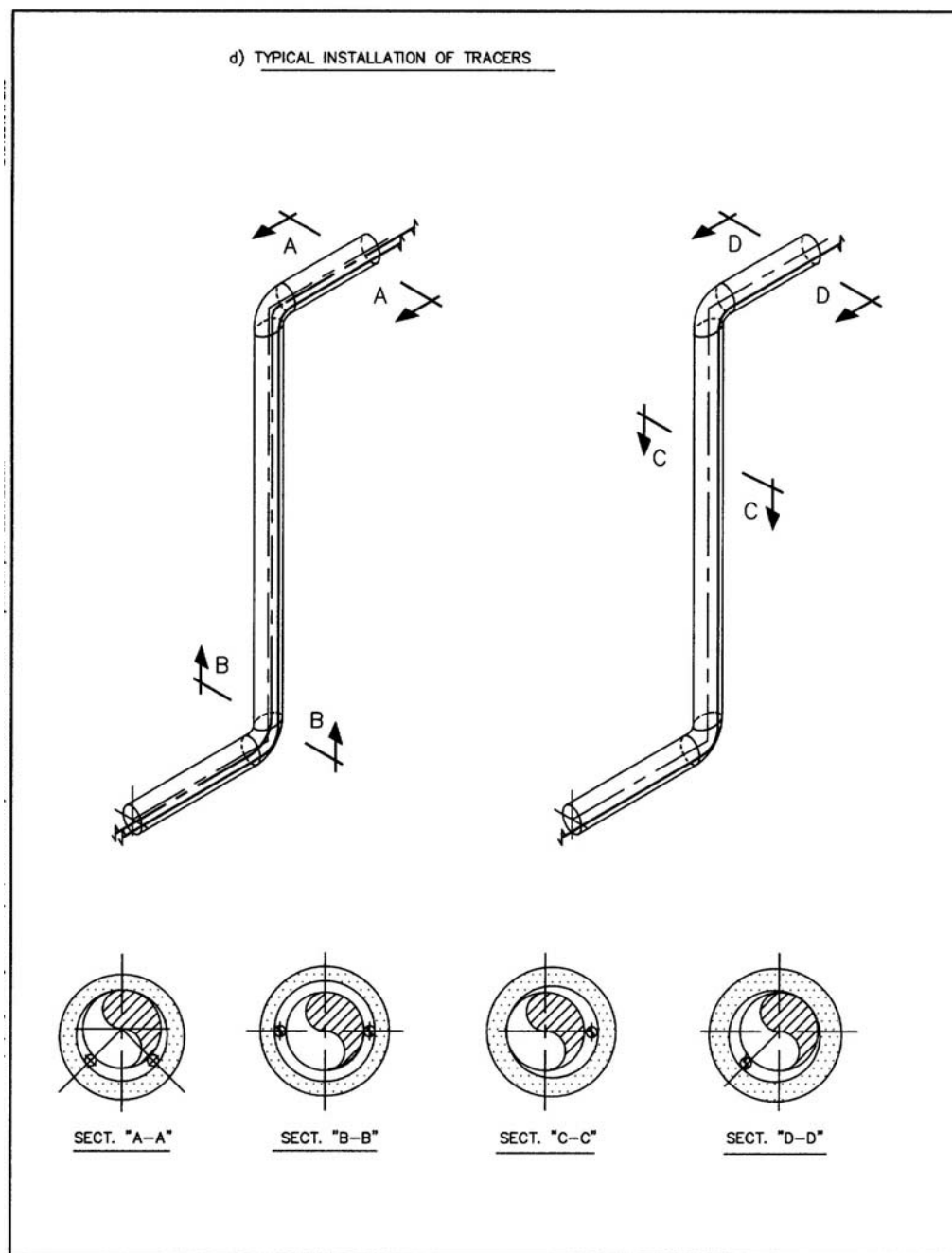




Figure 1-Sheet 2  
TYPICAL TRACER INSTALLATION

 <b>TechnipFMC</b>	 IndianOil	<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks</b>	
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a) ON STRAIGHT PIPE EXCEEDING 20 m LENGTH AN EXP. JOINT LOOP SHALL BE PROVIDED TO COMPENSATE DIFFERENTIAL EXPANSION BETWEEN TRACER AND PIPELINE

b) TRACING DETAIL WITHOUT EXPANSION LOOP

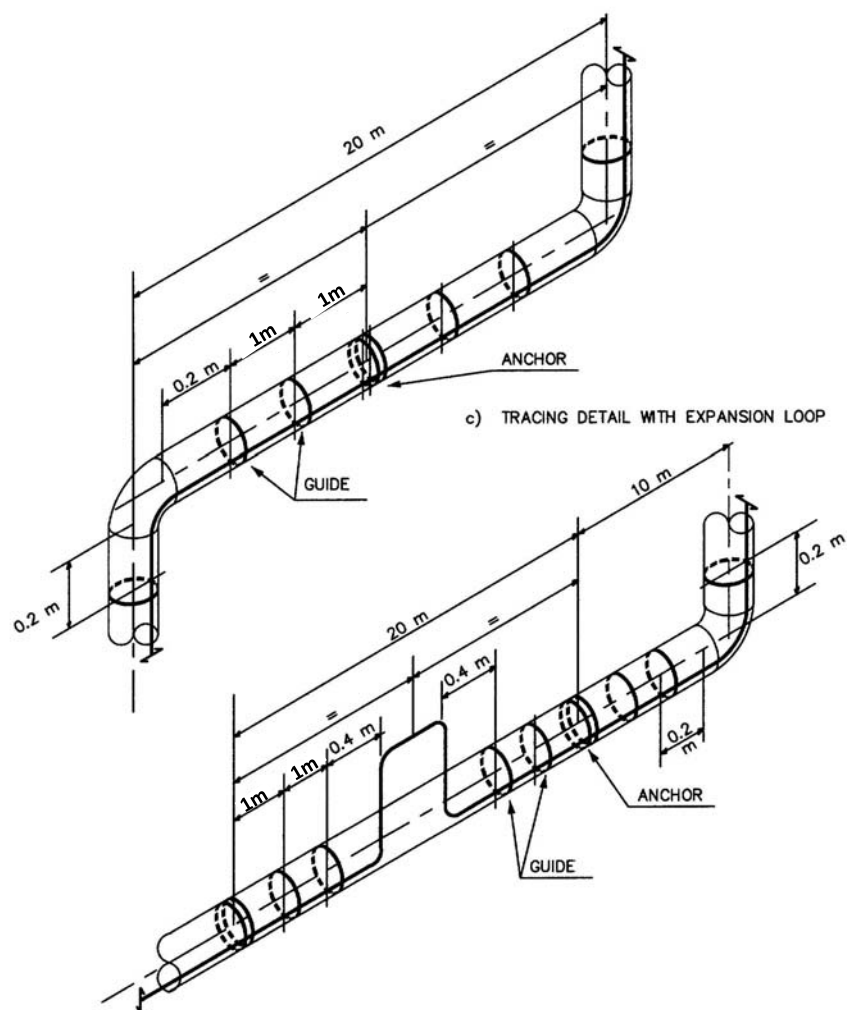
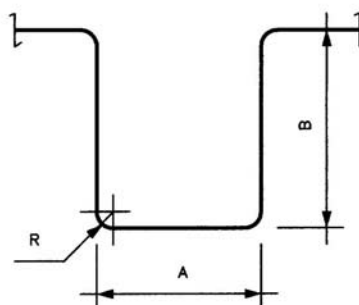


Figure 2 sheet 1  
TRACER EXPANSION LOOPS

d) DIMENSIONAL TABLE FOR EXPANSION LOOPS ON TUBING AND Sch. 40 PIPE TRACERS.

DIMENSIONS IN mm

TRACER	A	B	R
TUBING 3/8"	150	200	50
TUBING 1/2"	200	200	50
TUBING 3/4"	200	300	75
PIPE 1/2"	200	300	100
PIPE 3/4"	200	400	100
PIPE 1"	300	500	150



e) EXPANSION LOOP INSTALLATION ON TRACERS.

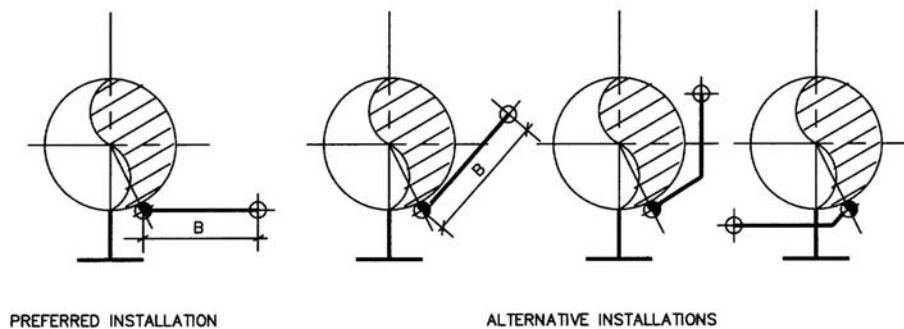




Figure 2 sheet 2  
TRACER EXPANSION LOOPS

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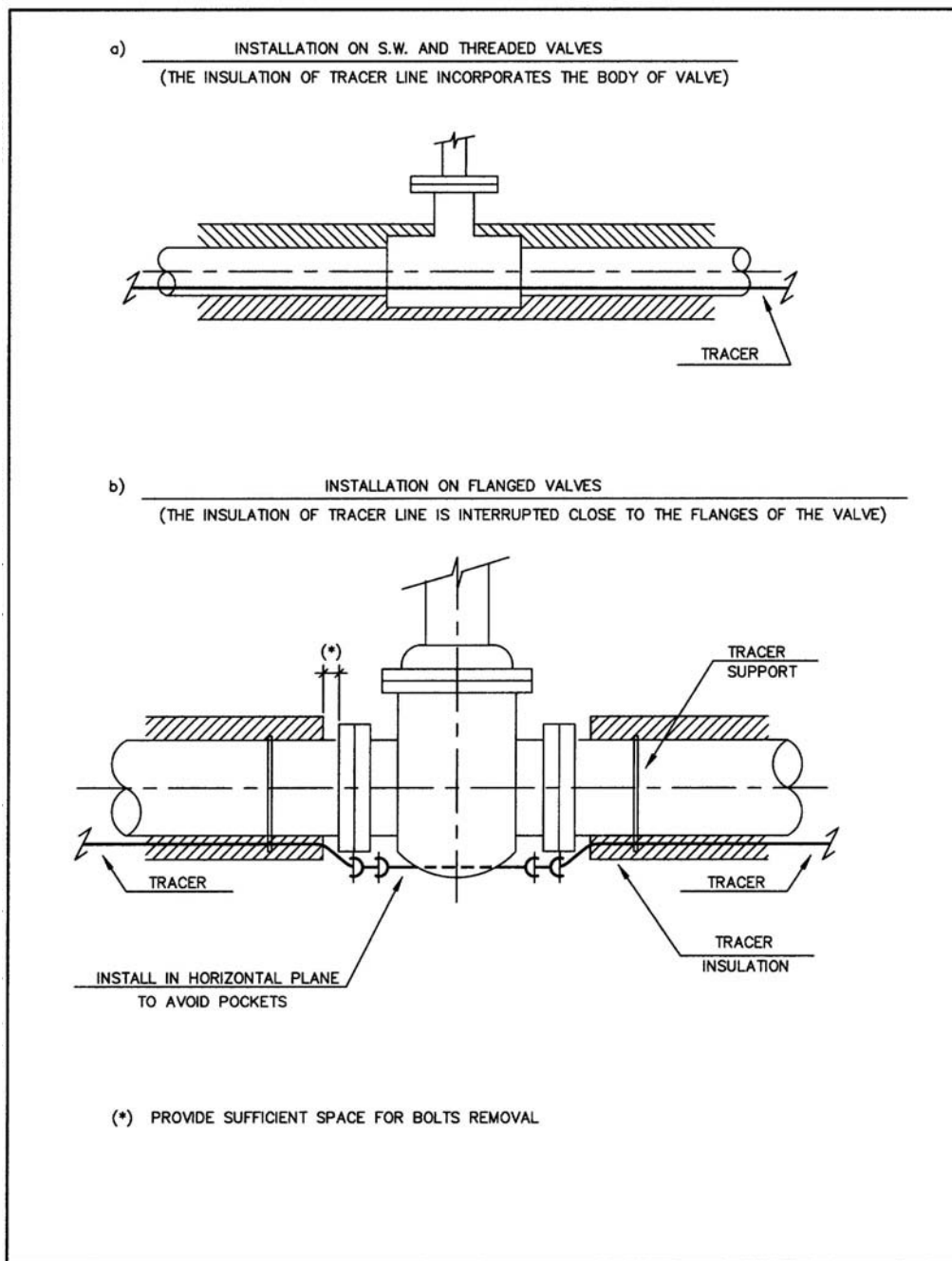


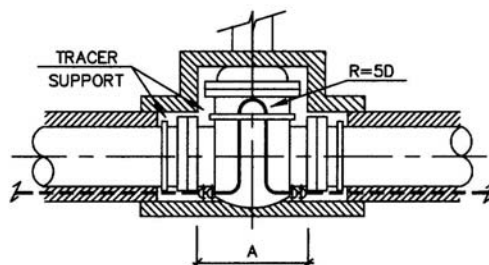


Figure 3  
TRACING OF VALVES

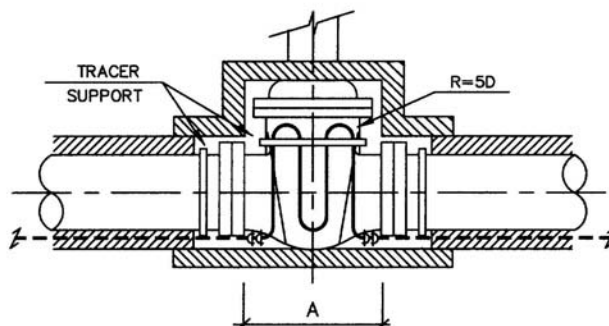
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- a) INSTALLATION ON S.W. AND THREADED VALVES  
(THE INSULATION OF TRACER LINE INCORPORATES THE BODY OF VALVE)

- b) INSTALLATION ON FLANGED VALVES AND CONTROL VALVES  
(THE INSULATION OF VALVE INCLUDES THE TRACER LINE)



FLANGED VALVES WITH "A" DIMENSION  $\leq 400$  mm





FLANGED VALVES WITH "A" DIMENSION  $> 400$  mm

**NOTES :**

- (1) WHEN PROCESS LINE IS TRACED WITH 2 OR MORE TRACERS, PROVIDE VALVE TRACING USING 2 TRACERS ONLY: ONE FOR EACH SIDE OF VALVE, THE OTHERS SHALL BE ROUTED PARALLEL TO THE VALVE.
- (2) TRACERS SHALL ADHERE TO THE VALVE'S BODY LEAVING THE POSSIBILITY TO DISMOUNT THE VALVES.

**Figure 4**  
**TRACING OF INSULATED VALVES**

 <b>TechnipFMC</b>	 IndianOil	<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks</b>	
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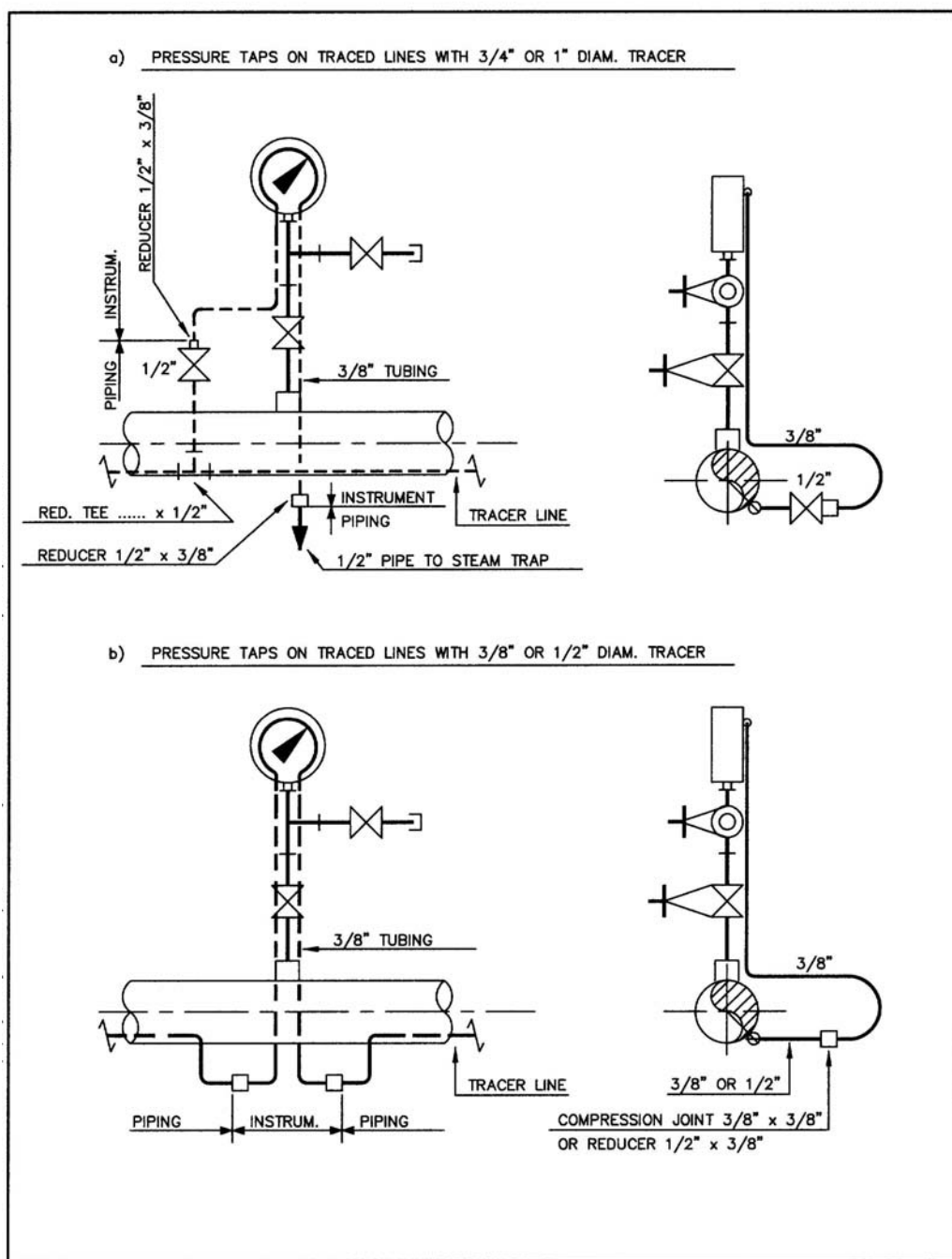


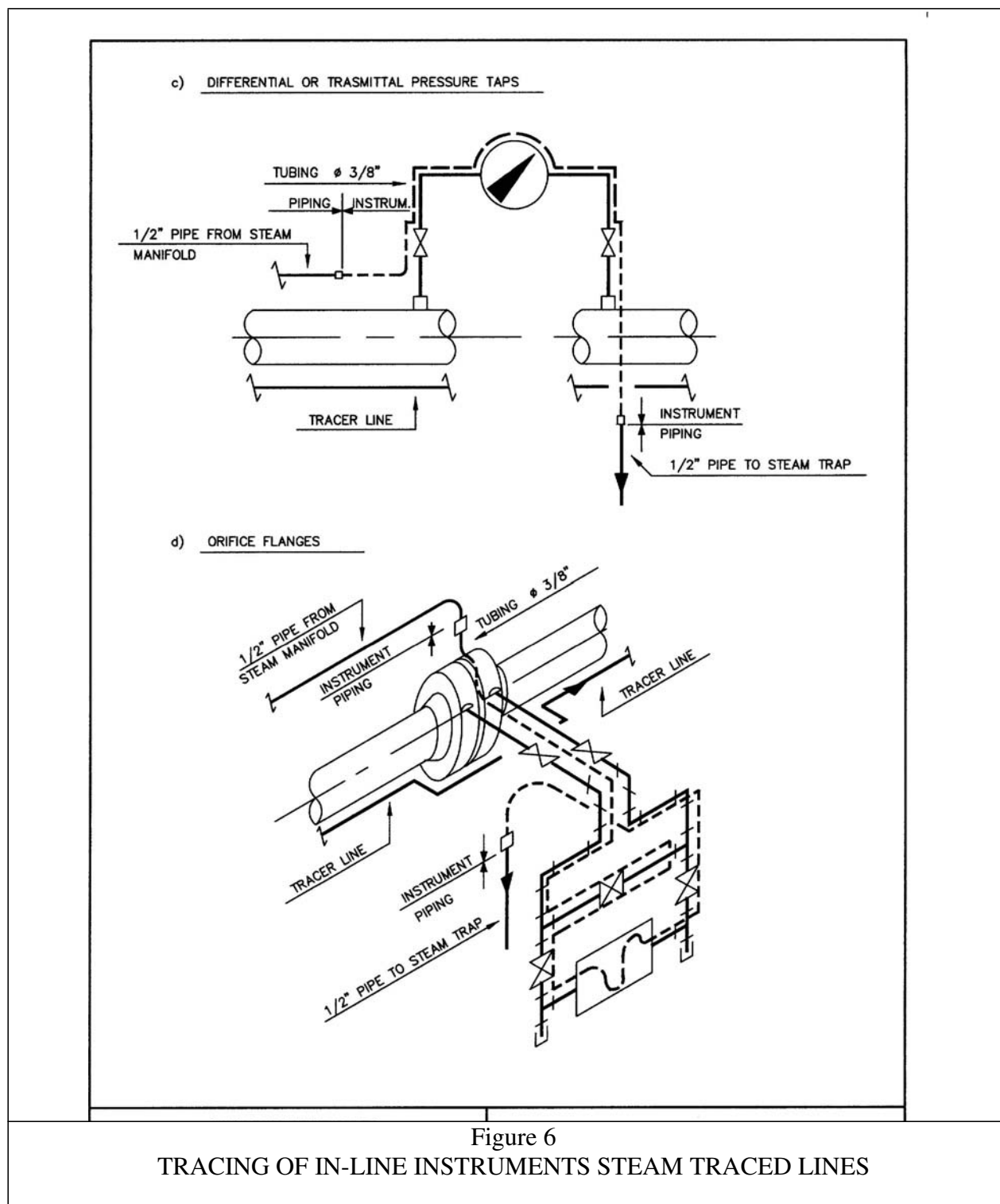




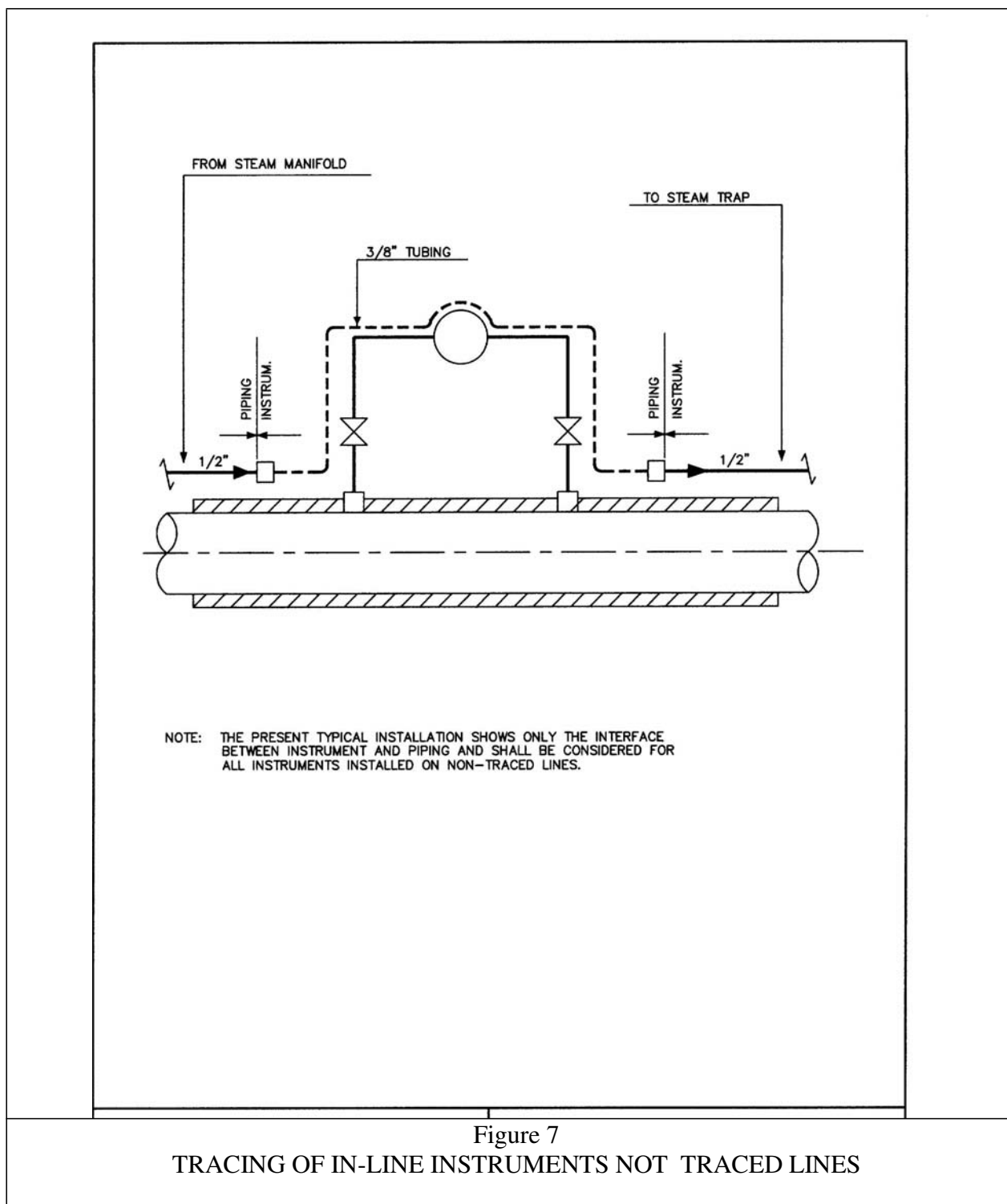
Figure 5  
TRACING OF IN-LINE INSTRUMENTS STEAM TRACED LINES





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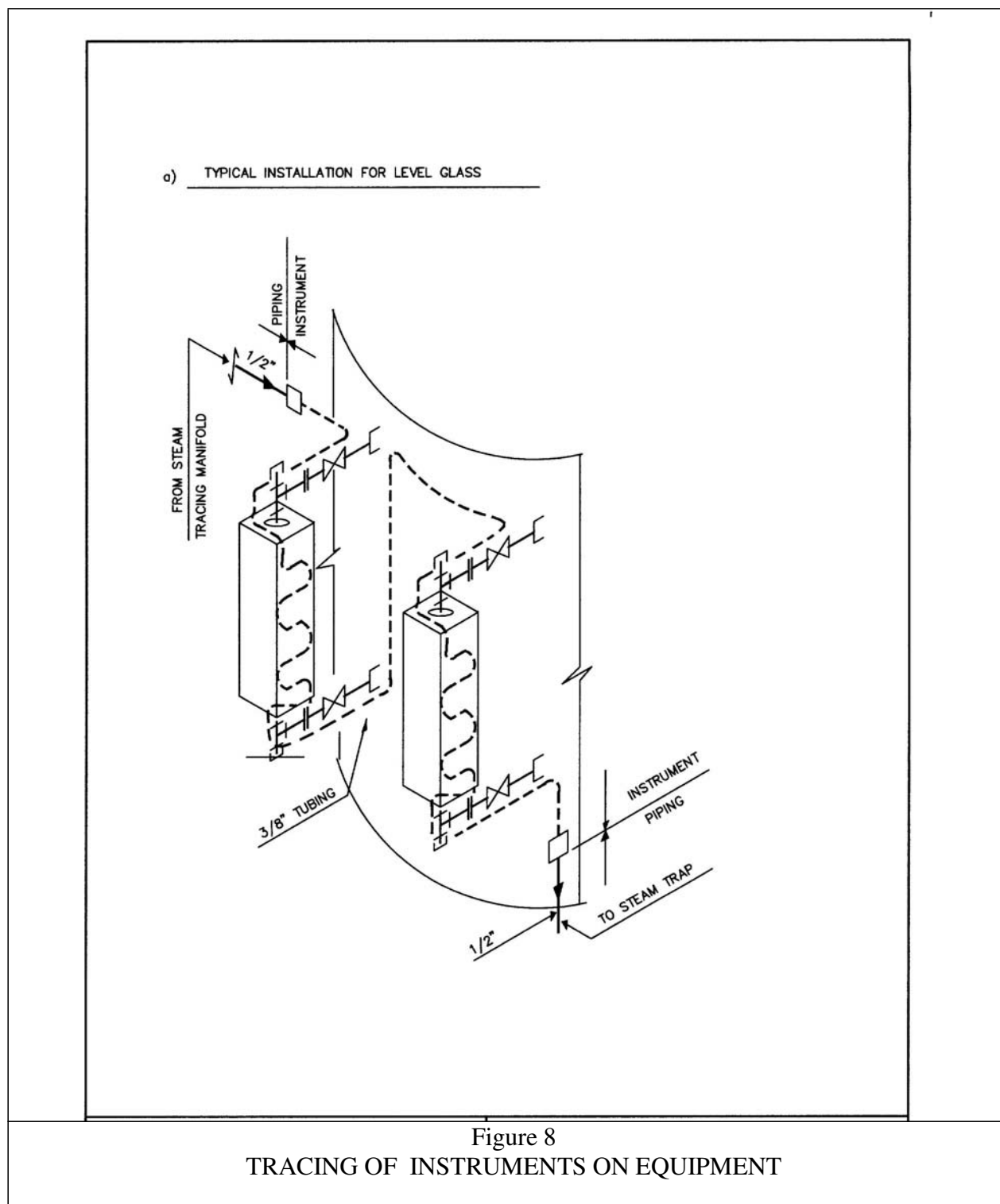




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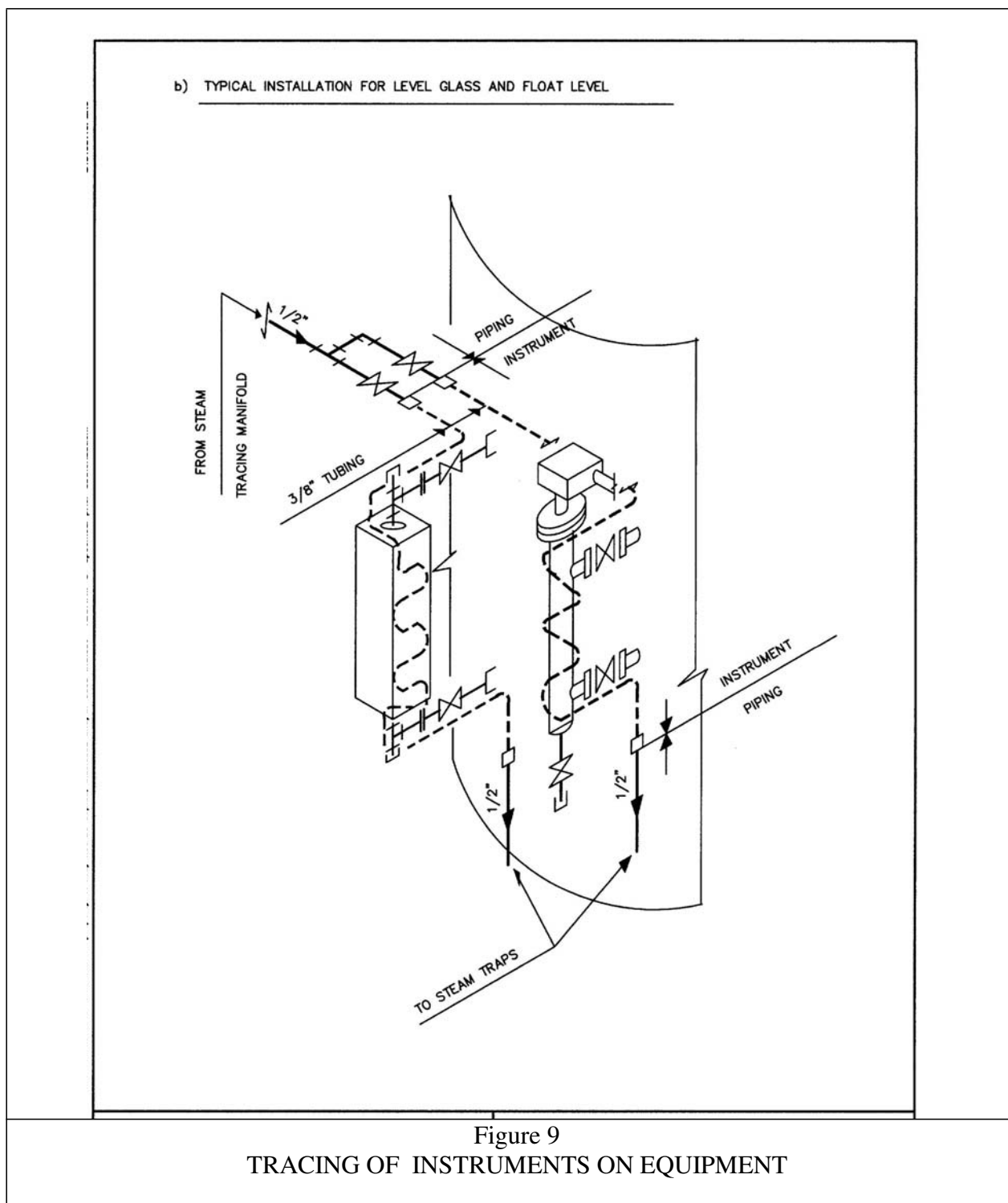






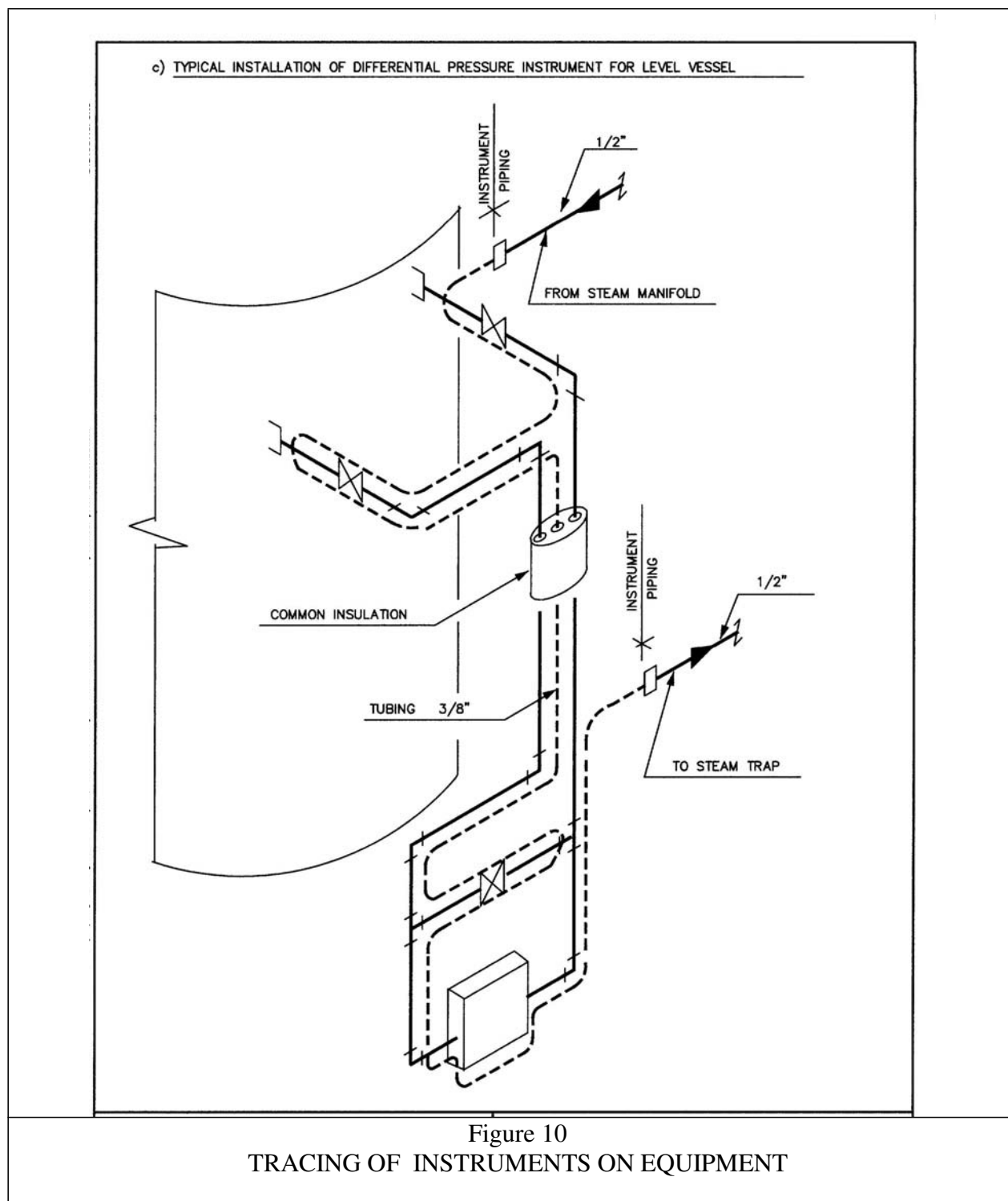
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			<b>IOCL Paradip Refinery</b>	
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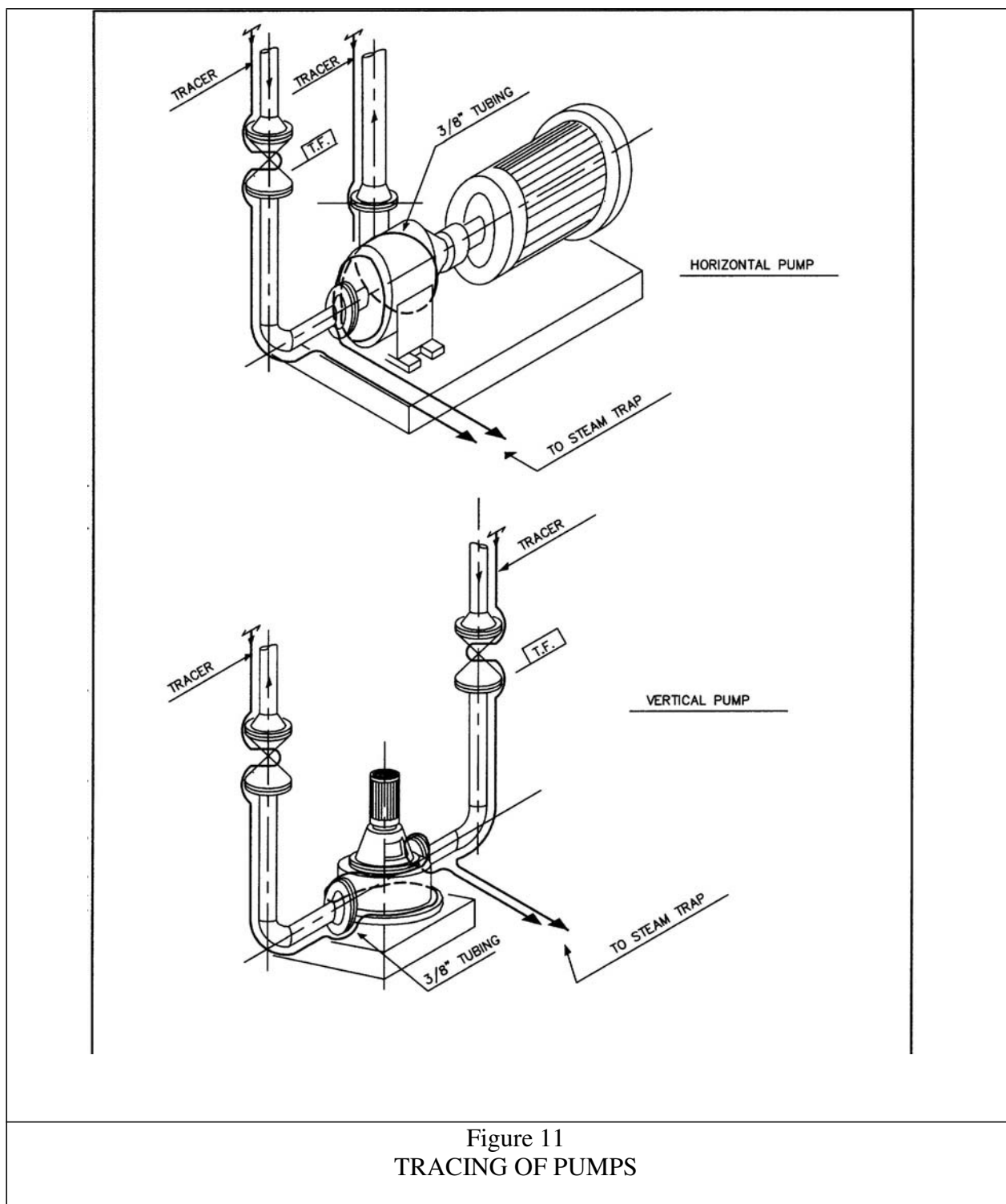
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			<b>IOCL Paradip Refinery</b>	
		<b>CLIENT</b>	<b>INDIAN OIL CORPORATION LIMITED</b>	
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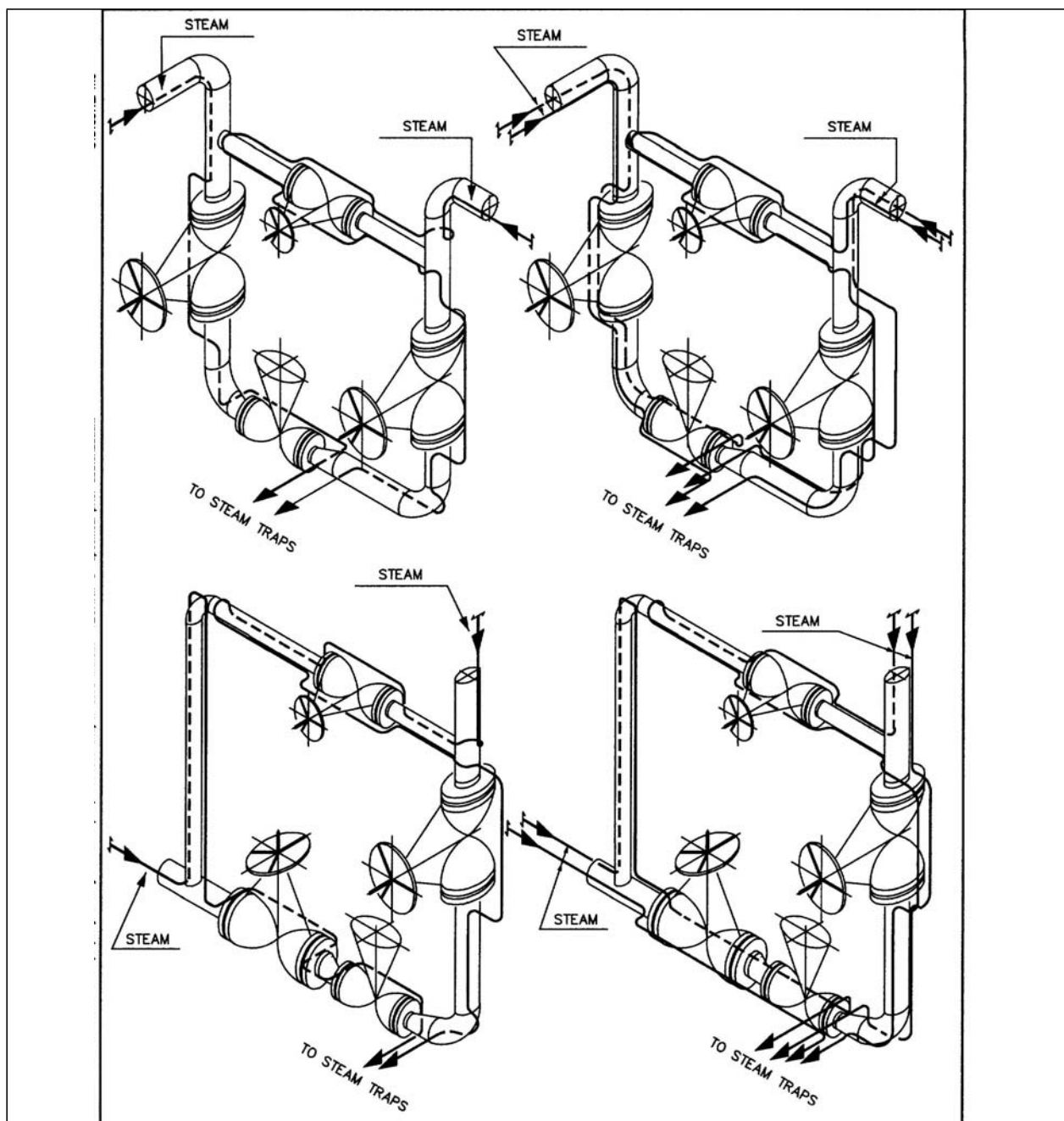


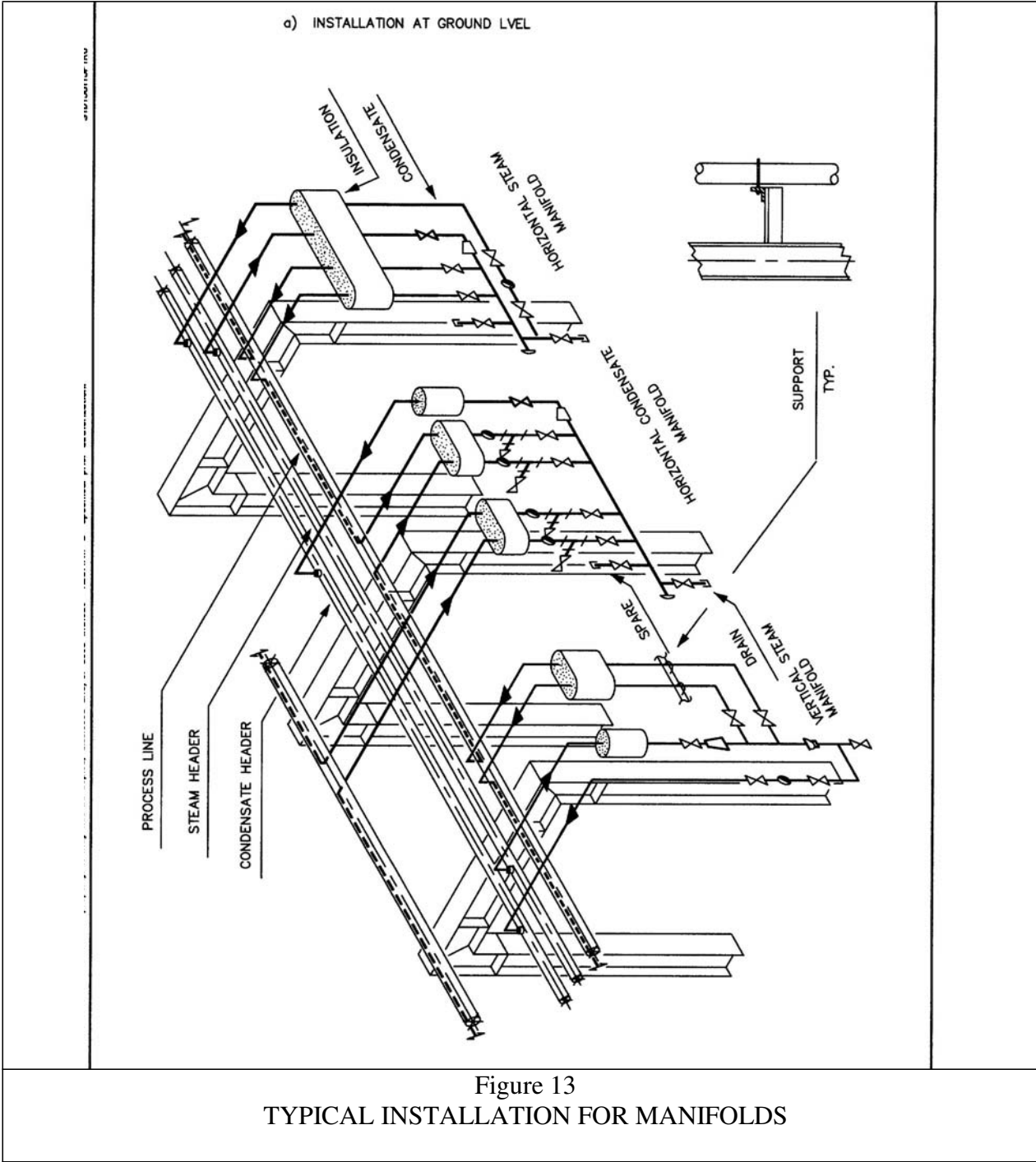




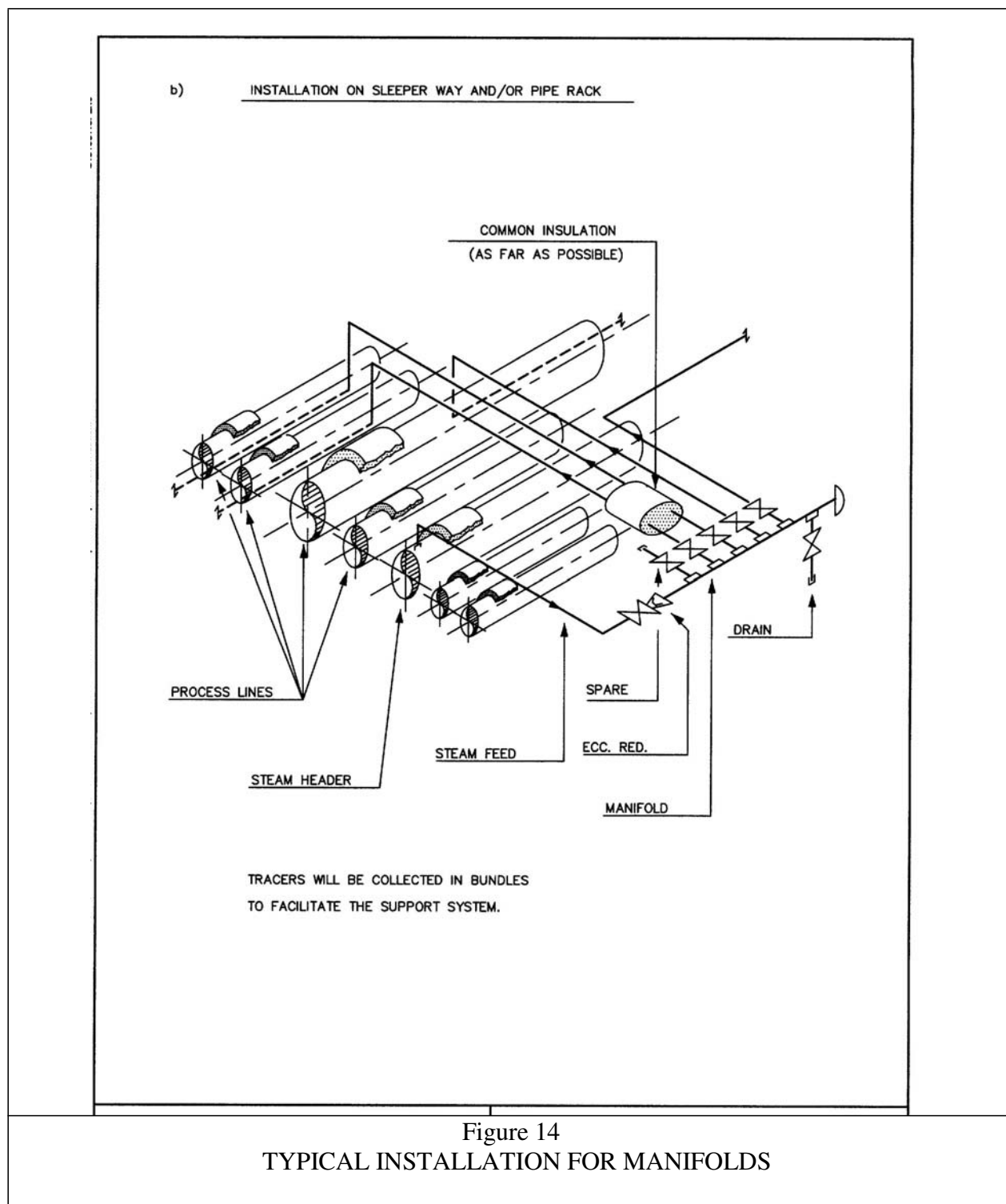
Figure 12  
CONTROL SET TRACING





 	PROJECT		Standby SRU & Additional Tanks	
	CLIENT		IOCL Paradip Refinery	
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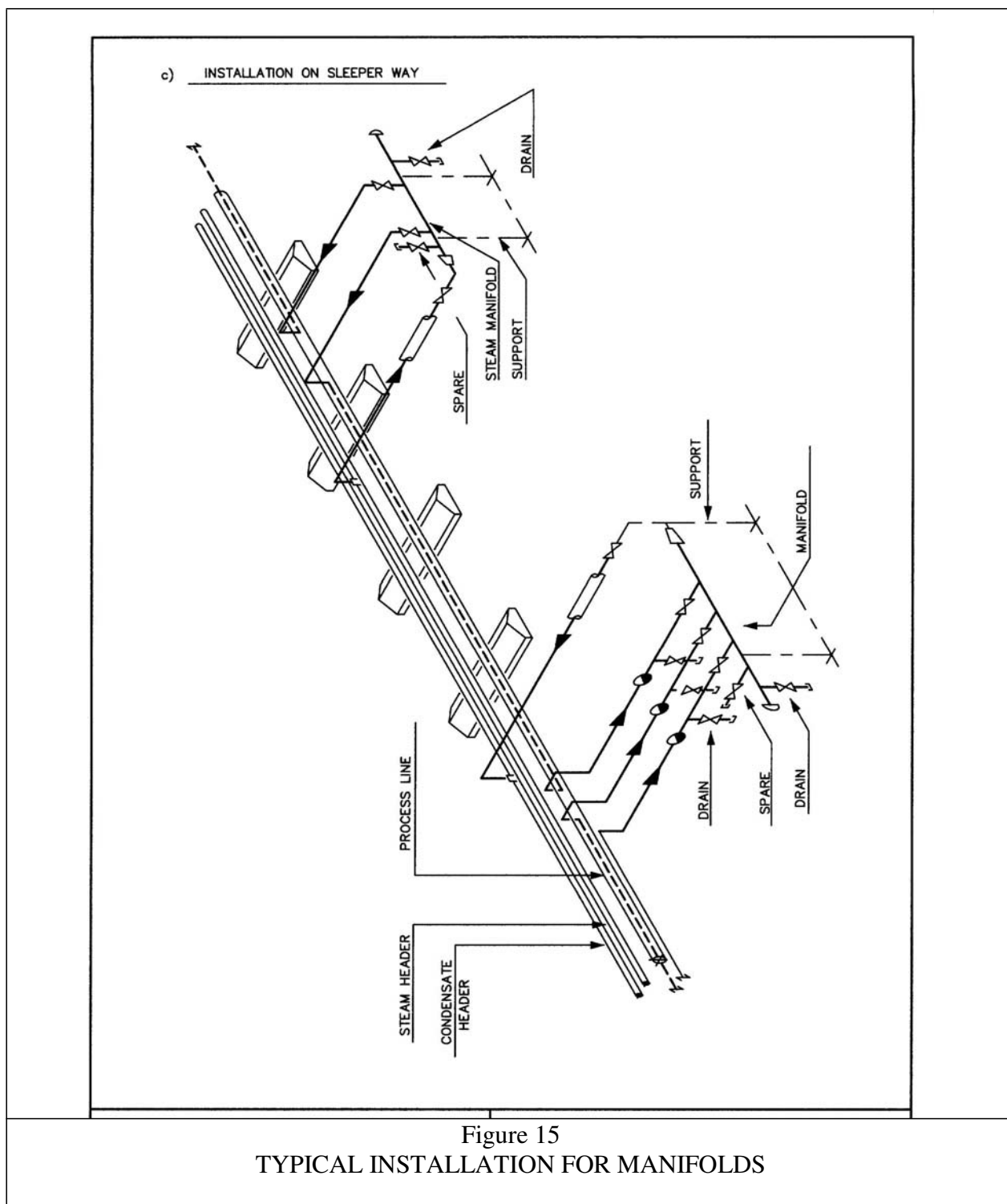




 <b>TechnipFMC</b>	 IndianOil	<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks</b>		
			<b>IOCL Paradip Refinery</b>		
		<b>CLIENT</b>	<b>INDIAN OIL CORPORATION LIMITED</b>		
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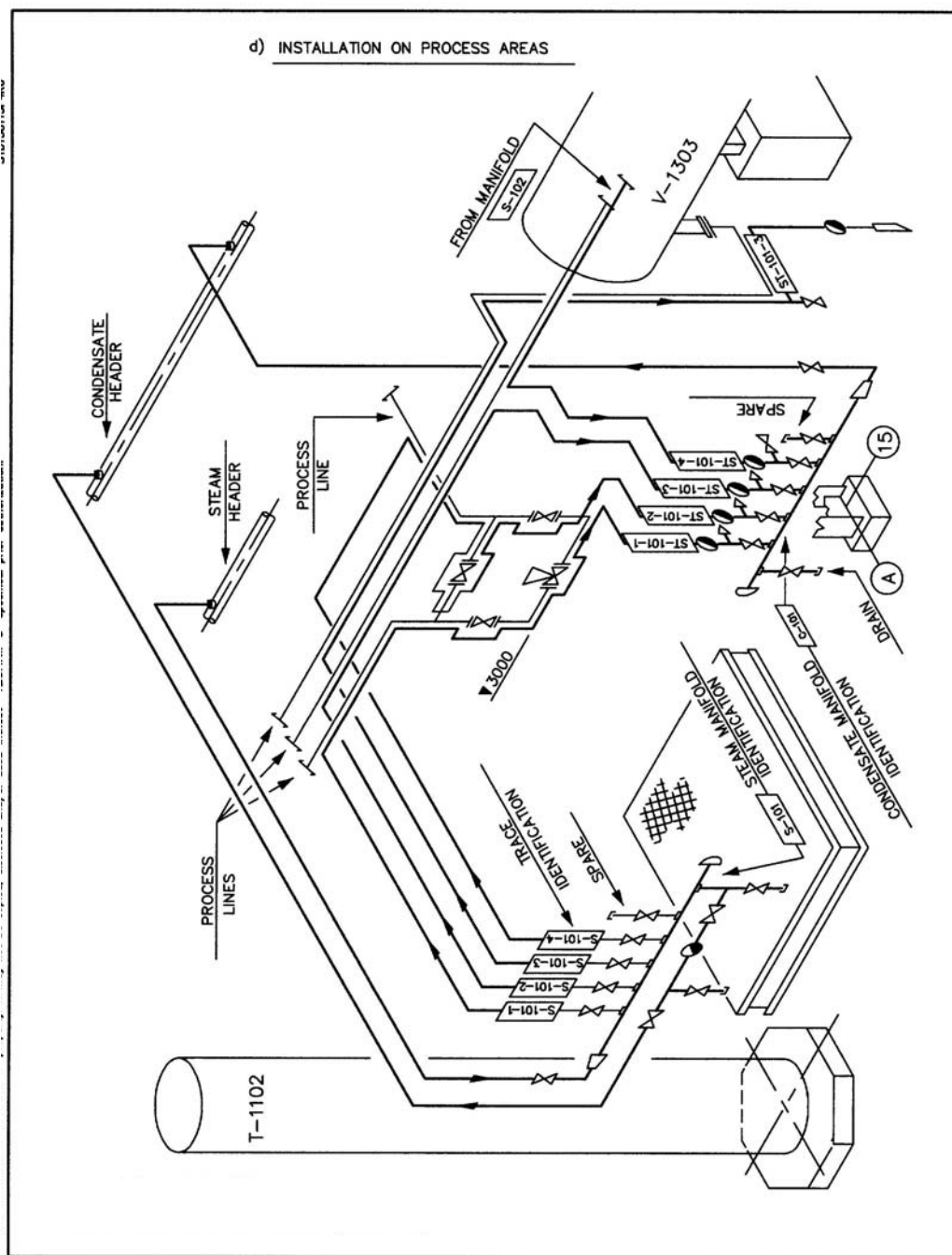




Figure 16  
TYPICAL INSTALLATION FOR MANIFOLDS

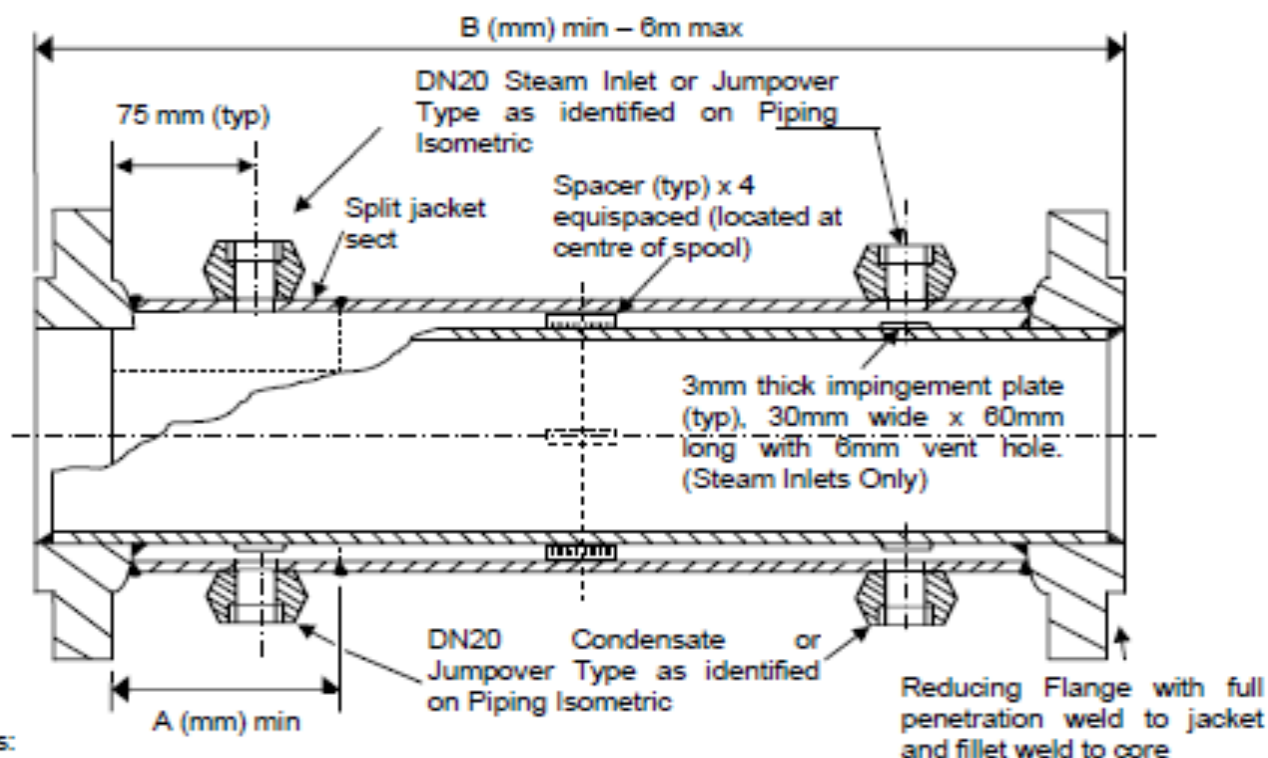
 	<b>PROJECT</b>		<b>Standby SRU &amp; Additional Tanks</b>	
	<b>CLIENT</b>		<b>IOCL Paradip Refinery</b>	
<b>Job Specification for Steam Tracing and Jacketed Piping</b>	<b>Project No.</b> 080557C001	<b>Document No.</b> 080557C-000-JSD-1300-006	<b>Rev. No.</b> B	Page 48 of 62

## APPENDIX B: Typical Installation Drawings for Steam Jacketed Piping

General Notes:

These figures shall be used as general guideline to detail the Issue for Construction Drawings.  
Figures:

1. Fabrication Method for Jacketed Spool
2. Jacketed Spool detail
3. Fabrication Method for Jacketed Cross and Tee
4. Jacketed Cross detail
5. Jacketed Tee for Instruments / Drains / Vents
6. Instrument Tee
7. Utility Steam Details
8. Fabrication Procedure for Field Fit Welded spools
9. Standard reducer spool
10. Standard Weld Detail
11. Fabrication Method for Partial Jacketed Spool
12. Seam Weld Orientation for DN80 x DN50 Jacketed Crosses
13. Typical Detail for Jumpover Connections
14. Typical Jumpover Connections

**Figure 1: Fabrication Method for Jacketed Spool**

**Notes:**

- 1.) Complete welding and hydrotesting of inner pipe welds prior to welding of jacket.
- 2.) Summary of Welding Sequences:
  - A: Weld first flange to inner pipe.
  - B: Weld spacers and impingement plate to inner pipe. (Material to ASTM A-36)
  - C: D: Weld second flange to inner pipe.
  - D: NDT / Hydrotest inner pipe.
  - E: Slide jacket length (excluding split jacket section) over inner pipe.
  - F: Weld jacket to first flange
  - G: Weld split jacket halves between jacket and second flange.
  - H: Inspect jacket welds and hydrotest jacket pipe.
- 3.) Utility connections to be DN20 Sockolets in locations as shown on piping isometric.
- 4.) Weld separations to be as defined in Figure 2.
- 5.) If pipework layout results in spool lengths less than specified in Table 1 a non standard cross with an extended leg shall be used.

**Table 1. Min Spool Lengths**

Jacket DN	A (mm)	B (mm)
80	200	500
100	200	500
150	200	500
200	250	600
250	300	700
300	350	800



TechnipFMC



PROJECT

Standby SRU & Additional Tanks

IOCL Paradip Refinery

CLIENT

INDIAN OIL CORPORATION LIMITED

Job Specification for  
Steam Tracing and Jacketed Piping

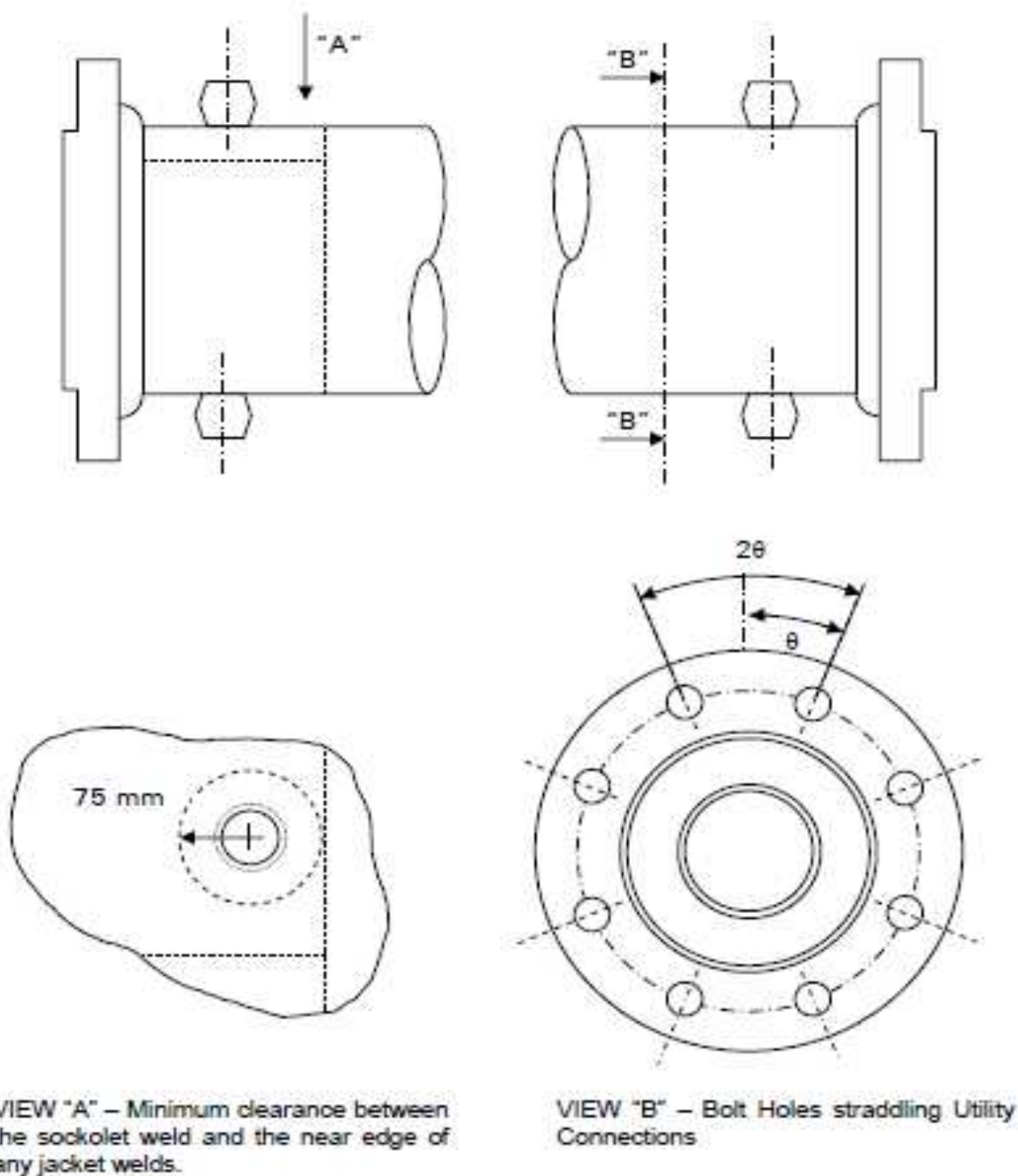
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Figure 2: Jacketed Spool detail

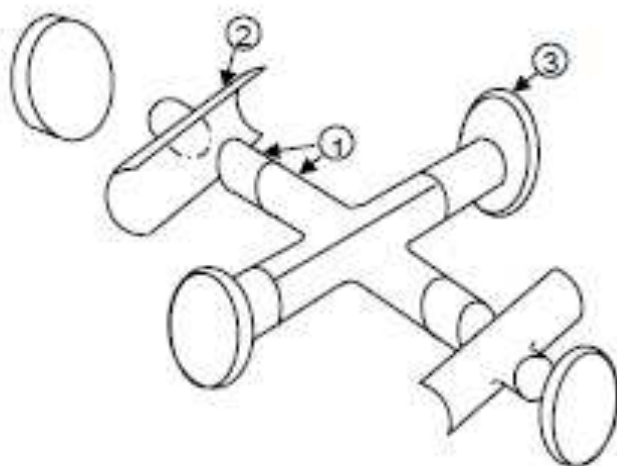




 <b>TechnipFMC</b>	 IndianOil	<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks</b>  <b>IOCL Paradip Refinery</b>	
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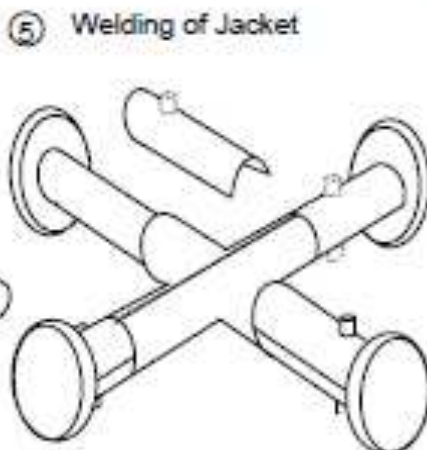
**Figure 3: Fabrication Method for Jacketed Cross and Tee**

#### Fabrication

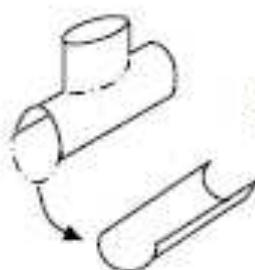


1. Weld straight pipe lengths onto inner (process) split tees NDE (x4).
2. Weld 3 mm thick impingement plate to inner pipe (at steam inlet).
3. NDT and hydrotest inner pipe assembly.
4. Slip unwelded jacket split tees (see detail) over inner cross (x2).
5. Weld flanges onto inner pipe lengths (x4).
6. Complete welding of jacket by welding split jacket tees and split jacket pipe sections.
7. Weld steam and condensate connections and pressure test jacket.

Split jacket pipe sections with DN20 utility connections (socket) at locations as identified on Piping isometric.



Jacket split Tee detail



Separate back from 2 forged tees

#### NOTE:

The longitudinal seam welds on the jacket pipe must be offset by at least 25 mm from those which join the two split tees. For jacket size DN80 and DN100 this will dictate the orientation of the seam welds with respect to that of the utility connections. See figure 12. Split jacket weld will be at 45 degree orientation from the horizontal for sizes greater than DN100. This allows unrestricted location of utility connections at these sizes.



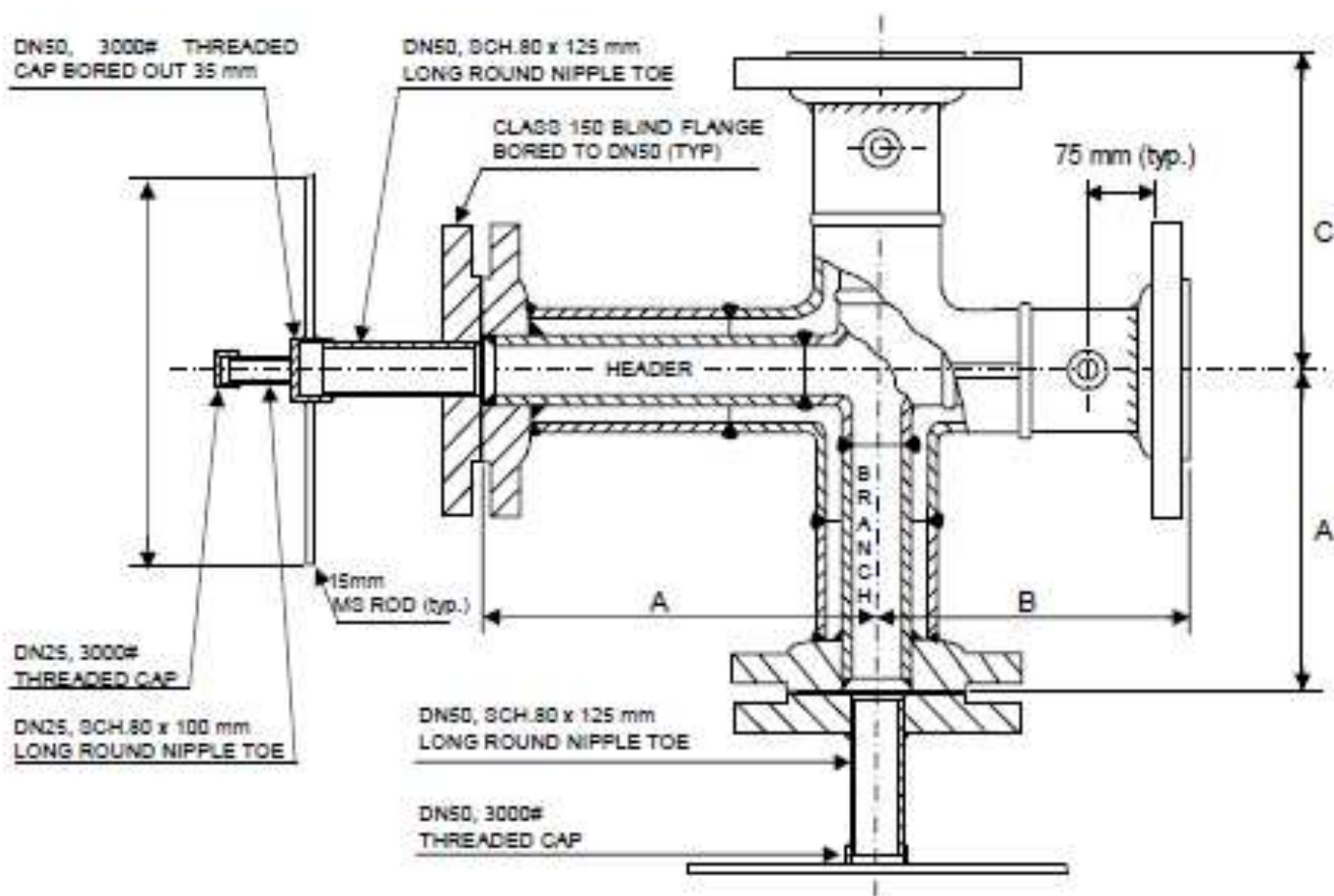
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				<b>IOCL Paradip Refinery</b>		
			<b>CLIENT</b>	<b>INDIAN OIL CORPORATION LIMITED</b>		
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Figure 4: Jacketed Cross details (with rodding out connections)



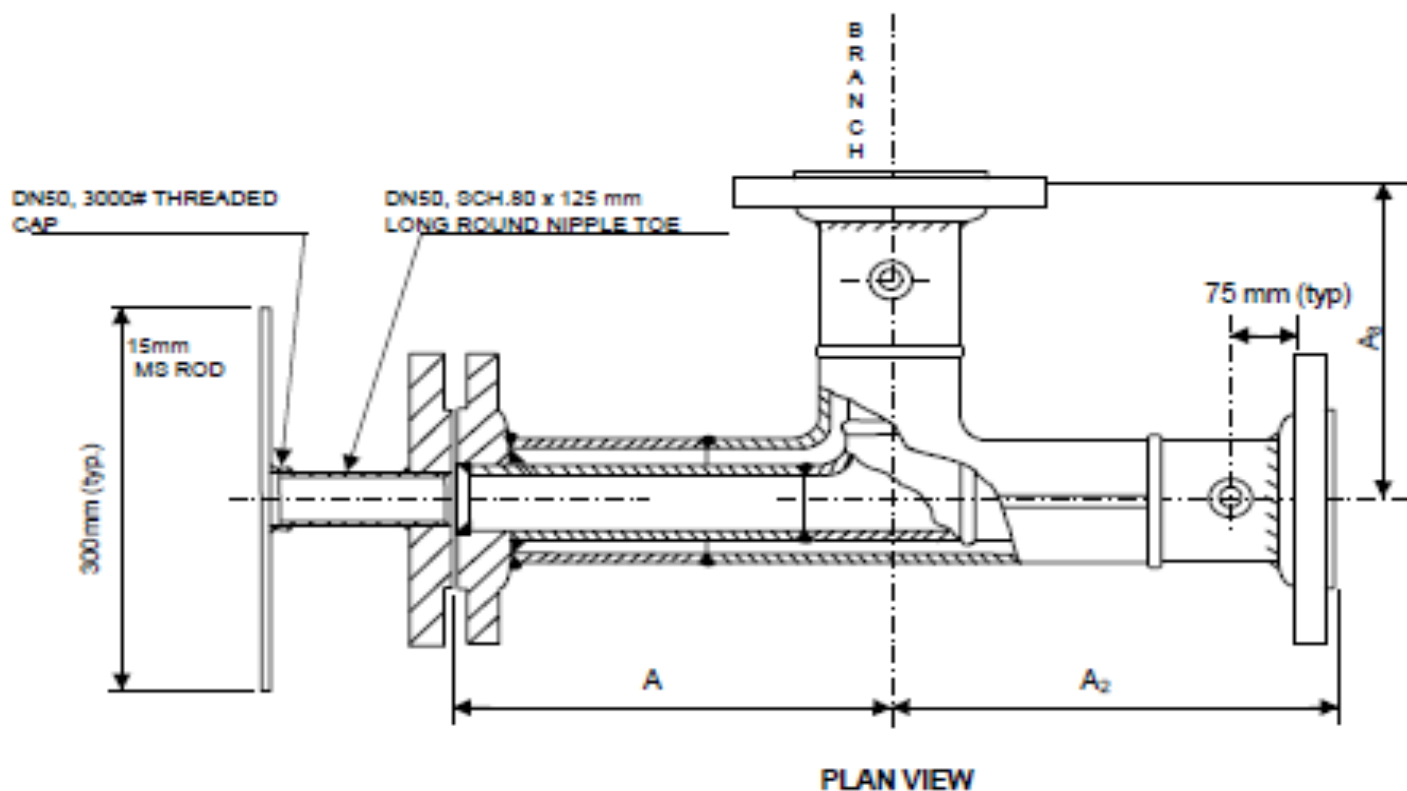
Jacket-Core Diameter (DN mm)		Dimension A (mm)
Jacket	Core	
80	50	300
100	80	300
150	100	340
200	150	380
250	200	450
300	250	490

1. Unless otherwise specified, dimensions B & C will be equal to dimension 'A'. If greater than 'A', dimension will be specified on piping isometric.
2. Steam and condensate connections (DN20 socklets) to be located as identified on the Piping isometric.
3. Fabrication sequence as shown in Figure 3.





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**Figure 5: Jacketed Tee details (with rodding out connections)**

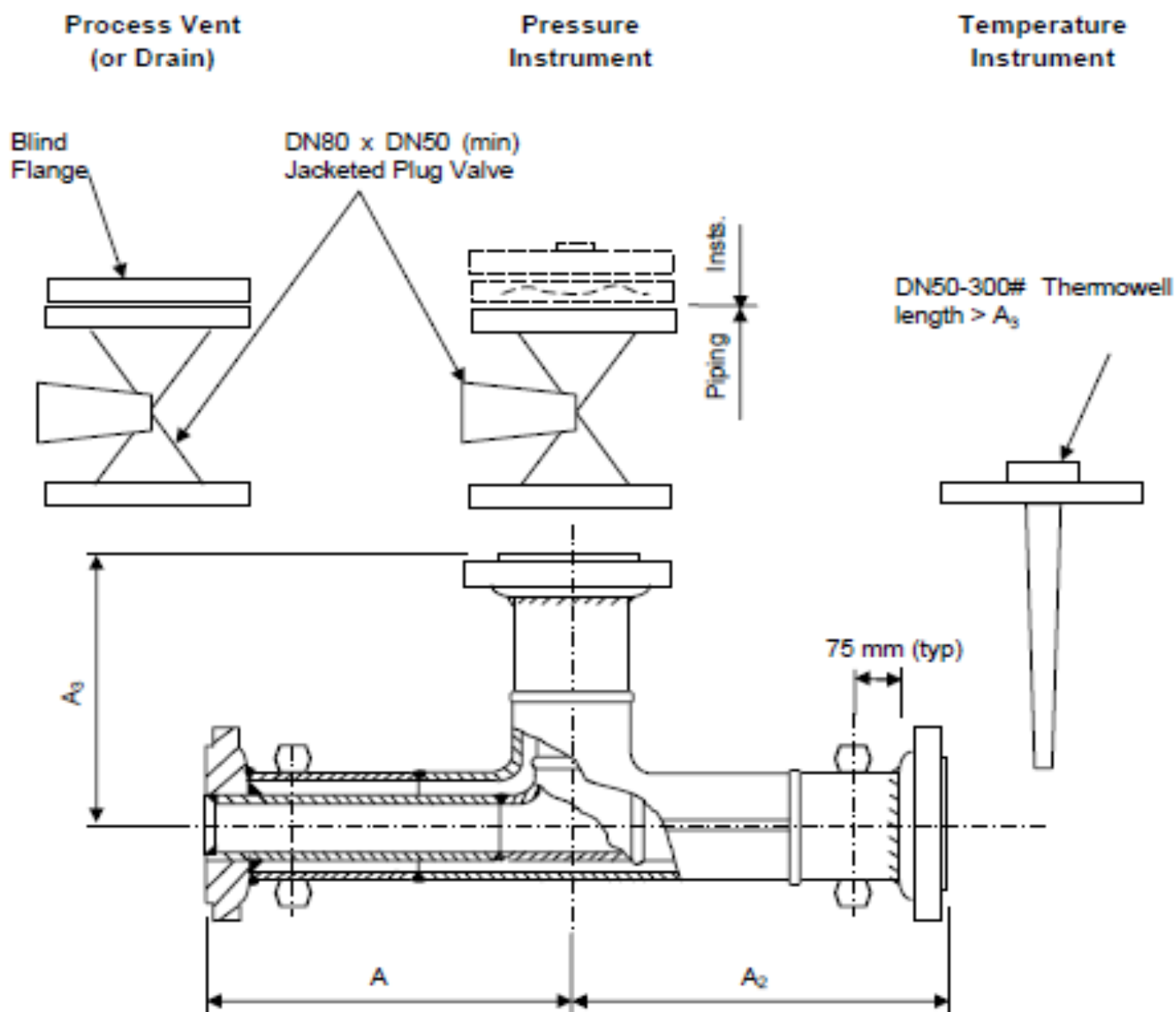


Jacket-Core Diameter (DN mm)		Dimension A (mm)
Jacket	Core	
80	50	250
100	80	300
150	100	340
200	150	380
250	200	450
300	250	490

1. Unless otherwise specified, dimensions  $A_2$  &  $A_3$  will be equal to dimension 'A'. If greater than 'A', dimension will be specified on piping isometric.
2. Reducing Tees may be used in order to reduce the instrument connection size to the minimum possible.
3. Deadleg does not require utility connections. The two in line branches shall have connections located as identified on the Piping isometric.
4. For horizontal headers, connections to be on top and bottom dead centre. (May not be possible with jacket sizes less than DN100, due to 25 mm min. jacket weld spacing, so a cross should be used)
5. Fabrication sequence as shown in Figure 3.
6. Rodding crosses shall be used in preference to tees wherever possible. Tees only to be used where space is a constraint.

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**Figure 6: Jacketed Tee for Instruments / Drains / Vents**



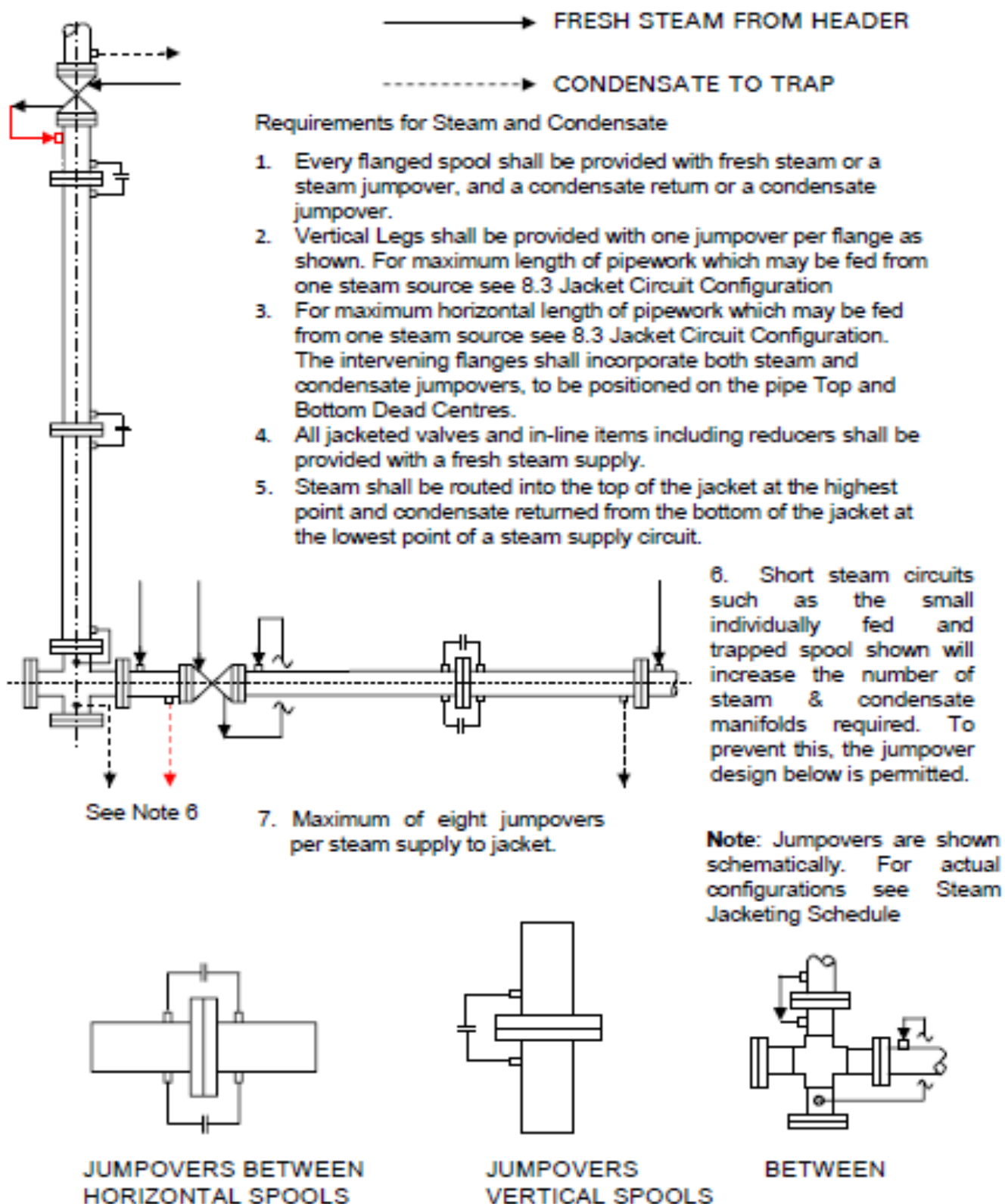
**Notes:**

1. Unless otherwise specified, dimensions A<sub>2</sub> & A<sub>3</sub> will be equal to dimension 'A'. If greater than 'A', dimension will be specified on piping isometric. (For dimensions see table in fig. 5)
2. Thermowell flange shall match the Jacket pipe size.
3. Reducing Tees may be used in order to reduce the instrument connection size to the minimum possible. If not available, stub-ins can be used for both inner and jacket branches.
4. If tee branch size is DN80 x DN50, plug valve shall be directly mounted on it.
5. For horizontal headers, connections to be on top and bottom dead centre.
6. Fabrication sequence as shown in Figure 3
7. Connection to instrument is to be a stub-in if the core size is greater than DN100.



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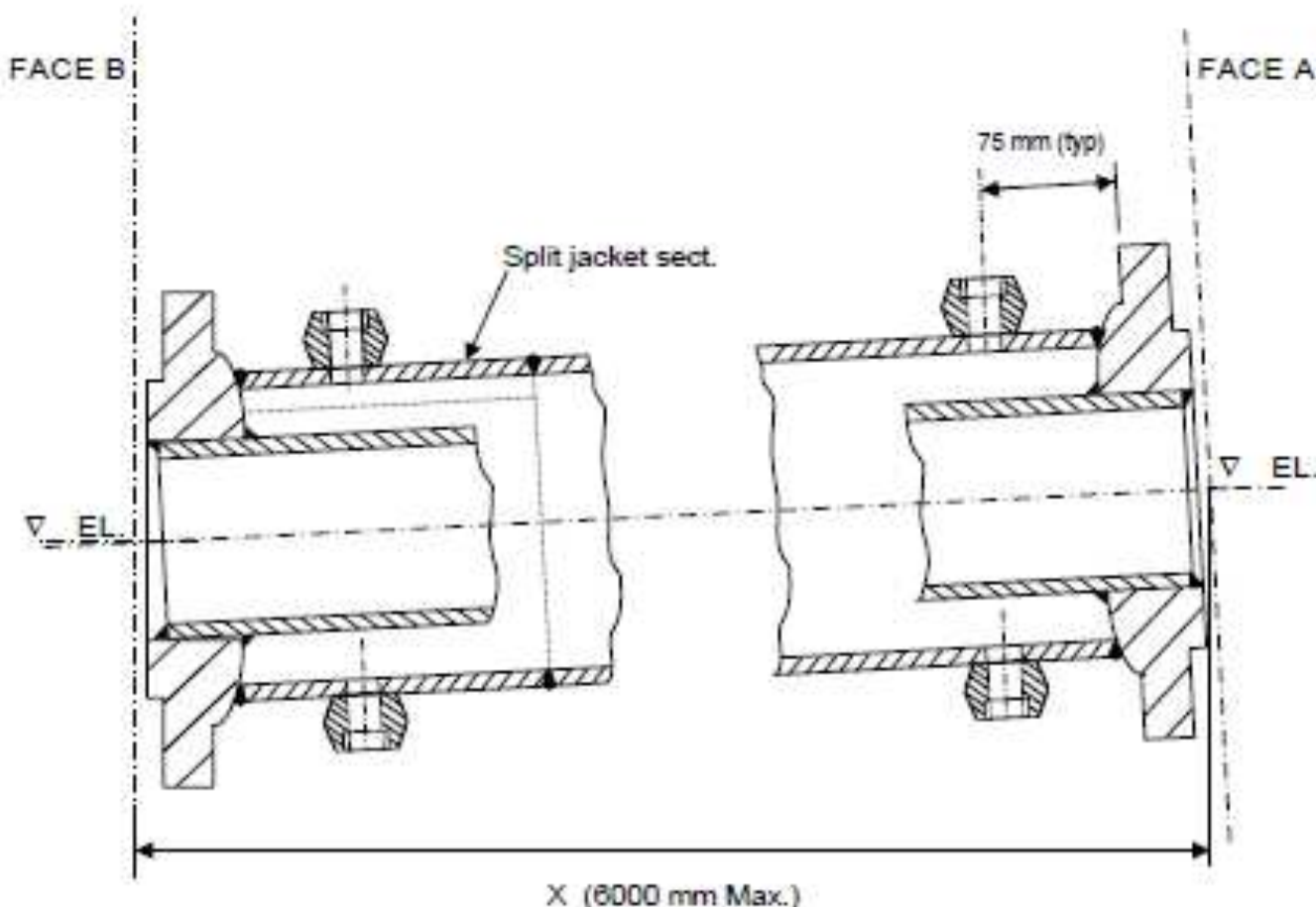
**Figure 7: Utility Steam Details**





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**Figure 8: Fabrication Procedure for Field Fit Welded spools**



**Fabrication sequence for Field Fit Welded Spools (Details as figure 1)**

1. Measure X. (There is not enough space for the steam and condensate connections/jumpovers on a spool shorter than the lengths given in Table 1 Fig.1., so use instead a special cross with one leg increased by the appropriate amount.)
2. Subtract gasket allowance and space for fillet weld detail (see Figure 10). Cut inner pipe to length.
3. Weld 3 mm thick impingement plate (at steam inlet) and 3 off spacers (where required) to inner pipe (see figure 1).
4. Slide main section of jacket over inner pipe, tack weld flanges to inner pipe.
5. Final fit – adjust flange angles / spacing.
6. Complete inner pipe to flange welds.
7. NDT / Hydrotest inner pipe.
8. Tack weld jacket and split jacket sections to flanges.
9. Complete jacket welds and utility connections.
10. NDT / Hydrotest jacket.
11. Note – in the example above, face A would mate with a shop fabricated pipe spool. If it is required to mate with a cross, face A will be set as per face B (i.e. true perpendicular)
12. Note – both faces will be vertical of run < 6m length.



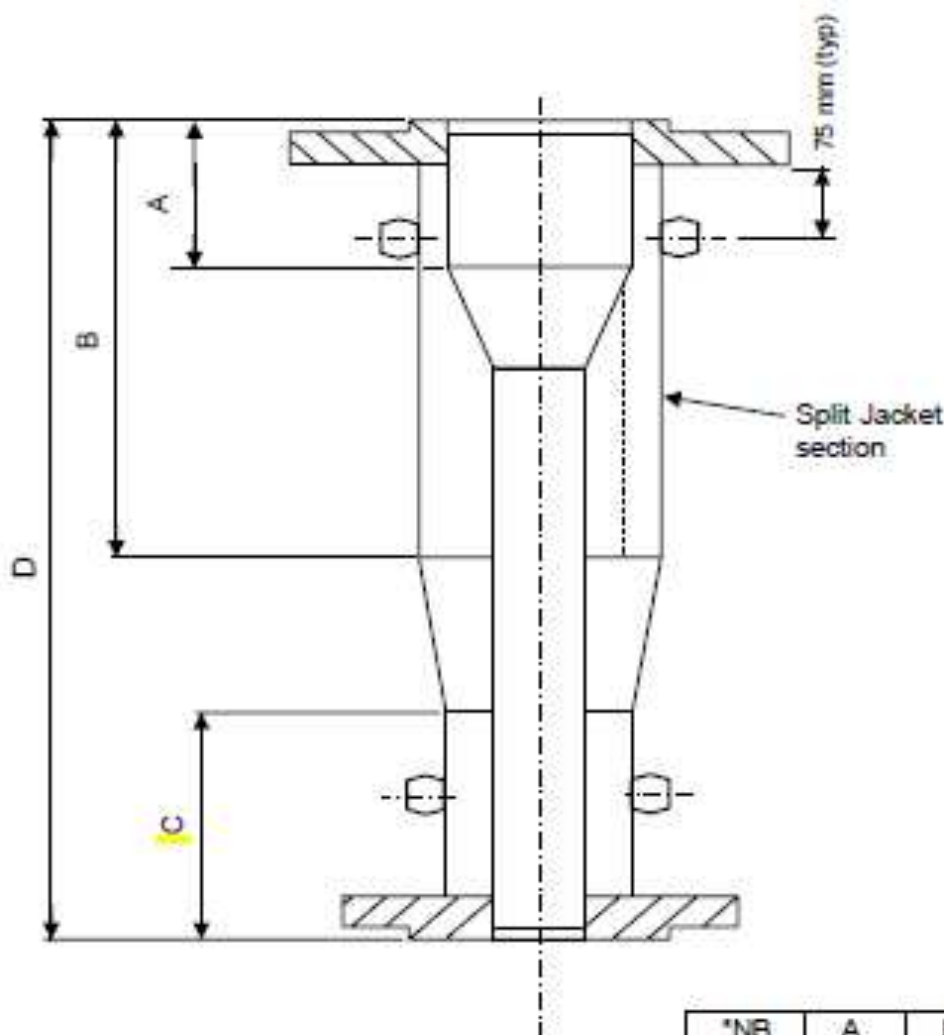
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Figure 9: Standard reducer spool





*NB	A	B	C	D
100	100	300	180	582
150	125	315	200	655
200	150	380	200	732
250	175	415	240	833
300	200	470	240	913

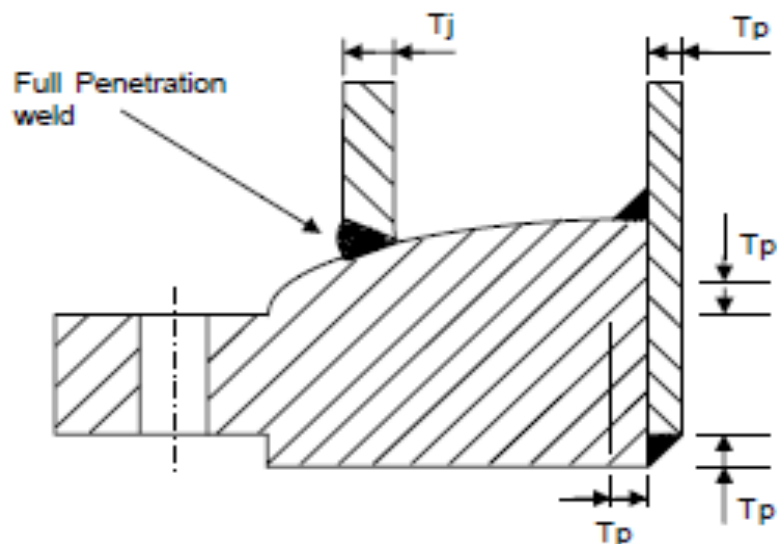
\*NB refers to larger jacket flange size

**Notes:**

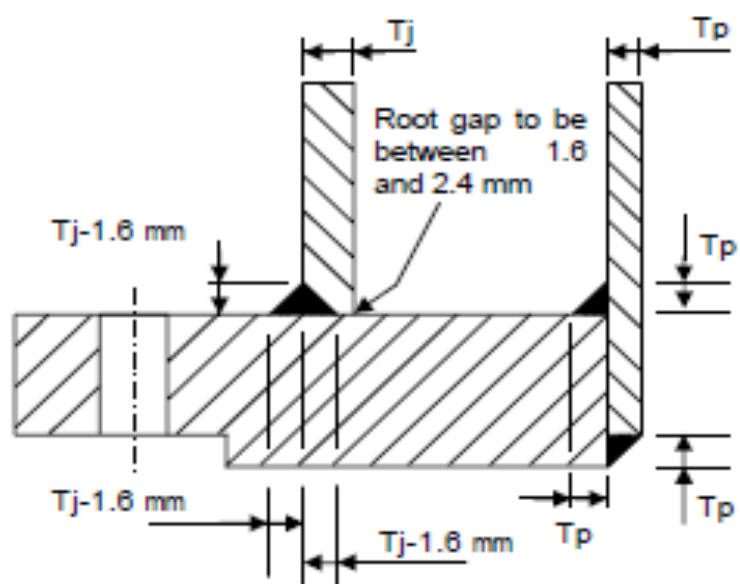
1. See table for minimum dimensions.
2. All reducers shall be concentric.
3. 1 fresh steam supply and 1 condensate connection or condensate jumpover is required for each reducer spool. See Figure 7 for positions of connections for vertical and horizontal configurations.

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**Figure 10: Standard Weld Details**





**Reducing Flange Welding details for Jacket and Process Pipe**

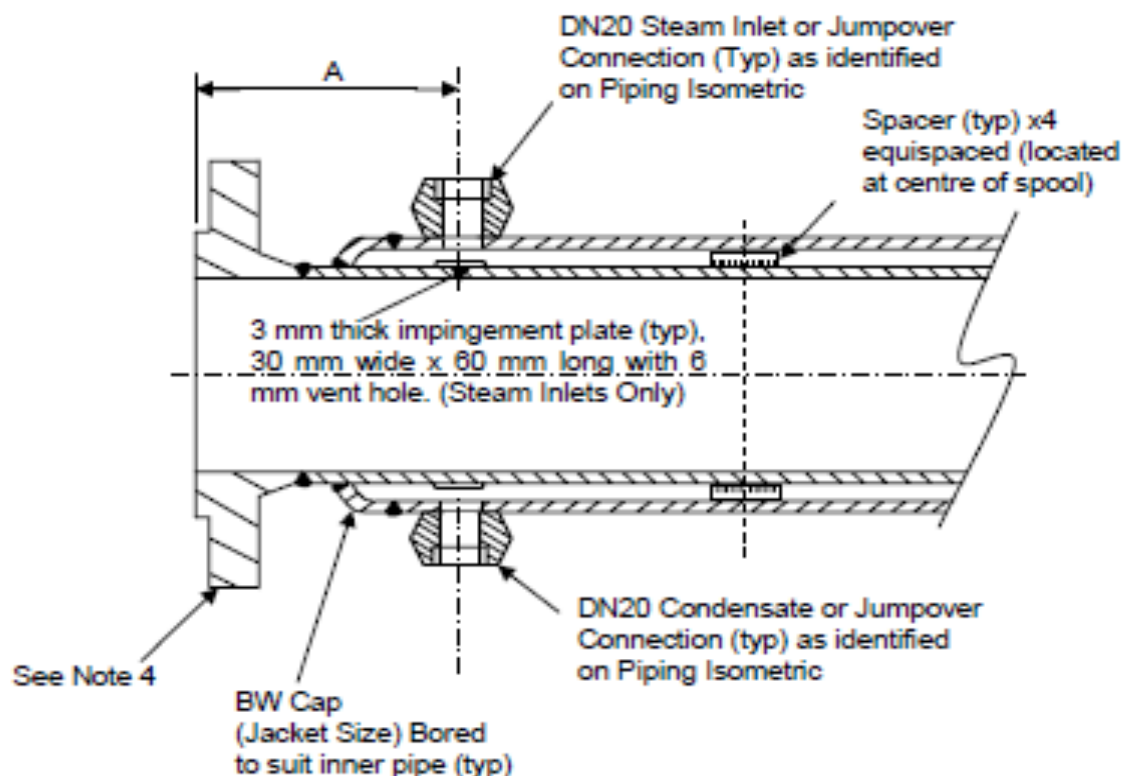


**Bored Blind Flange Welding details for Jacket and Process Pipe  
(where required)**

1.  $T_p$  = Thickness of Pressure Pipe (mm)
2.  $T_j$  = Thickness of Jacket (mm)
3. Minimum weld dimensions to be in accordance with ASME B31.3 Section 328.5

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**Figure 11: Fabrication Method for Partial Jacketed Spool**  
**(only to be used when connecting to a Non jacketed Nozzle or Valve\*)**



**Notes:**



- Complete welding and hydrotesting of inner pipe welds prior to welding of jacket.
- Summary of Welding Sequences:
  - Weld weldneck flange to inner pipe.
  - Slide cap over inner pipe.
  - Weld spacers and impingement plate to inner pipe.
  - Slide jacket length over inner pipe.
  - Weld reducing slip-on flange to other end of inner pipe.
  - NDT / Hydrotest inner pipe.
  - Weld caps to inner pipe & weld jacket to cap.
  - Complete the jacket by welding the split jacket to the jacket and slip-on flange.
  - Inspect jacket welds.
- Utility connections to be DN20 in locations as shown on piping isometric.
- Where the flange size is less than DN50, use a concentric reducer in the process pipe, boring the cap to suit the reduced size. Note that the jacket size is not reduced.

\* Not preferred.

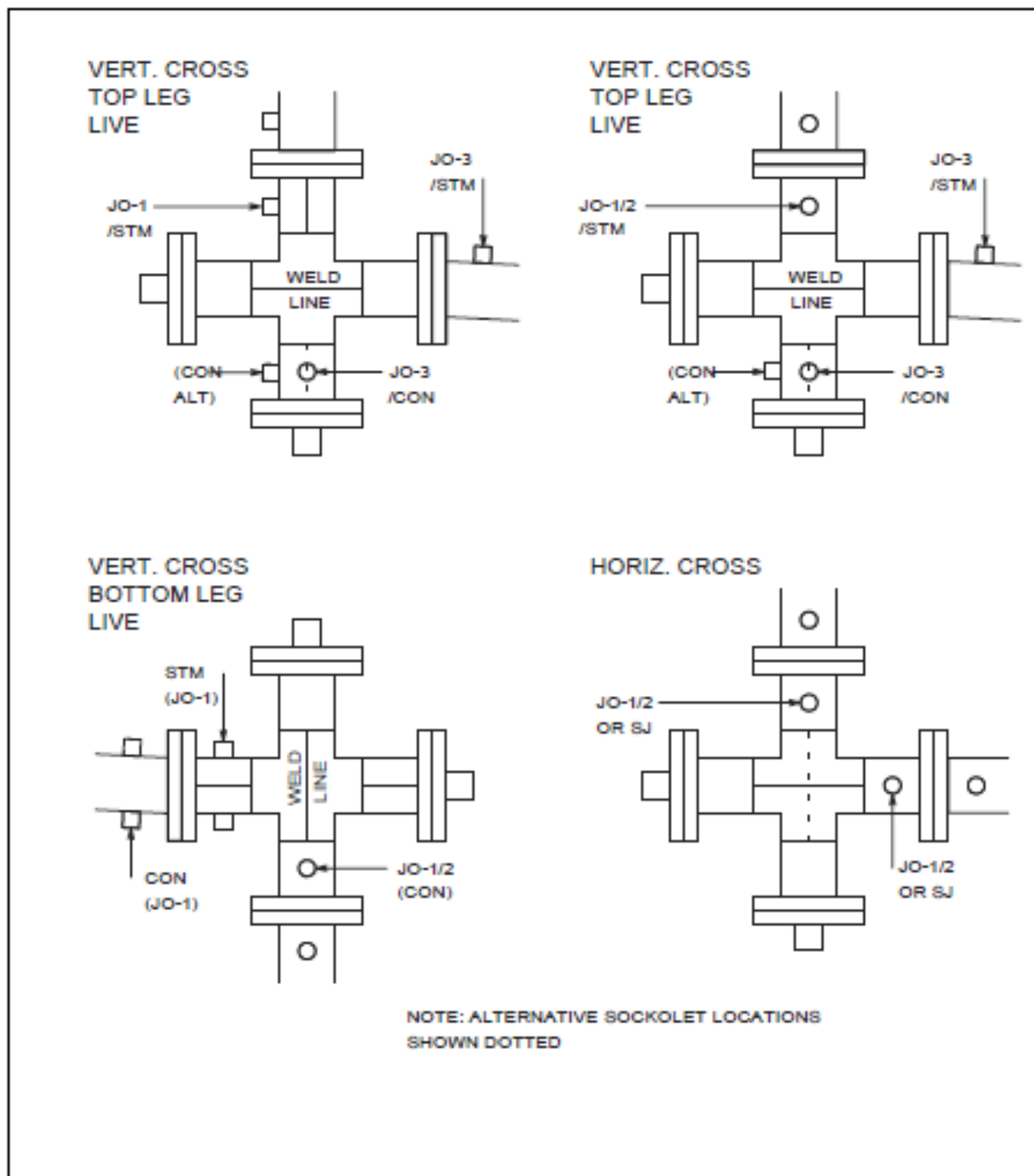
DN (mm)	A mm
50	260
80	285
100	325
150	355
200	395
250	435



**To suit 150 and 300 rated flgs.**



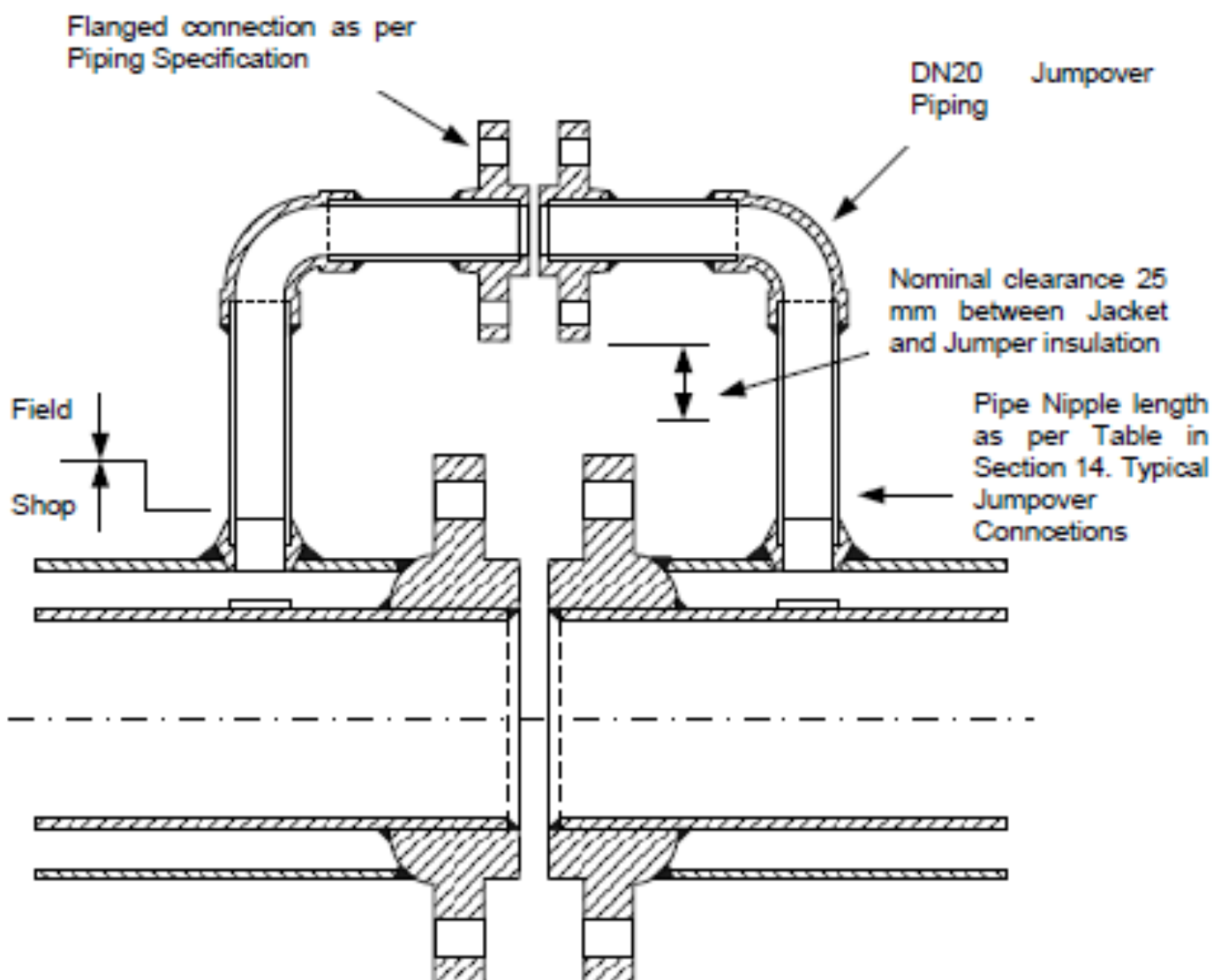
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**Figure 12: Seam Weld Orientation for DN100 x DN80 and DN80 x DN50 Jacketed Crosses**





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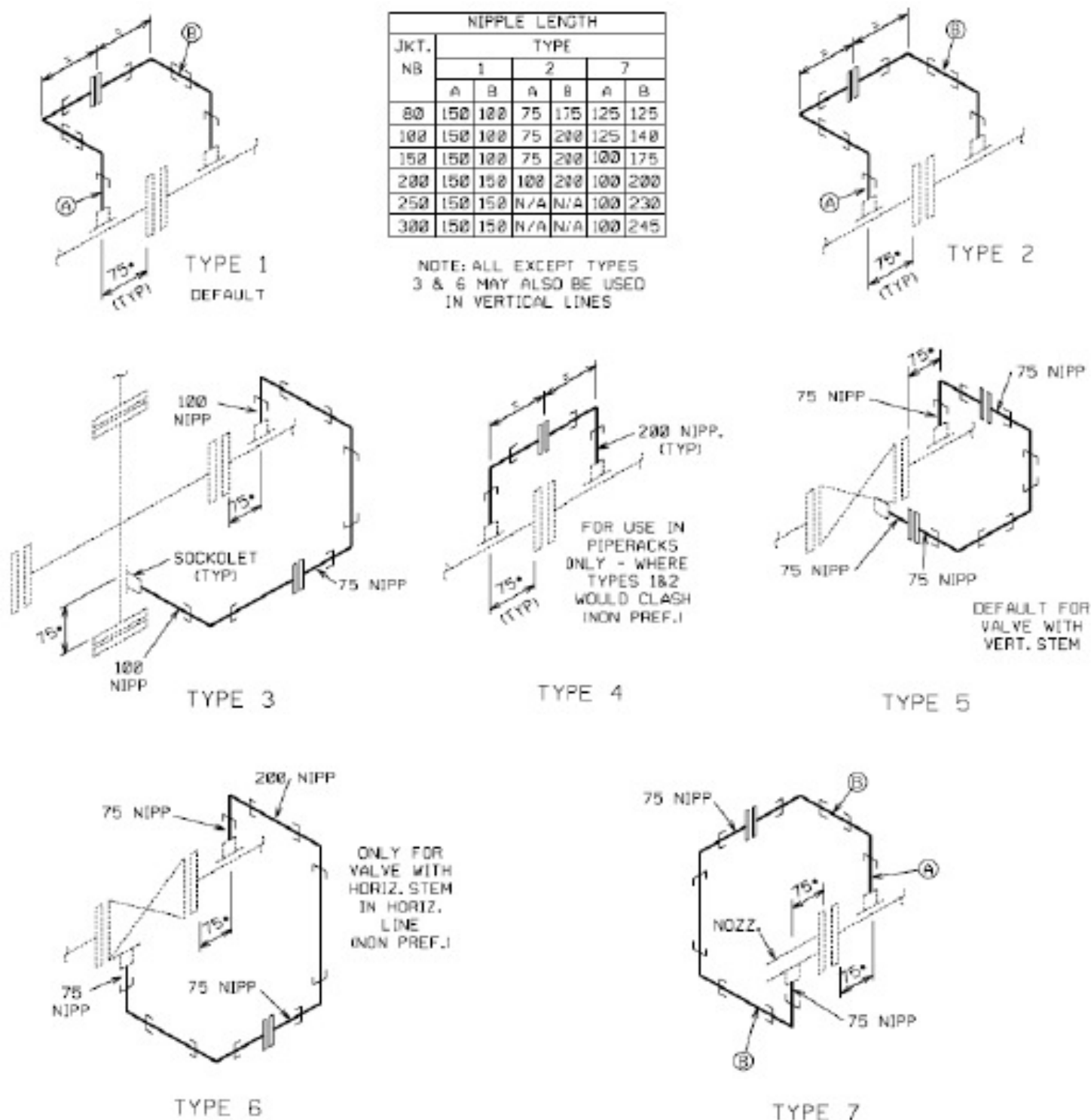
**Figure 13. Typical Detail for Jumpover Connections**





**Field fabricated components i.e. flanged connections and jumpovers to suit space constraints on site. See Fig 14.**

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**FIGURE – 14 : TYPICAL JUMPOVER CONNECTIONS**







DIMENSIONS MARKED THUS (\*) ARE TAKEN FROM BACK OF FLANGE HUB

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Page modified under this revision: Page number 18

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## 1. **INTRODUCTION**

**INDIAN OIL CORPORATION LIMITED (IOCL)** has awarded Fax of Acceptance (FOA) dated 29<sup>th</sup> August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

## 2. **DEFINITIONS & ABBREVIATIONS**

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit
OISD	Oil Industry Safety Directorate
ASME	American Society of Mechanical Engineers



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API	American Petroleum Institute
P&ID	Piping and Instrumentation Diagram
A/G	Above Ground
U/G	Under Ground
B/L	Battery Limit
ISBL	Inside Battery Limit
EOT	Electrically-operated Overhead Travelling
MTO	Material Take Off

### 3. **SCOPE**

This specification covers design and material requirements for above ground, external insulation of piping and equipment operating between ambient temperature and 760°C for the purpose of heat conservation, process stabilization, temperature maintenance, personnel protection and fire protection. Wherever necessary this specification indicates the basis for selecting a criterion.

This specification is suitable for use in normal process plant atmospheres. Alternative designs and materials would be specified if necessary for corrosive atmosphere or potential leaks and spills of chemicals.

All the codes/standards mentioned in this specification shall be of latest issue.

This specification does not cover cold service insulation.

This specification does not cover insulation for boiler or fired heaters and associated air heaters, economizers, flue ducting and air ducting.

Piping, equipment, storage tanks & vessels requiring insulation and the temperatures (operating temperatures) shall normally be specified, as applicable, on the following project documents:

- Piping and Instrument Diagrams (P&IDs) and Line Lists.
- Piping General Arrangement Drawings & Isometrics.
- Instrument Piping Details and Schedules.
- Vessel, Exchanger, Storage Tank and sphere documents and Insulation Schedules.
- Equipment suppliers General Arrangement Drawings for equipment items in Package plant.

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## 4. **DESIGN BASIS**

### 4.1 Criteria

Insulation thickness tables are based on heat loss criteria. For various parameters considered for insulation thickness calculations 'Guideline for selecting insulation material & thickness'. Selected 'Insulation thickness tables' for a particular job shall be as per 'Job Process design basis'.

Insulation is required for any of the following purposes, as indicated in P&IDs and line lists:

- Heat conservation
- Process stabilization to assist process control
- Steam tracing
- Electrical tracing
- Hot water or solvent tracing (liquid)
- Hot oil tracing
- Steam jacketing
- Hot water or liquid jacketing
- Hot Oil jacketing
- Fire Protection Personnel

Insulation for 'Personnel protection' is applicable where exposed surface temperatures exceed 60°C in normal or short-term operating conditions. Over internally insulated piping and equipment, provide open mesh metal guards and for surfaces which are not internally insulated, provide insulation on those parts of surfaces with which operating and maintenance personnel may come in contact while performing routine duties. The actual extent of insulation shall be determined by Field Construction Personnel and/or operating personnel using the criteria that the exposed surfaces located within 600mm horizontally or 2100mm vertically of a normal access, walkway or work area are to be insulated.

When heat dissipation is required in high temperature services, insulation shall not be provided. Wire mesh shall be used for high temperature surfaces up to 250°C to avoid the possibility of personnel contact. The minimum distance of mesh installation shall be 100mm. With reference to the Insulation Thickness Table for personal protection (Table 2), for thicknesses greater than 100mm the distance will be equal to the insulation thickness indicated in the table.

Internally refractory lined piping and equipment and any other items for which heat loss is essential shall not be insulated.

Insulation is not desired for piping and equipment for which heat loss is desired - excepting for personnel protection or to avoid thermal stress problems.

Instruments and associated piping (other than impulse piping/tubing) subject to operating flow and/or temperature conditions prevailing in the connected piping or equipment shall be insulated to the same requirements as that of piping or equipment. For impulse piping/tubing refer impulse piping insulation specifications described elsewhere in the document.

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## 4.2 Extent of Insulation on Piping Systems

Insulated piping systems shall have straight pipe, bends, tees and pipe-fittings completely insulated.

Unless otherwise specified, all valves and flanged joints shall be completely insulated only in steam, condensate service, hot oil lines and in lines which are trace heated or jacketed to maintain temperatures.

For bucket and float type traps the inlet piping and trap shall be insulated.

Insulation on inlet piping to thermostatic and thermodynamic steam traps shall terminate at approximately 500mm before the trap.

Steam trap outlet piping other than closed condensate recovery system shall not be insulated except for personnel protection reasons.

Heat traced instrumentation shall be insulated. The fluid content sections of such instruments and the associated piping shall be completely insulated. Indication length shall remain visible. Instrumentation other than heat traced shall not be insulated unless otherwise required by Instrumentation department.

Insulation shall not be applied to the following, unless otherwise specified.

- Piping which becomes hot intermittently, such as relief valves, vents, steam-out and snuffing steam systems, flare and blowdown systems.
- Steam condensate lines downstream of steam traps discharging to drainage system, unless otherwise mentioned.
- Supports for piping, excluding pipe hangers to the extent covered by insulation.
- Steam Traps (except as noted in paragraph 4.2).
- Valves, including control valves and flanges in process piping systems (except as noted in paragraph 4.2). However, personnel protection insulation for these items shall be applied, as required.
- Pipe Union fittings.
- Thermowell bosses, temperature and pressure tapings. Expansion joints, hinged joints and hose assemblies Sight flow indicators. Flange joints in Hydrogen service.

## 4.3 Extent of Insulation on Equipments

Support skirts of insulated vertical vessel greater than 1200mm diameter shall be insulated both internally and externally for a minimum distance of 600mm below the bottom tangent line. The insulation shall terminate not less than 300mm above the anchor chair.

Support skirts of insulated vertical vessels of 1200mm and less shall be insulated externally only, as described in above paragraph.

Bottom heads of insulated vertical vessels enclosed by a support skirt shall be insulated without finishing material and shall be insulated only when the vessel outside diameter is greater than 1200mm.

Turbines shall be insulated for heat conservation.

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Liquid ends of pumps shall be insulated when heat traced and jacketed.

Insulation shall not be applied to the following unless otherwise specified:

- Pumps with operating temperature below 200°C unless pumped fluid has a pour point above minimum design ambient temperature.
- Fans, compressors and blowers.
- Liquid ends of pumps except as noted in the above paragraph.
- Internally insulated or refractory lined equipment unless specially designed for metal temperature control.
- Internal surfaces of insulated vessel support skirts with vessel diameter 1200mm or less.
- Turbine casings to be insulated shall exclude shaft seal caps, shaft bearing housings, throttle valves, governors and supports.
- Expansion Joints of exchanger.
- Nozzles flanges, manholes, hand holes and flanges of equipment.
- Surfaces of coolers and condensers.
- Nameplates of all equipment items.
- Thermowell bosses, temperature and pressure tapings.

## **5. MATERIALS**

### **5.1 General**

Insulation materials shall be as per specifications described in para 5.2. Selected material

For a particular job shall be as per Process Design Basis.

All materials shall be of high quality and good appearance. Insulation materials shall be of low chloride content, chemically inert, non-sulphurous, rot proof, vermin proof, impervious to hot water and steam, non-injurious to health and non-corrosive to steel and aluminium (even if soaked in water at ambient temperatures for extended periods).

The use of insulation or finishing materials containing ASBESTOS in any form it's not permitted.


No inflammable material shall be attached to the insulation.

Fibrous insulants, calcium silicate, perlite and ceramic fibers can be used for the full temperature range mentioned against the respective material, for all applications except for electrically heated applications.

For electrically heated applications Polyurethane foam (PUR) or Polyisocyanurate (PIR) blocks shall be used in combination, with Rockwool as inner layer.

For low operating temperature (up to 125°C) services a suitable moisture barrier shall be used.

Insulation materials to be used over austenitic stainless steel surfaces shall be zinc free and shall be inhibited with sodium silicate as per ASTM C-795. The amount of leachable chloride in the insulation material (except for calcium silicate) before application shall not exceed 10ppm. In case of calcium silicate it should not exceed 50ppm. For the chemical analysis of insulation materials ASTM C-871

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shall be referred.

Dimensions and dimensional tolerances for pipe sections, mattresses & slabs shall generally be as per respective codes unless otherwise mentioned. The number of pieces to be used shall be as less as possible. When installed the insulation shall fit snugly and shall have a tight joint.

The insulation materials shall be as per ASTM/BS standards/codes for overseas jobs unless otherwise specified.

## 5.2 Insulation Materials

### Fibrous Materials (Rockwool)

Shall be a preformed insulation and shall be of long fibred rock wool material processed from a molten state into fibrous form bonded with a binder and suitable for the intended operational temperature range from ambient to 550°C for Rockwool . Slag wool is not acceptable.

Unless otherwise specified, insulation material shall strictly conform to all the requirements of quality standards listed below:

- **Preformed pipe insulation** IS:9842/ASTM C547 TYPE II or TYPE III
- **Metal-mesh covered bonded mineral fibre blanket and blanket type pipe insulation** IS:8183/ASTM C592 CLASSII for piping & equipt. Blankets shall be faced on one side with 20mm galvanised 22SWG wiremesh stitched through with 22 SWG galvanized lacing wire. For insulation over 'Austenitic SS Piping & Equipment' instead of galvanized wiremesh & lacing wire SS304/316 wiremesh & lacing wire shall be applied.
- **Bonded Mineral fibre slab insulation** IS:8183
- **Mineral fibre block & board thermal insulation** ASTM C612 TYPE IV/ TYPE V

Insulation shall conform to the requirements of respective codes, unless otherwise specified herein and shall be tested and test certificates on representative samples furnished as per IS:8 /83/IS:9842/ASTM:C547/ ASTM:C592 / ASTM:C612.

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• Density(min)	140 & 128 kg/m <sup>3</sup> for resin bonded pipe sections and resin bonded LRB blankets respectively of rockwool; 80 & 64 kg/m <sup>3</sup> for resin bonded pipe sections and resin bonded curved beveled segments or LRB slabs respectively of glasswool. Max resin content at the above mentioned densities shall be 2% and 5% for rockwool and glasswool respectively. 140 kg/m <sup>3</sup> for IS8183 bonded mineral fibre slabs and 240 kg/m <sup>3</sup> /320 kg/m <sup>3</sup> for ASTM C612 TYPEIV /TYPE V respectively.	
• Thermal Conductivity(max)*	**Mean Temperature °C	Thermal Cond. (mW/cm °C)
	50	0.43
	100	0.52
	150	0.62
	200	0.68
	250	0.80
	300	0.90
*The values mentioned are for insulation material as per IS code; For Apparent thermal conductivity for material as per ASTM codes refer respective ASTM code.		
**Mean Temperature = (Hot Face Temperature + Cold Face Temperature) / 2		
• Linear Shrinkage	Not more than 2 percent when subjected to soaking heat at the stated max. temperature of use (550°C), for 24 hours.	
• Compressive Strength (minimum) at 10% deformation	250 kg/m <sup>2</sup> for resin bonded pipe sections, curved bevelled segments and LRB slabs; 120 kg/m <sup>2</sup> for LRB blankets(mattresses) unless otherwise specified.	
• Chloride Content	For stainless steels, with inhibitors less than 10 PPM, for other materials not to exceed 20 ppm.	

Flame spread Index= 0 (non Combustible)

Low resistance to water vapor Transmission -0.3 mg/h/pa.


**Rigid Materials (Calcium Silicate, Moulded Expanded Polyisocyanurate / Polyurethane Foam Blocks and Cellular Glass)**

#### Calcium Silicate

It shall be suitable for temperatures up to 760°C. Insulation shall conform to the requirements of respective codes, unless otherwise specified herein and shall be tested and test certificates on representative samples furnished as per IS 9428/ASTM C533.

• Bulk Density	200 to 280 kg/m <sup>3</sup> .
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• Compressive Strength	Reduction in thickness shall not exceed 10% when tested a) Dry under a load of 415 kN/m <sup>2</sup> and b) Wet (after 18 hrs immersion in water) under a load of 170 kN/m <sup>2</sup> .	
• Heat Resistance	When tested at increasing temperatures, the material shall be deemed suitable for use under conditions of soaking heat, for 24 hrs, upto a temperature at which the following requirements are met: Max.Linear Shrinkage(length) 2% Max. Loss in Mass 15% Compressive Strength Reduction in thickness not exceeding 10% under a load of 345 kN/m <sup>2</sup> .	
• * Thermal Conductivity (max)	**Mean Temperature °C	Thermal Conductivity(W/mk)
	200	0.080
	250	0.088
	300	0.097
	350	0.110
	400	0.121
	450	0.135
	500	0.148
• Chloride content	Not to exceed 50 PPM for CS as well as SS	
*The values mentioned are for insulation material as per IS code; For Apparent thermal conductivity for ASTM code material refer respective ASTM code.		
**Mean Temperature = (Hot Face Temperature + Cold Face Temperature) / 2		

### Moulded Expanded Perlite


Insulation shall be block form and pipe sections in accordance with ASTM C610. It shall be compounded from moulded expanded perlite & sodium silicate binder and shall be suitable for temperatures up to 550°C. Insulation shall conform to requirements of respective codes, unless otherwise specified herein and shall be tested and test certificates on representative samples furnished as per ASTM C610. 'Perlite material shall be tested as per C-692 for application over SS surfaces'. This material shall be applied for lines with low ground clearance especially at culvert crossings to avoid loss of heat during water clogging.

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• Bulk Density(min)	192 kg/m <sup>3</sup> . Test as per ASTM C302 (pipe) & ASTM C303(block)	
• Compressive Strength (for blocks only) at 5% deformation	412 kPa(Min). Test as per ASTM C165.	
• Apparent Thermal Conductivity	Shall be as given below: Test method shall be as per ASTM C177/C518 (Block) & ASTM C335 (Pipe)	
	Mean Temp °C	Thermal Conductivity Max. W/mK
	93	0.079
	149	0.086
	204	0.095
	260	0.106
	316	0.111
	371	0.126
• Water Absorption of thermal insulation After heat aging & 48 hr water immersion, moisture gain, % by weight (max)	149	50
	260	50
	371	60
• Linear shrinkage	2%(max) at 649 °C for 24hrs	
• Chloride content	For stainless steels, less than 10 PPM, for other materials not to exceed 20 ppm	

#### Polyisocyanurate (PIR) / Polyurethane (PUR)

Rigid Polyisocyanurate / Polyurethane foam block, pipe and fitting insulation shall be manufactured with polyester or polyether resins, flammability retarding agents, special catalysts and a blowing agent. This can be used up to a temperature of 125°C. Insulation shall conform to following requirements and shall be tested and test certificates on representative samples furnished for conformance to each of the following requirements:

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• Selection of samples for testing	As per ASTM C390 OR BS:2972 (Frequency of sampling clause IV). Unless otherwise stated, the test specimens shall be conditioned without external stress at 23±1°C and 50±2 percent relative humidity for a minimum of 24 hours before testing.		
• Density	40 to 64 kg/m <sup>3</sup> To be tested as per ASTM C303 for Block-type and ASTM C302 for pipe covering.		
• Thermal Conductivity	Mean Temp. °C	Thermal Conductivity (Maximum) mW/cm deg	
	10	0.238	
	24	0.245	
	38	0.252	
	Thermal conductivity test shall be as per IS:3346 or ASTM C177. Specimen thickness shall be as per IS:3346 or 25mm per ASTM C177.		
• Comp. Strength (Min.)	After drying at 102°C - 120°C for constant mass as per ASTM C165, at 10% deformation or at yield point, whichever occurs first, shall be 205 KPa. Test shall be as per IS:11239 part X.		
• Water-vapour permeability (max)	8.5 & 5.5 ng/(Pa.s.h) for PIR & PUR respectively Test shall be as per BS5608 or IS12436		
• Fire properties	Insulation shall be self extinguishing type and shall satisfy the requirements for maximum extent of burn (less than 25mm for PIR and 125mm for PUR) when tested as per BS:5608 (Horizontal burning characteristics- max. extent of burn) or IS:12436		
• Flexural Strength	This is applicable to preformed pipe coverings only and shall be 275Kpa(min). Test shall be as per ASTM C446.		
• Humid aging	(Max. allowable value after aging at 60°C – 90 to 100% relative humidity)-Maximum percent change in linear dimension shall be 4. This limit applies to each of the three foam direction. Test shall be as per ASTM D2126.		
• Closed cell content	Minimum percent 85. Test as per BS:4370 Part – II (Test for closed cell content)		
• Dimension stability after heating	Test method as per IS:11239 Part – II The max. dimensional change at different temperatures shall be..		
	100°C ± 2°C (24 hr)	2%	
	125°C ± 2°C (24 hr)	2%	
• Standard size and dimensions	<u>Block</u>		
	Length	upto 2400mm	
	Width	upto 1200mm	
	Tolerance	On length	±6mm
		On width	±3mm
		On thickness	±1.6mm
	<u>Pipe Insulation</u>		
	Length	750 to 1000mm	
	Inside diameter	To suit standard steel pipe	
	Shall be supplied as cylindrical shape slit in half lengthwise or as curved segments cut from blocks or moulded segments cut from blocks or moulded to shape. Upto 14" size, only pipe sections slit in half lengthwise shall be used.		
	Dimensional Tolerance:		
	Length	± 6mm	
	Thickness	± 1.6mm	
• Thickness	20, 25, 30, 40, 50, 60 and 75mm		

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### Cellular Glass

Cellular Glass formed and fused into unicellular form can be used up to a temperature of 350°C. Insulation shall conform to the requirements of respective codes, unless otherwise specified herein and shall be tested and test certificates on representative samples furnished as per ASTM C552.

• Density		110 to 147 kg/m <sup>3</sup> . Test as per ASTM C303 except that no drying will be necessary. Determine the no. of specimens as per ASTM C390.	
• Thermal conductivity (max)	conductivity	Mean Temp°C	W/m.k
		149	0.078
		93	0.063
		38	0.052
		24	0.050
		10	0.048
		Thermal conductivity shall be tested as per ASTM C240, C177 and C518. Test at least 3 specimens.	
• Compressive (Average min)	Strength	517 kPa Test as per method ASTM C240 and recommended Practice ASTM C165. Test at least four specimens.	

### High Temperature Insulation Materials (Above 550°C)

Following types of insulations may be used for high temp insulation applications.

#### Ceramic Fiber

Ceramic Fiber shall be composed principally of Alumina silica fiber blanket. It should be used in the temperature range of 551°C to 760°C. Ceramic fiber blankets shall be made from fibers having fiber length of about 10 cm or more. It shall normally be of 610mm width, 13mm or 25mm thickness. Unless otherwise specified insulation shall conform to the requirements of ASTM C892 Type III, Grade 8 or to the specifications described in the table below. Insulation shall be tested and test certificates on representative samples furnished. Ceramic fiber blankets shall be sampled for the purpose of test in accordance with ASTM C390.

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SL No	Chemical & Physical characteristics of Ceramic Fibre Blankets		Test Method
• Chemical composition(By volume%)			
	Al <sub>2</sub> O <sub>3</sub> (Min)	43	IS 1335
	ZrO <sub>2</sub> (Min)	-	IS-10085
	Fe <sub>2</sub> O <sub>3</sub> (Max)	0.1	IS-1527
	TiO <sub>2</sub> (Max)	0.3	IS1527
	SiO <sub>2</sub> (Max)	57	-
• Mean Fibre Dia (Microns)			
	(Upto 3% Standard deviation)	2.5-3.5	BS-2972
• Dimensional Tolerance			
	Thickness	(-) 0% to (+)40%	-
	Width	(-)2% (Excess is permitted)	-
	Length	(-)0% (Excess is permitted)	-
• Shot Content(% Max)			
	20		ASTM C-892
• Bulk Density(Kg/m <sup>3</sup> Min)			
	128		ASTM C-167
• *Bulk Density Tolerance			
	(+) 30% & (-)0%		-
• Thermal Conductivity (Kcal/M/Hr°C)**Max (Mean Temp)			
	0.11(600°C)		ASTM C-177/IS-3346
• Linear Shrinkage(%) (at max temp) for 24hrs			
	3(1200°C)		ASTM C-356
• Tensile Strength(Kg/cm <sup>2</sup> g(min)			
	Longitudinal	0.6	BS 1902 part 6
	Transverse	0.5	
* The density shall be calculated on the basis of actual dimensions and actual weight only, as offered by the manufacturer.			
**In case of thermal conductivity, the test certificate from an international laboratory or any laboratory approved by department of Science & Technology could be considered. However, the same shall indicate values for other characteristics of the material. The test certificate shall not be more than 12 months old from the date of offer of material for inspection.			

- 2 **Calcium Silicate**  
For material specifications refer clause 3.2.2(1)
- 3 **Combination Insulation of Ceramic Fibre (Inner layer) & Rockwool (Outer layer)**  
For material specifications refer clause 3.2.3(1) & 3.2.1
- 4 **Combination Insulation of Cal. Silicate (Inner layer) & Rockwool (Outer layer)**  
For material specifications refer clause 3.2.2(1) & 3.2.1

### Insulation material for Impulse lines

For impulse lines (Austenitic Stainless Steel), insulation material shall be sodium silicate inhibited Ceramic fibre rope insulation of min density 250 Kg/m<sup>3</sup>, unless otherwise mentioned. Ceramic Fibre rope shall be made up of Ceramic Fibre insulation. It shall comprise of ceramic fibres laid parallel and finally wrapped with stainless steel wire to reinforce the fibres and holding it in position. Other properties of ceramic fibre shall conform to the specifications as described in paragraph 5.2.



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### Additional Tests / Checks for Materials

Additional tests/ checks for density, thickness, shape and size as per the requirements shall be repeated at site at the time of delivery once for each lot. The Contractor shall perform these tests in the presence of Client/Client's representative on the sample selected at random. In case of nonconformance the tests shall be repeated as per norms and frequency decided at site as per the directions of Site-in-Charge. In case of repeated nonconformance, the complete lot of insulation material shall be rejected. Special attention is required for fibrous material as its installed thickness could be reduced due to compaction during transportation & storage and thus affecting performance.

All the codes mentioned shall be the latest issues.

Client/Client's representative/Contractor shall have right to inspect any or all the tests conducted on insulation material by manufacturer at his shop or any laboratory.

### Quality Assurance Plan (QAP)

Vendor shall prepare and submit the Quality assurance plan (QAP). The QAP shall include every stage of manufacturing process starting from raw material stage to final stage of manufacturing. The QAP shall also include reference of purchase order number and date, the types of checks, methods of tests followed, frequency of checks, lot size & acceptable criteria with permissible deviations.

## 5.3 Weather Protection Jacket

Unless otherwise mentioned, aluminium jacketing shall be used as weather protection over insulation except in fire hazardous areas /above 550°C where it should be stainless steel or aluminized steel. Galvanized jacketing shall not be used over insulation on or near austenitic stainless steel and/or austenitic nickel steel Piping & Equipment. Aluminum jacketing shall be as per ASTM B209 Alloy 3003 H16 or IS:737 designation 31000 condition H3 for flat sheets and designation 31500/51300 condition H4 for corrugated sheets. For stainless steel cladding, the materials shall be in accordance with ASTM A167 or A240, type 304 or 316. For aluminized steel cladding, the material shall be in accordance with ASTM A463, type2, coating designation T2-100. Cladding shall be coated on the side in contact with the insulation. All metallic jacketing, except for sound control applications, shall be furnished with a factory laminated moisture barrier of 64µm thick coextrusion of polyethylene and Surlyn. Jacketing for sound control insulation shall be laminated to mass-loaded vinyl and provide a minimum sound transmission class of STC 26 in accordance with ASTM E90.

Thickness of the jacketing shall be as follows:

Item	Size	Thickness	material
PIPE	up to 6"	0.6mm	Flat Aluminium ASTM B209 Alloy 3003 or 5005 - H14 or H24
PIPE	8" up to 18"	0.71mm	Flat Aluminium ASTM B209 Alloy 3003 or 5005 - H14 or H24
PIPE	over 18"	1.0mm	Flat Aluminium ASTM B209 Alloy 3003 or 5005 - H14 or H24
EQUIPMENT	up to 18"	0.8mm	Flat Aluminium ASTM B209 Alloy 3003 or 5005 - H14 or H24
EQUIPMENT	over 18"	1.22mm	Flat Aluminium ASTM B209 Alloy 3003 or 5005 - H14 or H24
PIPE	All sizes	0.56mm	Flat Stainless Steel 304 or 306



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EQUIPMENT	up to 24"	0.56mm	Corrugated Stainless Steel 304 or 306
EQUIPMENT	over 24"	0.91mm	Corrugated Stainless Steel 304 or 306

**2 Rigid Material (Calcium Silicate, Moulded Expanded Perlite, Polyisocyanurate, Polyurethane Foam(PUR) Blocks, Cast-in-situ Polyurethane foam and Cellular Glass)**

• Application	Thickness for Aluminum jacket / cladding	Thickness for Stainless steel / Aluminized steel jacket/cladding
• Piping, Horizontal Vessel head & Tanks Roof	0.56mm(24 SWG) flat	0.46mm(26 SWG) flat
• Vertical Vessel Shells & vertical portion of storage Tanks.	0.56mm (24 SWG) corrugated. The circular profile of corrugated sheet shall be 32mm 5mm	0.46mm (26 SWG) corrugated. The circular profile of corrugated sheet shall be 32mm 5mm
• Removable covers	1.22mm (18 SWG) Flat	1.22mm (18 SWG) Flat

Jacketing for the acid area and fireproofed insulation systems shall be 304 or 316 stainless steel.

## 5.4 Ancillary Materials

### Securement Bands / Wires

If material is Aluminum, then specification shall be ASTM B209 Alloy 3003 H16 or IS:737 designation 31000 (Old NS3) condition H3; If Stainless Steel, it shall be 18/8.

For securing fibrous insulation

- On Piping Band, 24 SWG thick x 15mm (min) wide up to DN200 to 25mm (DN250 & above), Stainless Steel.
- On Equipment Band, 24 SWG thick x 20mm wide, Stainless Steel.
- On Vertical Storage Tanks Band, Stainless Steel, 25mm wide x 24 SWG thick.
- Horton Sphere 16 SWG SS Wire & Band, Stainless Steel, 25mm wide x 0.8mm (min.) thk.

For Securing Rigid Insulation


- All sizes of Piping, Vertical and Horizontal equipments Band, stainless steel. 20 wide x 24 SWG thick.

For Securing Cladding on Insulation (all types)

- For Piping Band, SS 12mm (min) wide x 24 SWG thick.
- On Equipment Band SS 20mm wide x 24 SWG thick.
- On Vertical Storage Tanks & Spheres Band, Stainless Steel, 25mm wide x 24 SWG thick.

### Rivets

Rivets required for metal jacket securement shall be the expanding Aluminium "POP" blind eye type/

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Stainless Steel, 9.8mm long x 5mm diameter.

#### **Screws**

Screws required for metal jacket securement shall be Stainless Steel/cadmium plated steel self tapping type A No.8 dia x 12mm long to BS 4176 complete with neoprene washers under the head.

#### **'S.' and 'J' clips**

Formed from 25mm wide stainless steel banding.

To ensure perfect water proofing, all the cladding joints shall be packed with sealing materials which may either be in the form of a elastomeric sealing compound or fibre based bituminous felt strips.

### **5.5 Personal Protection Guards**

Guards and their supports shall be manufactured from carbon steel, which may be galvanized or painted or with stainless steel (The mesh may be pointed with yellow stripes, 50 mm wide, and shall include a hazard sign indicating 'Hot surface') The guard mesh shall be of 2mm thick and 12 mm square. Guard shall be designed with end cap of 0.7 to 1 mm thick from galvanized Al-Zn coated or Al coated carbon steel with recommended spacing of 450 mm to 600 mm. Care to be taken that the end caps are filled in an orientation that will allow water drainage. If the metal surface required greater protection, a fibre glass insulation tape can be fitted to area where end caps make contact to protect pipe work and reduce heat transfer. Mesh shall be rolled to share as per normal cladding and shall be provided with 50 mm of overlap, sharp edges of cut mesh to be filed. In case of removable guard the same can be made from toggle clips.

## **6. APPLICATION**

### **6.1 General**

The application methods, given in this Standard are general in nature. The Contractor is responsible for applying an insulating system that will give a satisfactory operational performance and the requirements given herein shall be regarded as the acceptable minimum. The Contractor shall carryout the work in accordance with the best practices of insulation application with the minimum of waste and debris and the final job shall have a neat, efficient and workman like appearance.

The insulation shall be so designed/applied such that ingress of water is prevented, leaked product can drain off and vapor can escape.

All hydrostatic tests on piping and equipment, including steam tracing systems, shall be carried out before insulating material is applied.

The insulation Contractor shall only insulate those sections of the plant that have been specifically released for such work by the engineer in charge. If insulation must be installed before pressure test, then all welds and flanged joints in the pipe shall be left uncovered till successful completion of pressure test. Then insulation shall be completed.

Surfaces to be insulated shall be thoroughly cleaned, dried and made free from loose scale, oil or grease. It shall be the Contractor's responsibility to remove loosely adhering scale and dirt before applying insulation.

Insulation shall be finished, beveled and weatherproofed at all terminal points where it is required to remove bolts etc. without damage to the insulation.

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Equipment nameplates shall remain visible after insulation has been applied by bevelling back the insulating material and carefully sealing the exposed edges to prevent ingress of moisture.

All projections, such as lifting lugs, trunnions and stiffeners on piping, equipment & Tank (i.e. vacuum rings) shall be insulated with the same thickness of insulation as specified for the equipment item or pipeline.

Thermowell bosses, pressure tappings and weep hole nipples shall not be insulated in but left accessible.

For Insulation thicknesses up to 75mm only single layer insulation shall be used. Multi-layer insulation shall be required when the insulation thickness is greater than 75mm with the inner layer being larger. Insulation installed in two or more layers shall be staggered joint construction and each layer shall be secured in place and details of securement shall be the same for each layer.

Wet or Damaged Insulation shall not be used under any circumstances.

Material awaiting its protective cover shall be adequately protected from damage, rain and contamination and shall be covered with cladding at a minimum loss of time.

A minimum clearance of 25mm between outside surface of any insulation finish and adjacent equipment, pipe or structural members shall be maintained.

Insulation supports shall not project out of the insulation outer surface and shall be given sufficient coverage of insulating material to avoid hot spots on the metallic cover at support positions.

Where insulated horizontal piping is supported on steel shoes, the height of the shoe shall be such that the underside of the insulation finishing material is clear of the supporting structure upon which the shoe rests by 25mm minimum.

Pieces of insulation with crushed and damaged ends shall not be used.

### **Corrosion Prevention**

Piping, Equipment, Tanks etc shall be protected against corrosion by painting under insulation as per specifications 080557C-000-JSD-2300-001.

## **6.2 Piping**

### **Standard Shapes of insulation**

#### **Fibrous Material (Rock wool)**

Shall be preformed pipe section in 2 halves for sizes upto which manufactured and at least for all pipes with outside diameter over insulation of 500mm. In bigger sizes, multi-segments are preferable if manufactured, otherwise, blankets are acceptable.

#### **Calcium Silicate / Moulded Expanded Perlite**

Hollow cylindrical shapes slit in half lengthwise (in a plane including the cylindrical axis) or as curved segments. Up to 14" pipe size, only hollow cylindrical shapes slit in half lengthwise shall be used. Pipe sections bored / machined out of blocks shall not be used.

#### **Polyisocyanurate / Polyurethane**

Shall be supplied as cylindrical shape slit in half lengthwise (in a plane including the cylindrical axis)

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or as curved segments cut from blocks or moulded to shape. Up to 14" pipe size, only pipe sections slit in half lengthwise shall be used.

#### **Cellular Glass**

Shall be supplied as cylindrical shape slit in half lengthwise (in a plane including the cylindrical axis) or as segments. Up to 14" pipe size, only pipe sections shall be used.

#### **Ceramic Fibre**

Shall be supplied in blanket strips in sizes as mentioned in the material spec in paragraph 5.2.

#### **Application**

##### **Horizontal Pipe**

##### **General**

Insulation material shall be applied to fit snugly against the contours and shaped only where necessary to achieve this requirement. The insulation shall be carried out with the least number of material pieces as possible and all unavoidable gaps, cavities, and voids suitably filled up compatible loose fill material.

##### **Pipe Section / Moulded Blocks / Segments**

End joints of adjacent blocks shall be staggered one half of the length of the block.

Included angle between segments shall not be less than 30°C for both single and double layer insulation.

Further, minimum arc length of segments should meet following staggering requirements.

When double layer is applied, both longitudinal and circumferential joints shall be staggered. The arc between the longitudinal seam lines of the inside and outside layers of insulation shall have an angle of over 15°C or the longitudinal joints staggered at least by one layer thickness, whichever is more stringent. Circumferential seams of the inside and outside layers shall be at least 100mm apart.

##### **Blankets (Fibrous insulation- Rock wool)**

Shall be applied over the surface with joints tightly butted and laced together with 1mm diameter galvanized lacing wire.

##### **Insulation Securement (All insulation materials)**

Each layer of insulation shall be secured firmly in place with at least 3 loops of binding wire / band, one loop to be placed not more than 75 from each end and at least one loop to be equally spaced between end loops, for each section. Binding wire shall be drawn about the insulation with ends tightly twisted together, bent under & pressed into the surface of insulation. Bands or wires in no case be spaced more than 200mm apart.

For calcium silicate & Moulded expanded perlite, all joints shall be sealed with insulating cement of same composition as the Moulded block.

For Cellular glass, Polyurethane foam and polyisocyanurate, joints shall be sealed with suitable compatible material.

Each layer of insulation shall be secured by the same method as above.

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#### Frame work for supporting cladding fibrous insulation (See Fig: 3 and 4)

This is not necessary for rigid materials. This is required only for horizontal pipe runs provided with fibrous insulation, in blanket forms; vertical piping provided with fibrous materials need not be provided with this. Piping provided with fibrous resin bonded pipe sections also need not be provided with this framework.

Spacer rings shall be fabricated out of 25 x 3 M.S. Flats. The outside diameter of these rings shall be equivalent to the outside diameter of the insulation. Spacer rings shall be riveted to 'Z' shaped stays fabricated from the same sized M.S. Flats. These rings shall be suitably painted for corrosion protection. Stays shall be provided at intervals of not more than 300 along the circumference of the insulation, subject to a minimum of 3 stays. Spacer rings shall be provided at every approx. 900mm. To minimize direct heat conduction through the stays, a packing of 2 sheets of 3 thick mill board shall be provided at the joints of the stays and pipes. Joints between M.S. Spacer Ring and stays shall be riveted by 6 dia M.S. Rivets with 2 Sheets of 3 thick mill board interposed.

#### Vertical Pipe (All insulation materials) (See Fig.5)

Insulation on vertical or near vertical piping (i.e. greater than 45°C angle from horizontal) shall be supported by bolted on metal collars. Metal collars shall be of 6 thick M.S. or Alloy Steel bar (to suit piping material).

Outside diameter of collar shall be around 12 less than O.D. of insulation. Where multi-layer insulation is used, support collar shall be extended to provide for each layer.

Support positions shall be at no greater distance apart than the following:

<u>Pipe operating Temp.(°C)</u>	<u>Support Spacing</u>
Upto 400	4500mm
401 to 500	3500mm
501 to 550	2500mm
551 to 650	2000mm
651 to 760	1500mm

Expansion Joints (Both vertical and horizontal piping. All insulation Materials)

Expansion joint shall be provided at regular intervals as below:

<u>Temp (°C)</u>	<u>Spacing (m)</u>
Upto 200	Not required
201 to 300	10
301 to 350	8
351 to 400	6
401 to 550	5
551 to 650	4
651 to 760	3

Expansion joint shall be formed by a 25mm space between the pipe insulation sections and the space shall be filled by compressed mineral rock fibres. Expansion joints in each layer shall be offset at least 150 from each other in case of multi layer insulation. Expansion joint for first layer for vertical pipe shall preferably be just below insulation support collars.

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### **Elbows and Bends (All insulation materials) (See Fig.6 and Fig.7)**

Insulation material shall be mitred and shall be same as that of pipe. Insulation securement bands/wire shall be same as that for equivalent dia pipe. Each mitred section shall be secured with minimum 2 wires/bands. For bends / elbows of nom. pipe size 6" & below, due to lack of space, for all insulation materials, insulation shall be secured by spirally wound 16 SWG SS wire for hard materials & 10 SWG SS wire for soft materials. Insulation joints of block material shall be suitably sealed with adhesive for isocyanurate /PUR/cellular glass and by insulating cement for calcium silicate/Moulded expanded perlite. Fittings below 50mm nom. dia, if insulated of calcium silicate/Moulded expanded perlite, shall be insulated with insulating cement build up in 6mm layers to the thickness of insulation of the adjacent piping. Each layer of insulation cement shall be reinforced with 25mm No. 20 SWG wire netting.

### **Tee (All Insulation Materials) (See Fig.8)**

Preformed pipe sections or segments shall be carefully cut and shaped around "Tee," junctions and the insulation material of the tangential pipe shall be carefully and neatly cut to mate upto the material applied to the parent pipe without the creation of voids or gaps, at the junction. Insulation shall be adequately secured by wire / bands of same specification as that of same size pipe.

### **Flanged Joints or Valves (all insulation materials (Fig.9 and 10)**

Flanged Joints or Valves, if to be insulated, shall be insulated with prefabricated removable covers, lined with pipe sections / lags / slabs.

Welded valves, if insulated, shall be insulated with oversized pipe sections or lags, cut and shaped to fit around the body of the valve. Insulated valves shall be completely covered, but the insulation shall be cut and shaped around the valve stem and kept clear of the stuffing box gland.

### **Insulation Flashing (all insulation materials)**

Insulation shall be stopped short of flanged joints and unions by a sufficient distance to permit easy removal of the flange nuts and bolts or breaking of the unions to take place without disturbance or damage to the insulating material. At these positions the insulation shall be beveled and sealed with a metal closure which in turn shall be sealed with waterproof sealing material.

### **Pipe Supports: (All insulation materials) (Fig. 11)**

Insulation at solid welded or clamped supports shall be cut and shaped to fit around the support and banded securely to enable the insulation to be carried with the pipe movement. When the pipe hangers pass through insulation on piping outdoors, metal hoods packed with a waterproof sealing material shall be furnished and installed. Upper bolts of the hanger clamps are not to be covered with insulation.

### **Steam Traced Piping (All insulation materials) (Fig.12)**

Steam traced piping and fittings shall be installed with oversized sections to allow accommodation of both parent pipe and tracer without damage or deformation of the insulation. Traced instrument line and fittings shall be totally enclosed by the insulation in a similar manner and the designed warm air annulus maintained throughout the tracer pipe length. Insulation supports for vertical pipe shall have suitable clearance for tracer pipe. Composite box type insulation may be provided on the steam supply lead lines, in case they are routed together similarly this may be provided for the return lines to manifolds after the run of tracers.



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### **Electrical Traced Piping (Polyisocyanurate / PUR)**

Electrical traced piping shall be provided with the same size insulation as would be provided if the piping were not electrically traced, unless otherwise specified.

## **6.3 Horizontal Equipments**

### **Standard Shapes of insulation**

#### **Fibrous Material (Rock wool)**

Shells: Preferably preformed pipe or multi pipe segments or slabs cut and shaped to fit. Alternately, blanket may be accepted.

Heads: Preformed blocks and slabs cut and shaped to fit. Alternatively, blanket may be accepted.

#### **Calcium Silicate/ Perlite/ PUR / Polyisocyanurate / Cellular Glass**

Curved segments / blocks, mitre cut and shaped to fit.

#### **Ceramic Fibre**

Shall be supplied in blanket strips in sizes as mentioned in the material spec in paragraph 5.2.

#### **Application (All Materials)**

Following provided by the vessel fabricator for insulator / cladding support / securement, shall be verified for their presence by the insulation contractor, before commencing insulation work:

For vessels of diameter 2000mm and above are provided insulation support at horizontal centre line as also vertically at tangent lines. Ring support at tangent lines are provided with 6mm diameter holes. These are to be used for insulation securement.

At vessel heads above 600mm outside diameter are provided flats having 6mm dia holes. The flats are for insulation support and holes provided in them are to be used for insulation securement. Also provided on either head is a central ring made of 10 dia galvanized steel rod. For vessels which do not have central nozzle, these rings shall not be provided by vessel fabricator. For such vessels, insulation contractor shall provide these rings.

Boot of vessel, if any, is provided with circular support ring with holes, as indicated in sketch.

Blanket shall be applied over the surface with joints tightly butted and laced together with 1mm dia galvanized lacing wire.

Other block insulation shall be applied with the longer dimension parallel to the axis of the vessel or equipment. When blocks are applied in multiple layers, all joints in successive layers shall be parallel to the long axis, shall be staggered and sealed with insulating cement for calcium silicate or suitable adhesive for others. In all cases, the insulation is to fit the contour of the vessel or equipment, so that the use of a leveling coat of insulating cement should not be normally necessary to get an acceptable smooth exterior.

### **Special considerations for insulating high temperature Vessels (Required only if provided with calcium silicate insulation) (Fig. 15)**

This provision is required to take care of the effects of equipment circumferential thermal expansion on insulation. This provision is required only for Vessels and Exchangers provided with calcium

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silicate insulation.

Calcium silicate insulation should be installed in beveled or curved segments only, to avoid voids and provide an efficient insulation system.

For equipment's up to 3000mm in diameter and 200°C, to take care of equipment circumferential expansion, the circumferential block is cut and fitted to be 13mm greater in circumference than the equipment and secured so that tension of the bands produces compression on the butt edges rather than on the surface towards the vessel; the little annular space and the compressiveness of the blocks would suffice to take care of circumferential expansion of equipment.

If the vessel is above 3000mm in diameter or if temperature is above 200°C or both, a 25mm thick Rockwool fiber blanket insulation shall be applied around the equipment prior to the application of calcium silicate. This acts as an expansion area around the equipment to act as mechanical and sometimes thermal cushions. The calcium silicate block must be cut and fitted to the outside radius of the equipment plus the thickness of the Rockwool spacer insulation. The insulation, when installed, should not compress the fibrous blanket.

Above provision to take care of circumferential expansion is required both for shell and head.

#### **Insulation Securement (for all insulation materials) (Refer Fig.13 and 14)**

Each layer of insulation on shells of equipment shall be secured by bands at every 225mm centres. Each band shall be machine stretched and tensioned to remove slack only.

Each layer of insulation on vessel heads shall be secured as follows:

Band shall be in radial direction connecting the head central floating ring and shell girth ring. The radial bands shall be placed at not more than 150mm centres for rigid and 300 for fibrous insulation, measured at the girth ring. These bands shall be machine stretched and sealed. Outermost layer of insulation shall also be supported by drawing and securing 16 SWG annealed wire through the 6 diameter holes provided in the shell girth ring as also the flats provided on heads. The wire shall be drawn through every hole and it shall be secured to the ring with a knot.

## **6.4 Vertical Equipments**

### **Standard Shapes**

Shapes for different materials shall be same as specified for horizontal equipment.

### **Application (For all insulation materials) (Fig 16 & 17)**



Application details on shell, top and bottom heads shall be similar to that of horizontal equipment. Insulation shall be laid on insulation support rings provided by the fabricator.

### **Insulation Securement (For all insulation materials) Fig. 16, 17 & 18)**

Bottom and Top Head insulation shall be supported by 16 SWG SS wire drawn through holes in the insulation supports provided by the fabricator.

Top head insulation shall be secured by floating ring/bands provided by vessel fabricator similar to head of horizontal vessel.

Shell insulation shall be supported by bands at every 225mm centres on the cylindrical portion and the bands shall be kept horizontal.

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Insulation Securement for Bottom head for vessel supported on legs shall be identical to that of Top head.

For insulation securement of bottom heads inside skirt no floating rings/bands need be provided; Firm securement should be ensured just by 16 SWG annealed SS wire drawn over insulation tightly and through the holes on support rings provided by the fabricator.

#### **Expansion Joints (All insulation materials)**

Expansion joints shall be provided every 4000mm (max.). The joint shall be provided at insulation support rings. It shall be a 25mm space between the top of the insulation and the bottom of the support ring. The space shall be filled up by compressed rockwool fiber.

### **6.5 Flange, Nozzle, Channel Cover, Manway & Handhole Flanged Cover (For all Insulation Materials)**

Where insulation is required, these shall be insulated with lined removable prefabricated covers secured with bands or quick release toggle clips.

Otherwise, insulation shall be stopped short of uninsulated flanges and nozzles etc., a sufficient distance to permit withdrawal of bolts without disturbing the insulation. Insulation shall be weatherproofed and sealed at these locations.

### **6.6 Irregular Surfaces Such as Pumps, Compressors, Turbines etc.**

#### **Application**

#### **Fibrous Material: Material, application and insulation securement**

This shall be Prefabricated removable covers, lined with pipe sections / lags / slabs / mattresses.

#### **Calcium silicate/Moulded Expanded Perlite**

Insulation material shall be loose fill insulating cement/block insulation cut and fitted. Insulation shall be applied in maximum 25mm thick layers until the scheduled thickness is obtained.

Each layer shall be covered with a layer of 25mm hex. 20 SWG galvanized iron wire mesh for other than SS surfaces and with SS wire mesh for SS surfaces. The final layers shall be travelled to a smooth finish with a 6mm thick finishing cement.

Insulation shall be beveled back at 45°C from all casing flanges, shaft seal caps and bearing boxes.

### **6.7 Vertical Storage Tanks (Carbon Steel)**

#### **Standard Shapes of insulation**

Fibrous Material (Rock wool) Shall be in slab form.


Polyisocyanurate / Polyurethane foam Shall only be foamed cast in-situ.

#### **Application**

Supporting rings / spikes (rods) for supporting insulation / cladding

#### **Shell**

Insulation contractor shall check for its presence before insulation application work. Following is

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provided by tank fabricator.

#### **Water Shed**

At the junction of shell and roof, a watershed is provided to act as top covering for the shell.

#### **Insulation Support**

Insulation support will consist of 5mm dia steel rods provided at 400mm dia diamond pitch. Length of these lugs is 3mm less than insulation thickness.

#### **Cladding Support**

From tank top, horizontal rings shall be provided at every 1175mm on tank shell.

#### **Tank Roof**

#### **Insulation laying and securement**

##### **Shell (Application of fibrous insulation)**

Insulation shall be applied between rings in horizontal mode. Mattresses insulation shall be applied with joints tightly butted and laced together with 1mm dia. galvanized lacing wire. Matts shall be impaled to the 5mm rod and speed washers fixed and pressed home for intimate contact of the insulation. In the case of multiple layers, speed washers are necessary only over the final layers, (up to and including 150mms). Rods and speed washers of spring steel should be selected to suit each other. While rods are provided by tank fabricator, speed washers shall be furnished by insulation contractor. Insulation shall be further secured by bands spaced centrally between insulation supports.

##### **Shell (Application of Polyisocyanurate / Polyurethane foam)**

Shall be foamed cast in-situ as per vendor's procedure (approved by CONTRACTOR/Client/Client's representative) and to the satisfaction of Site-in-Charge. The minimum requirement for thermal conductivity, density, compressive strength, fire properties and water vapor permeability shall be as per para 5.2. Depending upon the application the thickness of cladding and bands shall be as per para 5.3 & 5.4 respectively. Contractor shall ensure that cladding & band thicknesses are capable of withstanding foaming pressures which are developed at the time of injection of foam. Contractor can use foamed cast in-situ insulation only after getting the approval to material specification and application procedure.

##### **Roof (For all materials)**

Application of both fibrous, Polyisocyanurate and Polyurethane foam shall be similar to that as for shell. Insulation support from 5mm dia M.S. lugs shall be exactly same as in shell.

## **6.8 Horton Spheres**

#### **Standard shapes & Material**

Shall be only Rockwool blanket.

#### **Application**

Structural members provided by spheres fabricator for insulation/cladding securement.

#### **Insulation laying and securement**

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Insulation shall be applied between rings. Insulation shall be applied with joints tightly butted and laced together with 1mm dia galvanized lacing wire.

Insulation shall be secured by drawing and securing tightly 16 SWG stainless steel wire through the 6 dia holes, provided every 200mm centres, in the horizontal leg of the insulation support angle ring. The wire shall be rightly drawn over the insulation and the insulation firmly secured. The wire shall be drawn through every single individual hole and it shall be secured with angle with a knot at every fourth hole. For application of bands for securement of insulation and cladding refer figure20.

## 6.9 Inspection Windows

### Piping

Plug type inspection windows of ellipsoidal shape shall be provided on all the insulated pipelines having diameter 2" and above. One inspection window shall be provided at a distance of every 20meters of straight length of pipe. It should be provided at the bottom i.e. At 4-6-8 clock position whichever is convenient. There must be atleast one inspection window between two bends which are minimum 10 meters apart. Atleast 50% of the bends shall be provided with inspection windows. The sheet metal of the inspection windows shall be of same thickness as that of the sheet metal cladding on insulation. The size of the inspection windows shall be as follows:

<b>Pipe dia 2"</b>	<b>35mm minor diameter x 120mm major diameter</b>
<b>Pipe dia 3"</b>	<b>45mm minor diameter x 120mm major diameter</b>
<b>Pipe dia 4"</b>	<b>75mm minor diameter x 120mm major diameter</b>
<b>Pipe dia 6"</b>	<b>100mm minor diameter x 120mm major diameter</b>
<b>Pipe dia 8"</b>	<b>100mm minor diameter x 120mm major diameter</b>
<b>Pipe dia &gt; 8"</b>	<b>120mm minor diameter x 120mm major diameter</b>

### Exchangers

All the heads shall be provided with one inspection window each. Minimum two inspection windows shall be provided on the shell side.

### Columns & Vessels

Heads shall be provided with one inspection window each. One inspection window shall be provided at every platform. Minimum two inspection windows shall be provided on shell portion.

### Tanks

One inspection window shall be provided at each course of the tank and also at the top.

## 6.10 Impulse Lines

Wrap the impulse lines with insulation (Sodium Silicate inhibited Ceramic rope) of required thickness (refer note below) after cleaning the impulse lines of dust, rust, grease etc. Ensure that the rope(s) have been tightly wrapped without leaving any gaps. Apply two layers of self adhesive Aluminium foil tape of minimum 0.1mm thick spirally bound over the fibre rope surface with the joints in two layers staggered. Ceramic rope shall have minimum density of 250 Kg/m<sup>3</sup> with other properties conforming to para 5.2 of the specification for Hot Insulation. A suitable sealant shall be provided to stop the water ingress at the termination points of insulation.

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Note: Impulse line insulation details shall be as follows:

<u>Size</u> (Impulse line)	<u>Temp</u>	<u>No. of Ins layers</u>	<u>Thickness of each layer</u>
1/2"	150degC	2	1/2"
3/4"	150degC	2	1/2"
1/2"	250degC	2	3/4"
3/4"	250degC	2	3/4"

## 7. **INSULATION FINISH**

### 7.1 **General**

#### **Moisture Barrier**

On all surfaces except horton sphere, provided with fibrous materials, Moulded, Expanded Perlite , Calcium silicate, Polyisocyanurate & Polyurethane foam .

For surfaces upto 125°C & on PIR/PUR in case of electric heat tracing apply a breathing type moisture barrier as below. A 3mm thick coating of mastic shall be applied to the surface of the insulation as soon as possible, after erection, to reduce the time the insulation is exposed to the weather, to a minimum. Whilst this coat is still wet, glass cloth shall be laid over the surface and embedded in the mastic. Care shall be taken to ensure that the glass cloth is laid smooth and free from wrinkles and that no pockets of air are trapped beneath the surface. At junctions in the glass cloth, the overlap shall not be less than 75mm. A second 3mm thick coat of mastic shall be applied after approximately 12 hrs. When dry this coating shall be a minimum of 1.5mm thick. Care must be taken, however, to ensure that the individual coats are not greater than 3mm (especially corners) otherwise some cracking of dried coat may result. The mastic shall not be applied over wet insulation or until the adhesive is dry. During the drying time, the insulation shall be protected from the weather by "Alkathene" film type tarpaulin or similar materials approved by Engineer-in-Charge. Mastic vapour barrier quality shall be Ar-cryl CP-9 of Childers or equivalent.


#### **Insulation Finish**

The insulation finish shall provide a weatherproofed and covering over the whole of the insulated areas and be applied and fitted in such a manner as to provide a close-fitting assembly without gaps.

### 7.2 **Piping (For all Materials)**

Straight pipe shall have metal jacketing cut and machine rolled, (approx. 1 metre long) wrapped around, with 50mm minimum overlap for longitudinal and 75mm overlap for circumferential overlaps. All laps shall be arranged to shed water. All longitudinal overlaps on horizontal pipes shall be arranged weatherside down to the prevailing wind and to shed water and shall be located along the lower half at approximately 135° or 225° positions. Longitudinal overlaps on the vertical



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pipes shall be arranged away from the prevailing site weather conditions and also overlapped circumferentially to shed water.

A single bead shall be made on all overlaps to ensure tight metal to metal water tight arrangement. Self tapping screws, at every 150mm shall be provided at all longitudinal overlaps for both horizontal & vertical piping.

At all operating temperatures the seams at overlap positions shall be rendered watertight as per para 5.4 to ensure that insulation remains dry and unwetted, whether the possible water impingement is from rain, hose or fire sprinklers.

The metal coverings shall be secured tightly around the insulated pipe and held in place with bands on a maximum of 300mm centres. One band shall be located on each circumferential lap and the distance between laps divided at equal band spacings. The band securing seals shall be kept neatly in line and positioned away from viewing angles as much as is possible.

Vertical overlaps on vertical or near vertical piping shall be staggered to provide overlaps at 'North,' and 'South' positions in alternate sections of covering.

Each sections of metal covering on vertical piping with insulation OD's larger than 250mm shall be supported from the next lower section with two 'S' clips, fabricated from banding material. The 'S' clip shall be of sufficient length to allow the minimum overlap of 50mm.

On vertical piping with OD's of 600mm and larger, the securing bands shall be supported by 'J' clips, fabricated from banding material. The 'J' clip spacing shall be a minimum of two per band. All 'J' clips shall be screwed into position and secured.

Insulated bends and elbows in piping 80mm and larger, shall be metalled with 'lobster back' segments using 10mm minimum ball swage to assist shaping. The metal bands shall be screwed with self-tapping screws and metal sealants are to be provided to get a completely waterproofed arrangement.

Insulated bends and elbows in piping smaller than 80mm may use complete pressed and humped back flat metal elbows or fabricated 'stove pipe' elbows.

The practice of locating all joints in the top portion of elevated horizontal pipes for the sake of good appearance when looking up from grade shall be strongly discouraged. The joints shall be located to shed water.

Insulation Supports shall be installed at the following locations:

300mm above an elbow or tee in a vertical run of piping,

Bolt length plus 30mm above flanges of vertical piping,

Every 3.5m of vertical carbon steel pipe elevation and every 2.75m of vertical stainless steel pipe elevation.

### 7.3 Equipments (For All Materials)

The metal jacket over vertical vessel shells shall be constructed of sheet metal panels with the weight of the panel taken on the equipment insulation support rings, via angle brackets bolted to the panel.

The first insulation support ring from grade shall be 25mm more than the total insulation thickness,

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All other insulation support rings shall be 15mm less than the total insulation thickness.

The panels shall be applied commencing at the bottom of the vessel. Each circumferential ring of panels shall be tensioned by means of tensioning bands until the final joint is screwed tight.

'S' clips shall be used as sheeting support at unscrewed circumferential overlaps.

The panels shall be held tight over the vessel insulation by means of circumferential bands and sealed as per para 5.4. The bands shall be positioned on all horizontal overlaps and at 450mm centres. Bands shall be held in their relative positions with 'J' clips and be machine-stretched and sealed to remove slack only. Those bands which are not supported by 'J' clips, shall be held in position on cladding by providing pop rivets every 2 meter centres.

The panels shall have a minimum overlap of one corrugation on vertical joints and 80mm on horizontal joints. The overlaps shall be arranged to shed water at all times.

The vertical and horizontal overlaps shall be secured with self-tapping screws at 150mm pitch except the horizontal overlaps pre-selected to act as expansion joints, these shall be constructed with a 150mm overlap and shall remain unscrewed and left free to permit expansion. All overlaps shall be rendered watertight as per para 5.4.

All equipment projections such as nozzles, shall have the jacketing sealed using a metal flashing, cut to fit the projection and extending above the jacket at least 80mm. The seal between the flashing and jacket shall be made watertight by use of self-tapping screws and sealing mastic.

Horizontal cylindrical equipment shall be furnished with flat metal jacket arranged in circumferential bands with the edge of the sheets, with the longer dimension applied around the circumference of the equipment insulation.

The panels shall have a minimum of 80mm overlap of both longitudinal and circumferential edges, both overlaps being finished with a simple ball swage and rendered watertight as detailed in para 5.4.

Horizontal overlaps shall be secured with No. 8 x 12mm long self-tapping screws set in the overlap at 150mm intervals and shall be so arranged that staggered bands of panelling encircle the equipment. Vertical overlaps shall not be screwed for horizontal equipment.

The metal finish shall be banded and sealed at 450mm centres.

The insulated heads of vertical and horizontal equipment shall be fabricated from flat metal, an "Orange peel" construction with all radial seams overlapping a minimum of 50mm and secured with self-tapping screws at 150mm centres. All overlaps shall be ball swaged and be rendered water tight as per para 5.4.

Projections from the heads shall be sealed using metal flashings, neatly cut to fit around the projections and extending above the jacket for a minimum of 80mm. The seal between flashing and jacket shall be weatherproofed with self-tapping screws and mastics.

Insulation at bottom heads of fully skirted equipment does not require weatherproofing.

Heads of equipment 24" OD and smaller shall be finished and waterproofed with square ended fabricated covers.

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## 7.4 Vertical Storage Tanks

### Cladding Applications and Securement

Cladding is applied over the system of horizontal rings as follows:

Overlaps in the vertical joints will be one corrugation. Overlaps in the horizontal joints shall be 50mm (min.). Cladding to cladding fastening, at both horizontal and vertical overlaps shall be alternately by "POP" Rivets & self-tapping screws at 150mm pitch.

Cladding shall be secured to support ring by bolting. Bolts are provided by tank fabricator at 300mm centres on angles provided at every 1175mm centres vertically. Felt washer, aluminium washer and nut shall be supplied by insulation contractor for all bolted connections at shell, roof and curb angle.

Insulation shall be tucked into the skirt portion of the curb angle. Shell cladding and extended roof cladding shall be secured to curb angle by bolting at every 1500mm.

### Roof

All cladding joints shall be sealed by elastomeric metal sealants. Min. 75mm overlap shall be ensured at all joints. At all joints, cladding-to-cladding securement shall be provided by self tapping screws and pop rivets alternately, every 150mm centres.

Cladding shall be secured by bolting at every 300 provided by tank fabricator.

## 8. GURANTEE & TEST CERTIFICATES

Insulation contractor shall guarantee all insulation works against the defects due to material and workmanship effecting performance for a period of eighteen months from the date of completion of total insulation works and shall repair /replace promptly, without cost, any part or parts of the material that fails within said period.

All the test certificates required as per this document shall also be furnished along with the supply of materials.

## 9. REFERENCE CODES AND STANDARDS

The following list includes standards and specifications referenced in this Spec.:

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### ASTM STANDARDS AND SPECIFICATIONS

ASTM A167	Specification for stainless and heat-resisting chromium nickel steel plate, sheet and strip
ASTM A240	Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet and strip for Pressure Vessels
ASTM A463	Specification for steel sheet, aluminum coated, by hot-dip process
ASTM A526	Specification of steel sheet, zinc coated (galvanized) by the hot-dip process, commercial quality
ASTM B209	Aluminum - Alloy sheet and plate
ASTM C165	Measuring Compressive properties of thermal insulations
ASTM C177	Standard test method for Steady-state heat flux measurements & thermal transmission properties by means of the 'guarded-hot-plate' apparatus
ASTM C240	Standard test methods of testing Cellular glass insulation block
ASTM C302	Standard test method for Density and dimensions of preformed pipe-covering-type thermal insulation
ASTM C303	Standard test method for Density and dimensions of preformed block and board type thermal insulation
ASTM C335	Standard test method for Steady-state heat transfer properties of horizontal pipe insulation
ASTM C356	Standard test method for Linear shrinkage of preformed high-temperature thermal insulation subjected to soaking heat
ASTM C390	Standard criteria for Sampling and acceptance of preformed thermal insulation lots
ASTM C446	Standard test method for Breaking load and calculated modulus of rupture of preformed insulation of pipes
ASTM C518	Standard test method for Steady-state thermal transmission properties by means of the heat flow meter apparatus
ASTM C533	Standard specification for Calcium silicate block and pipe thermal insulation
ASTM C547	Standard specification for Mineral fiber pipe insulation
ASTM C552	Standard specification for Cellular glass thermal insulation
ASTM C591	Standard specification for Unfaced preformed rigid cellular polyisocyanurate thermal insulation
ASTM C592	Standard specification for Mineral fiber blanket insulation and blanket-type pipe insulation (metal-mesh covered) (industrial type)
ASTM C610	Standard specification for block and pipe thermal insulation
ASTM C612	Standard specification for Mineral fiber block and board thermal insulation
ASTM C795	Standard specification for thermal insulation for use in contact with austenitic stainless steel
ASTM C871	Standard test methods for Chemical analysis of thermal insulation materials for leachable chloride, fluoride, silicate and sodium ions
ASTM C892	Standard specification for High temperature fiber blanket thermal insulation
ASTM D1622	Test method for apparent density of rigid cellular plastics
ASTM D2126	Test method for response of rigid cellular plastics to thermal and humid aging
ASTM E96	Standard test methods for Water vapor transmission of materials

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### BS STANDARDS AND SPECIFICATIONS

- BS 1902 Pt 6 Ceramic fibre products  
BS 2972 Method of test for Inorganic thermal insulating materials  
BS 4370 Pt 2 Method of test for rigid cellular materials  
BS 5608 Specification for preformed rigid polyurethane (PUR) and polyisocyanurate (PIR) foams for thermal insulation of pipework and equipments

### IS STANDARDS AND SPECIFICATIONS

- IS 10085 Method for chemical analysis of zircon flour or sand  
IS 11239 Method of test for Rigid cellular thermal insulation materials  
IS 12436 Specification for Preformed rigid Polyurethane (PUR) and Polyisocyanurate (PIR) foams of thermal insulation  
IS 1335 Method of direct determination of alumina in refractory material  
IS 1527 Methods for Chemical analysis of high silica refractory materials  
IS 277 Specification for Galvanized steel sheets  
IS 3346 Method for determination of Thermal conductivity of thermal insulation materials  
IS 737 Specification for wrought aluminum and aluminum alloy sheet and strip for general engineering purposes  
IS 8183 Bonded mineral wool-Specification  
IS 9428 Calcium silicate insulation blocks and pipe-coverings  
IS 9842 Preformed fibrous pipe insulation- Specification

IS14164:2008 INDUSTRIAL APPLICATION AND FINISHINGS OF THERMAL INSULATION MATERIALS AT TEMPERATURE ABOVE -80°C AND UPTO 750°C

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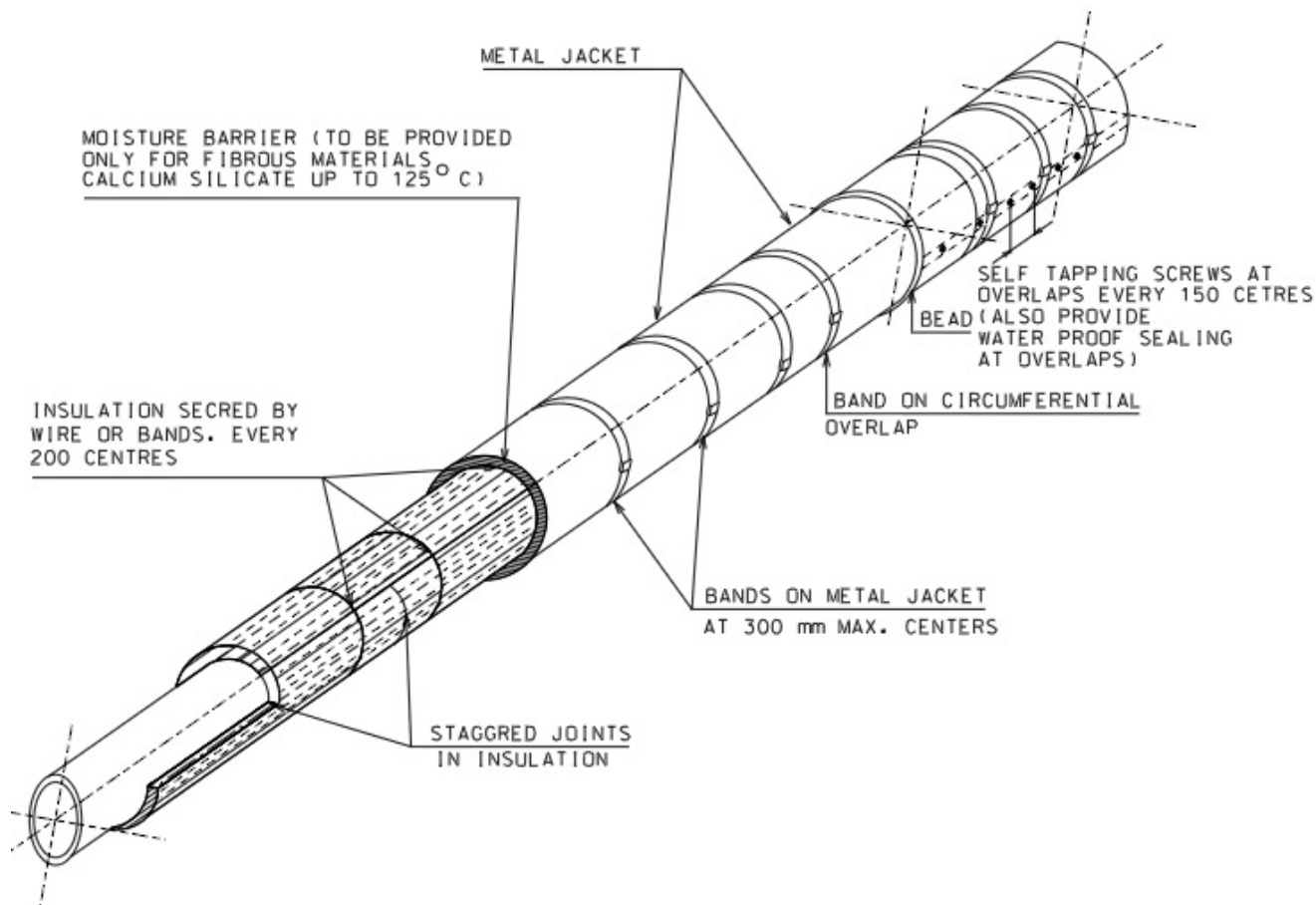
## 10. ATTACHMENT DRAWINGS AND TABLES

### FIG NO. DESCRIPTION

1. Pipe Insulation Details (Fibrous & Rigid Insulation)
2. Pipe Insulations: Method of staggering of sections Rigid & Fibrous Insulation (Preformed Pipe Sections only)
3. Horizontal Pipe: Fibrous Mattress Insulation; Detail of Spacer Rings for Cladding Support
4. Detail of Spacer Ring Fibrous Insulation (Mattress)
5. Bolted Insulation Support for Vertical Pipe
6. Insulation Details for Bends / Elbows
7. Insulation Details: Pipe Bends & Elbows
8. Insulation Details: Pipe Branched & Reducers
9. Insulated Removable Cover: Valves
10. Insulation Removable Cover: Flanged Joints
11. Insulation Details: Pipe Supports
12. Insulation for Steam Traced Piping
13. Horizontal Equipment Insulation
14. Horizontal Equipment Heads
15. Use of Flexible Insulation in combination with Rigid Insulation to compensate for Vessel Expansion
16. Insulation Details : Vertical Vessel
17. Insulation Details : Vertical Vessel Heads
18. Insulation Details : Vertical Vessels
19. Insulation Details : Vertical Storage Tank

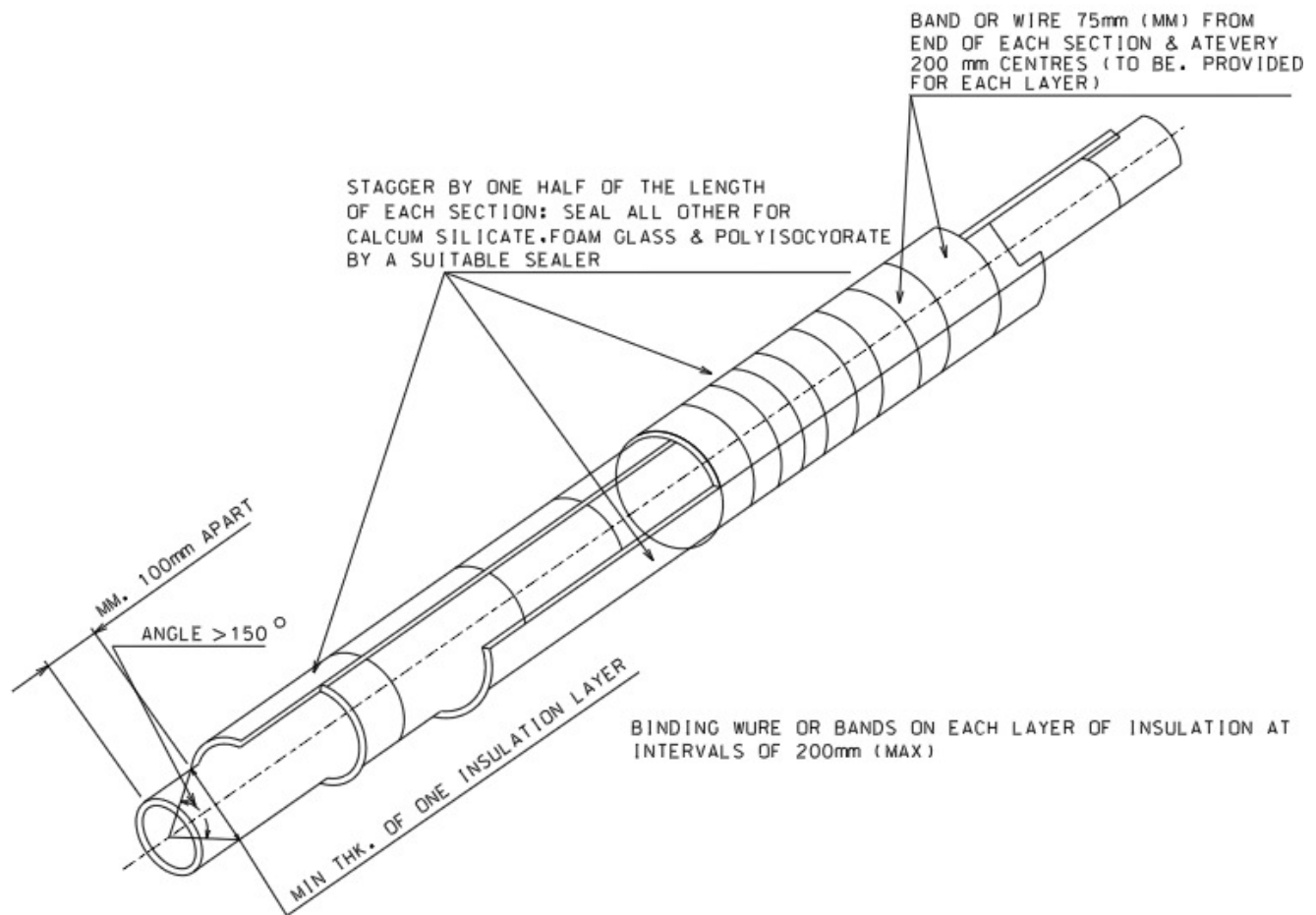


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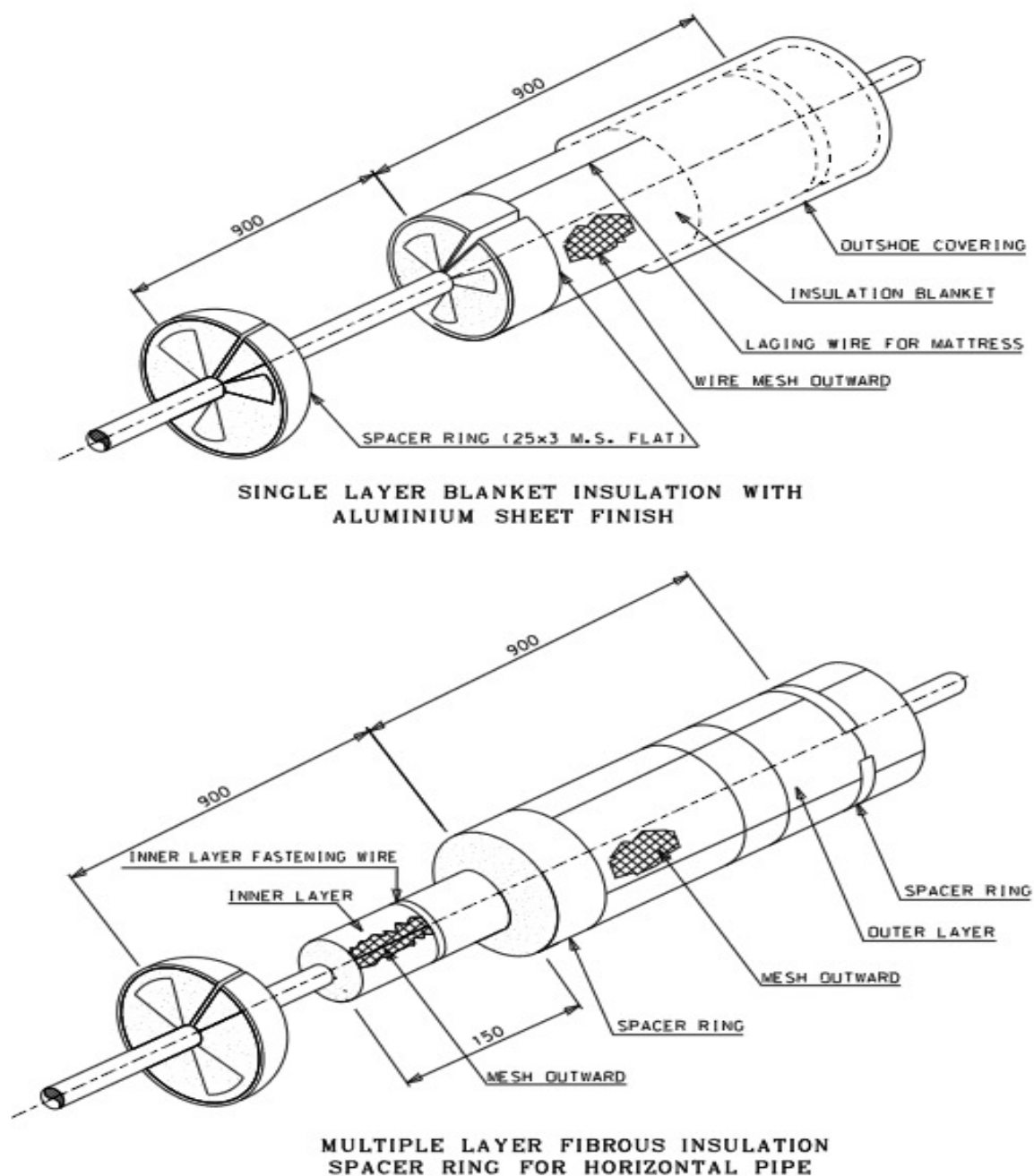


**FIGURE 01 – PIPE INSULATION DETAILS (FIBROUS & RIGID INSULATION)**

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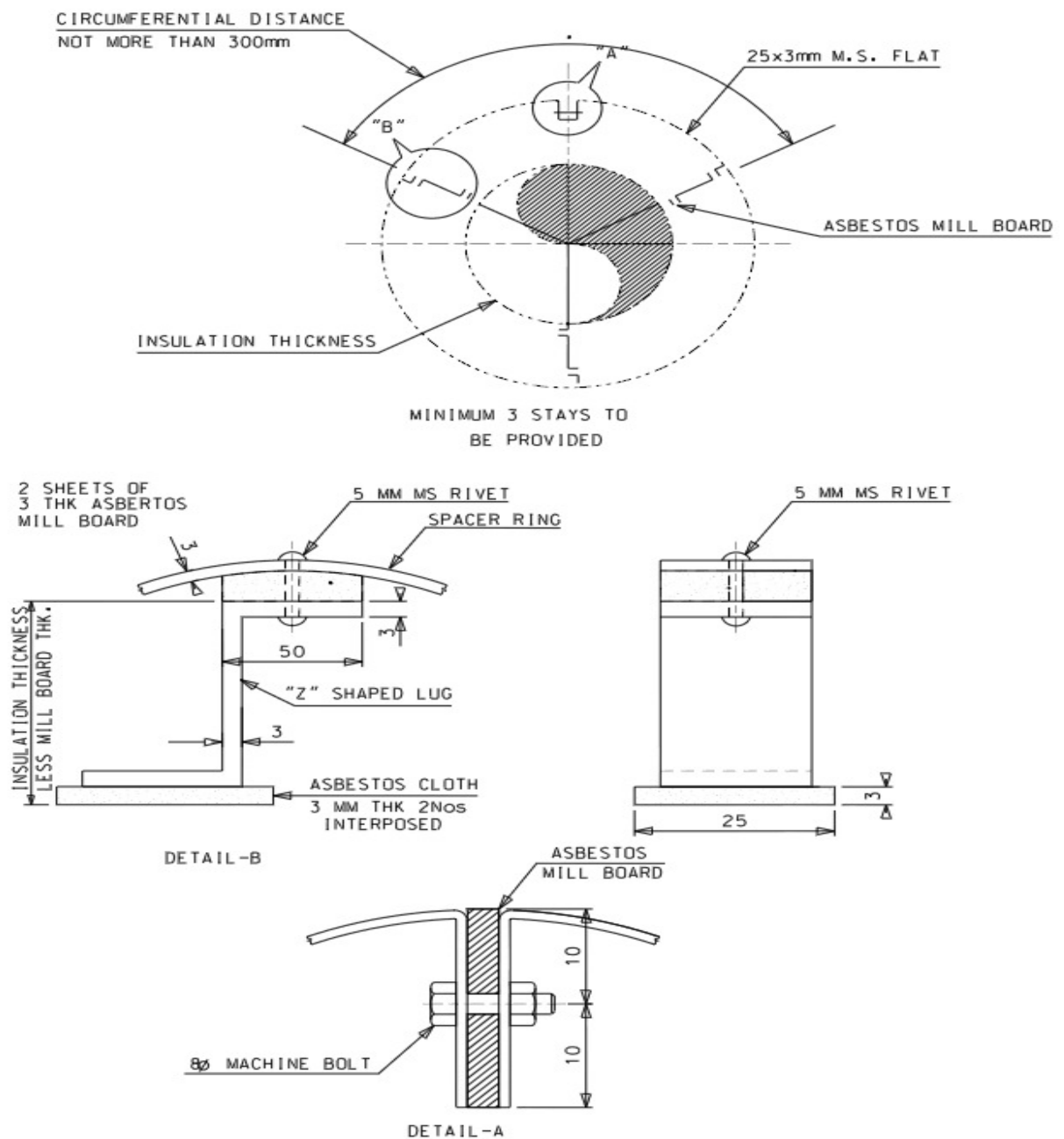


**FIGURE-02 – PIPE INSULATION METHOD OF STAGGERING OF SECTIONS RIGID & FIBROUS INSULATION (PREFORMED PIPE SECTIONS ONLY)**



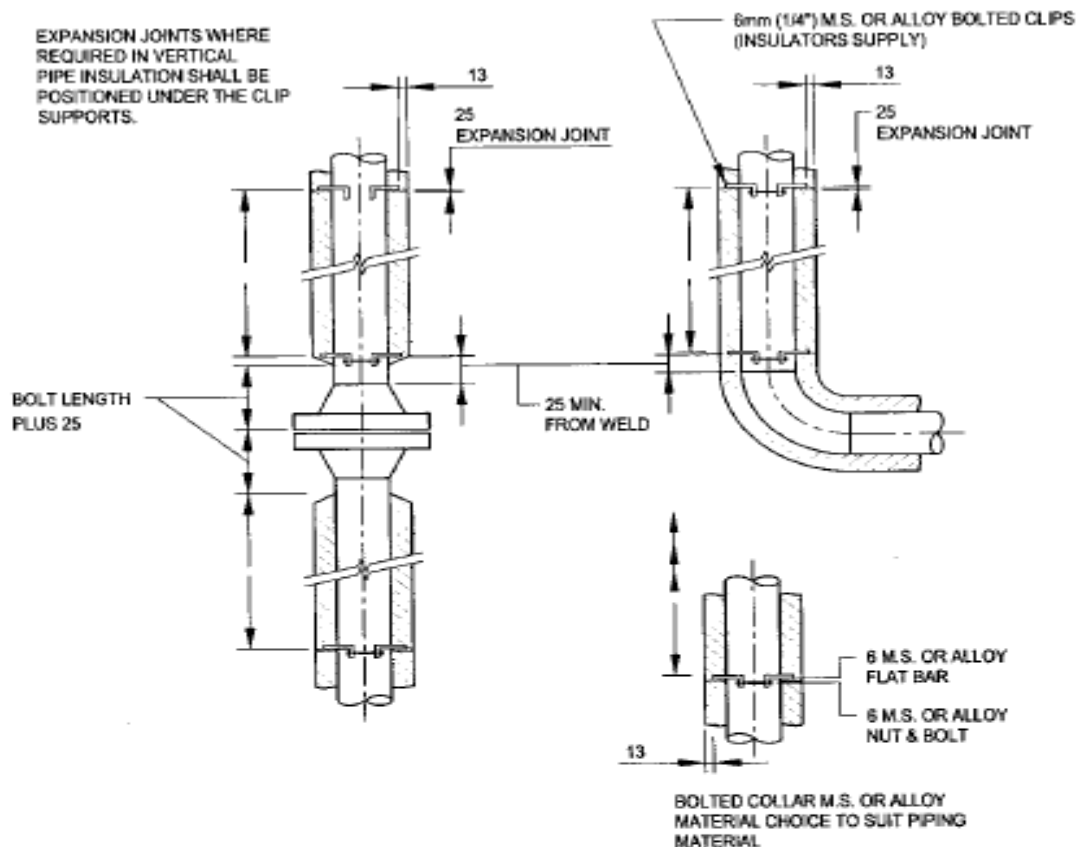
**FIGURE -03 HORIZONTAL PIPE FIBROUS MATTERSS INSULATION DETAILS OF  
SPACER RING FOR CLADDING SUPPORT**

		PROJECT	Standby SRU & Additional Tanks IOCL- Paradip Refinery		
		CLIENT	INDIAN OIL CORPORATION LIMITED		
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**FIGURE -04 – DETAILS OF SPACER RING FIBROUS INSULATION (MATTRESS)**

<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks IOCL- Paradip Refinery</b>		
<b>CLIENT</b>	<b>INDIAN OIL CORPORATION LIMITED</b>		
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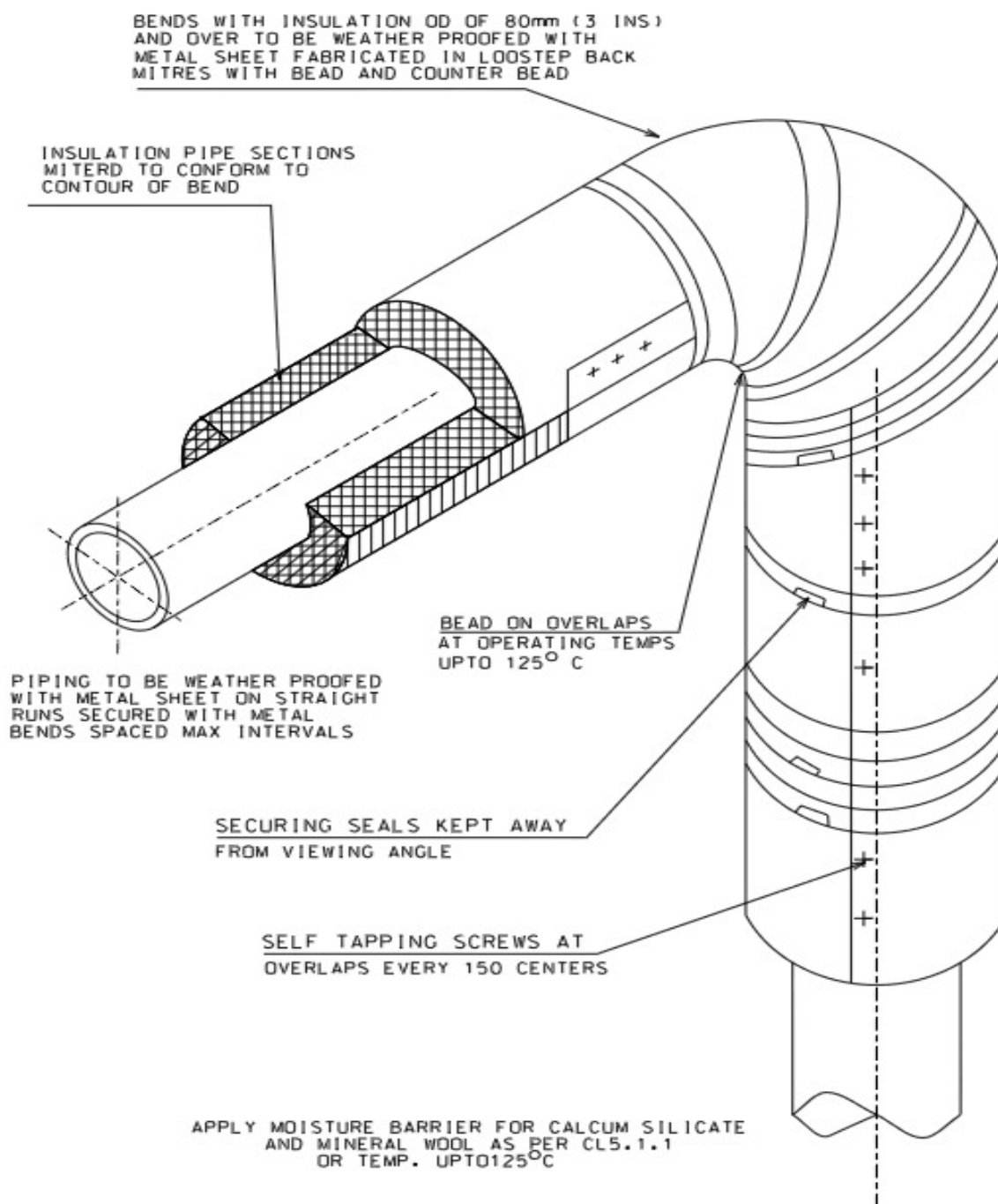
#### CLIP SPACING

PIPE TEMP. °C	MAX. SPACING 'D' MM
UPTO 400	4500
400 TO 500	3500
500 TO 550	2500

\* CIRCUMFERENTIAL EXPANSION SHALL BE CONSIDERED AT THESE OPERATING TEMPERATURES.

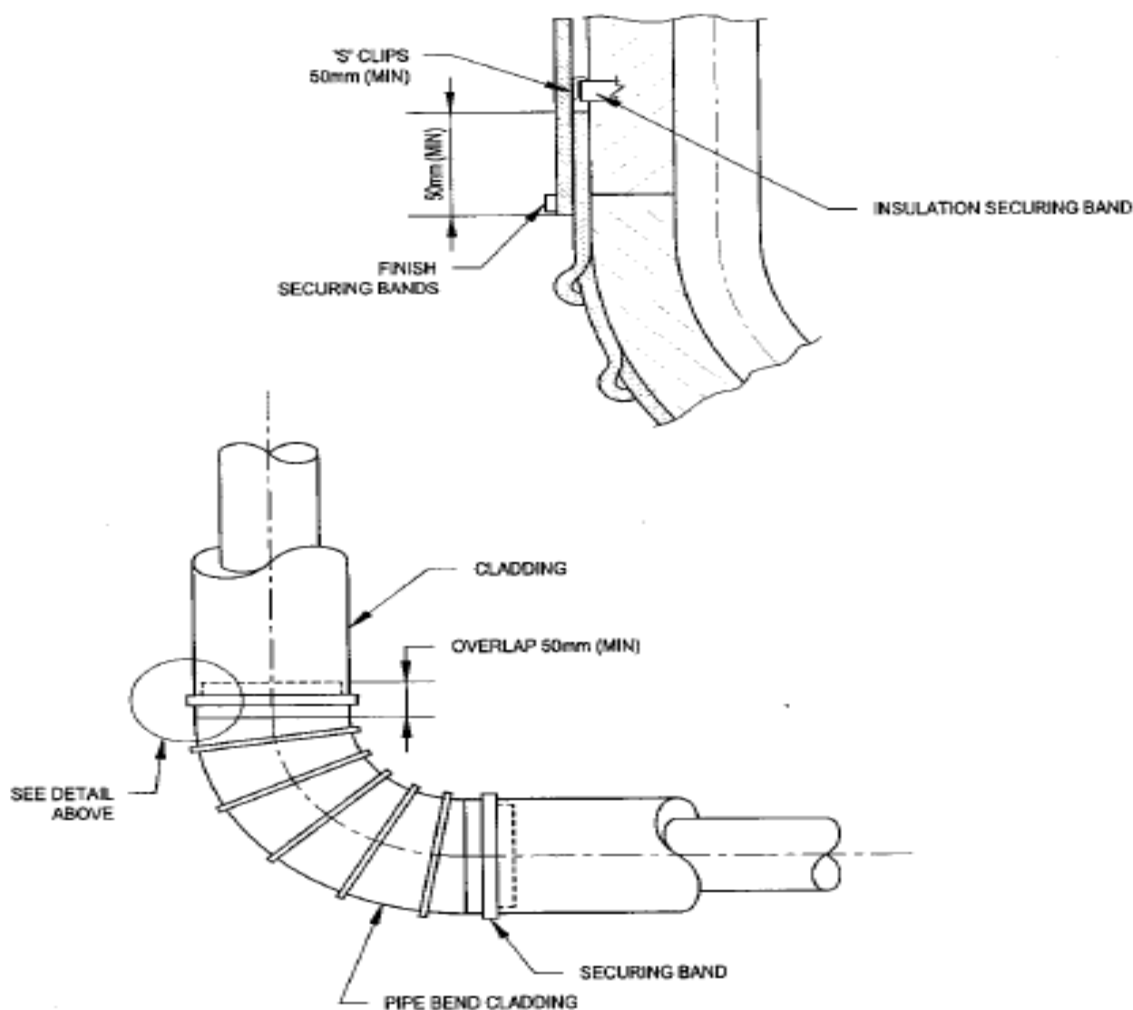
**FIGURE – 05**  
**BOLTED ON INSULATION SUPPORT FOR VERTICAL PIPE**

 <b>TechnipFMC</b>		<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks IOCL- Paradip Refinery</b>		
		<b>CLIENT</b>	<b>INDIAN OIL CORPORATION LIMITED</b>		
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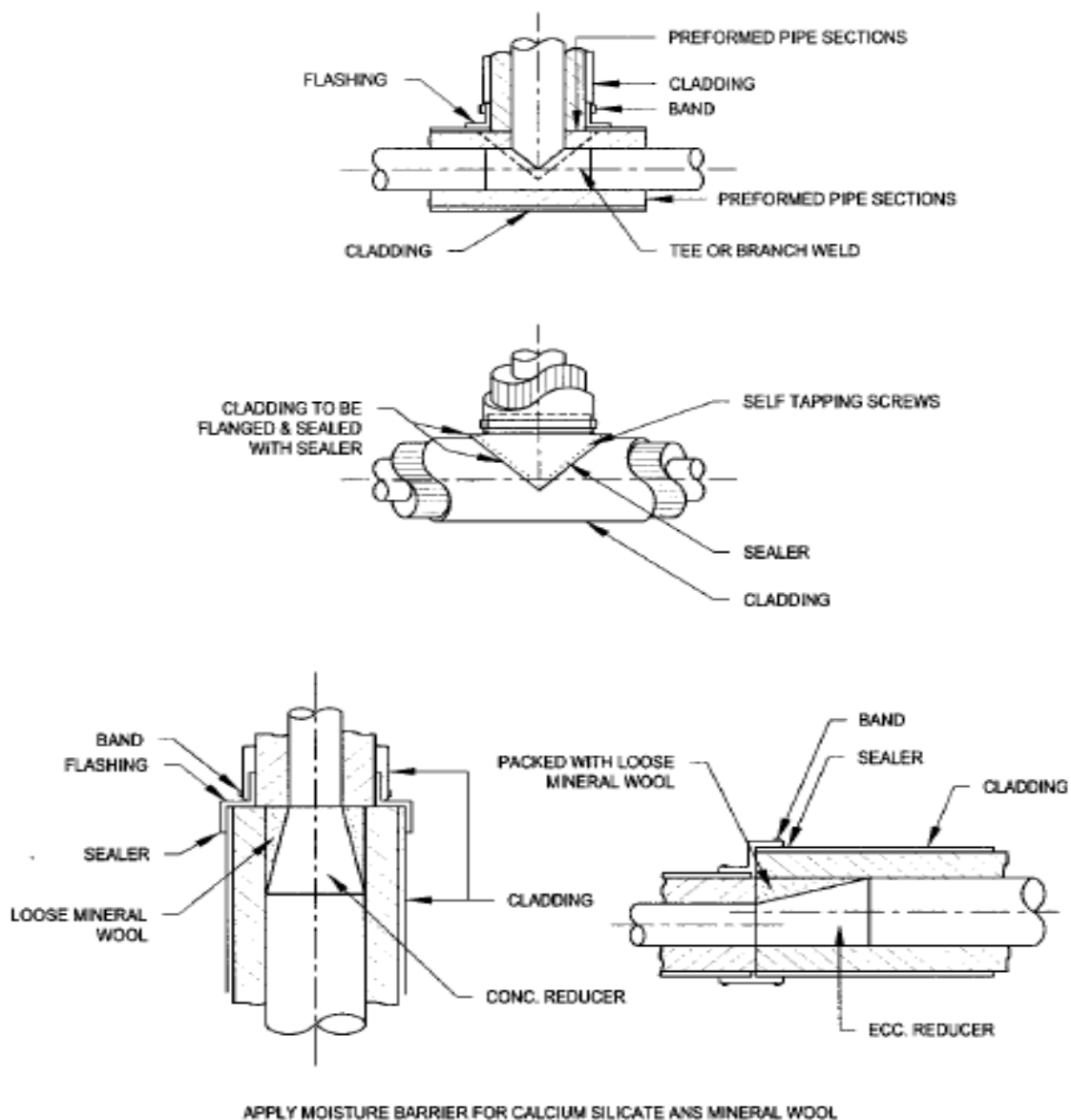


**FIGURE 06 – INSULATION DETAILS FOR BENDS / ELBOWS**

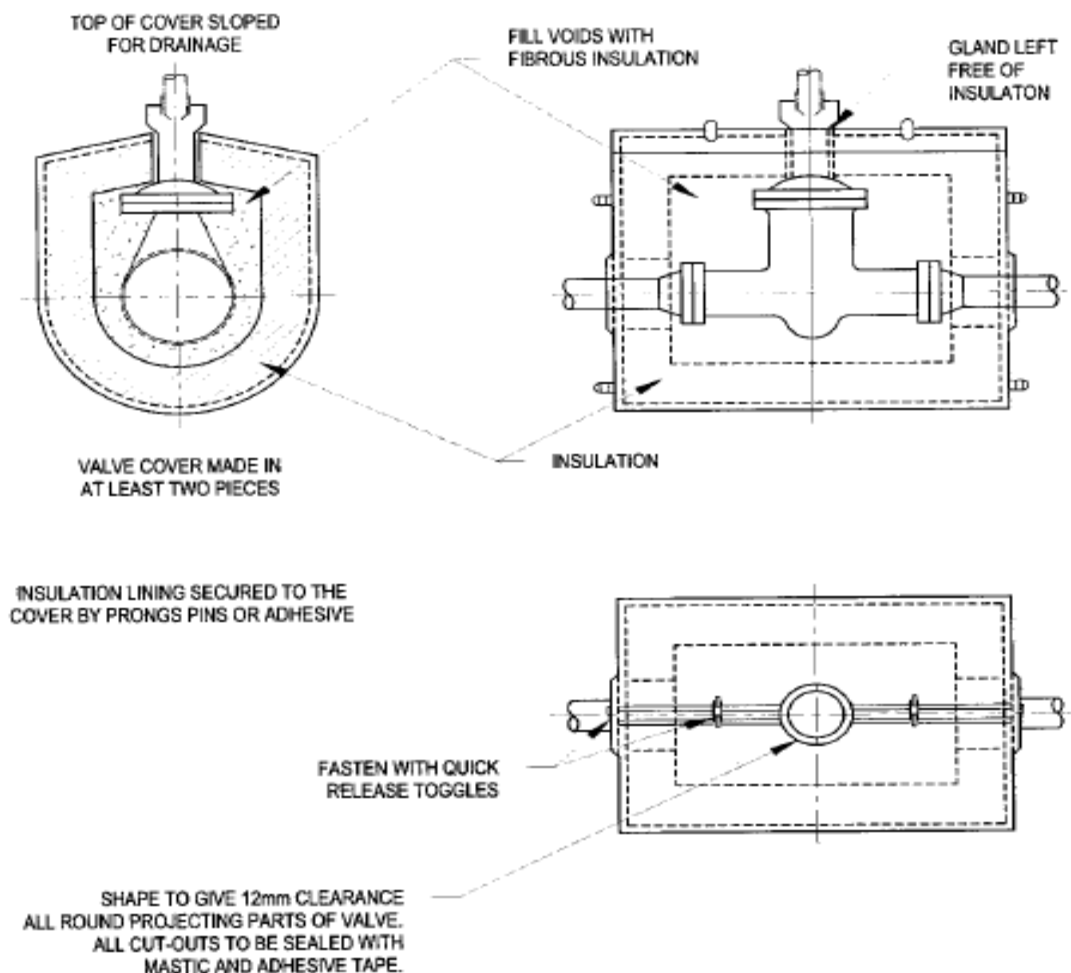




**FIGURE – 07**  
**INSULATION DETAILS : PIPE BENDS & ELBOWS**

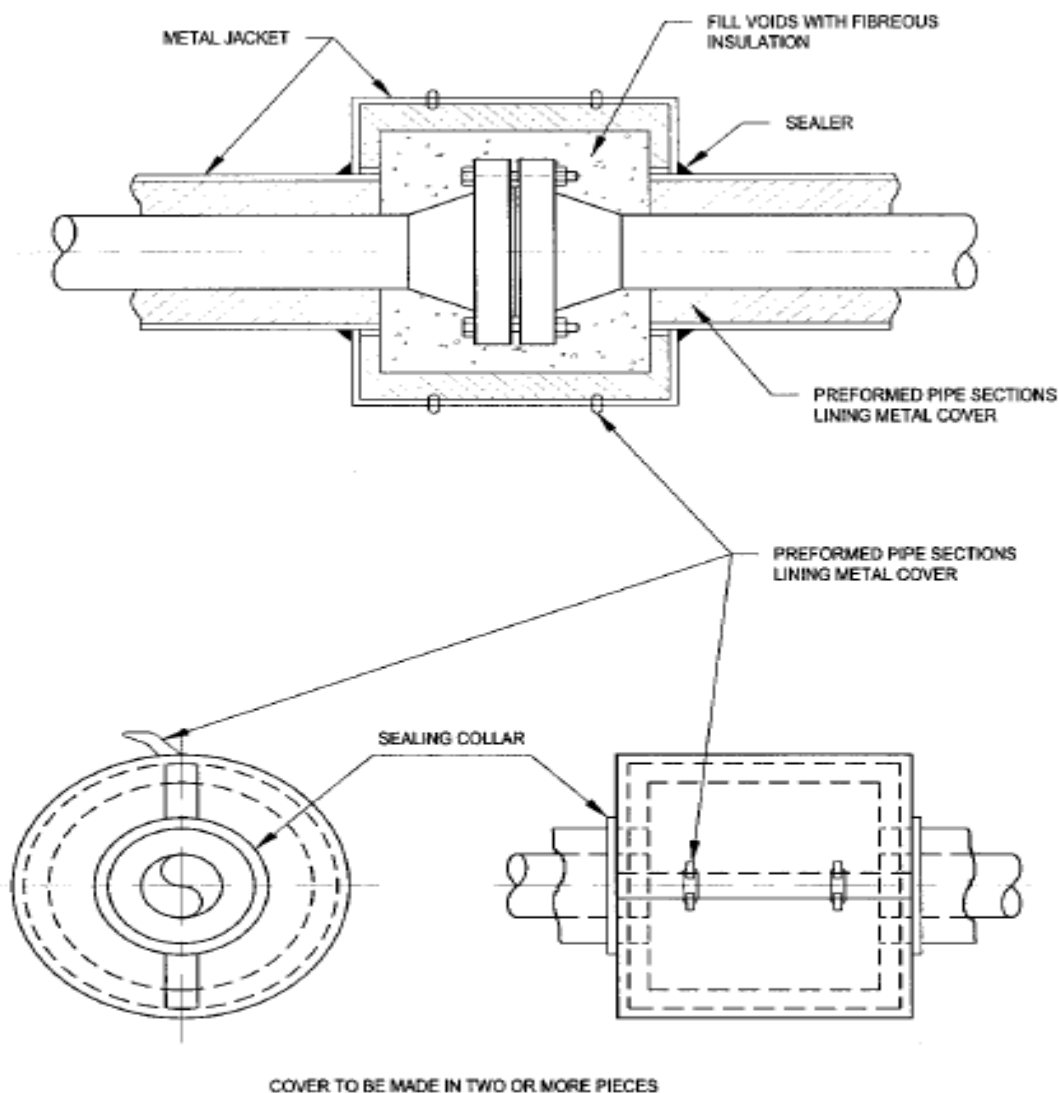


**FIGURE – 08**  
**INSULATION DETAILS: PIPE BRANCHED & REDUCER**

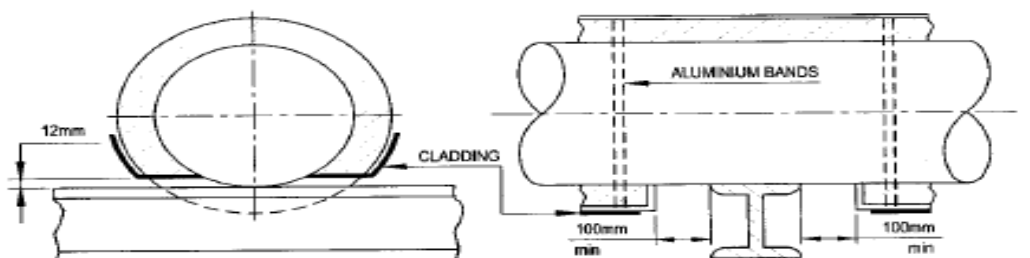


**FIGURE – 09  
INSULATED REMOVABLE COVER: VALVES**

<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks IOCL- Paradip Refinery</b>		
<b>CLIENT</b>	<b>INDIAN OIL CORPORATION LIMITED</b>		
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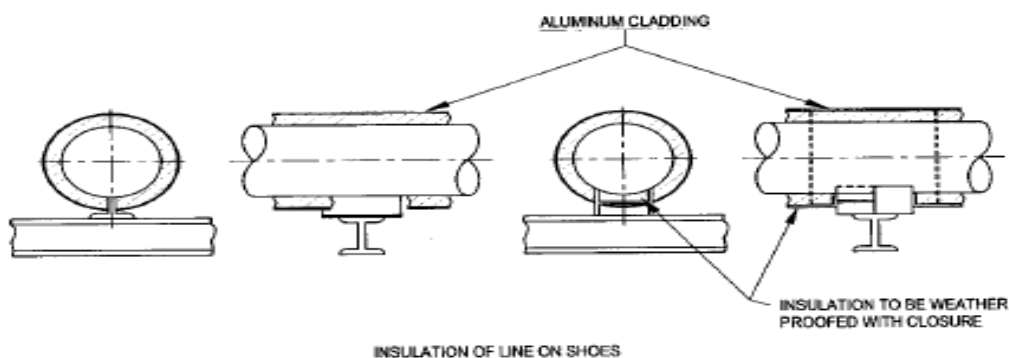


**FIGURE – 10**  
**INSULATION REMOVABLE COVER – FLANGED JOINTS**



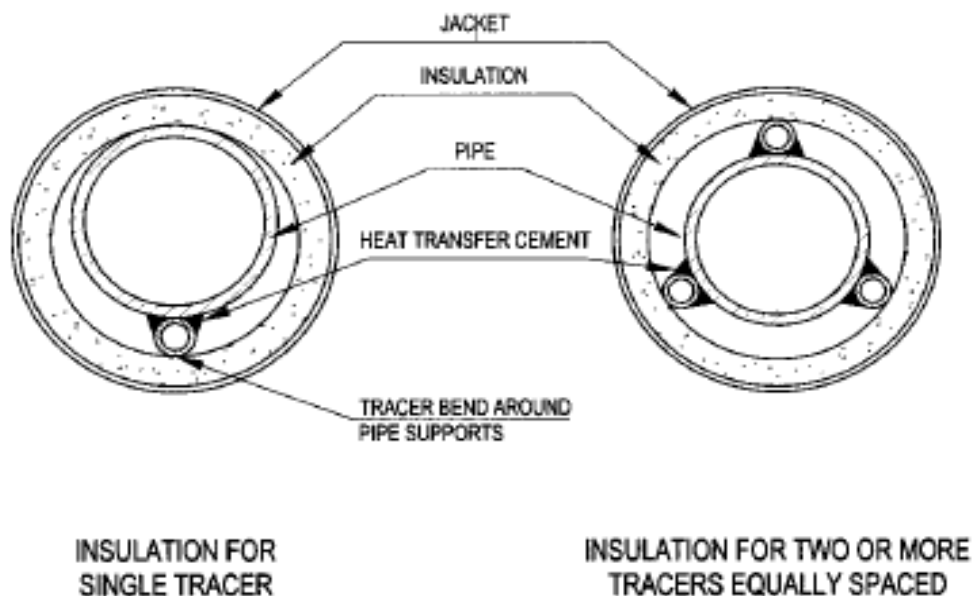
WHERE CLADDING IS TO BE CUT AWAY IT SHALL FIT CLOSELY TO  
THE PIPE AND TO BE COMPLETELY WEATHERPROOF

INSULATION DETAIL AT LINES WITHOUT SHOES  
(THIS SHOULD ONLY BE REQUIRED IN EXCEPTIONAL CIRCUMSTANCES)



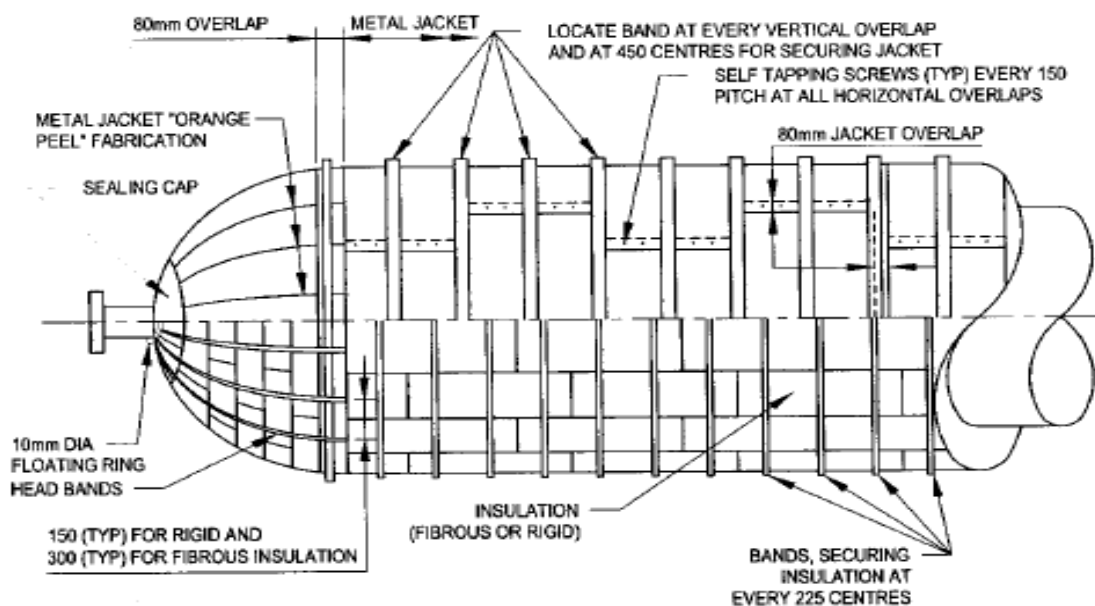
**FIGURE – 11  
INSULATION DETAILS PIPE SUPPORTS**

 <b>TechnipFMC</b>	 IndianOil	<b>PROJECT</b>	<b>Standby SRU &amp; Additional Tanks IOCL- Paradip Refinery</b>		
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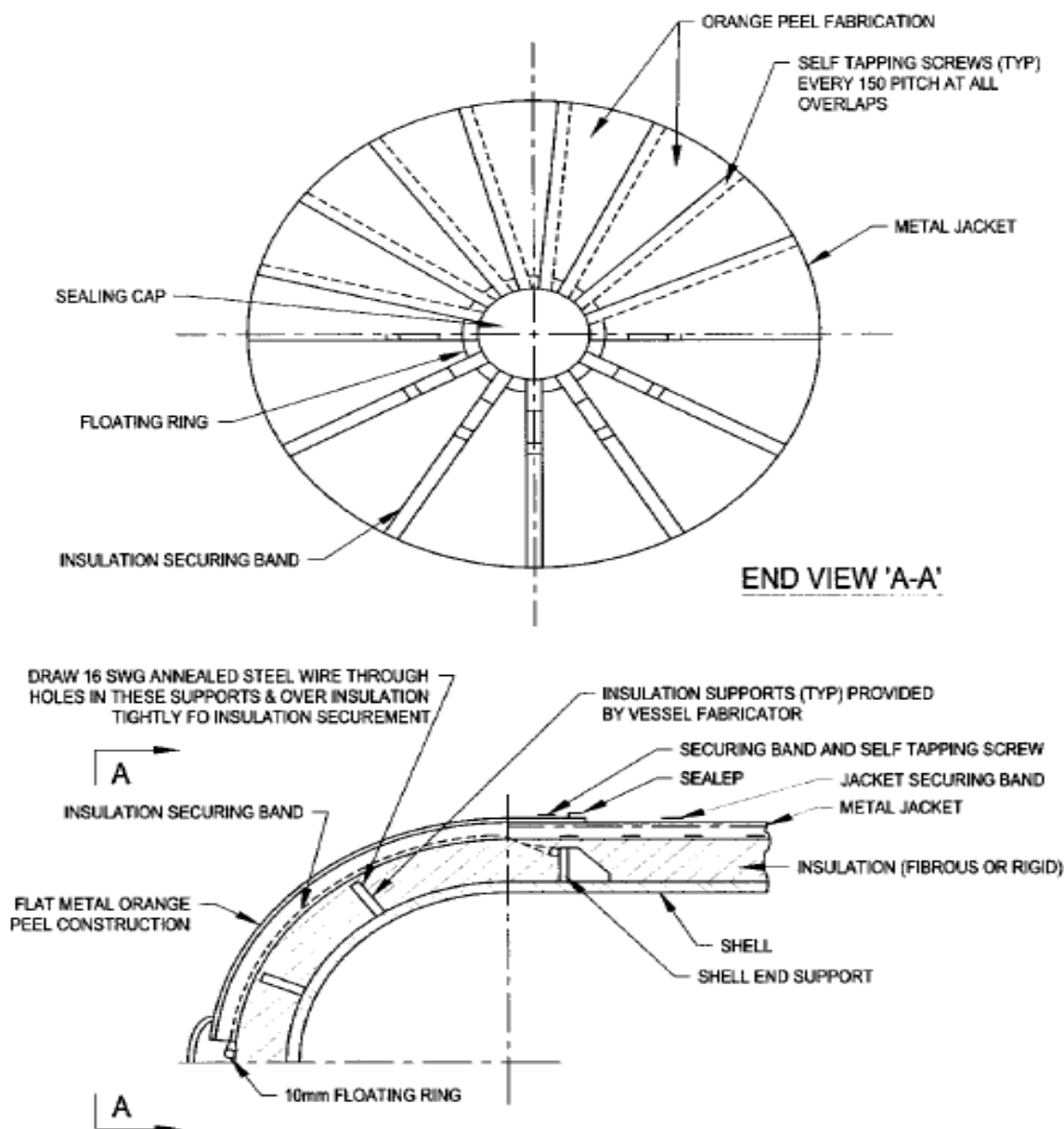
**FIGURE – 12**  
**INSULATION OF STEAM TRACED PIPING**





**NOTES :-**

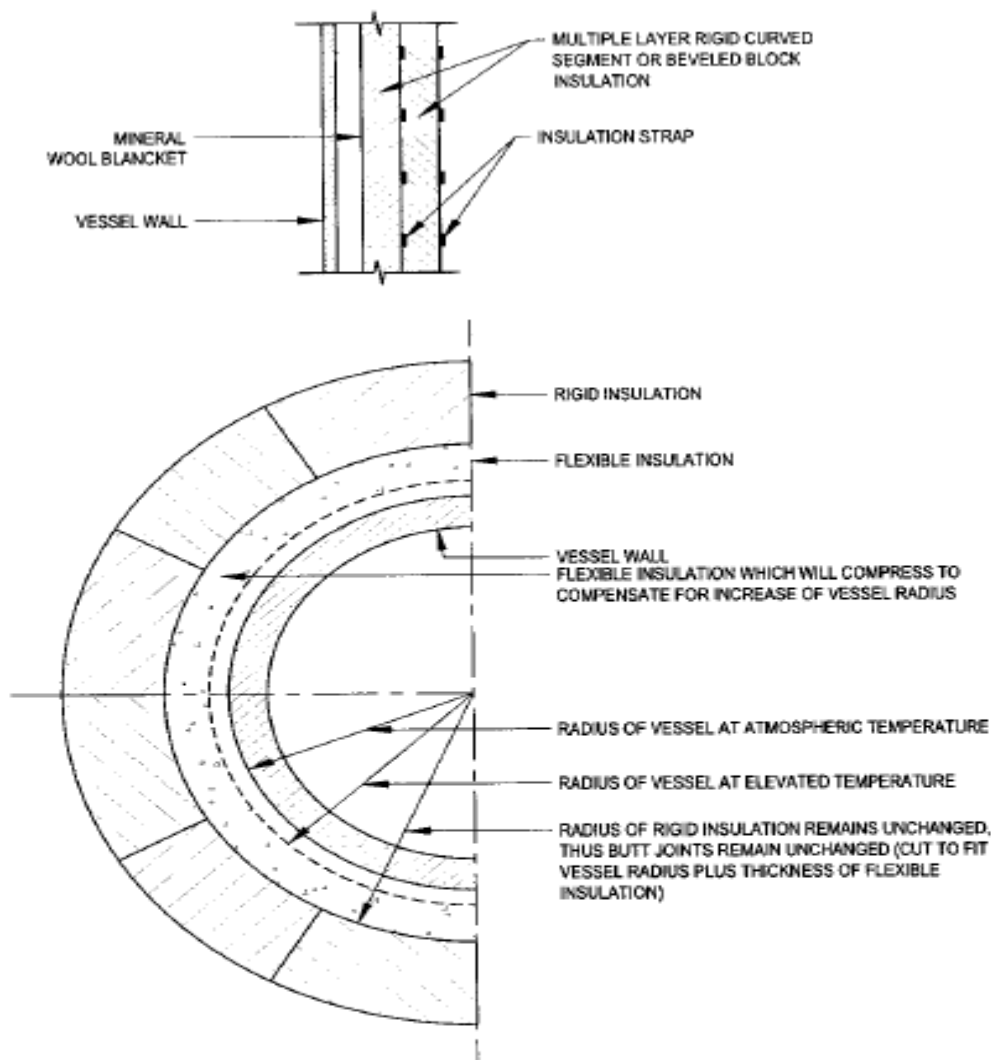
1. SADDLE SUPPORTS FOR HORIZONTAL EQUIPMENT TOGETHER WITH SHOE AND ANCHOR SUPPORTS FOR HORIZONTAL PIPING SHALL BE DESIGNED TO INCLUDE ELONGATED CUT-OUTS IN THE SUPPORT AT SUCH A DISTANCE FROM THE SUPPORTED EQUIPMENT AND PIPING TO ALLOW THE PASSAGE OF INSULATION SECURING BANDS AND TIES AROUND THE OUTSIDE FACE OF THE INSULATING AND FINISHING MATERIAL.
2. APPLY MOISTURE BARRIER FOR CALCIUM SILICATE AND MINERAL WOOL PER CLAUSE 5.1.1 FOR TEMPERATURES UPTO 125°C.

**FIGURE – 13  
HORIZONTAL EQUIPMENT INSULATION**

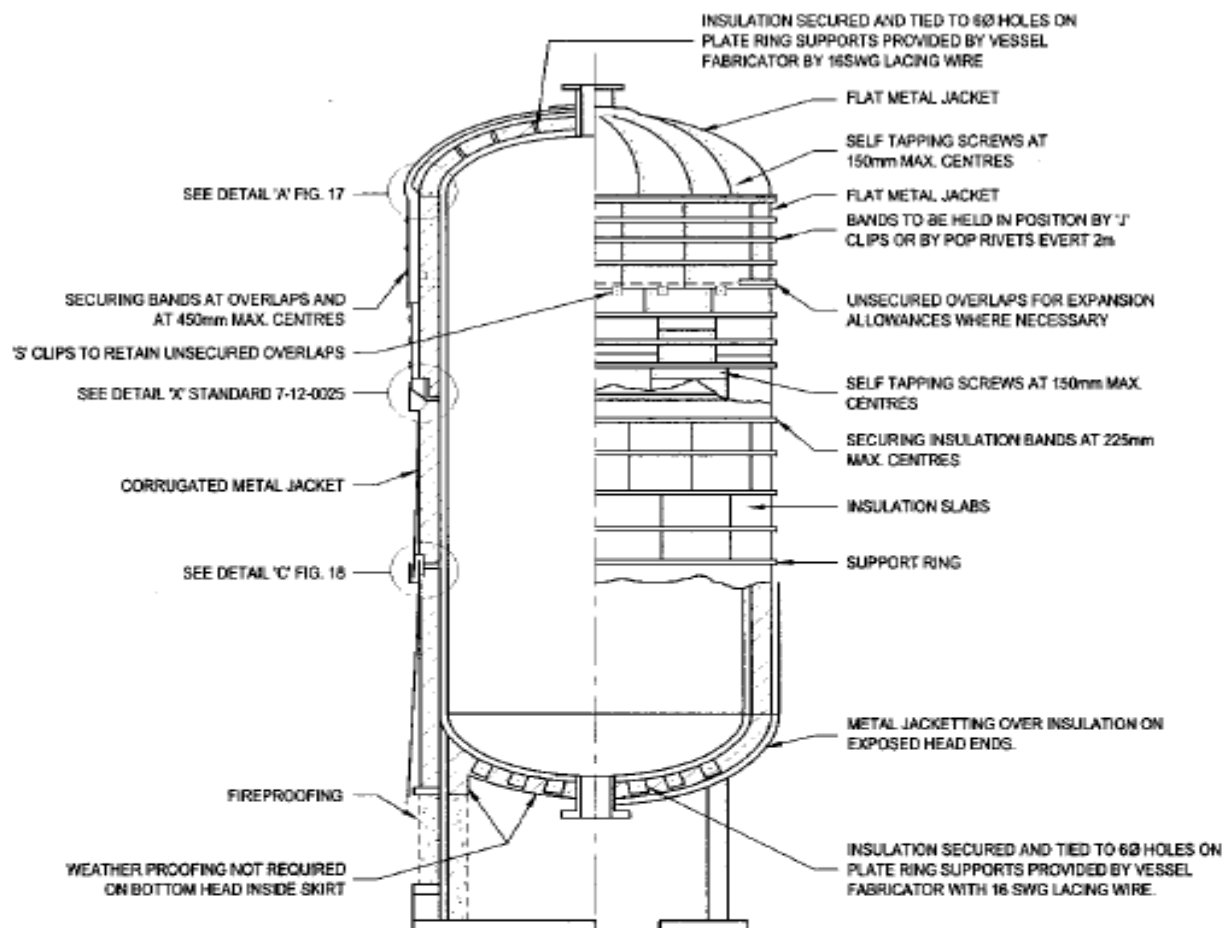


**FIGURE – 14  
HORIZONTAL EQUIPMENT HEADS**

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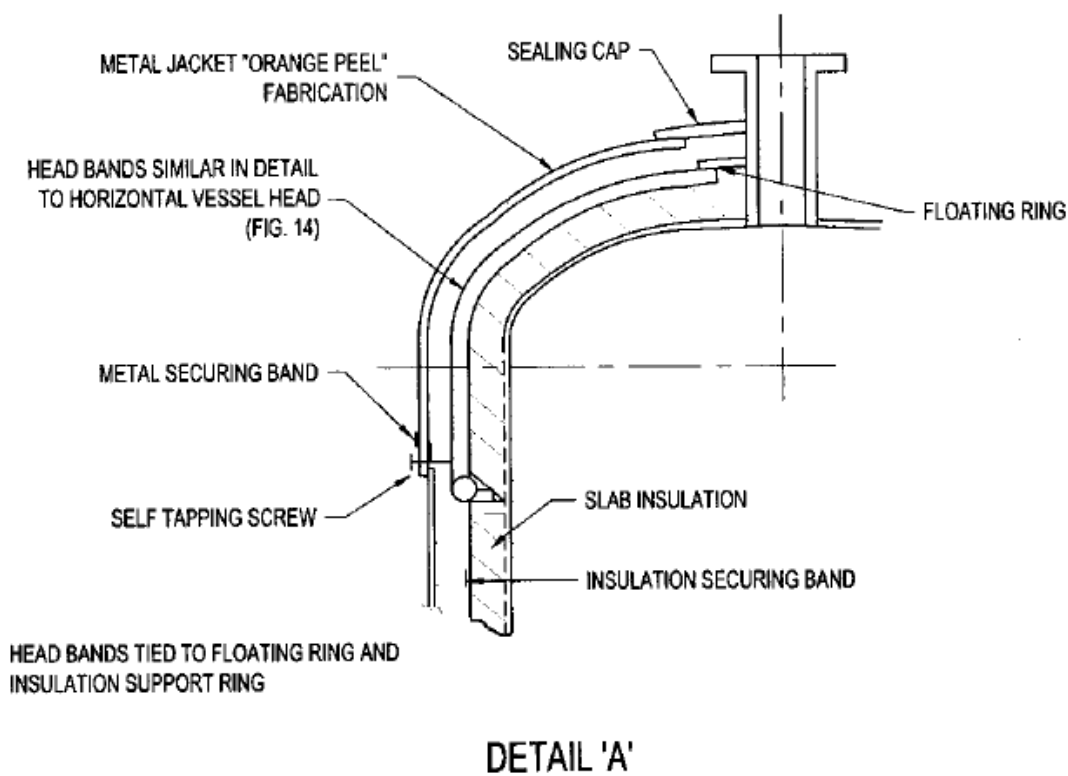


**FIGURE – 15**  
**USE OF FLEXIBLE INSULATION IN COMBINATION WITH RIGID INSULATION TO COMPENSATE FOR VESSEL EXPANSION**

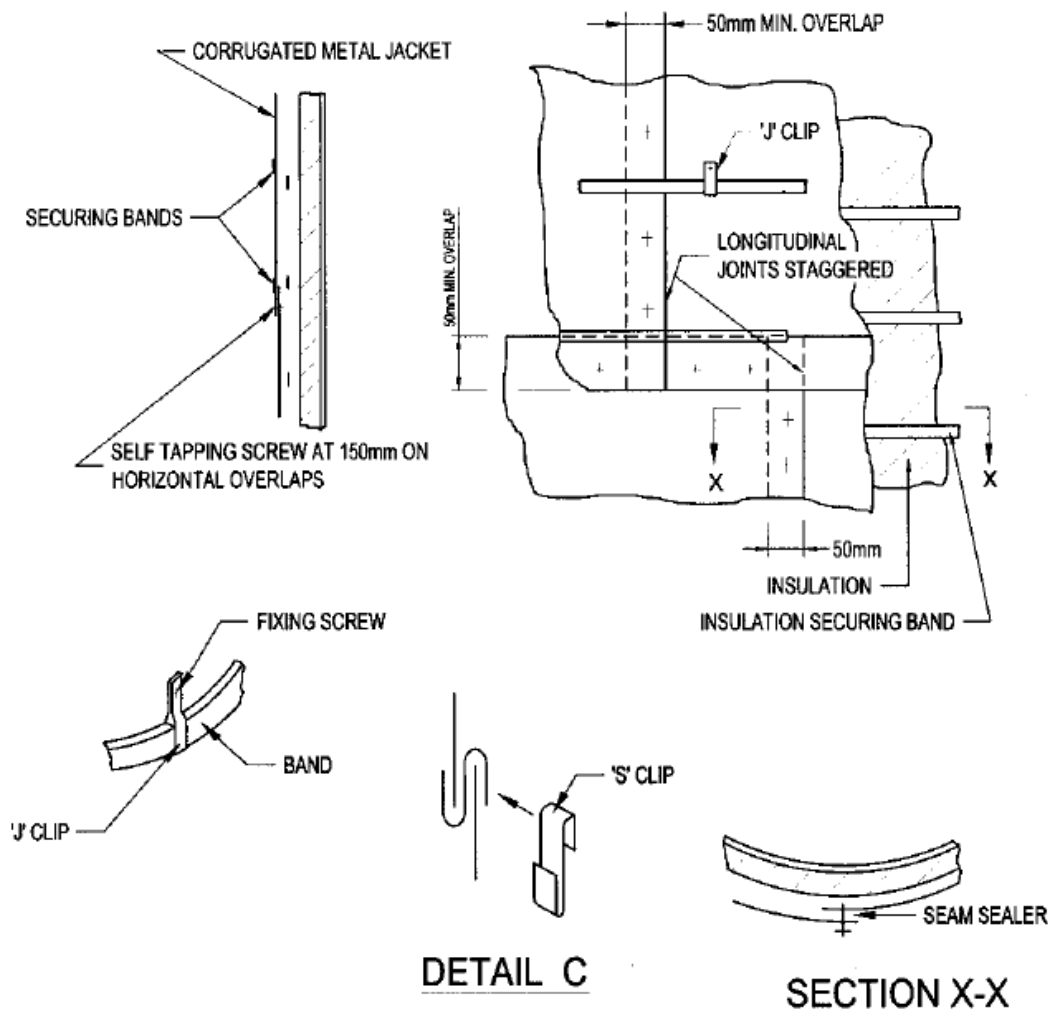


**NOTE:-**  
APPLY MOISTURE BARRIER FOR CALCIUM SILICATE AND MINERAL WOOL PER CLAUSE 5.1.1  
FOR TEMPERATURES UPTO 125°

**FIGURE – 16  
INSULATION DETAILS : VERTICAL VESSEL**



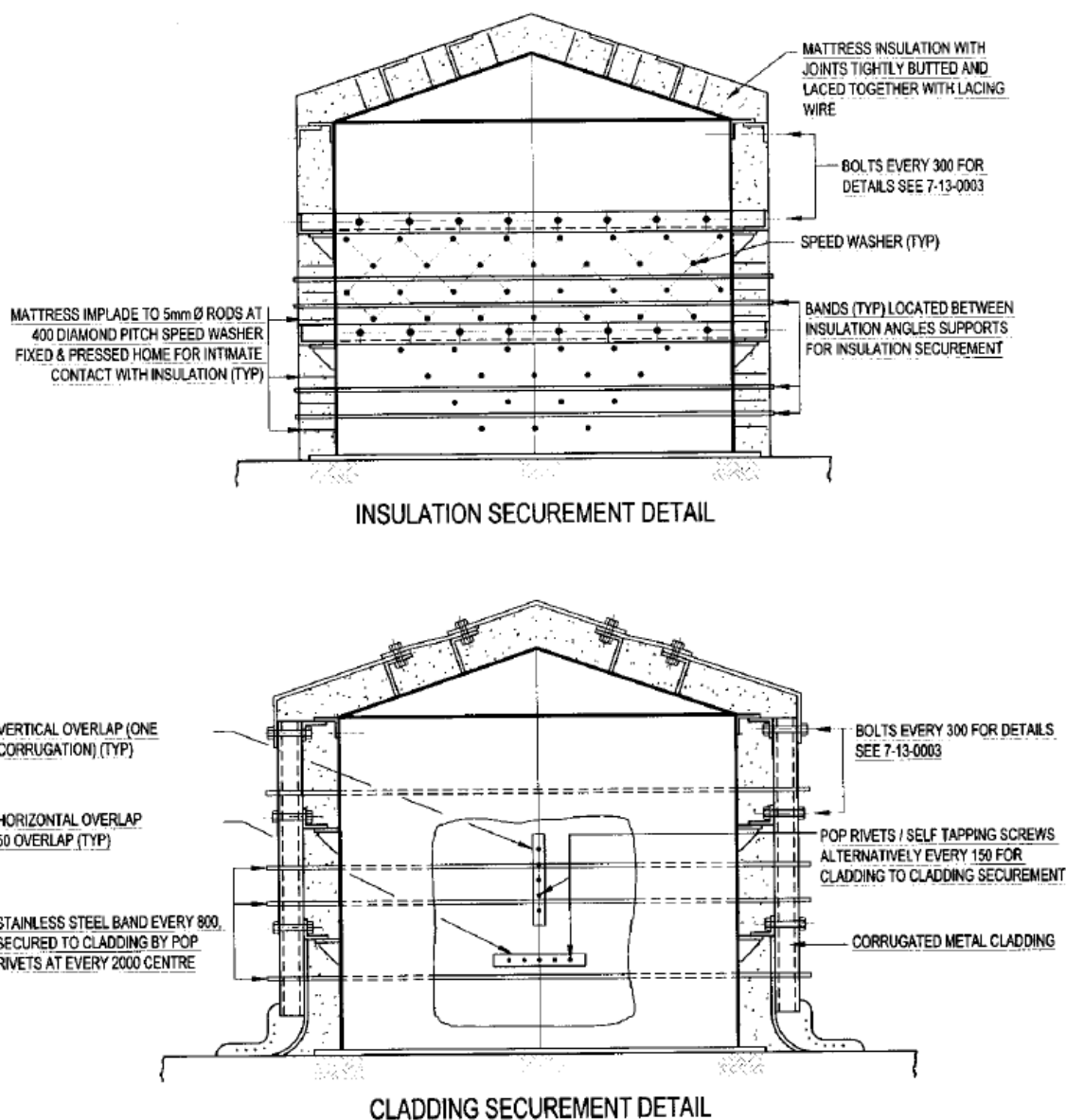
**FIGURE – 17**  
**INSULATION DETAILS VERTICAL VESSEL HEADS**


**NOTE:**

FINISHING SHEETING TO BE BANDED AND SCREWED. HORIZONTAL OVERLAPS LEFT UNSCREWED FOR EXPANSION PURPOSES SHALL BE SECURED AND SUPPORTED WITH 'S' CLIPS.

**FIGURE – 18  
INSULATION DETAILS : VERTICAL VESSELS**





NOTE :- PROVIDE MASTIC MOISTURE BARRIER ON SHELL & ROOF INSULATION, PER CLAUSE 5.1.1 BEFORE APPLYING CLADDING

**FIGURE – 19  
INSULATION DETAILS : VERTICAL STORAGE TANK**

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		CLIENT	INDIAN OIL CORPORATION LIMITED		
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## 11. INSULATION MATERIALS

### 1.Piping and Equipment Heat Conservation (Process Temp up to 550°C).

Insulation material for heat conservation(IH&IT): Mineral wool(ASTM C 612). For insulation thickness table refer to TABLE-01

### 2. Piping and Equipment Personnel Protection (Process Temp up to 550°C)

Insulation material for Personal protection (PP): Mineral wool(ASTM C612) for process temperatures up to 550°C. For insulation thickness table refer to TABLE-02

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	CLIENT	INDIAN OIL CORPORATION LIMITED			
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**TABLE-01**

**INSULATION THICKNESS FOR HEAT CONSERVATION**

NOMINAL PIPE SIZE	NORMAL OPERATING TEMPERATURE (°C) AND THICKNESS (mm)										
	Up to 100	101 to 150	151 to 200	201 to 250	251 to 300	301 to 350	351 to 400	401 to 450	451 to 500	501 to 550	551 to 600
MM	THK	THK	THK	THK	THK	THK	THK	THK	THK	THK	THK
15	25	25	30	40	50	55	65	75	90	100	115
20	25	25	30	40	50	60	70	85	95	110	125
25	25	25	30	50	60	70	80	95	100	115	130
40	25	25	40	50	60	70	85	100	110	125	140
50	25	25	40	50	60	70	90	105	115	130	150
65	25	25	40	50	60	75	95	110	120	140	160
80	25	30	40	50	70	80	95	115	125	150	170
100	25	30	40	60	70	80	100	125	140	160	180
150	25	30	50	60	70	90	105	130	150	170	190
200	25	30	50	60	80	95	110	140	160	180	200
250	25	40	50	60	80	95	115	140	160	190	210
300	25	40	50	70	80	100	120	150	170	190	215
350	25	40	50	70	80	100	120	150	170	200	220
400	25	40	50	70	90	100	125	150	170	200	225
450	25	40	50	70	90	105	125	150	175	200	230
500	25	40	50	70	90	105	130	150	180	205	240
OVER 500 & FLAT	25	40	50	70	100	125	160	190	230	270	320
SINGLE LAYER						MULTI LAYER					


**Design Basis:** Maximum Heat Loss = 150w/m<sup>2</sup>

Ambient Temp.: 31°C

Wind speed: 11.5 m/sec

Emissivity: 0.15

Mineral wool preformed pipe section: 140kg/m<sup>3</sup>.



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#### Multi-Layer Thickness Table:

Multi Layer shall be constructed with layer thickness as follows:

Thickness	1st Layer	2nd Layer	3rd Layer
55	30	25	-
60	30	30	-
65	40	25	-
70	40	30	-
75	50	25	-
80	40	40	-
85	60	25	-
90	60	30	-
95	70	25	-
100	50	50	-
105	80	25	-
110	80	30	-
115	90	25	-
120	90	30	-
125	100	25	-
130	100	30	-
140	100	40	-
150	100	50	-
160	100	30	30
170	100	40	30
175	100	50	25
180	100	50	30
185	100	60	25
190	100	60	30
195	100	70	25
200	100	50	50
205	100	80	25
210	100	80	30
215	100	90	25
220	100	90	30
225	100	100	25
230	100	100	30
240	100	100	40
250	100	100	50
260	100	100	60
270	100	100	70

320 mm thickness shall be constructed with layer thickness: 100 + 100 + 90 + 30 mm.

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**TABLE-02**

**INSULATION THICKNESS FOR PERSONNEL PROTECTION**

NORMAL OPERATING TEMPERATURE (0°C) WITH STILL AIR AT 31°C TO GIVE SURFACE TEMPERATURES NO GREATER THAN 60°C.						
NOMINAL PIPE SIZE	60 to 200	201 to 300	301 to 400	401 to 500	501 to 550	550 and Over
mm	Thk	Thk	Thk	Thk	Thk	Thk
15	Personnel protection shall be by guards.	40	55	80	90	Personnel protection at elevated temperatures shall be subject to calculation and special consideration.
20		40	60	90	105	
25		50	65	95	110	
40		50	75	105	120	
50		50	80	110	130	
65		60	85	120	140	
80		60	90	125	150	
100		60	95	140	160	
150		70	105	150	175	
200		80	115	160	190	
250		80	120	180	200	
300		80	125	180	200	
350		90	130	180	200	
400		90	140	180	200	
450		90	140	180	205	
500	90	140	180	210		
OVER 500 & FLAT	90	140	180	210		
SINGLE LAYER			MULTI LAYER			





**Design Basis:** Maximum Cladding temperature = 60°C  
Ambient Temp.: 31°C  
Wind speed: 0 m/sec  
Emissivity: 0.15  
Mineral wool preformed pipe section: 140kg/m<sup>3</sup>

Multi Layer shall be constructed with layer thickness in accordance with the heat conservation layer thickness as provided above.

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## SPECIFICATION FOR PAINTING

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## 1. INTRODUCTION

**INDIAN OIL CORPORATION LIMITED (IOCL)** has awarded Fax of Acceptance (FOA) dated 29<sup>th</sup> August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

## 2. DEFINITIONS & ABBREVIATIONS

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related

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SRU	Sulphur Recovery Unit
OISD	Oil Industry Safety Directorate
ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
P&ID	Piping and Instrumentation Diagram
A/G	Above Ground
U/G	Under Ground
B/L	Battery Limit
ISBL	Inside Battery Limit
EOT	Electrically-operated Overhead Travelling
MTO	Material Take Off

### 3. **SCOPE**

This specification defines the requirements of surface preparation, selection and application of paints and primers for all piping, equipment and structures etc.

The specification is applicable for supply of all paints, coatings, primers and other ancillary items etc. Method of surface preparation, supply and application of paints and primers shall suit given environment, location and temperature. Items requiring painting, field application procedures, inspection and testing of painting shall be governed by this specification.

This specification is suitable for use in normal, corrosive and marine environment of various process, utility and other plants and offsite of refineries, petro-chemicals, onshore terminals and other chemical / industrial plants. Alternative paints / coatings would be specified if necessary for specific or more stringent requirements.

The painting specification covers every type of equipment such as tanks, vessels, drums, heat exchangers/ coolers, air fin coolers, pumps, turbines, compressors, filters, engines, motors, boilers or heaters /furnaces their accessories, fans, stacks / chimney and package units etc.

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The painting specification covers all types of process and utility piping services which can be non-insulated / insulated, jacketed or lined requiring painting. All types of pipe supports, hangers, spring boxes are also covered.

All types of structural steel members, platforms ladders, chequered plates, gratings, walkways, trolleys, monorails, davits, structural steel sheds and buildings are also covered under this painting specification.

The painting of equipment shall conform to equipment data sheets. Painting of piping shall conform to line schedule and piping isometrics etc.

#### 4. **TERMINOLOGY**

MR	Material Requisition
PR	Purchase Requisition
PO	Purchase Order
CS	Carbon steel
LTCS	Low Temp. Carbon Steel
AS	Alloy Steel
SS	Stainless steel
MS	Mild Steel
GI.	Galvanized Iron / steel
ITP	Inspection Test Plan
TPI	Third Party Inspection
DFT	Dry Film Thickness
WFT	Wet Film Thickness
TSAC	Thermally Sprayed Aluminium Coating
Micr.	Micron

#### 5. **EXCLUSIONS**

The following surfaces and materials shall not require painting in general. However, if there is any specific requirement by the owner, the same shall be painted as per the relevant specifications:

- Plastics and or plastic coated surfaces
- Non-ferrous materials like Aluminum, Cu-Ni alloy, Monel, Incoloy
- RCC or cement lined surfaces except those specified
- Gaskets / seals

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- Gauge Glasses
- Meter Faces
- Valve Stem and Threads
- Name Plates
- Insulation or Fireproofing
- Factory Finished Control Panels
- Factory Finished Instrument Cases and Meters

## 6. REFERENCE CODES & STANDARDS

The following codes shall be applicable, however purchaser may specify any other relevant code for any purpose at any time. The codes latest edition as on date of issue of material requisition shall be applicable.

Code /Std. No	Description
IS: 5	Colours for ready mixed paints and enamels
IS: 101	Methods of test for ready mixed paints and enamels
IS: 2379	Indian Standard for Pipe line identification-colour code
ISO 209	Aluminium and aluminium alloys Chemical composition
ISO 8501-01	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness
ISO 8502-3 & 9	Preparation of steel substrates before application of paints and related products - Test for assessment of surface cleanliness : Field method for conductometric determination of water soluble salts
ISO12944	Corrosion Protection of steel Structures by Protective Paint System
ASTM E3	Metallographic Examinations
ASTM VOL 6.01 & 6.03	American standard test methods for Paints and Coatings.
ASTM B833	Standard Specification for Zinc and Zinc Alloy Wire for Thermal Spraying (Metallizing) for the Corrosion Protection of Steel , corrosion protection
ASTM C633	Test Method for Adhesive / Cohesive Strength of Flame Sprayed Coatings.

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ASTM D4285	Method for indicating Oil or Water in Compressed Air.
ASTM D4417	Test Method for Field Measurement of Surface Profile of Blasted Steel.
ASTM D4541	Test method for Pull-Off Strength of Coating using Portable Adhesion Testers.
ASTM D4940	Standard Test Method for Conductimetric Analysis of Water Soluble Ionic Contamination of Blasting Abrasives.
ASTM D6677	Standard Test Method for Evaluating Adhesion by Knife1
ANSI A13.1	Scheme for identification of piping systems: American National Standards Institution
ANSI/AWS C2.18	Guide for the Protection of Steel with Thermal Spray Coatings of Aluminium, Zinc and Their Alloys and Composites.
AWS C.2.17	Recommended Practice for Electric Arc Spray.
SSPC-SP	Steel Structures Painting Council
SSPC Publication	The inspection of coatings and linings: A Handbook of Basic practice for Inspectors, Owners, and Specifiers.
SSPC-AB 1	Mineral and Slag Abrasives.
SSPC-AB 3	Ferrous Metallic Abrasives.
SSPC-PA 1	Shop, Field, and Maintenance Painting of Steel.
SSPC-PA 2	Measurement of Dry Coating Thickness with Magnetic Gages.
NACE No. 1 / SSPC-SP 5	White Metal Blast Cleaning.
NACE No. 2 / SSPC-SP 10	Near -White Metal Blast Cleaning.
SSPC-VIS 1	Guide and Reference Photographs for Steel Surfaces Prepared by Dry Abrasive Blast Cleaning.
RAL DUTCH	International Standard for color shade (Dutch Standard)
SIS-05 59 00	Pictorial surface preparation standard for painting of steel surfaces
BS1475	Specification for Wrought Aluminium & Aluminium Alloys for General Engineering Purposes.
BS 2569	Specification for Sprayed Metal Coating.
BS 4232	British Standards (Surface Finish of Blast-cleaned Steel for Painting
NACE Std. RP 0287	Field Measurement of Surface Profile of Abrasive Blast Cleaned Steel Surfaces Using a Replica Tape.



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NACE No.12 / AWS C2.23 M / SSPC-CS 23.00	Specification for the application of thermal spray coatings (Metallizing) of aluminium, zinc, and their alloys and composites for the corrosion protection of steel.
NACE RP 198	The control of corrosion under Thermal Insulation and Fireproofing Materials

ISO 8501-1/ SIS-05 59 00: ISO standard for preparation of steel substrates before application of paints and related products. This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer in charge.

The Contractor shall arrange, at his own cost, to keep a set of latest edition of above standards and codes at site.

The Contractor shall perform the work in accordance with the following reference documents issued to him for execution of painting works.

- Bill of quantities for piping, equipment, machinery and structures etc
- Piping Line List
- Specifications for Painting
- Any Specific requirements from client

## **7. GENERAL REQUIREMENTS**

- This specification shall govern all works covered by the contract, and without prejudice to the provisions of various Indian and international codes of practice, standard specifications etc. The Contractor shall carry out the works in all respects with the best quality of materials and workmanship and in accordance with the best engineering practices and instructions of Owner / Engineer in charge.
- All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipment, scaffolding materials, shot / sand blasting equipment and air compressors etc. required to be used shall be suitable for the work and all in good order and shall be arranged by the Contractor at site and in sufficient quantity.
- The compressed air supply used for blasting shall be free of water and oil. Adequate separators and traps shall be provided and these shall be drained continuously. Pressure Gauges fitted to compressor shall be calibrated with necessary certificate.
- Blast cleaning equipment shall be in accordance with all applicable regulations. The spraying equipment to be used shall meet the recommendations and instructions set forth by the paint supplier for each specific paint or coating system.
- All mechanical equipment shall be earthed and all necessary precautions shall be taken to prevent the build-up of static electricity. Especially blasting equipment, its operators and the equipment being blasted shall be properly earthed to prevent the occurrence of electro-

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static discharges

- Mechanical mixing shall be used for paint mixing operations in case of two pack systems except that the Engineer in charge may allow the hand mixing of small quantities at his discretion.
- All painting materials and ancillary materials needed for completion of the contract shall conform to the prescribed specifications. Contractor shall procure these materials from specified manufacturers or their stockiest with proper marking and identification as proof of original materials.
- Any sub-standard or duplicate materials or lower grade/ brand materials shall not be used. Owner / Engineer in charge shall have the right to reject all such materials at any stage. Contractor shall seek prior approval from Owner before actual application to avoid rejection of works carried out with such sub-standard materials.
- The Contractor shall bring to the notice of Owner any discrepancy between this specification and codes specified herein. Contractor may request Owner for clarification of any of the applicable clause of this specification or about applicability of a particular painting system for any service / surface. Any deviation from this specification pertaining to supply or application without written permission of Owner shall be rejected by Engineer in charge.
- The items listed in the paint systems is indicative only, however Engineer in charge may decide about the applicability of the paint system for any of the works.
- The Contractor shall ensure all safety and protective apparatus are fully provided to their staffs.
- The contractor shall be fully responsible for carrying out all the necessary painting, coating and lining on external and internal surfaces as per the tender requirement.
- The paint manufacturer's instructions shall be followed as far as practicable at all times for best results. Particular attention shall be paid to the following:
  - Instructions for storage to avoid exposure as well as extremes of temperature.
  - Surface preparation prior to painting shall be followed as per the specification.
  - Mixing and thinning.
- Paint manufacturers shall furnish the characteristics of all paints materials on original printed literature, along with the test certificate for all specified characteristics given in this specification. All the paint materials shall be of first quality and conform to the general characteristics described in various tables.
- Contractor shall fully comply with the client specification for Colour Coding of Piping, Equipment and Structures issued during EPC stage of the project. This specification covers colour codes, identification marking on piping and equipment, recommended colours for paint systems and painting for "Civil Defence" requirements etc.
- Contractor shall ensure that the paint material supplied are fully within the validity period of the product and not exposed to open atmosphere.

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## 8. EXTENT OF PAINTING

The following surfaces and materials shall require shop, pre-erection and field painting:

- All Non-insulated carbon steel and alloy steel piping as described under scope Including valves, flanges, fittings, specialty items, in line items, and all supports (including painting of identification marks), flare lines ,furnace ducts and stacks.
- Titanium catalyzed inorganic copolymer can be used commonly for all valves.
- All insulated parts of vessels, boilers, chimneys, stacks, piping and steam piping, and any other insulated items present.
- All items contained in a package unit requiring painting.
- All types of structural steel members, platforms ladders, chequered plates, gratings, walkways, trolleys, monorails, davits, structural steel sheds and buildings are also covered under this painting specification.
- External surfaces of MS chimney with or without refractory lining and internal surfaces of MS chimney without refractory lining. (If present)
- Representation of colour bands on all piping including insulated aluminum clad, galvanized, SS and nonferrous piping.
- Identification lettering / numbering on all painted surfaces of equipment / piping insulated aluminum clad, galvanized SS and non-ferrous piping.
- Marking / identification signs on painted surfaces of equipment / piping including hazardous service.
- Supply of all primers, paints and all other materials required for painting (other than Owner supplied materials)
- Metal Area over which insulation surface of equipment and pipes wherever required.
- Painting under insulation for carbon steel, alloy steel and stainless steel as per relevant NACE RP 198 to prevent corrosion.
- Painting of pre-erection / fabrication and Shop primer.
- Repair work of damaged pre-erection / fabrication and shop primer and weld joints in the field / site before and after erection as required.

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- All CS Piping, equipment, storage tanks and internal surfaces of RCC tanks in ETP plant.
- Quality control, testing and inspection during all stages of work (surface preparation, application of coating and testing of furnished coating).

## 9. **SURFACE PREPARATION**

Any one of following methods of surface preparation shall be followed, depending on condition of surface to be painted and as approved or instructed by Engineer in charge.

- Manual or hand tool cleaning
- Mechanical or power tool cleaning
- Dry abrasive blast cleaning

Before blasting salt contamination test to be carried out for metals & Testing for chloride and soluble salt concentrations and the pH level shall be done using a Bresle Sampler according to ISO 8502-6. The chloride and soluble salt concentrations shall be less than 20 mg/ m<sup>2</sup> and the pH shall be neutral (between 6 and 8). When these levels are exceeded, the surfaces shall be either steam cleaned or high pressure water washed as per SSPC SP1 or ISO 12944 before abrasive blasting. The cleaned surface shall be retested to verify that the contaminant levels are within the acceptable range. Checks shall be done on each component at least once per 200 m<sup>2</sup> of blasted surface and a minimum of 3 checks per shift. The test report shall be maintained recording the ambient and substrate temperature, relative humidity, abrasive medium, test obtained valves etc., Measuring device shall be regularly calibrated.

### 9.1 **Surface Finish Requirements:**

- When surface is exposed to normal atmospheric conditions and where other methods cannot be adopted. May also be used for spot cleaning during maintenance.
  - Solvent Cleaning to SSPC - SP1. Remove oil, grease or wax with a suitable solvent/degreaser (Non-Chloride solvent to be used on SS substrate)
  - Manual or hand tool cleaning to: SSPC-SP-2 or ST.2 Level

Remove loose rust / mill scale / loose paint thoroughly by chipping, scrapping, sanding and or wire brushing. Finished surface shall have a faint metallic

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sheen.

- Mechanical or power tool cleaning to SSPC-SP-3 or ST.3 Level

Remove loose rust / mill scale / loose paint to degree specified by power tool chipping, de-scaling, sanding, wire brushing and grinding, after removal of dust, surface should have a pronounced metallic sheen.

Care to be taken where the welding / riveting portion of the joints.

- **Dry abrasive Blast cleaning:**

There are four different methods of dry abrasive blast cleaning as described below. Each method shall be selected depending on surface finish required for particular paint system. However Engineer in charge may instruct about any of the system to be followed for a particular job / item as deem necessary.

- White metal to SSPC-SP-5 or SA.3 or NACE #1 Level

Remove all visible rust / Mill scale / paint and foreign matter 100% to achieve desired surface profile with blast cleaning to white metal cleanliness in order to achieve extremely clean surface for prolonged life of paint system.

- Near white metal to SSPC-SP-10 or SA.2 ½ or NACE # 2 Level



Blast clean to near white metal cleanliness until at least 95% of each element of surface area is free of all visible residues with desired surface profile in order to have minimum acceptable clean surface. This is the minimum requirement for chemically resistant paint systems such as epoxy, vinyl, polyurethane based and inorganic zinc silicate paints, also for conventional paint systems used under fairly corrosive conditions to obtain desired life of paint system.

- Commercial Blast to SSPC-SP-7 or SA.2 or NACE # 3 Level

Blast clean until at least two-third of each element of surface area is free of all visible residues with desired surface profile. Used for steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint systems.

- Brush-off Blast to SSPC-SP-7 or SA.1 or NACE # 4 Level

Blast cleaning to white metal cleanliness, removal of all visible rust, mill scale, paint and foreign matter where surface profile is not so important

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## 9.2 Equipment surface Preparation:

- All tools, brushes, rollers, spray guns, blast material, hand power tools for cleaning and all equipment, scaffolding materials, shot & grit blasting equipment and air compressors etc. required to be used shall be suitable for the work and all in good order and shall be arranged by the Contractor at site and in sufficient quantity. The manufacturer's test certificates & data sheets for all the above items shall be reviewed by Engineer in charge at site before start of work.
- Mechanical mixer shall be used for paint mixing operations in case of two pack systems except that the Engineer in charge may allow the hand mixing of small quantities at his discretion in case of specific requirement for touch up work only.
- Mill scale, rust, rust scale and foreign matter shall be removed fully to ensure that a clean and dry surface is obtained. The minimum acceptable standard, in case of thermally sprayed metal coatings, in case of mechanical or power tool cleaning it shall be St. 3 or equivalent. In case of blast cleaning it shall be Sa 2-1/2 as per Swedish Standard SIS-055900 or SSPC-SP or ISO 8501-01. Blast cleaning shall be Sa 3 as per Swedish Standard in case thermally sprayed metal coatings.
- Before surface preparation by blast cleaning, the surface shall be degreased by aromatic solvent to remove all grease, oil etc.

## 9.3 Use of Dehumidifiers:

- Blast cleaning shall not be performed for internal or external surface, where dust can contaminate surfaces undergoing such cleaning or during humid weather conditions having humidity exceed 85%. In case of internal coating of storage tanks, dehumidifier shall be used, to control humidity level below 60%. Dehumidifier should depress the dew point of air in the enclosed space, enough to maintain it 3°C below the metal substrate temperature during entire period of blasting and coating application. During the interval time between application of primer coat and subsequent intermediate and top coats or between blast cleaning completion and start of application of primer coat,



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dehumidifier unit should be in continuous operation to ensure that no condensation occurs on substrate.

- Dehumidifier should be able to maintain grain drop (moisture removal) at the rate of 25 grains per pound of air per hour. Dehumidifier should have capacity of at least 2 air changes per hour of the enclosed space. All necessary psychometric data should be collected by contractor for the given site conditions before starting operation of dehumidifier to ensure that desired values of dew point, moisture content in enclosed scope is achieved.
- Dehumidification shall be maintained round the clock for surface preparation and painting till the total coating application is over.
- Dehumidifier shall not be stopped under any condition till the entire blasted surface is primed to the satisfaction of the technical representative of the paint manufacturer interested with quality assurance for the work. In case the dehumidifier breaks down in middle of the job, the same shall be replaced at the risk and the cost of the contractor and the entire unfinished work shall be repeated.
- The Engineer in charge shall have the right to disallow usage of dehumidifier if the performance is not meeting the specified requirements. Under such circumstances the contractor shall remove the equipment and replace the same with another equipment to provide satisfactory results without any additional cost to the owner.
- Irrespective of the method of surface preparation, the first coat of primer must be applied by airless spray / air assisted conventional spray if recommended by the paint manufacturer on dry surface. This should be done immediately and in any case within 4 hours of cleaning of surface. However, at times of unfavourable weather conditions, the Engineer in charge shall have the liberty to control the time period, at his sole discretion and/or to insist on recleaning, as may be required, before primer application is taken up. In general, during unfavourable weather conditions, blasting and painting shall be avoided as far as practicable.
- The external surface of R.C.C. chimney stack to be painted shall be dry and clean. Any loose particle of sand, cement, aggregate etc. shall be removed by scrubbing with soft wire brush. Acid etching with 10-15% HCL solution for about 15 minutes shall be carried and surface must be thoroughly washed with water to remove acid & loose particles and then dried completely before application of paint.

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#### 9.4 Air Blast Cleaning with abrasives:

- The surfaces shall be blast cleaned using one of the abrasives like angular chilled cast iron or steel grit, copper slag or Nickel slag,  $Al_2O_3$  particles at pressure of 7 kg/cm<sup>2</sup> at an appropriate distance and angle depending of nozzle size maintaining constant velocity and pressure.
- Chilled cast iron or steel shall be in the form of shot or grit of size in the range of G 16 - G42 conforming to SSPC AB1 and S250 grade size of steel shots (maximum) to obtain a desired surface profile of 35-50 microns trough to peak. For all other abrasives, size shall be in the range of G16 -G24. The combination of steel grits and shots shall be normally in the ratio of 3 : 1 . The quality of abrasives shall be free from contaminants and impurities and shall meet the requirements of SSPC AB1.
- Compressed air shall be free from moisture and oil. The blasting nozzles should be venturi style with tungsten carbide or boron carbide as the materials for liners. Nozzles orifice may vary from 3/16" to 3/4". On completion of blasting operation, the blasted surface shall be clean and free from any scale or rust and must show a grey white metallic luster. Primer / first coat of paint shall be applied within 4 hours of surface preparation. Blast cleaning shall not be done outdoors in bad weather without adequate protection or when there is dew on the metal, which is to be cleaned. Surface profile shall be uniform to provide good key to the paint adhesion (i.e. 35 to 50 microns). If possible vacuum collector shall be installed for collecting the abrasives and recycling.

#### 9.5 Mechanical or Power Tool Cleaning:

Power tool cleaning shall be done by mechanical striking tools, chipping hammers, grinding wheels or rotating steel wire- brushes. Excessive burnish of surface shall be avoided as it can reduce paint adhesion. On completion of cleaning, the detached rust mill scale etc. shall be removed by clean rags and /or washed by water or steam and thoroughly dried with compressed air jet before application of paint.

#### 9.6 Non-Compatible Shop Coat Primer:

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- For equipment on which application of total protective coating (Primer+ Intermediate + top coat) is carried out at shop, compatibility of finish coat with primer should be checked with paint manufacturer. Specific duration mentioned in the manufacturer specification shall be fully If the shop coat is in satisfactory condition showing no major defect upon arrival at site, the shop coat shall not be removed.
- Shop coated equipment (coated with Primer & finishing coat) should not be repainted unless paint is damaged. Repair shall be carried out as per **Table 10.2** of paint systems depending upon compatibility of paint.
- Shop primed equipment and surfaces will only be 'spot cleaned' in damaged areas by means of power tool brush cleaning or hand tool cleaning and then spot primed before applying one coat of field primer unless otherwise specified. If shop primer is not compatible with field primer then shop coated primer should be completely removed before application of selected paint system for particular environment.
- For Package units/equipment, shop primer should be as per the paint system given in this specification. However, manufacturer's standard can be followed after review.
- Coating application at field (field primer, intermediate and top coat) on equipment, structures, piping, etc. shall be carried out only after its erection and all welding, testing, steam purging (wherever carried out) have been completed.

## 10. **COATING PROCEDURE & APPLICATION**

- All paint coatings shall be applied by airless spray excepting at the following special cases where application can be carried out by brush subject to suitability of the application of the paint product by brush.
  - Spot repair
  - Stripe coating on edges
  - Small bore parts not suitable for spray application
- Irregular surfaces such as sharp edges, welds, small brackets, and interstices may stripe coated to ensure specified DFT is achieved. Paint manufacture's recommendation should be followed before deciding for brush application.

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- Surface shall not be coated in rain, wind or in environment where injurious airborne elements exists, when the steel surface temperature is less than 5°F above dew point when the relative humidity is greater than 85% or when the temperature is below 40°F and when the ambient/substrate temp is below the paint manufacturer's recommended temperature of application and curing. De-humidifier equipment shall be used to control RH and Dew point. The paint application shall not be done when the wind speed exceeds 20 km per hour.
- Blast cleaned surface shall be coated with one complete application of primer as soon as practicable but in no case later than 4 hours the same day.
- To the maximum extent practicable, each coat of material shall be applied as a continuous film uniform thickness free of probes. Any spots or areas missed in application shall be recoated and permitted to dry before the next coat is applied. Applied paint should have the desired wet film thickness.
- Each coat shall be in proper state of cure or dryness before the application of succeeding coat. Material shall be considered dry for recoating when an additional coat can be applied without the development of any detrimental film irregularities, such as lifting or loss of adhesion of the under coat. Manufacturer instruction shall be followed for inter-coat interval.
- When the successive coat of the same colour have been specified, alternate coat shall be tinted, when practical, sufficiently to produce enough contrast to indicate complete coverage of the surface. The tinting material shall be compatible with the material and not detrimental to its service life and shall be recommended by the original paint manufacturer.
- Airless spray application shall be in accordance with the following procedure: as per steel structure paint Manual Vo. 1 & Vol. 2 by SSPC, USA, Air less spray relies on hydraulic pressure rather than air atomization to produce the desired spray. An air compressor or electric motor is used to operate a pump to produce pressures of 1000 to 6000 psi. Paint is delivered to the spray gun at this pressure through a single hose within the gun, a single paint stream is divided into separate streams, which are forced through a small orifice resulting in atomization of paint without the use of air. This results in more rapid coverage with less over spray.

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- Airless spray equipment is mounted on wheels, and paint is aspirated in a hose that sucks paint from any container, including drums. The unit shall have in built agitator that keep the paint uniformly mixed during the spraying. The unit shall consist of in built strainer. Usually very small quantity of thinning is required before spray. In case of high build epoxy coating (two pack). 30:1 pump ratio and 0.020-0.023" tip size will provide a good spray pattern. Ideally fluid hoses should not be less than 3/8" ID and not longer than 50 ft to obtain optimum results. In case of gun choking, de-choking steps shall be followed immediately.
- Brush application of paint shall be in accordance with the following:
  - Brushes shall be of a style and quality that will enable proper application of paint.
  - Round or oval brushes are most suitable for rivets, bolts, irregular surface, and rough or pitted steel. Wide flat brushes are suitable for large flat areas, but they shall not have width over five inches.
  - Paint shall be applied into all corners.
  - Any runs or sags shall be brushed out.
  - There shall be a minimum of brush marks left in the applied paint
  - Surfaces not accessible to brushes shall be painted by spray, doublers, or sheepkin.
- For each coat the painter should know the WFT corresponding to the specified DFT and standardize the paint application technique to achieve the desired WFT. This has to be ensured in the qualification trial.
- No coat shall be applied until the preceding coat has dried. The material shall be considered dry for re-coating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Drying time of the applied coat should not exceed maximum specified for it as a first coat; if it exceeds the paint material has possibly deteriorated or maxing is faulty.
- No paint shall be force dried under conditions which will cause chalking, wrinkling, blistering formation of pores, or detrimentally affect the conditions of the paint.
- No drier shall be added to paint on the job unless specifically called for in the manufacturer's specification for the paint.

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- Paint shall be protected from rain, condensation, contamination, snow and freezing until dry to the fullest extent practicable.

## 11. **SURFACE PREPARATION METHOD**

The table below describes the methods for surface preparation and the standards used for cleanliness and surface preparation for painting /coating works.

### **SURFACE PREPARATION**

Sr. No.	Description	International Standards (Equivalent)			Remarks
		ISO 8501-1 / SIS-05 59 00	SSPC-SP, USA	NACE, USA	
1.	<b>- Solvent Cleaning</b> Remove oil, grease or wax with a suitable solvent/degreaser (Non-Chloride solvent to be used on SS substrate)	ST-1	SSPC - SP1		
2.	<b>Manual or hand tool cleaning:</b> Removal of loose rust, loose mill scale and loose paint, chipping, scrapping, standing and wire brushing. Surface shall have a faint metallic sheen.	ST.2	SSPC-SP-2	-	This method is applied when the surface is exposed to normal atmospheric conditions when other methods cannot be adopted and also for spot cleaning during maintenance painting.
3.	<b>Mechanical or power tool cleaning:</b> Removal of loose rust loose mill scale and loose paint to by power tool chipping, de-scaling, sanding, wire brushing and grinding, after removal of dust, surface shall have a pronounced	ST.3	SSPC-SP-3	-	



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	metallic sheen.				
<b>4</b>	<b>Dry abrasive Blast cleaning:</b>  There are four common grades of blast cleaning White metal				
<b>4.1</b>	<b>Blast cleaning to white metal cleanliness:</b> Removal of all visible rust. Mill scale, paint & foreign matter 100% cleanliness with desired surface profile	SA 3	SSPC-SP-5	NACE #1	Where extremely clean surface can be expected for prolong life of paint system.
<b>4.2</b>	<b>Near white metal:</b>  Blast cleaning to near white metal cleanliness, until at least 95% of each element of surface area is free of all visible residues with desired surface profile.	SA 2 ½	SSPC-SP-10	NACE #2	For chemically resistant paint systems such as epoxy, vinyl, polyurethane based and inorganic zinc silicate paints, and for paint systems used under fairly corrosive conditions to obtain desired life of paint system.
<b>4.3</b>	<b>Commercial Blast:</b>  Blast cleaning until at least two-third of each element of surface area is free of all visible residues with desired surface profile.	SA 2	SSPC-SP-6	NO. 3	For steel required to be painted with conventional paints for exposure to mildly corrosive atmosphere for longer life of the paint systems.
<b>4.4</b>	<b>Brush-off Blast:</b>  Blast cleaning to white metal cleanliness, removal of all visible rust, mill scale, and paint foreign matter. Surface profile is not so important	SA 1	SSPC-SP-7	NO. 4	

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## 12. PAINTING / COATING MATERIALS

### 12.1 List of Primers and Finish Paints used:

A broad list of primers and finish paints to be used for painting and coating works is as given below:

PRIMERS	
PR-1	Chlorinated Rubber Zinc Phosphate Primer
PR-2	Etch Primer / Wash Primer
PR-3	Two component <b>Epoxy Zinc Phosphate</b> Primer cured with polyamine hardener
PR-4	Single pack, cold galvanizing compounds containing minimum 92% <b>Electrolytic Zinc</b> in dry film. make <b>ZINGA, LOCKTITE</b> (of HENKEL) or <b>ZRC</b>
FINISH COATS / PAINTS	
FP-1	Two component <b>Acrylic – Polyurethane</b> finish paint
FP-2	<b>Chlorinated Rubber</b> finish paint
FP-3A	<b>High Build Epoxy</b> finish coating cured with polyamine hardener
FP-3B	<b>High Build Epoxy</b> finish coating cured with polyamide hardener
FP-3C	<b>Solvent less Epoxy</b> Coating cured with polyamine hardener
FP-4	<b>High build Coal Tar Epoxy</b> coating cured with polyamine hardener
FP-5	Self-priming surface Tolerant <b>High Build Epoxy</b> coating. cured with polyamine hardener
FP-6	Two component <b>Inorganic Zinc Silicate</b> coating
FP-7	Heat resistant synthetic medium based <b>Aluminium</b> paint
FP-8	Two component Heat resistant <b>Silicone Aluminium</b> paint.
FP-9	Specially formulated <b>Coal Tar Epoxy</b> coating. cured with polyamine hardener
FP-10	Two component <b>Epoxy Phenolic</b> coating cured with Polyamine adduct hardener system
FP-11	Engineered Epoxy <b>Poly Siloxane</b> Coating or High Build cold applied inorganic Co-polymer based Aluminium coating
FP-12	Two component solvent free type <b>High Build Epoxy Phenolic / Novalac Epoxy</b> Phenolic coating cured with Polyamine adduct hardener system

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## 12.2 Detailed Specification of Primers and Finish Paints

The following are the various parameters of primers, finish paints and coating materials to be used for carrying out various painting / coating works

### PRIMERS

Sr. No.	Description	PR-1	PR-2	PR-3	PR-4
1.	Technical Name	Chlorinated Rubber Zinc Phosphate Primer	Etch Primer / Wash Primer	Epoxy Zinc Phosphate Primer	Zinga, Locktite or ZRC Cold Galvanized
2.	Pack Type	Single Pack	Two Pack	Two Pack	Single Pack
3	Composition	Air Drying Chlorinated, Rubber based medium Plasticized with unsaponifiable Plasticizer, pigmented with zinc phosphate	Polyvinyl butyral resin medium cured with phosphoric acid solution. pigmented with zinc tetroxy chromate	Polyamine cured epoxy resin, medium, pigmented with zinc phosphate	Synthetic resin based zinc galvanizing containing min 92% of electrolytic zinc dust of 99.95% purity.
4.	Vol. Solids %	40±3	10±1	50±1	37%
5.	DFT (Micron) / Coat	40-45	8-10	40-50	40-50fl
6.	Covering M <sup>2</sup> / Coat / Litre	8-10	8-10	8-10	4 m <sup>2</sup> /kg
7.	Wt. Kg. / Litre	1.3±0.05	1.2±0.05	1.4±0.05	2.67 kg at 15°C
8.	Touch Dry at 30°C Min.	30 minutes	2hrs.	After 30 min.	10 minutes
9.	Hard Dry at 30°C Max.	8 hrs.	24 hrs.	8 hrs.	24 hrs.
11.	Over-coat Interval at 30°C	Min.: 8 hrs.	Min.: 4-6 hrs.	Min.:8hrs.	Min.:4 hrs
12.	Pot Life at 30°C	Not applicable	Not applicable	6-8 hrs.	Unlimited
13.	Temperature. Resistance min	60°C Drv service	NA Dry service	80°C Dry service	50°C Dry service

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### FINISH PAINTS

Sr. No.	Description	FP-1	FP-2	FP-3A /B	FP-3C	FP-4
1.	Technical Name	<b>Acrylic Polyurethane</b> finish paint	<b>Chlorinated Rubber</b> based finish paint	<b>Epoxy-High Build</b> coating	<b>Solvent less Epoxy</b> coating	<b>High Build Coal Tar Epoxy</b> coat.
2.	Pack Type	Two pack	Single pack	<b>FP-3A:</b> Two pack	Two pack	Two pack
3.	Composition	Aliphatic isocyanate cured acrylic finish paint with Glossy-High Glossy finish	Plasticized chlorinated rubber based medium with chemical and weather resistant pigments.	<b>FP-3A:</b> Aromatic amine cured epoxy resin medium suitably pigmented.  <b>FP-3B:</b> polyamide cured epoxy resin medium suitably pigmented	Cured with Amine Adduct; catalyzed epoxy resin suitably pigmented.	Polyamide cured epoxy resin blended with coaltar medium, suitably pigmented
4.	Vol. Solids %	40±3	38±2	60±3	99±1	65±3
5.	DFT (Micron) / Coat	30-40	30-40	100-125	200-500	100-125
6.	Covering M <sup>2</sup> / Coat / Litre	11-15	11-15	5-6	2-3	5.2-6.5
7.	Wt. Kg. / Litre	1.15±0.03	1.15±0.03	1.42±0.03	1.40±0.03	1.40±0.03
8.	Touch Dry at 30°C Max.	30 Min.	30 Min.	3 Hrs.	3 Hrs.	4 Hrs..
9.	Hard Dry at 30°C Max. Full Cure at 30°C for Immersion	8 Hrs.  NA	8 Hrs..  NA	16 Hrs.  5 days	16 Hrs.  NA	48 Hrs.  5 days
10.	Over-coat Interval at 30°C (Min)	12 Hrs.	Overnight.	Overnight. Max.: 5 days	8 Hrs.. Max.: 48 hrs	24 Hrs. Max.:5 days
11.	Pot Life at 30°C for paints -two components	6-8 Hrs.	NA	4-6 Hrs.	30 Min.	4-6 Hrs.
12.	Temperature. Resistance - Dry service - Immersion	80°C  -	-  60°C	80°C  -	120°C  50°C	-  125°C

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Sr. No.	Description	FP-5	FP-6	FP-7	FP-8
1.	Technical Name	<b>High Build Epoxy</b> , self-priming type surface tolerant coating (for complete rust control)	<b>Inorganic zinc silicate</b> coating	<b>Aluminum Paint</b> Heat resistant synthetic medium based suitable up to 250°C dry temp	<b>Silicone Aluminum Paint</b> Heat resistant suitable up to 500°C dry temp.
2.	Pack Type	Two pack	Two pack	Two pack	Single pack
3	Composition	Epoxy resin based suitable pigmented and capable of adhering to manually prepared surface and old coating.	Air drying self curing solvent based inorganic zinc silicate coating with minimum 80% zinc content on dry film. The final cure of the dry film shall pass the MEK rub test. Zinc purity shall be Type-II of ASTM D520	Heat resistant synthetic medium based Aluminium paint suitable upto 250°C.	Silicon resin based medium with Aluminum flakes.
4.	Vol. Solids %	78±3	60±3	38±0.03	20±2
5.	DFT (Micron) / Coat	100-125	65-75	15-20	15-20
6.	Covering M <sup>2</sup> / Coat / Litre	6.0-7.2	8-9	10-12	8-10
7.	Wt. Kg. / Litre	1.41 ± 0.03	2.3 ± 0.03	0.95 ± 0.03	1.0 ± 0.03
8.	Touch Dry at 30°C Max.	3 Hrs.	30 Min.	3 Hrs.	30 Min.
9.	Hard Dry at 30°C Max. Full Cure 30°C for Immersion	24 Hrs. 5 days	12 Hrs. NA	12 Hrs. NA	24 Hrs. NA
10.	Over-coat Interval Min.	10 hrs.	12 hrs. at 20°C & 50% RH.	24 hrs.	24 hrs.
11.	Pot Life at 30°C	90 Min.	4-6 Hrs.	NA	NA
12.	Temperature. Resistance Min. Dry service	80°C	540°C.	250°C	500°C .

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Sr. No.	Description	FP-9	FP-10	FP-11	FP-12
1.	Technical Name	<b>Coal Tar Epoxy</b> Polyamine cured	<b>Epoxy Phenolic</b> coating Two-component cured with Polyamine adduct hardner system (primer + intermediate coat + finish paint).	<b>Poly Siloxane Coating</b> - ambient temperature curing / <b>High build inorganic copolymer based Aluminium</b> coating, cold applied suitable for under insulation coating of CS and SS piping for high temperature service	<b>High Build Epoxy phenolic based</b> - Two components solvent free type / <b>Novalac Epoxy Phenolic coating</b>
2.	Pack Type	Single pack	Two pack	Two pack	Single pack
3	Composition	Specially formulated polyamine cured coal tar epoxy suitable for application under insulation	Temperature curing epoxy phenolic coating system suitable for application under insulation of CS/AS/SS piping	Amercoat 738 from PPG Protective & Marine Coatings or Interterm 751 CSA of International (Akzo Nobel). Note: 6	High build epoxy phenolic / Novalac Epoxy phenolic coating cured with Polyamine adduct hardner system
4.	Vol. Solids %	70 ± 3	70 ± 3	60 ± 2	98 -100
5.	DFT (Micron) / Coat	100-125	75-100	75-100	125-150
6.	Covering M <sup>2</sup> / Coat / Litre	5-8	4-5	7-9	6.5-8
7.	Wt. Kg. / Litre	1.45 ± 0.03	1.65 ± 0.03	1.3	1.7
8.	Touch Dry at 30°C Min.	4 Hrs.	3 Hrs.	1 Hrs.	2 Hrs.
9.	Hard Dry at 30°C Max.Full Cure 30°C for Immersion	24 Hrs. 168 Hrs.(7days)	24 Hrs. 168 Hrs.(7days)	16 Hrs. -	24 Hrs. 168 Hrs.7days)
10.	Over-coat Interval Min,	6 Hrs. Max.: 5 days	16 Hrs. Max.: 21 days	16 Hrs.. Max.: NA	16 Hrs. Max.: 21 days
11.	Pot Life at 30°C	4 Hrs.	4-6 Hrs.	1 Hr.	1 Hr.



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<b>12.</b>	Temperature. Resistance Min.	-45°C to 125°C under insulation And immersion	-45°C to 150°C under insulation & immersion. <b>(Note: 5)</b>	<ul style="list-style-type: none"> <li>• Up to 400 °C for CS &amp; SS for Intertherm 751 CSA</li> <li>• Up to 480 °C for CS and up to 600 °C for SS for Amercoat 738 <b>(Note 6)</b></li> </ul>	-45°C to 150°C for immersion service
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**Notes:**

1. Covering capacity and DFT depends on method of application. Covering capacity specified above is theoretical. Allowing the losses during application, min. specified DFT shall be maintained.
2. All primers and finish coats shall be cold cured and air drying unless otherwise specified.
3. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. The surface preparation, quality and workmanship shall be ensured. In case of conflict between this specification and manufacturer's recommendation, the same shall be clarified with Engineer in charge.
4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.
5. FP-10 Two-component Epoxy phenolic coating cured with Polyamine adduct hardner system (primer + intermediate coat + finish paint) suitable upto 225°C (Intertherm 228 from M/s Akzo Nobel Coatings India Pvt Ltd. Bangalore). For all other companies, the temperature resistance shall be a maximum of 150°C.
6. FP-11 Ambient temperature curing epoxy poly siloxane Coating or high build cold applied inorganic co-polymer based aluminium coating. Amercoat 738 from PPG Protective & Marine coatings, Mumbai is suitable up to 480°C for CS surfaces and 600°C for SS surfaces. Intertherm 751 from Akzo Nobel Coatings India Pvt Ltd., Bangalore, Inorganic co- polymer cold applied Aluminium spray coating is suitable upto 400°C of CS & SS surfaces.

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### 13. PAINTING SYSTEM TABLES & SELECTION CRITERIA

#### 13.1 Painting System Tables:

There are 11 painting system tables in this specification covering most of painting and coating works. However, new table may be added based on project requirement for any specific painting works as necessary. The tables are as under:

<b>Table-01</b>	Painting systems for uninsulated piping, equipment and structures in process units, power plant, DM plant, cooling tower, chimney / stack, package units and any other equipment in process units also including offsite in coastal areas
<b>Table-02</b>	Painting system for insulated equipment and piping (under insulation) in process units and off sites (Carbon steel, LTCS, SS & low alloy steel)
<b>Table-03</b>	Painting system for uninsulated storage tanks in process units and off sites (Carbon steel & low alloy steel)
<b>Table-04</b>	Painting system for internal surface of storage tanks in process units and off sites (Carbon steel & low alloy steel)
<b>Table-05</b>	Painting system for external surface of underground piping and vessels in units and off sites (Carbon steel)
<b>Table-06</b>	Painting system for internal protection of components of coolers / condensers in fresh water service in units and off sites (Carbon steel)
<b>Table-07</b>	Painting system for internal protection of components of coolers / condensers in fresh water service in units and off sites (Stainless steel, duplex stainless steel, non-ferrous materials & galvanized steel)
<b>Table-08</b>	Painting system for effluent treatment plants (ETP)
<b>Table-09</b>	Coating systems for gratings, rolling & stationery ladders, spiral stairways and hand rails in all location
<b>Table-10</b>	Repair of pre-erection / pre-fabrication or shop primer after erection / welding of uninsulated piping and equipment in all environments. (CS, LTCS & low allow steel)
<b>Table-11</b>	Painting system for uninsulated Piping, Equipment, Tanks & Package units in Process Units & Off-Sites (Stainless Steel)

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### 13.2 Table selection Criteria:

The painting Table shall be selected based on following broad parameters given below. The selection criteria shall also be in the order below. All necessary precaution shall be taken in selecting the applicable table. In case of any difficulty Contractor may seek clarification before starting the works from Engineer in charge whose decision shall be final and binding on the Contractor.

Sr. No.	Criteria	Description	Details
1	Plant Location	<ul style="list-style-type: none"> <li>Non Coastal / Inland</li> <li>Coastal / Marine</li> </ul>	More than 50 KM from Sea shore Coastal / Marine Within 50 KM from Sea shore
2	Environment	<ul style="list-style-type: none"> <li>Industrial</li> <li>Industrial Marine</li> </ul>	Use Industrial , if Marine environment is not mentioned
3	Type of facility	<ul style="list-style-type: none"> <li>Units</li> <li>Offsite</li> </ul>	Process Units, Power Plant, Cooling Towers, DM Plant, pipe Rack in units, Package units, chimney/ stack, any other equipment in units Offsite- pipe racks, Piping on Sleepers
4	Temperature Ranges	(-) 180°C to 600°C	Temperature varies for case to case. Selection of painting systems according to the operating temperatures of the line.
5	Material of Const. (MOC)	Carbon Steel (CS) Low Alloy Steel, Stainless Steel (SS)	Aluminium, Copper , Monel, Incoloy, Nickel No painting is required
6	<ul style="list-style-type: none"> <li>Insulated</li> <li>Non Insulated</li> </ul>	Equipment / Piping Equipment / Piping	See Under insulation table

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<b>7</b>	<ul style="list-style-type: none"> <li>Aboveground</li> <li>Underground</li> </ul>	Equipment / Piping Equipment / Piping	Equipment /piping in pit consider underground
<b>8</b>	Surface	<ul style="list-style-type: none"> <li>External</li> <li>Internal</li> </ul>	Equipment /piping Equipment only

**NOTES: (For ALL Tables)**

1. The list of items specified in tables is not exhaustive. More items may be included for a particular Contract as necessary. The Contractor shall complete painting including prefabrication primer for all the items in his scope of work as per tender documents and instructions of Engineer in charge.
2. If the pre-erection / prefabrication and shop primer has already been completed, the same shall not be repeated again in the field. In case the damages of primer are severe and spread over large areas, the Engineer in charge may decide and advise re-blasting and priming again. Repair of pre- fabrication / pre-erection primer, as instructed, shall be carried out by Contractor.
3. All coating system including surface preparation, primer and finish coat for piping shall be done at site / field only.
4. Finish coating is not permitted at equipment manufacture shop.

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**TABLE -01**  
**PAINTING SYSTEMS FOR UNINSULATED PIPING, EQUIPMENT AND STRUCTURES IN**  
**PROCESS UNITS, POWER PLANT, DM PLANT, COOLING TOWER, CHIMNEY / STACK,**  
**PACKAGE UNITS AND ANY OTHER EQUIPMENT IN PROCESS UNITS ALSO INCLUDING**  
**OFFSITES (Carbon Steel, LTCS & Low Alloy Steel)**

Sl. No.	Temp.in °C	Surface Preparation & Pre erection / Shop Primer	Painting System (Post-erection / Field)		Total Final DFT in Micr. (min.)	Remarks
			Primer	Finish Coat		
						<ul style="list-style-type: none"> <li>No over coating to be done on FP-6 as it will lead to mud cracking.</li> </ul>
<b>1.2</b>	-14 to 100	SSPC-SP-10  FP-6 = 75 µm  FP-3A =150 µm  FP-1 =35 µm  Total DFT at shop = 260 µm	FP-1 =40 µm will apply after pressure water wash & surface rubbing  Cumulative DFT = 300		300	<ul style="list-style-type: none"> <li>FP-8 shall be ambient temperature curing type.</li> <li>Finish coat including primer compatible with finish coat. (I.e. field primer) shall be applied at site only.</li> </ul>
<b>1.3</b>	101 to 400	SSPC-SP-10; 1 coat of FP-6 @ 65 - 75 micr. DFT / Coat	None	2 Coat of FP-8 @ 20 micr. DFT / Coat  2x20 =40	105 - 115	
<b>1.4</b>	401 to 540	SSPC-SP-10; 1 coat of FP-6 @ 75 micr. DFT / Coat	None	2 Coat of FP-8 @ 25 micr. DFT / Coat (2x25 =50)	125	

➤ For external surface of MS chimney with or without refractory lining and for internal surface without refractory lining, paint system at Sl. No.1.3 of the above table shall be followed.

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- For external surface of RCC Chimney 2 coats of FP-3A @ 100 Micr. DFT/ coat to obtain total DFT of 200 Micr. shall be applied after proper surface preparation as per Clause 9.3.7
- In case of paint systems as per Sl. Nos. 1.3 and 1.4, the colour bands shall be applied over the Aluminum paint as per the Color coding system requirement for specific service of piping.
- For 1.3 & 1.4 finish coat at field may be applied at shop itself and touch-up will be done at field.




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**TABLE -02**  
**PAINTING SYSTEM FOR INSULATED EQUIPMENT AND PIPING (UNDER INSULATION) IN**  
**PROCESS UNITS AND OFFSITES (Carbon Steel, LTCS, SS & Low Alloy Steel)**

Sl. No.	Temp.in °C	Surface Preparation & Pre erection / Shop Primer	Painting System (Post-erection / Field)		Total Final	Remarks
			Primer / Intermediate	Finish Coat	DFT in Microns (min.)	
2.1	Equipment & Piping - Carbon steel, LTCS and low Alloy steel					
2.1.1	- 45 to 200	SSPC-SP-10 1 coat of FP-10 @ 125 micr. DFT/coat.	None	1 coat of FP-10 @ 75micr. DFT/coat.  (1x125=125)	250	
2.1.2	201 to 540	SSPC-SP-10;  1 coat of Titanium catalyzed inorganic ceramic coploymer @ 150 micr. DFT/coat.	None	1 coat of Titanium catalyzed inorganic ceramic coploymer @ 150micr. DFT/coat.	300	
2.2	Piping -Stainless Steel including Alloy-20 (Note:2)					
2.2.1	-180 to 600	For SS SSPC-SP-6 Commercial Blast/ For SS SSPC-SP-1  With non-chloride solvent  1 coat of Titanium catalyzed inorganic ceramic coploymer @ 150 micr. DFT/coat.	None	1 coat of Titanium catalyzed inorganic ceramic coploymer @ 150micr. DFT/coat.  (150x1=150)	300	
2.3	No painting is required for insulated Monel, Incoloy and Nickel lines.					

- **"Cyclic Service"** is characterized by rapid temperature fluctuation.
- The blast cleaning abrasives for SS and Alloy steel surfaces shall be Aluminium oxide grits/shots or garnet.
- Surface shall be thoroughly degreased using an appropriate emulsion cleaner and

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abrasive cleaned (sweep blasting) to create a sufficient anchor profile. Abrasive for blast cleaning of stainless steel surfaces shall be performed with a suitable non-metallic abrasive such as aluminum oxide. When hand or power tool cleaning is required on stainless steel, only stainless steel wire brushes that have not been previously used on carbon steel surface must be used. All coatings and solvents for use on stainless steel shall be free of substances such as chlorides and other halides, sulfur, and shall be free of low melting point metals (zinc, aluminum, tin and lead).

- For 2.1.1 ,2.1.2 & 2.2.1 finish coat at field may be applied at shop itself and touch-up will be done at field.

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**TABLE -03**  
**PAINTING SYSTEM FOR UNINSULATED STORAGE TANKS IN PROCESS UNITS AND**  
**OFFSITES (Carbon Steel & Low Alloy Steel)**

Sl. No.	Temp.in °C	Surface Preparation (Field)	Painting System (In field after welding & erection)		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
3.1	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external and internal floating roof and associated external structural works.					
3.1.1	-14 to 100	SSPC-SP-10	1 coat of  FP-6 @ 65-75 micr. DFT/coat +1 coat of  PR-3@ 40 micr. DFT/coat.	2 coats of  FP=3A @ 100 micr. DFT/coat + 1 coat of FP-1 @ 70 micr.  DFT/coat;	345-355	FP-3A should be suitable for occasional water immersion.
3.1.2	101 to 150	SSPC-SP-10	1 coat of  FP-10 @ 80 micr. DFT/coat +1 coat of  FP-10 intermediate coat @ 80 micr. DFT/coat.	1 coats of  FP-10 @80 micr. DFT/coat + 1 coat of FP-1@ 40 micr.  DFT/coat;	280	-
3.1.3	151 to 500	SSPC-SP-10	1 coat of  FP-6 @ 65-75 micr. DFT/coat	2 coats of  FP-8 @20 micr. DFT/coat (or) 1coat of FP-11 @ 50 micr.	105	-
3.2	External surfaces of bottom plate (soil side) for all storage tanks.					
3.2.1	-14 to 80	SSPC-SP-10	1 coat of  FP-6 @ 75 micr. DFT/coat.	2coat of  High Glass Flake Epoxy @ 200 micr. DFT/coat.(2x200=400)	475	

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<b>3.2.2</b>	81 to 150	SSPC-SP-10	1 coat of FP-10 @ 80 micr. DFT/ coat +1 coat of FP-10 intermediate coat @ 80 micr. DFT/ coat. (80+80=160)	1 coats of FP-10 finish coat @80 micr. DFT/coat.	240	-
<b>3.2.3</b>	151 to 550	SSPC-SP-10	1 coat of FP-11 @ 125 micr. DFT/coat	1 coats of FP-11 finish coat @80 micr. DFT/coat.	250	-
<b>3.3</b>	<b>For underside of the bottom plate (in case tank is not lifted during PWHT) (see Note 2c)</b>					
<b>3.3.1</b>	-180 to 650	For CS SSPC-SP-6 Commercial Blast For SS SSPC-SP-1 With non-chloride solvent	1 coat of inter polymeric matrix coating @ 125 microns.	2 coat of inter polymeric matrix coating @ 125 microns.	350-400	Products from JOTUN or HI-TEMP coating or SK FOMULATION recommended.

- All paint coating application including primer for tankage shall be carried out at field after erection and completion of all welding.
- For underside of bottom plate, painting shall be carried out before laying of bottom plate for tanks with Non-Post Weld Heat Treatment (PWHT).
- For tanks with PWHT, painting shall be carried out after PWHT.
- In case tank is not lifted during PWHT then painting shall be applied before laying of bottom plate, SI no. 3.3.1 shall be followed.

**Caution:** PWHT temperature shall not exceed 650°C.

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**TABLE -04**

**PAINTING SYSTEM FOR INTERNAL SURFACE OF STORAGE TANKS IN PROCESS UNITS AND OFFSITES (Carbon Steel & Low Alloy Steel)**

Sl. No.	Temp.in °C	Surface Preparation (Field)	Painting System (In field after welding & erection)		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
4.1	<b>Crude oil, ATF, Turpentine oil, Lubricating oil and Vegetable oil</b>  Underside of floating roof, internal surface of cone roof, inside of bottom plate, Internal surfaces of Shell - including wetted and free board height, oil side surfaces of deck plates, oil side surfaces of pontoons, roof structures, structural steel, ladders and other carbon steel internals.					
4.1.1	-14 to 90	SSPC-SP-10	1 coat of FP-10 primer@ 80 micr. DFT/coat.	1 coats of FP-10 intermediate coat @80micr. DFT/coat+ 1coat of FP-10 finish coat@ 80 micr.	240 - 300	-
4.2	Petroleum products & Intermediates Like LDO, HSD, Gas oil, Feeds of FCC -PC, FCC-LCO, VGU-HDT, ISOM, DHDT, Reformate, DCU, NHT & Gasoline, Naphtha, Isomerate and Kerosene. Underside of Floating roofs, internal surface of cone roof, inside of bottom plate, internal surfaces of Bare shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures and ladders etc.					
4.2.1	-14 to 45	SSPC-SP-10	1 coat of FP-6 @ 75 micr. DFT/coat.	-	75	Note-1
4.2.2	46 to 90	SSPC-SP-10	1 coat of FP-10 primer@ 80 micr. DFT/coat+	1 coats of FP-10 intermediate coat @80micr. DFT/coat+ 1coat of FP-10 finish coat@ 80 micr. DFT/coat;	240-300	-
4.3	Raw / Fresh water, Potable water and Fire water All internal surfaces, accessories and roof structures of cone and dome roof tanks					
4.3.1	-14 to 65	SSPC-SP-10	1 coat of PR-3 @ 100 microns. DFT/coat	2 coats of FP3A @ 100 micr. DFT/coat. (2x100=200)	300	Note-2

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<b>4.4</b>	De-mineralized water (DM) All internal surfaces, accessories and roof structures of cone and dome roof tanks					
<b>4.4.1</b>	-14 to 60	SSPC-SP-10	1 coat of PR-3@ 100micr. DFT/coat.	2 coats of FP-3C @ 200 micr. DFT/coat. (2x100=200)	400 - 450	-
<b>4.4.2</b>	61 to 150	SSPC-SP-10	1 coat of FP-10 primer@ 80 micr. DFT/coat.	1 coats of FP-10 intermediate coat @80micr. DFT/coat+ 1coat of FP-10 finish coat@ 80 micr. DFT/coat; (80+80=160)	240 - 300	-
<b>4.5</b>	<b>Hydrochloric Acid (HCl) 10%</b> All internal surfaces, accessories and roof structures of cone and dome roof tanks					
<b>4.5.1</b>	-14 to 60	SSPC-SP-10	None	Natural Rubber Lining	4.5 mm	-
<b>4.6</b>	<b>Aggressive Solvents like Hexane, Hexene, Benzene, Xylene and Toluene</b> All internal surfaces, accessories and roof structures of cone and dome roof tanks.					
<b>4.6.1</b>	-14 to 65	SSPC-SP-10	1 coat of FP-6 @ 75microns. DFT/coat	-	75	-
<b>4.7</b>	<b>Ethylene Glycol (EG) Tanks</b> Internal shell-full height, bottom plate, underside of roof and all accessories					
<b>4.7.1</b>	ALL	SSPC-SP-10	1 coat of FP-10 primer@ 80micr. DFT/coat.	31 coats of Vinyl chloride Co-polymer Amercoat 23 @75micr. DFT/coat (3x75=225)	225	-
<b>4.8</b>	<b>Inside pontoon and inside of double deck of all tanks floating roofs</b>					
<b>4.8.1</b>	-14 to 80	SSPC-SP-3	1 coat of FP-5@ 100micr. DFT/coat.	1 coats of FP-5 coat @100micr. DFT/coat	200	-
<b>4.9</b>	<b>Wet Slops, Amine Solutions, Sour water, Water draw off</b> All internal surfaces, accessories and roof structures of Cone and Dome roof tanks.					

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4.9.1	-14 to 90	SSPC-SP-10	1 coat of Novolac Phenolic Epoxy Primer@ 125micr. DFT/coat.	1coat of Novolac Phenolic Epoxy finish coat@ 125 micr. DFT/coat; (80+80=160)	250	-
4.10	<b>Vacuum Residue, Fuel oil, Dry Slop, Bitumen and other High Temperature Hydrocarbon Liquids.</b> Underside of floating roof, internal surface of cone roof, bottom plate, inside of bare shell - including wetted and non-wetted surfaces, oil side surfaces of deck plates, oil side surfaces of pontoons, roof structures, structural steel and ladders.					
4.10.1	Up to 150	SSPC-SP-10	1 coat of FP-12 Primer@ 125micr. DFT/coat.	1 coats of FP-12 intermediate coat @125micr. DFT/coat+ 1coat of FP-12 finish coat@ 125 micr. DFT/coat; (125+125=250)	375	Note-3
4.11	<b>Alkalis up to 50 % Concentration</b> All internal surfaces accessories and roof structures of cone and dome roof tanks					
4.11.1	Up to 60	SSPC-SP-10	1 coats of Novolac Phenolic Epoxy primer @125micr. DFT/coat.	1coats of Novolac Phenolic Epoxy @100micr. DFT/coat. (1x125=1250)	250	-

**Notes:**

1. FP-6 shall be suitable and resistant for immersion service for the respective Hydrocarbons.
2. FP-3A shall be suitable for drinking water service and should have competent authority certification.
3. This system can be used where maximum operating temperature is below 150°C and design temperature is up to 200°C. Cases of operating temperature above 150°C are not covered in this spec; such cases shall be covered in the job specifications.

**TABLE -05**



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**PAINTING SYSTEM FOR EXTERNAL SURFACE OF UNDERGROUND PIPING AND VESSELS IN UNITS AND OFFSITES (Carbon Steel)**

Sl. No.	Temp.in °C	Surface Preparation & Shop Primer	Coating System (Field)		Total	Remarks
			Surface Preparation & Primer	Finish Coat	Final DFT in Microns (min.)	
5.1	External surface of non-insulated underground piping					
5.1.1	25 to 65	-	SSPC-SP-10; Three layer polyethylene coating, thickness as per JSS for coating.			
5.1.2	66 to 150	-	SSPC-SP-10; 1 coat of FP-12 primer @ 125micr. DFT/coat.	1 coats of FP-12 intermediate coat @125micr. DFT/coat+ 1coat of FP-12 finish coat @ 125 micr. DFT/coat;	375	-
5.1.3	151 to 400	-	SSPC-SP-10; 1 coat of FP-11 primer @ 125micr. DFT/coat.	1 coat of FP-11 finish coat @ 125micr. DFT/coat.	250	-
5.2	External surface of non-insulated underground storage vessels					
5.2.1	-14 to 80	SSPC-SP-10; 1 coat of FP-6 @ 65-75 micr. DFT/coat.	-	3 coat of FP-4 @ 100 micr. DFT/coat.	365-375	-
5.2.2	81 to 150	SSPC-SP-10; 1 coat of FP-6 @ 125 micr. DFT/coat.	-	1 coat of FP-12 Intermediate coat @ 125micr. DFT/coat+ 1coat of FP-12 finish coat @ 125 micr. DFT/coat;	375	-
5.2.3	151 to 400	SSPC-SP-10; 1 coat of FP-11 @ 125 micr. DFT/coat.	-	1 coats of FP-11 finish coat @125micr. DFT/coat	250	-

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**TABLE -06**  
**PAINTING SYSTEM FOR INTERNAL PROTECTION OF COMPONENTS OF COOLERS /**  
**CONDENSERS IN FRESH WATER SERVICE IN UNITS AND OFFSITES (Carbon Steel)**

Sl. No.	Temp.in °C	Surface Preparation & Shop Primer	Coating System (Field)		Total	Remarks
			Surface Preparation & Primer	Finish Coat	Final DFT in Microns (min.)	
6.1	Fresh water boxes, channels, partition plates, end covers and tube sheets etc.					
6.1.1.	Up to 80	SSPC-SP-10;	1 coat of FP-10 @ 80micr.	2 coat of FP-10@ 80 micr. DFT/coat;	240	-
6.1.2.	80 to 140	SSPC-SP-10;	-	1Coat of glass Fibre Reinforced <b>Novolac</b> epoxy of 1.5mm DFT	1500	-

**TABLE -07**  
**PAINTING SYSTEM FOR INTERNAL PROTECTION OF COMPONENTS OF COOLERS /**  
**CONDENSERS IN FRESH WATER SERVICE IN UNITS AND OFFSITES**  
**(Stainless Steel, Duplex Stainless Steel, Non-ferrous materials & Galvanized Steel)**

Sl. No.	Temp.in °C	Surface Preparation & Shop Primer	Coating System (Field)		Total Final DFT in Microns (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
<b>7.1</b>	Up to 80	Sweep Blasting	1 coat of FP-10 @ 80micr. DFT/coat;	1 coat of FP-105@ 80 micr. DFT/coat;	160	-
<b>7.2.</b>	80 to 140	Sweep Blasting	-	1Coat of glass Fibre Reinforced <b>Novolac</b> epoxy of 1.5mm DFT	1500	-

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**TABLE -08**

**PAINTING SYSTEM FOR EFFLUENT TREATMENT PLANTS (ETP)**

Sl. No.	Temp.in °C	Surface Preparation	Coating System		Total	Remarks
			Primer	Finish Coat	DFT in Microns	
8.1	External Surface of C.S./ M.S. items screens, walk way, bridges, baffles, dual media filters, Vertical pumps, piping in treated effluent sump, bio sludge pump,					
8.1.1	-14 to 80	SSPC-SP-10	1 coat of  FP-6 @ 65-75 micr. DFT/coat	2 coats of  FP-3A@100 micr. DFT/coat+ 1coat of FP-1 @ 40 micr.  DFT/coat; (2x100+40=240)	305 - 315	
8.2	Internal surfaces of CS/MS Items: Bio-sludge sump, Filter feed sump, Process sump, Sanitary sump, Transfer sump, Sludge, Slop oil tank, scrapping mechanism in Clarifier					
8.2.1	-14 to 80	SSPC-SP-10	1 coat of FP-6 @ 65-75 micr. DFT/ coat.	3 coats of FP-3A @100 micr. DFT/coat  (3x100=300)	365 - 375	See * below
8.3	R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc. in process sump, TPI separator (Process and oil), Aeration tank and Transfer sump etc.					
8.3.1	-14 to 80	Blast cleaning to SSPC-SP guide lines and Acid etching with 10-15% HCl acid followed by thorough water washing.	Epoxy Screed lining		3mm	Epoxy screed lining shall be applied as per specific manufacturer and Engineer in charge instructions.
8.4	C.S/ M.S Dual media filters (Internal), Chemical dosing tanks(internal) such as Di Ammonium Phosphate (DAP) and Urea					
8.4.1	Up to 60	SSPC-SP-10	Natural Rubber Lining  (As per IS 4682, Part I)		4.5mm	Natural Rubber lining shall be applied as per specific manufacturer and Engineer in charge instructions.

- The paint /coating manufacturers shall provide their Quality control test certificate of coating materials (F-3A) for immersion service of the exposed effluent given in 9.2.

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**TABLE -09**

**COATING SYSTEMS FOR GRATINGS, ROLLING & STATIONERY LADDERS, SPIRAL STAIRWAYS  
AND HAND RAILS IN ALL LOCATION**

<b>Sl. No.</b>	<b>Temp.in °C</b>	<b>Coating System</b>	<b>Total DFT in Microns (min,)</b>
9.1	Up to 60	1 coat of High Build Epoxy @ 75 micr. DFT/Coat and 1 coat pf FP-1 @ 50 micr. DFT/Coat	80 microns of finish coat (excluding the thickness of galvanizing )  125

**NOTES:**

1. No galvanized specimen shall have thickness less than 125 microns.
2. Repair of the damaged area of galvanized coatings due to welding during erection shall be carried out as per recommended practice IS 11759 using cold galvanizing spray process. Organic Paint systems are not acceptable for repair.
3. Approved Cold Galvanizing manufacturers are **ZINGA, LOCKTITE** or **Z.R.C.**

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**TABLE -10**

**REPAIR OF PRE-ERECTION / PRE-FABRICATION OR SHOP PRIMER AFTER ERECTION /  
WELDING OF UNINSULATED PIPING AND EQUIPMENT IN ALL ENVIRONMENTS.  
(CS, LTCS & low allow steel)**

Sl. No.	Temp.in °C	Surface Preparation	Coating System	Total DFT in Micr (min.)	Remarks
10.1	-90 to 400	SSPC-SP-3	1coat of FP-6	65-75	See note below and clause 5.9.3
10.2	401 to 550	SSPC-SP-3	1coat of FP-8	20	

- The repair of pre-erection / pre-fabrication or Shop Primer given above shall be done for all items requiring repairs. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with FP-6 or FP-8 as applicable.
- The primer shall be quickly removed from damaged area by mechanical scraping and emery paper conforming to SSPC-SP-3 to expose the white metal. Blast cleans the surface, if possible. Feather the primed surface over the intact adjacent surface(approximately 50mm) surrounding the damaged area by emery paper.

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**TABLE -11**

**PAINTING SYSTEMS FOR UN-INSULATED PIPING, EQUIPMENT, TANKS & PACKAGE  
UNITS IN PROCESS UNITS AND OFFSITES  
(STAINLESS STEEL)**

Sl. No.	Temp.in °C	Surface Preparation	Painting System (Post-erection / Field)		Total Final DFT in Micr. (min.)	Remarks
			Primer	Finish Coat		
11.1	0 to 120	SSPC-SP-6 'Sweep blast' using Aluminium Oxide or Garnet abrasive media SSPC-SP-1 With non-chloride solvent	2 Coats of FP-10 @ 125 micr. DFT / Coat 2x125=250	1 Coat of FP-1 @ 75 micr. DFT / Coat 1x75 =75	325	
11.2	121 to 200	SSPC-SP-6 'Sweep blast' using Aluminium Oxide or Garnet abrasive media SSPC-SP-1 With non-chloride solvent	2 Coats of FP-10 @ 125 micr. DFT / Coat 2x125=250	2 Coats of Silicon Acrylic @ 20 micr. DFT / Coat 2x20 =40	290	

- Surface preparation of stainless steel shall be in accordance with IS 8504-2, Sa 1 light blast cleaning to achieve a 25-40µm profile.
- Surface shall be thoroughly degreased using an appropriate emulsion cleaner and abrasive cleaned (sweep blasting) to create a sufficient anchor profile. Abrasive for blast cleaning of stainless steel surfaces shall be performed with a suitable non-metallic abrasive such as aluminum oxide. When hand or power tool cleaning is required on stainless steel, only stainless steel wire brushes that have not been previously used on carbon steel surface must be used. All coatings and solvents for use on stainless steel shall be free of substances such as chlorides and other halides, sulfur, and shall be free of low melting point metals (zinc, aluminum, tin and lead).
- Only air curing heat resistant silicone aluminium paints shall be applied, post heat curing materials are not acceptable
- The colour bands shall be applied over the Aluminum paint as per the Color coding system requirement for specific service of piping.
- Finish coat at field may be applied at shop itself and touch-up will be done at field.

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## 14. FINISH COLOUR SCHEDULE

### 14.1 General

This section covers the general colour requirements for structural steelwork and equipment with operating temperatures below 120 deg.C:

Structural Steel, Tanks, Spheres, Electrical Equipment		
Sl. No:	Service	Shade – Shade Number
N/A	Structural Steelwork	Light Grey – RAL 7035
N/A	Spheres and Storage tanks	White – RAL 9003
N/A	Electrical Switch Boards, Cable Conduit and Transformers and all other electrical equipment	Manufacturers Painting standard (including RAL 7035) conforming to relevant code and practices prevailing in the country of manufacture
Un-insulated Equipment, Tanks and Structures		
Sl. No:	Service	Shade – Shade Number
-	Loading Arms (i) Structural Steel (ii) Arms	Light Grey – RAL 7035 Yellow – RAL 1023
96	Heater Structure	Signal Grey – RAL 7004
97	Heater Casing	Aluminium – RAL 9006
98	Vessels and Columns	Aluminium – RAL 9006
99	Hydrogen Bullets	Antique Pink – RAL 3014
100	LPG Vessels	Oxide Red – RAL 3009
101	SO <sub>2</sub> Vessel	Yellow – RAL 1023
102	Heat Exchangers	Aluminium – RAL 9006
103	FO Tank and Hot Tanks	Black – RAL 9017
104	All Other Tanks	Aluminium – RAL 9006
105	Caustic/Amine/Acid Tanks	Gold/Yellow – RAL 1004
106	Sour Water	Sky Blue – RAL 5015
107	Outer Surface in Boiler House	Aluminium – RAL 9006
108	Steam Turbine	Aluminium – RAL 9006
109	Compressors and Blowers	Dk Grey BS4800 18 B 25
110	Pumps	Cobalt Blue RAL – 5013
111	Motors (Except Fire Motors)	Bluish Green RAL 5021
112	Hand Railing	Red – RAL 3001
113	Staircase, Ladders and Walkways	Black – RAL 9017
114	Load lifting equipment & mono rails etc.	Brown – RAL 8003



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Safety Colour Schemes		
Sl. No:	Service	Shade – Shade Number
115	General Structure	Black – RAL 9017
116	Switchgear (including inside sub- station)	Light Grey RAL 7035
117	Dangerous Obstruction	Alternate Black (RAL 9017) and Orange (RAL 2008) Diagonal Banding
118	Dangerous or Exposed Parts of Machinery	Orange – RAL 2008

## 14.2 Pipe Colour Bands

This section covers the requirements for a colour scheme identifying the contents of piping carrying products. The colour coding system is based on international specifications such as ASME, ANSI, BS and Indian Standards including IOCL's existing specification for colour coding.

The system of coding consists of a ground/base colour superimposed with secondary colour bands. The ground colour identifies the basic nature of the service and the secondary colour bands distinguish the particular service product contained.

Ground colour shall be applied to the entire length of un-insulated piping.

The ground colours and secondary banding colours are defined in section 14.4.

The frequency of banding on un-insulated pipe shall be as follows:

- Unit Area – Bands at intervals of 6 metres
- Offsite Area – Bands at intervals of 10 metres

Each pipe segment will have a minimum of 1 identification band irrespective of length.

Colour bands of the correct size shall be applied to the pipe, at:

- Both sides of valves, tees and other fittings
- Where pipes enter and emerge through walls
- Where pipes enter and emerge from walkway overpasses and battery limits
- At uniform intervals along long sections of pipe
- Adjacent to tanks, vessels and pumps.

Insulated piping shall received ground colouring and coloured (secondary) identification bands at a minimum of either side of valves, flanges and the like, at each change in flow direction and at no greater than 6 metre intervals, ground colours should be 2 metres long.

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Secondary colours are to be applied using adhesive plastic tapes to the specified colour.

Bands widths are shown below for different pipe diameters and are to be spaced 25mm apart when two bands (or more) are used:

<b>Outside diameter of pipe or covering (inches)</b>	<b>Width of colour bands (mm)</b>
< 2"	200
2" – 4"	300
6" – 8"	600
>= 10"	800

Bands shall also be displayed conspicuously near walkways, both sides of culverts, tanks, dykes, vessels, suction and discharge of pumps/compressors, unit battery limit, near valves of line, etc.,

### 14.3 Identification Lettering

Name of service and direction of flow, for all lines shall be positioned at the following locations:

- Offsite lines: Both sides of culverts, any one side of walkways, near tank dykes, at tank inlet/outlet points and suction/discharge pumps/compressors.
- Unit lines: At the battery limit, suction/discharge of pumps/compressors, near vessels, columns, tanks, exchangers etc.,

Identification/legend letter sizes on piping shall depend on the pipe diameter. Either white or black letters are to be selected so as to afford maximum contrast with the identification band colour.

<b>Outside diameter of pipe or covering (inches)</b>	<b>Size of legend letters (mm)</b>
< 2"	19
2" – 4"	32
6" – 8"	64
>= 10"	89

Pipe contents and direction of flow is to be identified using legend letters and arrows, any hazard must be identified clearly by the legend.

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Size of letters (stenciled or pre-formed adhesive) for equipment shall be:

<b>Equipment</b>	<b>Size of legend letters</b>
Column and vessel	150 mm (height)
Pump, compressor and other machinery	50 mm (height)

Lettering shall be black on pipes painted with light shade colours and white on pipes painted with dark shade colours to give good contrast.

#### 14.4 IOCL Paint Colour Code and Banding

The following base / ground and secondary colour designation for identification of various important services shall be followed:

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Sl. No:	Service	Base/Ground Colour	Secondary Band Colours
	<b>Hydrocarbon Lines – (Un-insulated)</b>		
1.	Crude Sour	Dk Grey BS4800 18 B 25	(x1) Orange – RAL 2008
2.	Crude Sweet	Dk Grey BS4800 18 B 25	(x1) Red – RAL 3001
3.	Lube Oils	Dk Grey BS4800 18 B 25	(x1) Green – RAL 6002
4.	Flare Line	Aluminium – RAL 9006	Aluminium – RAL 9006
5.	L.P.G.	Orange – RAL 2008	(x1) Oxide Red – RAL 3009
6.	Propylene	Orange – RAL 2008	(x2) Oxford Blue – RAL 5003
7.	Naptha	Orange – RAL 2008	(x1) Green – RAL 6002
8.	M.S.	Orange – RAL 2008	(x1) Dk Grey BS4800 18 B 25
9.	AV. Gasoline (96 RON)	Orange – RAL 2008	(x1) Green – RAL 6002 + (x1) White – RAL 9003 + (x1) Red – RAL 3001
10.	Gasoline (regular, leaded)	Orange – RAL 2008	(x1) Black – RAL 9017
11.	Gasoline (premium, leaded)	Orange – RAL 2008	(x1) Blue – RAL 5017
12.	Gasoline (white)	Orange – RAL 2008	(x1) White – RAL 9003
13.	Gasoline (aviation 100/130)	Orange – RAL 2008	(x1) Red – RAL 3001
14.	Gasoline (aviation 115/145)	Orange – RAL 2008	(x1) Purple – RAL 4006
15.	N-Pentane	Orange – RAL 2008	(x2) Blue – RAL 5017
16.	Diesel Oil (white)	Oxide Red – RAL 3009	(x1) White – RAL 9003
17.	Diesel Oil (black)	Oxide Red – RAL 3009	(x1) Yellow – RAL 1023
18.	Kerosene	Oxide Red – RAL 3009	(x1) Green – RAL 6002
19.	HY. Kero	Oxide Red – RAL 3009	(x2) Green – RAL 6002
20.	Disulfide Oil (Ex-Merox)	Oxide Red – RAL 3009	(x1) Black – RAL 9017
21.	M.T.O.	Oxide Red – RAL 3009	(x3) Green – RAL 6002
22.	DHPPA	Oxide Red – RAL 3009	(x2) White – RAL 9003
23.	Flushing Oil	Oxide Red – RAL 3009	(x2) Black – RAL 9017
24.	Lab FS	Oxide Red – RAL 3009	(x2) Dk Grey BS4800 18 B 25
25.	Lab RS	Oxide Red – RAL 3009	(x3) Dk Grey BS4800 18 B 25
26.	Lab (Off. Spec.)	Oxide Red – RAL 3009	(x1) Lt Grey RAL 7036
27.	N-Paraffin	Oxide Red – RAL 3009	(x1) Blue – RAL 5017
28.	Heavy Alkylate	Oxide Red – RAL 3009	(x1) Red – RAL 3001
29.	Blow Down, Vapour Line	Aluminium – RAL 9006	(x1) Brown – RAL 8003
30.	Blow Down	Aluminium – RAL 9006	(x2) Brown – RAL 8003

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Sl. No:	Service	Base/Ground Colour	Secondary Band Colours
31.	A.T.F.	Brown – RAL 8003	(x1) White – RAL 9003
32.	Toluene	Brown – RAL 8003	(x1) Yellow – RAL 1023
33.	Benzene	Brown – RAL 8003	(x1) Green – RAL 6002
34.	Lab Product	Brown – RAL 8003	(x1) Blue – RAL 5017
35.	Fuel Oil	Black – RAL 9017	(x1) Yellow – RAL 1023
36.	Fuel Oil (aromatic rich)	Black – RAL 9017	(x2) Yellow – RAL 1023
37.	Asphalt	Black – RAL 9017	(x1) White – RAL 9003
38.	Slop and Waste Oils	Black – RAL 9017	(x1) Orange – RAL 2008
39.	Slop Aromatic	Black – RAL 9017	(x2) Orange – RAL 2008

<b>Chemical Lines (Un-insulated)</b>			
40.	Tri-Sodium Phosphate	Yellow – RAL 1023	(x1) Violet – RAL 4008
41.	Caustic Soda	Yellow – RAL 1023	(x1) Black – RAL 9017
42.	Sodium Chloride	Yellow – RAL 1023	(x1) White – RAL 9003
43.	Ammonia	Yellow – RAL 1023	(x1) Blue – RAL 5017
44.	Corrosion Inhibitor	Yellow – RAL 1023	(x1) Aluminium – RAL 9006
45.	Hexameta Phosphate	Yellow – RAL 1023	(x2) Black – RAL 9017
46.	Acid Lines	Gold/Yellow – RAL 1004	(x1) Red – RAL 3001
47.	Rich Amine	Yellow – RAL 1023	(x2) Blue – RAL 5017
48.	Lean Amine	Yellow – RAL 1023	(x3) Blue – RAL 5017
49.	Solvent	Yellow – RAL 1023	(x1) Green – RAL 6002
50.	LCS	Yellow – RAL 1023	(x1) Grey – RAL 7001

<b>Water Lines (Un-insulated)</b>			
51.	Raw Water	Sky Blue – RAL 5015	(x1) Black – RAL 9017
52.	Industrial Water	Sky Blue – RAL 5015	(x2) Red – RAL 3001
53.	Treated Water	Sky Blue – RAL 5015	(x1) Oxide Red – RAL 3009
54.	Drinking Water	Sky Blue – RAL 5015	(x1) Green – RAL 6002
55.	Cooling Water	Sky Blue – RAL 5015	(x1) Pale Brown – RAL 8025
56.	Service Water	Sky Blue – RAL 5015	(x1) Red – RAL 3001
57.	Tempered Water	Sky Blue – RAL 5015	(x2) Green – RAL 6002
58.	DM Water	Sky Blue – RAL 5015	(x1) Aluminium – RAL 9006
59.	DM Water above 150°F	Sky Blue – RAL 5015	(x2) Black – RAL 9017
60.	Sour Water	Sky Blue – RAL 5015	(x2) Yellow – RAL 1023

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Sl. No:	Service	Base/Ground Colour	Secondary Band Colours
61.	Stripped Water	Sky Blue – RAL 5015	(x2) Blue – RAL 5017
62.	ETP Treated Water	Sky Blue – RAL 5015	(x2) Oxide Red – RAL 3009

Fire Protection System (Above Ground)			
63.	Fire Water, Foam and Extinguishers	Red – RAL 3001	Red – RAL 3001

Air and Other Gas Lines (Un-insulated)			
64.	Service Air	May Green – RAL 6017	(x1) Red – RAL 3001
65.	Instrument Air	May Green – RAL 6017	(x1) Black – RAL 9017
66.	Nitrogen	May Green – RAL 6017	(x1) Orange – RAL 2008
67.	Freon	May Green – RAL 6017	(x1) Yellow – RAL 1023
68.	Chlorine	Yellow – RAL 1023	(x1) Oxide Red – RAL 3009
69.	SO <sub>2</sub>	Yellow – RAL 1023	(x2) White – RAL 9003
70.	H <sub>2</sub> S	Orange – RAL 2008	(x2) Oxide Red – RAL 3009
71.	Gas (fuel)	Orange – RAL 2008	(x1) Aluminium – RAL 9006
72.	Gas (sour)	Orange – RAL 2008	(x2) Aluminium – RAL 9006
73.	Gas (sweet)	Orange – RAL 2008	(x1) Red – RAL 3001
74.	Hydrogen	Orange – RAL 2008	(x1) May Green – RAL 6017

Steam and Condensate Lines (Un-insulated)			
75.	HP Steam & VHP Steam Line	Aluminium – RAL 9006	(x1) Yellow – RAL 1023
76.	MP Steam	Aluminium – RAL 9006	(x1) Red – RAL 3001
77.	MLP Steam	Aluminium – RAL 9006	(x1) Orange – RAL 2008
78.	LP Steam	Aluminium – RAL 9006	(x1) Green – RAL 6002
79.	Condensate	Sky Blue – RAL 5015	(x1) White – RAL 9003
80.	Condensate above 150°F	Sky Blue – RAL 5015	(x3) Oxide Red – RAL 3009
81.	BFW	Sky Blue – RAL 5015	(x2) Traffic Red – RAL 3020
<b>Note:</b> For all insulated steam lines, the colour coding shall be followed as given for un-insulated lines with the specified length of colour bands			

Insulated Hydrocarbon Lines			
82.	IFO Supply	Black – RAL 9017	(x1) Yellow – RAL 1023
83.	IFO Return	Black – RAL 9017	(x1) Green – RAL 6002
84.	HPS	Black – RAL 9017	(x1) Red – RAL 3001
85.	Bitumen	Black – RAL 9017	(x2) Red – RAL 3001

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Sl. No:	Service	Base/Ground Colour	Secondary Band Colours
86.	CLO	Black – RAL 9017	(x1) Brown – RAL 8003
87.	VB Tar	Black – RAL 9017	(x2) Brown – RAL 8003
88.	VR AM (Bitumen/VBU Feed)	Black – RAL 9017	(x1) Blue – RAL 5017
89.	VR BH	Black – RAL 9017	(x2) Blue – RAL 5017
90.	VAC. Slop	Black – RAL 9017	(x1) White – RAL 9003
91.	Slop	Black – RAL 9017	(x1) Orange – RAL 2008
92.	Crude Sweet	Dk Grey BS4800 18 B 25	(x1) Red – RAL 3001
93.	Crude Sour	Dk Grey BS4800 18 B 25	(x1) Orange – RAL 2008
94.	VGO/HCU Feed	Oxide Red – RAL 3009	(x1) Signal Grey – RAL 7004
95.	OVCU Bottom/FCCU Feed	Oxide Red – RAL 3009	(x2) Signal Grey – RAL 7004

## 15. STORAGE

All paints and painting materials shall be stored only in rooms to be arranged by contractor and approved by Engineer in charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word **"Paint Storage – No Naked Light - Highly Inflammable"** shall be clearly displayed outside. Manufacturer's recommendation shall be followed for storage of paint materials.

## 16. QUALITY CONTROL, INSPECTION & TESTING

- All painting materials including primers and thinners brought to site by contractor for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturer's test certificates. Paint formulations without certificates are not acceptable
- The contractor must produce Test Certificate from Pre-Qualified Paint Manufacturer for various tests as specified in this document, for each batch and for each category of product. The Engineer in charge shall have the right to test wet samples of paint from each batch at random for verifying quality of paint supplied. Contractor shall arrange to have such tests, when called for by Engineer in charge, performed at his cost any one of the independent laboratories listed in this document.

Samples for the test will be drawn at random in presence of Engineer in charge or his



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representations. Following tests to be carried out if called for by Engineer in charge:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer)
- Drying time (touch dry & full curing)
- Adhesion
- Flexibility
- Hardness
- Storage stability (pot life)

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

- The painting work shall be subject to inspection by Engineer in charge at all times. In particular, following stage-wise inspection will be performed and contractor shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:
  - Surface preparation
  - Primer application
  - Each coat of paint

During surface preparation, following tests are to be carried out:

- Test for absence oil and grease after degreasing before blasting.
- Tests for surface finish of blasted surface shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-9 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component at least once per 200 m<sup>2</sup> of blasted surface and minimum of 3 checks per shift.
- Test for presence of soluble salt as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg /m<sup>2</sup>. Checks shall be done on each component at least once per 200 m<sup>2</sup> of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of ISO: 12944-4 (water cleaning). After cleaning surface shall be retested for salt after drying.
- Blast profile measurement
- Test for blasting Media and Blasting air- In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate, or zinc rich epoxy, or zinc phosphate.

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Any defect noticed during the various stages of inspection shall be rectified by the contractor to the entire satisfaction of Engineer in charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, contractor shall be responsible for making good any defects found during final inspection/guarantee period/defect liability period as defined in general condition of contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make- up the DFT specified without any extra cost to owner, the extra coat should have prior approval of Engineer in charge.

- **Primer Application:** After surface preparation, the primer should be applied to cover the crevices, comers, sharp edges etc. in the presence of inspector nominated by Engineer in charge.
- The shades of successive coats should be slightly different in colour in order to ensure application of individual coats, the thickness of each coat and complete coverage should be checked as per provision of this specification. This should be approved by Engineer in charge before application of successive coats.
- The contractor shall provide standard thickness measurement instrument with appropriate range(s) for measuring.
  - Dry film thickness of each coat,
  - Surface profile gauge for checking of surface profile in case of sand blasting.
  - Holiday detectors and pinhole detector and protector whenever required for checking in case of immersion conditions.
- Prior to application of paints on surfaces of chimneys, the thickness of the individual coat shall be checked by application of each coat of same paint on M.S.test panel. The thickness of Paint on test panels shall be determined by using gauge such as 'Elkometer'. The thickness of each coat shall be checked as per provision of this specification. This shall be approved by Engineer in charge before application of paints on surface of chimney.
- At the discretion of Engineer in charge, the paint manufacturer must provide the expert technical service at site as and when required. This service should be free of cost and without any obligation to the owner, as it would be in the interest of the manufacturer to ensure that both surface preparation and application are carried out as per their recommendations. The contractor is responsible to arrange the same.
- Final inspection of finished coating shall consist of measurement of:
  - Paint dry film thickness (DFT),

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- Adhesion, and,
- Holiday detection check as well as for finish and workmanship.

- Coating DFT measurement shall be as per ISO: 2808. Type II electromagnetic gauges should be used for ferrous substrates. DFT gauge calibration, number of measurement shall be as per SSPC-PA 2. Measured DFT shall be within + 10% of the dry film thickness, specified in the specifications.
- Adhesion of the primer to the steel substrate and intercoat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife-test in accordance with ASTM D6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is defective and:-tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform the adhesion test on a steel coupon coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m<sup>2</sup> (2000 ft<sup>2</sup>) of coated surface.
- Holiday testing shall be conducted in accordance with NACE SP0188. For immersion services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP0188. Any holiday is unacceptable and should be marked and repaired immediately.
- The contractor shall arrange for spot checking of paint materials for Specific gravity, glow time (ford cup) and spreading rate.
- **Final Inspection of coating system:**

A final inspection shall be conducted prior to the acceptance of the work. The Contractor and the Owner / Engineer in charge shall both be present and they shall sign an agreed inspection report. Such reports shall include:

  - General
    - Names of the painting Contractor and the responsible personnel
    - Dates when work was performed
  - Painting Materials

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- Information on painting materials being applied
- Condition of painting materials received
- Environmental Conditions
  - Weather and ambient conditions
  - Painting periods
- Surface Preparation
  - Condition of surface before preparation
  - Tools and methods used to prepare surface
  - Condition of surface after preparation
- Painting Application
  - Equipment used
  - Mixing procedure prior to application
  - Coating application techniques used
- Testing
  - Type and calibration of inspection instruments used
  - Type of quality control tests performed, and results

## 17. **GUARANTEE**

The Contractor shall guarantee that the chemical and physical properties of paint material used are in accordance with the specifications contained herein / to be provided during execution of work.

## 18. **QUALIFICATION CRITERIA OF PAINTING CONTRACTOR / SUB-CONTRACTOR**

Painting contractor who is awarded the contract for painting by the Owner, must have necessary equipment's, machinery, tools and tackles for surface preparation, paint application and

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inspection. The contractor must have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The Contractor supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

## 19. **QUALIFICATION / ACCEPTANCE CRITERIA FOR PAINT COATING SYSTEM**

- Pre-Qualification of Paint Coating Manufacturer and his Products  
Paint / coating manufacture meeting the following requirements shall be considered for supply of their products. Contractor is advised to select coating manufacturer. Only after obtaining prequalification from Owner for the manufacturer based on following requirements. Even those manufacturers, whose names are appearing elsewhere in the tender document, under the list of "Owner Recommended or Approved Vendors", will also be required to meet the following prequalification requirements.
  - Manufacturer should have been in continuous business of paint / coating formulation and manufacturer for at least past 5 years.
  - Manufacturer should possess past experience of supplying his products to hydrocarbon processing industry or offshore platforms in the past 5 years.
  - Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon processing industry or offshore platform.
  - The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 Requirements and preferably should possess ISO 14000 certificate.
  - The Quality control set up should be manned by qualified paint technologists whose bio data should be sent along with quality control organization chart.
- Pre-Qualification Testing:  
Manufacturer should have got his products tested at least one time in last 3 years at a reputed independent laboratory for the following test items. Test certificates which are more than 3 years old will not be considered.

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Test	Test Method
Specific gravity	ASTM D1475
Dipping properties	ASTM D823
Film characteristics	-
Solid content by weight	ASTM D2369
Drying Time	ASTM D1640
Flexibility	ASTM D1737 / D522
Hardness	ASTM D3363
Adhesion	ASTM D2197
Abrasion resistance	ASTM D968/ D1044
DFT/coat	As per SSPC guidelines
Storage Stability	ASTM D1849
Resistance to moisture vapour permeability for 2000 hrs	ASTMD2247
Cyclic Test for the duration of 4200 h (25 cycles a 168 hours)	ASTM D5894
% Zn in Dry film for Inorganic Zinc Silicate primer	-
Chemical Resistance test - 10% & 40% NaOH (applicable only for F-6 & F-15) - 10% H <sub>2</sub> SO <sub>4</sub> (applicable only for F-6 & F-15) - 10% Nitric Acid test (applicable only for F-6 & F-15) - Benzene / Toluene (applicable only for F-6 & F-15) - Kerosene (applicable only for F-6 & F-15) - Sea water (applicable only for F-6 & F-15) - MIBK test (applicable only for F-6 & F-15)	ASTM D543
Resistance to water using water immersion (applicable only for F6-, F-7, F-8, F-14 & F-15)	ASTM D870
Dry Heat Resistance test (applicable only for F-9, F-6AIB, F-2, F-15, F-16, Polysiloxane, heat;:resistance Al silicone)	ASTM D2485
Thermal shock resistance test (only for F-9, F-6, Polysiloxane)	ASTM D2485 - 91
Cathodic Disbondment Test	ASTM G42 @60 deg C

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- Each coating product to be qualified shall be identified by the following
  - An infrared scan (fingerprint), for Part A and B, each component as per ASTM D2621
  - Specific gravity of Base and curing agent (Ref. ISO 2811)
  - Ash content (ASTM 01650), volatile and non-volatile matters (ISO 3251) of each component
- The identification shall be carried out on the batch, which is used for the Pre-qualification testing. Pre-qualification of the products shall be carried out at an independent laboratory.
- Test shall be carried out at any one of the following laboratories and tests to be witnessed & certified by third party inspection agency (TUV, BY, DNV)
  - IICT, Hyderabad
  - HBTI, Kanpur
  - DMSRDE, Kanpur
  - BIS Laboratories
  - UICT, Matunga, Mumbai
  - UTES, Kolkata
  - PDIL, -Sindri
  - NTH, Kolkata
- Contractor shall furnish to Owner for approval / acceptance of all necessary documents / information including test certificates to prove that the paint manufacturers, from whom he intends to procure paint products, meet the various requirements for fulfilling the pre-qualification criteria as given above. The paint manufacturer shall be qualified and approved for supply after review / assessment of the submission made by the contractor.
- Contractor along with delivery of paint material has to furnish following information from paint manufacturer to Owner for acceptance / approval of products.
  - a) Batch test certificates (Batch Testing)
 

Contractor has to produce test certificate from paint manufacturer for each batch and for each category of product for the following test items. Test to be witnessed & certified by third party inspection agency. All test results must mention clearly the batch no. and category of product tested. Tests to be conducted for following properties:

    - Infrared scan for Part A and B, each component
    - Specific Gravity
    - % solids by weight (% zinc content in case of inorganic or organic zinc primer)
  - b) Product information sheet Technical data sheet for each category of product.



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## 20. **METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING**

(Pre-Qualification tests, Batch testing and Inspection testing)



Samples of coating materials should be submitted to the Govt. laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory. The sampling shall be certified and sealed by a certifying agency.

All test panels should be prepared by Govt. testing agency coloured photographs of test panels should be taken before and after the test and should be enclosed along with test report.





Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

Manufacturers should intimate the company, details of sample submitted for testing, name of Govt. testing agency, date, and contact personnel of the govt. testing agency. At the end of the test the manufacturer should submit the test reports to the company for approval.

Coating systems for panel test shall be decided after discussion with Owner.

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**JOB SUPPLY SPECIFICATION FOR  
3 LAYER POLYETHYLENE COATING  
(Fusion Bonded Epoxy and Polyethylene Tapes)**

			 Written By Karthikeyan Chokkalingam 2019.10.14 12:04:31 +05'30'	 Checked By Subramanian Anumugam 2019.10.14 12:09:35 +05'30'	 Approved By Vaidyasekharan V 2019.10.14 12:18:29 +05'30'	 Authorized By Munisichandhar 2019.10.15 21:09:47 +05'30'
A	14-OCT-2019	ISSUED FOR DESIGN	CK	AS	VV	JM
REV.	DATE	DESCRIPTION	PREPARED	CHECKED	APPROVED	AUTHORIZED

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## **APPENDIX 1**

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## 1. INTRODUCTION

**INDIAN OIL CORPORATION LIMITED (IOCL)** has awarded Fax of Acceptance (FOA) dated 29<sup>th</sup> August 2019 to M/s. Technip India Limited (TPIL) for Consultancy services (PMC/EPCM services) for overall project management, FEED Review / FEED, Detailed Engineering, Procurement & expediting services, Tendering & award, Construction Management & Supervision, Assistance in start-up, Commissioning & performance test runs for installation of a Standby SRU of 525 TPD capacity and execution of Additional tanks for Paradip Refinery, Odisha, India.

## 2. DEFINITIONS & ABBREVIATIONS

Abbreviation	Definition /Expanded form
IOCL/ CLIENT	Indian Oil Corporation Limited
PMC/ CONSULTANT	Technip India Limited
LICENSOR	Party selected by IOCL for process technology ownership for any UNIT
CONTRACTOR	Party whose services are obtained for performing the works specified as part of LSTK / packages.
EPCM	Engineering, Procurement & Construction Management Services.
LSTK	Lump Sum Turn Key portion of the work to be executed by CONTRACTOR
FEED	Front End Engineering Design
AUTHORISED REPRESENTATIVE	IOCL's/ CONSULTANT's representative authorized to act for and on behalf of them.
VENDOR	Any third party supplying the equipment/materials for setting up the Plant
PROJECT	Indicates Standby SRU and Additional tanks Project, Paradip Refinery
UNIT	Indicates any particular portion of the project to be built which can be Process related or Utilities/Offsites related
SRU	Sulphur Recovery Unit

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OISD	Oil Industry Safety Directorate
ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
P&ID	Piping and Instrumentation Diagram
A/G	Above Ground
U/G	Under Ground
B/L	Battery Limit
ISBL	Inside Battery Limit
EOT	Electrically-operated Overhead Travelling
MTO	Material Take Off

### 3. **SCOPE**

This Technical Specification covers the minimum requirements for surface preparation and the supply, application, inspection and testing of external anti-corrosion coating of pipes using 3 Layer Side Extruded Polyethylene coating (3LPE) conforming to DIN 30670, 2012 Edition, "Polyethylene coatings on steel pipes and fittings – Requirements and testing". The specification specifically relates to the plant application of 3LPE.

The VENDOR shall supply all materials, labour, equipment and plant necessary for the satisfactory completion of the Work under this Specification, including, but not limited to: -

- Taking receipt of bare line pipe from dockyard / rail / road (as the case may be) and its handling, loading and transport to the coating plant(s).
- Handling and storage of pipe before and after coating.
- Supply, handling, transport and storage of coating materials.
- Preheating and pre-cleaning of pipe prior to abrasive cleaning.

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- Surface preparation.
- Application, curing, inspection and repair of all external coatings.
- Handling, temporary storage and loading for transport of coated pipes.
- Supply of repair material and making good all coating damage caused by handling, loading and transport, off-loading and stockpiling.

Information to be supplied by the vendor as detailed in Appendix 1.

### 3.1 Scope of Work

The Schedule of Specific Requirements lists the specific quantity of pipe that shall be coated with the system detailed herein.

### 3.2 Design Information

The 3LPE coating shall consist of a three-layer coating system comprising: -

- A layer of fusion bonded epoxy (FBE).
- A layer of chemically modified polyethylene copolymer adhesive.
- A layer of medium-density UV stabilized polyethylene (MDPE).

The 3LPE external coating is the primary part of the corrosion protection system to be provided for a buried high-pressure pipeline. The corrosion protection system will be supplemented with a cathodic protection system to protect the Pipeline for the specified minimum design life with minimum maintenance.

The coating system is required to withstand transport, construction handling and installation in the trench without significant damage, and which, once installed, can withstand the stresses imposed on it by the soil and associated environment, for the required design life. An increased coating thickness will be applied to provide additional gouging and abrasion resistance at long Horizontal Directional Drills.

Bare line pipe may be supplied with a Bar Code label system for pipe identification and tracking purposes. The VENDOR shall obtain and/or utilize such equipment as necessary for the scanning, reading and writing of bar codes.