APPENDIX-V

TEST FOR EFFECT ON COMPRESSIVE STRENGTH BY ADDITION OF CPCIA

TEST PROCEDURE

Cast three concrete blocks of size 100mm x 100mm x 100mm each without and with CPCIA 1% (w/w) of cement or as recommended by the manufacturer, by casting the concrete of M20 grade as per Clause 6.2.3 of IS 9103.

The above casted blocks shall be demoulded after 24 hrs. These blocks shall be moist cured for 28 days. After completion of the curing period, the blocks of each type shall be tested for compressive strength in compression testing machine (Universal Tensile Machine) and data recorded.

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APPENDIX-VI

BRIEF OUTLINES OF ELECTROCHEMICAL POLARIZATION TEST CONDUCTED ON STEEL REBARS EMBEDDED IN CONCRETE (AS PER ASTM G 3)

TEST PROCEDURE

Cast three concrete cylinders, of size 75mm dia and 150mm length each without and with CPCIA 1% (w/w) of cement or as recommended by the manufacturer, by casting the concrete of M 20 grade as per Clause 6.2.3 of IS 9103, and placement of one cleaned rebar conforming to IS1786 of size 375mm length and 12mm dia (preferably cleaned by pickling in Hydrochloric acid 20% (v/v) approximately, till surface shines and washed in running water) in each block .

The above casted blocks shall be demoulded after 24 hrs. These blocks shall be moist cured for 28 days.

After completion of the curing period, the blocks shall be subjected for Polarization test for 20 days as per ASTM G-3 and observations recorded.

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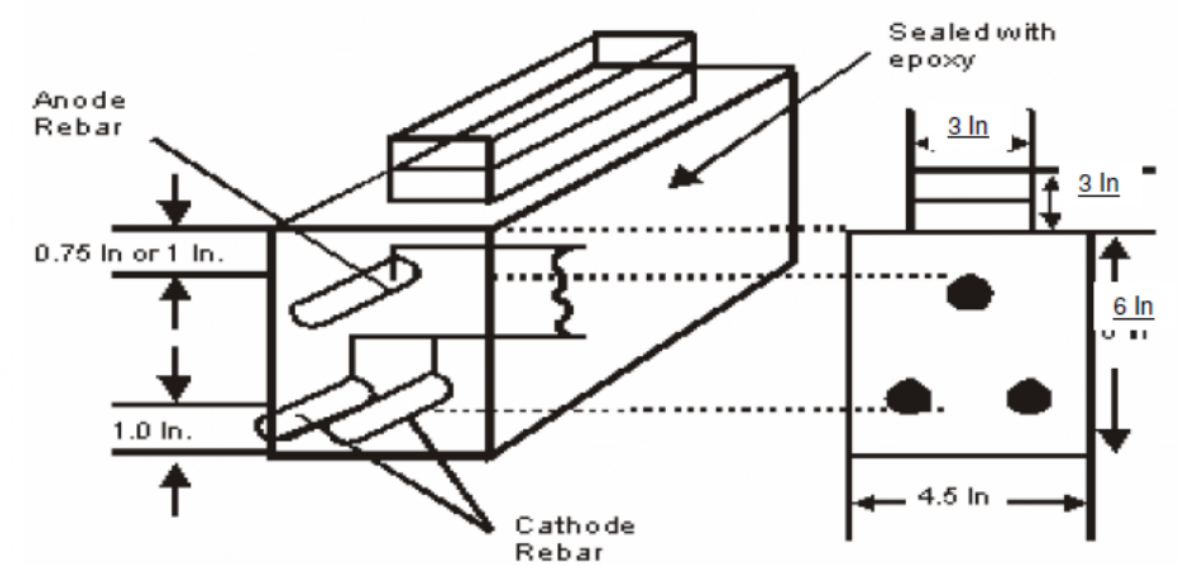
APPENDIX-VII

BRIEF OUTLINES OF LONG TERM CORROSION TEST (AS PER ASTM G 109)

TEST PROCEDURE

Three specimens each of control concrete and that of CPCIA admixed concrete (1% w/w of cement or as recommended by the manufacturer) should be cast as per the size 280mmx150mmx115mm and with placement of three cleaned reinforcement bars conforming to IS 1786 (preferably cleaned by picking in Hydrochloric acid 20% (v/v) approx, till surface shines and washed in running water) of size 12mm and length 375mm as per the details shown in the figure. Admixture shall be added as per manufacturers recommended dosage. All the casted concrete samples shall be moist cured for 28 days.

Ponding of samples with 3% NaCl solution as shown in the figure to be continued and measuring of voltage across 100-ohm resistor to be continued beginning of the second week of ponding. Calculate the current IJ from the measured voltage and record. Also measure the corrosion potential of the bars against reference electrode. The experiment should be continued till the macrocell current reaches a value of 10 µA. After the experiment break the specimens and examine the rebars for extent of corrosion, measure the corroded area and record.



Note - All Measurements in In. (25.4 mm = 1 In.)

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APPENDIX-VIII

BRIEF OUTLINES OF RESISTANCE OF CONCRETE TO MIGRATION OF CHLORIDE ION TEST (AS PER AASHTO T259)

Part-A : Chloride Ion Penetration (Salt Ponding Test As per IS 456)

TEST PROCEDURE

Cast three concrete blocks of size 300mmx300mmx75mm each without and with CPCIA 1% (w/w) or as recommended by the manufacturer, by using the concrete mix as under:

S.No.	Material	M30 (Kg)	M40 (Kg)
i)	53 Grade Cement	50	50
ii)	Coarse Sand	104	87
iii)	Aggregate, passes through 20 mm and retained on 10 mesh	160	134
iv)	Water (subject to 55±5 slump)	24	20
v)	CPCIA	0.5*	0.5*
	* as recommended by the manufacturer with each type of cement viz. Ordinary Portland Cement, Portland Pozzolana Cement, Portland Slag cement, Sulphate resisting Cement		

AASHTO T259 test (commonly referred to as the salt ponding test) is a long-term test for measuring the penetration of Chloride ions into concrete. Three slabs of 75 mm thick and having a surface area of 300 mm square shall be casted. These slabs are moist cured for 14 days and then stored in drying room at 50 percent relative humidity for 28 days. The sides of the slabs are sealed except for bottom and top face. After the conditioning period, a 3% NaCl solution is ponded on the top surface for 90 days, while the bottom face is left exposed to the drying environment (see figure below).

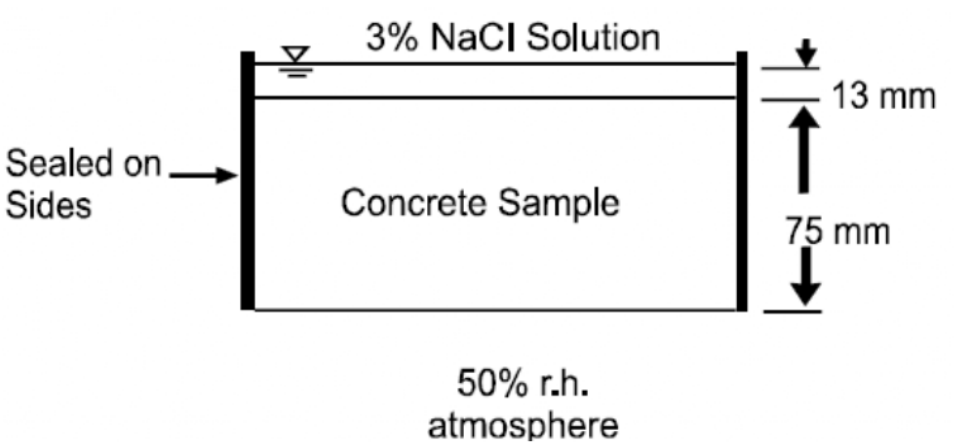

Figure: AASHTO T259 (Salt ponding) test setup

At the end of this time (90 days) the slabs are removed from the drying environment and the Chloride concentration of 10 mm thick slices is then determined (AASHTO T259). Two or three slices are taken at progressive depth. The salt ponding test does provide a crude one-dimensional chloride ion ingress profile. Test results should meet the requirements as stipulated in IS 456.

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BRIEF OUTLINES OF RESISTANCE OF CONCRETE TO MIGRATION OF CHLORIDE ION TEST (AS PER AASHTO T259)……Contd.

Part-B : Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration (Rapid Chloride Permeability test As per ASTM C-1202)

TEST PROCEDURE

Cast three concrete cylinders of size 50 mm thick, 100 mm diameter without and with CPCIA 1% (w/w) or as recommended by the manufacturer, by using the concrete mix as under:

S.No.	Material	M 30 (Kg)	M 40 (Kg)
i)	53 Grade Cement	50	50
ii)	Coarse Sand	104	87
iii)	Aggregate, passes through 20 mm and retained on 10 mesh	160	134
iv)	Water (subject to 55±5 slump)	24	20
v)	CPCIA	0.5*	0.5*
	* as recommended by the manufacturer with each type of cement viz. Ordinary Portland Cement, Portland Pozzolana Cement, Portland Slag cement, Sulphate resisting Cement		

As per ASTM C-1202, water-saturated concrete specimen is subjected to a 60 V applied DC voltage for 6 hrs. using the apparatus shown in Figure below. In one reservoir is a 3.0% NaCl solution and in the other reservoir is a 0.3 M NaOH solution. The total charge passed is determined and this is used to rate the concrete's resistance to chloride ion penetration.

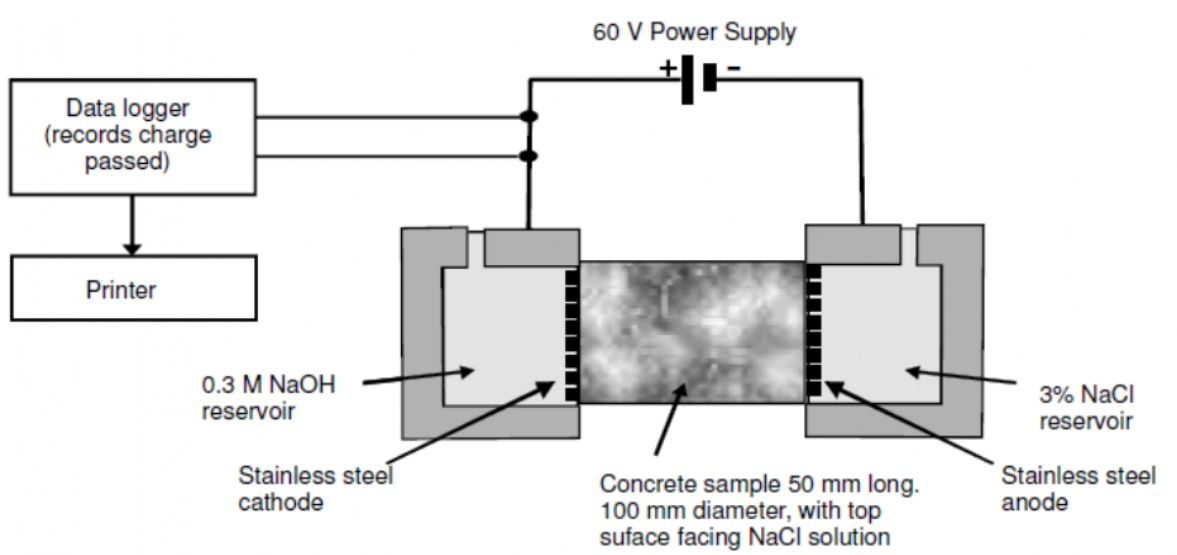

Figure: AASHTO T277 (ASTM C1202) test setup

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STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

इपोक्सी रेज़िन के इंजेक्शन की प्रणाली

EPOXY RESIN INJECTION SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
			Approved by			
5	21.12.20	REAFFIRMED &REISSUED AS STANDARD SPECIFICATION	AS	RBS	AS	SM
4	11.03.16	UPDATED & ISSUED AS STANDARD SPECIFICATION	MK	AJS	RS	S.CHANDA
3	05.04.10	REAFFIRMED & REISSUED AS STANDARD SPECIFICATION	AS	PKM	SCH	N. DUARI
2	10.01.05	REAFFIRMED & REISSUED AS STANDARD SPECIFICATION	PAPIA	RKB	AK	SKG
1	28.03.98	UPDATED & ISSUED AS STANDARD SPECIFICATION	RKB	SK PURI	SC JAIN	A. SONI

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Abbreviations:

RCC : Reinforced Cement Concrete

Structural Standards Committee:

Convener: Mr. Anurag Sinha

Members: Mr. C. Damodaran
Mr. VK Panwar
Mr. Samir Das
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Charanjeet Singh (Projects)
Mr. Ravindra Kumar (Construction)

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1.0 SCOPE

1.1 This specification defines the material, construction and other performance requirements for repair works of cracked RCC structures by epoxy injection method. Any special requirements as shown or noted on the drawings and directed by the Engineer-in-Charge shall govern over the provision of this specification. This specification is not applicable for repairing of corroded concrete structures.

1.2 The repair works shall be carried out in accordance with this specification together with the material manufacturer's specific requirements. In case of any conflict, this specification shall govern.

1.3 Before carrying out rectification works as per this specification, the reason for development of such cracks shall be thoroughly investigated and proper precautionary or strengthening measures, if required shall be completed to ensure that such cracks do not reappear under normal loading conditions. However, in cases where reasons for such cracks are attributable to poor workmanship and/or inadequate strength of concrete in the completed structure, repairing of cracks and strengthening of concrete shall be simultaneously taken up.

2.0 REFERENCES

Manufacturer's specifications

3.0 MATERIALS

3.1 Epoxy resin system used for jointing cracked concrete by injection process shall consist of a low viscous resin mixed with a hardener. Any crack which is still active and expected to further movement, shall be filled with a flexible resin system so as to accommodate such subsequent movements after repair.

3.2 The injection material shall be compatible with the concrete to which it is to be injected and shall have the following properties:

Compressive strength	80-90 N/mm^2
Tensile strength	60-65 N/mm^2
Elongation at break	2.5-3.0%
Elastic modules	3100-3300 N/mm^2
Adhesion to dry concrete	4.0-4.5 N/mm^2
Viscosity at 25^0C	for non-active crack=300 Centipoise (max.) for active crack=550 Centipoise (max.)
Adhesion to water saturated concrete (after six days immersion in water)	2.6 N/mm^2
Pot life at 25^0 C	30 minutes minimum
Viscosity of hardener at 25^0 C	5 Centipoise (max.)
Specific gravity	1.2 (maximum)

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3.3 The resin and hardener shall be mixed in the proportion as specified by the manufacturer. The preparation, mixing and application of the resin system shall strictly be in accordance with the manufacturer's recommendations.

3.4 The surface sealant shall be a resin system comprising of slightly viscous resin, a hardener and finely powdered filler material mixed in proportions as recommended by the manufacturer to achieve the following properties:

Useable life at 30 - 40 ^{0}C	25 minutes (minimum)
Compressive strength at 25^{0}C after 2 hours of application	25 N/mm^2
Tensile strength	12N/mm^2
Specific gravity	1.8 - 2.0
Consistency	Trowelable

3.5 Certificate of test results of all the materials from the reputed laboratories duly authenticated by the approved manufacturer(s) shall be submitted to Engineer-in-Charge and got approved by him in writing prior to commencement of work. In the event of failure to submit such test results from manufacturer for any material, the contractor shall carry out the tests from an approved laboratory and submit the test results including the name(s) of manufacturer(s) to the Engineer-in-Charge and got approved by him in writing prior to commencement of work.

4.0 SPECIAL REQUIREMENT

All repairing works covered by this specification shall be carried out by experienced and approved agency having sufficient knowledge in epoxy resin treatment works. Only skilled and experienced operators shall be employed for the purpose.

5.0 APPLICATION

5.1 Preparation of Concrete

Grease, oil, algae or any other substances likely to impair good bonding shall be thoroughly removed from the surface by scrubbing or using some detergent and clean water. All loose and spalling concrete pieces shall also be removed. The surface shall then be cleaned and dried with dry compressed air. In case the cracks are not too fine, they shall be washed with clean water jet first and then blowout with dry compressed air.

5.2 Fixing of Injection Nipples

5.2.1 In case the cracks are not too fine, a V-groove of 10-12mm depth shall be cut all along the line of crack with sharp and flat chisel and the surface cleaned with dry compressed air as described under para 4.1.1 above.

5.2.2 Injection nipples shall then be inserted in drilled holes along the line of cracks. The nipples shall extend about 10-12mm beyond the V-groove and fixed with epoxy putty (Surface sealant).

5.2.3 The V-groove shall then be sealed flush with epoxy surface sealant keeping the nipples in position. The nipples shall sufficiently project out of concrete surface so that the nozzle of injection gun can be properly fitted with them.

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5.2.4 In cases where the cracks are only on the surface and not deep inside the concrete, injection nipples with flange attachment shall be fixed on dry and clean surface with surface sealant ensuring a complete seal. The surface of the cracks between the nipples shall then be sealed with a band of surface sealant 30-40mm wide and 2-3mm thick.

5.2.5 Spacing of nipples shall generally be between 200-500mm. In cases where the cracks extend on both sides of beam or wall or slab, the nozzles shall be fitted as per procedure described above on both the surfaces in a staggered fashion and cracks sealed.

5.2.6 Every precaution shall be taken to keep the ends of the nipples in contact with concrete free from epoxy sealant so as to ensure proper injection of epoxy grout into the concrete without any resistance.

5.3 Injection of Epoxy Grout

5.3.1 After 24 hours of fixing the nipples and sealing the gaps, dry compressed air shall be blown through all the nipples in succession to ensure that the cracks are dust free.

5.3.2 The approved resin system shall be prepared strictly as per manufacturer's recommendation. Each crack shall be treated in a single, continuous operation and sufficient material shall be kept ready for such operation prior to the commencement of work.

5.3.3 Injection of resin system shall be done by means of suitable gun or pump. Grout injection shall be started only after minimum 24 hours of curing of the surface sealant at an ambient temperature of 25^0C-30^0C. At low ambient temperatures, more curing time for the sealant shall be allowed as per manufacturer's recommendation. The injection gun shall have suitable provision for entry of compressed air and fixing of pressure gauge. The nozzle of the gun shall properly match with the type of nipples provided to minimize loss of material and air pressure. The pressure in the gun shall be suitably adjusted depending upon the width and extent of the crack and viscosity of the system so as to ensure full and complete penetration of grout. A pressure of 3 to 7 kg/cm^2 is recommended. However, where pressure up to 1 kg/cm^2 is required, suitably modified spring loaded grease gun may be used. Specially fabricated lever arm type grout pump may be used for moderate pressures up to 3.0 kg/cm^2. However prior approval of the Engineer-in-Charge shall be obtained by the contractor regarding the method/ equipment to be used for pressure grouting.

5.3.4 For vertical cracks, injection shall be started from the lowest nipple keeping the nipple just above (i.e. the 2nd) open and all others temporarily plugged. Pumping shall be continued till the injected epoxy grout starts flowing out of the next higher nipple. The first nipple shall then be closed off and the third opened. Injection shall then be started in the second nipple and continued till the injected grout starts flowing out of the third. This process shall be repeated till the whole length of the crack is treated. Similar appropriate method shall be followed for cracks at other locations.

5.3.5 After finishing the injection operation and allowing the system to cure, the nipples shall be cut flush with the surface or removed. The left over grooves or holes or damaged areas shall be filled with the surface sealant putty and finished flush. The surface shall be made smooth and flush with the surrounding surfaces by rubbing with suitable sand paper.

5.3.6 All care shall be taken during injection of epoxy resin. In the event of any spillage of epoxy material, it shall be immediately removed and cleaned. Temporary protection to all installed machineries/ equipment shall be arranged to guard against any such spillage over them.

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5.4 Precautionary Measures

Only skilled and experienced workers shall be entrusted with the application of epoxy grouting. The resin and hardener shall not be allowed to come into direct contact with the skin. Rubber or polythene gloves with cotton gloves underneath must be worn by the workers handling resin products. Parts of skin which have accidentally come into contact with resin or hardener shall immediately be washed with lukewarm water and a mild soap. Special cleaning creams or chemicals shall be kept readily available and used as recommended by the manufacturer.

5.5 Cleaning and Maintenance of Equipments

Tools and mixing equipment shall be cleaned immediately after use by using scrapers and other solvents (e.g. Toluene, Xylene or Acetone) as recommended by the manufacturer.

6.0 APPROACH, WORKING PLATFORM & SCAFFOLDINGS

6.1 The contractor shall arrange all approaches, stair ways, ladders, working platforms etc. for carrying out the entire operation safely. The working area shall be neatly maintained and all facilities required by the Engineer-in-Charge for proper supervision of the work shall be provided.

6.2 All precautionary measures required for the safety of the structure during the progress of the grouting operation and till its successful completion and handling over shall be the responsibility of the contractor. He shall carry out all such measures as directed by the Engineer-in-Charge.

6.3 For all underground works, excavation, back filling, removal of surplus earth, keeping the pit dry by pumping/ bailing out subsoil water, shall be under the scope of this contract.

7.0 PAYMENT

7.1 Payment for execution of Epoxy Injection System shall be made per nozzle for the number of nozzles through which epoxy resin is injected (Epoxy resin system measured separately). The rate quoted shall be inclusive of all labour and materials required for the successful and satisfactory completion of the work including all cleaning operation before and after the work, preparation of surface and making of grooves, providing and applying sealing to the V-grooves with surface sealants, supply, installation, cutting and removal of nipples including plugging at the end of the work, providing required access, working platforms, props, scaffolding and other safety measures including their removal after completion, all plant and tools etc. complete.

7.2 Payment for the epoxy resin system shall be made by weight of actual material injected in the structure. The batching shall be made strictly depending on the pot life of the material and amount which can be injected within this period so as to minimise the wastage. The contractor shall properly assess the nature of the structure in determining the quantities to be mixed per batch. Any wastage shall be included in the rate quoted. The rate quoted shall also include all plants and tools required and all other necessary works as specified for satisfactory and successful completion of the work.

7.3 Any test specified (Rebound Hammer, Ultrasonic Pulse Velocity or Load test) and directed to establish the soundness and monolithicity of the rectified work shall be separately paid. If such tests as per above clause fail to meet the requirement of this specification, no such payment shall be made and the contractor shall repair/ rectify or re-do the work as directed by Engineer-in-Charge at no extra cost to the owner.

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7.4 Underground works like excavation, back filling, removal of surplus earth, keeping the pit dry by pumping/ bailing subsoil water shall be paid separately as per relevant item in the contract.

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STANDARD SPECIFICATION
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इपोक्सी रेजिन प्रणाली द्वारा नई कंक्रीट को पुरानी कंक्रीट से जोडना

BONDING FRESH CONCRETE TO OLD CONCRETE BY EPOXY RESIN BONDING SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	28.02.25	REVISED & REISSUED	RIJA	VIKRAM	AS	MN
4	28.01.20	REAFFIRMED & REISSUED	IQBAL	ALPANA	RS	RKT
3	21.08.14	REAFFIRMED & REISSUED	AJS	AS	PKM	SC
2	30.06.09	REAFFIRMED & REISSUED	AS	SCH	VINAY KUMAR	N.DUARI
1	16.06.99	REISSUED AS STANDARD SPECIFICATION	RPM	RS	SCJ	A. SONI

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Abbreviations:

ASTM	:	American Society for Testing & Materials

Structural Standards Committee

Convenor: Mr. Anurag Sinha

Members:
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Mr. Deepak Agrawal
Ms. Alpana Srivastava
Dr. Sudip Paul
Mr. Charanjit Singh (Projects)
Mr. Indrajit Neog (Construction)
Ms. Papia Mandal
Mr. Vikram Kumar Gupta

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1.0 SCOPE

1.1 This specification defines the material, constructional and other performance requirements for proper bonding of fresh concrete to old, hardened concrete by epoxy resin bonding system which is able to cure under humid conditions and bond to damp surfaces. Any special requirement as shown or noted on the drawings and directed by the Engineer-in-Charge shall govern over the provisions of this specification.

1.2 Actual working shall be carried out in accordance with this specification and recommendation of the manufacturer of the resin system to suit specific requirements for the particular site and other climatic conditions existing there. In case of any conflict, this specification shall govern.

2.0 MATERIALS

2.1 Epoxy resin system used for bonding fresh concrete to old hardened concrete shall consist of two components, viz. epoxy resin and hardener for combining immediately prior to use as per manufacturer's recommendations. Filler material shall be added, if required, as per manufacturer's specification. However, this shall be incorporated in any of the two components. The system shall cure under humid conditions and bond to damp surfaces.

2.2 The bonding material shall be compatible with the concrete to which it is to be applied and shall have the following minimum properties:

Compressive Yield Strength	55 N/mm^2 (7 days)
Tensile Strength	40 N/mm^2 (7 days)
Bond Strength	10 N/mm^2 (14 days)
Flexure Strength	35 N/mm^2 (7 days)
Shear Strength	10 N/mm^2 (7 days)
Pot Life	45 minutes
Full Cure	7 days at 20°C to 35°C
Overlaying Time (open time)	1 hour at 20°C to 35°C

2.3 The resin and hardener shall be mixed in the proportion as specified by the manufacturer. The preparation, mixing and application of the resin system shall strictly be in accordance with the manufacturer's recommendations.

2.4 Certificate of test results of all the materials from BIS/NABL recognised laboratories duly authenticated by the approved manufacturer(s) shall be submitted to Engineer-in-Charge and got approved by him in writing prior to commencement of work. In the event of failure to submit such test results from the manufacturer for any material, the contractor shall carry the tests from an approved laboratory and submit the test results including the name(s) of manufacturer(s) to the Engineer-in-Charge and get approved by him in writing prior to commencement of work. All tests shall be in accordance with ASTM C881M (Type V) in case of non-availability of any specific Indian Standard.

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2.5 Pot life and open time

Pot life is the period during which the resin system after mixing retains sufficient workability for proper use and the resin system must be applied to the prepared concrete surface within this period.

The 'open time' is the maximum period of time allowable between application of resin system and pouring of fresh concrete. Exceeding the 'open time' shall result in considerably reduced adhesion. The adhesive shall be applied to the prepared substrata as soon as the components have been mixed and fresh concrete shall be poured immediately before adhesive begins to gel. The bonding of fresh concrete to old concrete shall not to be done if the temperature is below 10°C.

3.0 SPECIAL REQUIREMENT

3.1 All works covered by this specification shall be carried out by experienced and approved agency having sufficient knowledge in epoxy resin treatment works. Only skilled and experienced operators shall be employed for the purpose.

4.0 APPLICATION

4.1 Preparation of Concrete Surface

4.1.1 Grease, oil, algae and other foreign substances likely to impair good bonding shall be thoroughly removed from the surface by scrubbing or using detergent and washing with clean water. All loose and spalling concrete pieces shall be removed. The surface to be bonded shall be made thoroughly rough by chiselling, taking off the skin of concrete and sharp edges of aggregate shall be exposed. The surface shall be washed, wetted cleaned and dried with dry compressed air. Exposed reinforcement shall be thoroughly cleaned with sand paper and wire brushes to remove all dust and sticking mortar.

4.2 Mixing

4.2.1 The resin and hardener shall be thoroughly mixed in a mixer. The approved resin system shall be prepared strictly as per manufacturer's recommendations. It shall not contain lumps and shall have uniform colour. Filler material shall be added if so specified by the manufacturer. Hand mixing shall be allowed for small quantity with prior permission of the Engineer-in-Charge.

4.3 Method of Application

4.3.1 The resin system shall be applied by spraying to the prepared surface. Manual application by using stiff nylon bristle brush may also be allowed with prior permission of the Engineer-in-Charge. The manufacturer shall specify the method of application suitable for the specified work.

4.4 Coverage

4.4.1 A minimum of half kilogram per square metre (½ kg/m^2) or resin system shall be applied to prepared concrete surface. However, the covering capacity depends on the nature of surface over which the system is being applied and the contractor shall use additional quantity of the resin system as per the recommendation of the manufacturer.

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4.5 Handling Precaution

4.5.1 Only skilled and experienced workers shall be entrusted with the application of epoxy system. The resin and hardener shall not be allowed to come into direct contact with the skin. Rubber or polythene gloves with cotton gloves underneath must be worn by the workers handling resin products. Parts of skin which have accidently come into contact with resin or hardener shall immediately be washed with lukewarm water and a mild soap. Special cleaning creams or chemical shall be kept readily available and used as recommended by the manufacturer.

4.6 Cleaning and Maintenance of Equipment

4.6.1 Tools and mixing equipment shall be cleaned immediately after use by using scrapers and other solvents (e.g. toluene, xylene or acetone) as recommended by the manufacturer.

5.0 APPROACH, WORKING PLATFORM & SCAFFOLDING

5.1 The contractor shall arrange all approaches, stairways, ladders, working platform etc. for carrying out the entire operation safely. The working area shall be neatly maintained and all facilities required by the Engineer-in-Charge for proper supervision of the work shall be provided by the contractor.

5.2 All precautionary measures required for the safety of the structure during the progress of operation and till the successful completion and handing over shall be the responsibility of contractor. He shall carry out all such measures as directed by Engineer-in-Charge.

6.0 PAYMENT (applicable to item rate tenders only)

6.1 Payment shall be made by weight of resin system actually used in the work.

6.2 The rate quoted shall be inclusive of all labour and materials required for the successful completion of the work including all cleaning operation before and after the work, preparation of the old, hardened concrete surface as specified, mixing, application of epoxy resin and other safety measures including their removal after completion, all plants and tools etc. complete. Rate shall also be inclusive of all tests required to check the specific properties of materials.

6.3 Any test specified and directed to establish the soundness and monolithicity of bonding of fresh concrete to old concrete actually executed shall be paid separately unless such tests fail to meet the requirements of this specification. In case of failure, no such payment shall be made and the contractor shall repair/ rectify or re-do the work as directed by Engineer-in-Charge at no extra cost to the owner.

6.4 Underground work like excavation, backfilling, removal of surplus earth, keeping the pit dry by pumping/ bailing out subsoil water shall be paid separately as per relevant item in the contract.

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STANDARD SPECIFICATION
CIVIL & STRUCTURAL WORKS

पाडं का डिजाईन
(आर सी सी वीम एवं स्लैब के लिए)

DESIGN OF SCAFFOLDING
(FOR RCC BEAM AND SLAB)

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	02-09-2024	REVISED & ISSUED AS SPECIFICATION	AH	AH	AS	MN
1	27.08.2018	REVISED & ISSUED AS SPECIFICATION	MA	AS	RS	RKT
0	27.03.2012	ISSUED AS SPECIFICATION	AH	PJS	SC	DM

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Abbreviations:

C/C	:	Centre to centre distance
IS	:	Indian Standards
NB	:	Nominal bore
RCC	:	Reinforced Cement Concrete
RCM	:	Resident Construction Manager/ Site-in-Charge

Structural Standards Committee

Convenor: **Mr. Anurag Sinha**

Members:
Mr Virender Goel
Mr Sambhu Charan Maity
Mr Deepak Agrawal
Ms Alpana Srivastava
Dr Sudip Paul
Mr Prasenjit Saha *
Mr Charanjit Singh
Mr Ravindra Kumar

*** For Fireproofing Specifications**

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1.0 SCOPE OF WORK

Purpose of this document is to provide guideline for design of steel scaffolding and staging generally used for supporting the members of formwork system for construction of RCC slab and beams. This document consists of:

a) Guidelines for design of steel scaffolding (Props/ Staging)
b) One set of schematic drawing of scaffolding

Contractor has to design the scaffolding arrangement to facilitate the construction. Structural design should be as per section 11 of IS 800 i.e. working stress design method. Design shall meet the specific requirement as mentioned in this document. Contractor has to submit the design calculation to EIL site office for review. However, in case to case basis, RCM/Site-in-Charge (From EIL) may refer the submitted document to EIL design office.

Contractor may follow attached arrangement drawing for scaffolding. In such case, submission of design shall be as per direction of RCM/ Site-in-Charge.

2.0 REFERENCES

2.1 Codes

IS 226 : Specification for structural steel (Standard Quality).
IS 800 : Code of practice for general construction in steel
IS 806 : Code of practice for use of steel tubes in general building construction
IS 2750 : Specification for steel scaffoldings
IS 4014 (Part I and Part II) : Code of practice for steel tubular scaffolding
IS 14687 : Falsework for concrete structure-Guidelines

2.2 EIL Specifications

6-68-0001 : General Scope
6-68-0002 : Materials

3.0 MATERIAL FOR SCAFFOLDING

Steel tubes sections of NB40 conforming to requirement specified in clause No.4.1 of IS 2750 shall be used as vertical members and bracing. Standard available IS rolled section/ prefabricated frames (like ACROSPAN or equivalent) shall be used as staging supporting arrangement. Prefabricated frame should conform to requirement as specified in clause No. 7.4 of IS 2750. Material properties of steel sections shall conform to IS 226.

Base plate as indicated in drawing may be used under vertical member. Equivalent alternative arrangement to suit at site may be adopted. Base plate and adjustable base plate arrangement shall conform to requirement specified in clause No. 7.3.11 and 7.3.12 of IS 2750.

4.0 GENERAL ARRANGEMENT

Preferably vertical supporting arrangement shall consist of towers as indicated in the attached drawing (Refer Annexure-I).

Single vertical pipes used as props may be alternative arrangement. Spacing of such props shall be based on design. In no case such spacing shall exceed 1.6 m. All vertical props shall be tied laterally with adjacent members in two orthogonal horizontal directions. C/C distance of such lateral tie member in vertical direction shall not exceed 1.6 m.

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At least one bay in such case shall be braced by inclined member. Intention to use this member is to form triangulation, so that lateral force can be safely transferred to base. Inclination of this bracing members with horizontal plane must be >30° but <55°. Bracing shall be installed along with progress of formwork to ensure strength and stability at every stage of progress.

Base under vertical support shall be rigid enough to cause uniform pressure distribution. In order to achieve that objective either base plate as shown in drawing or alternative arrangement to suit at site shall be adopted.

5.0 CONNECTIONS & FITTINGS

Connections to be used for height adjustment purpose (marked as adjustable parts in drawing), shall be pin/bolted type connection. Alternate arrangement which shall capable to provide mechanical locking type may also be adopted.

In case of alternative arrangement designed/purchased by contractor, steel Fitting (coupler, joint pin, and putlog etc.) shall conform the requirement mentioned in clause No. 7.3.1 to 7.3.10 and clause No. 4.2 of IS 2750.

6.0 DESIGN CONSIDERATION

6.1 Loads

In addition to clause No. 7.3 of IS 14687 loads and combination of loads as mentioned hereunder shall strictly be followed.

6.1.1 Dead Load

It includes self weight of formwork, and any ancillary temporary work connected or supported by formwork. Additional weight of fitting shall be included in the self weight calculation.

6.1.2 Imposed Load

Load during constructional operation shall constitute the imposed loads. Such load may occur due to construction person, plants and equipments, vibration and impacts of machine delivering concrete, concentrated load, storage of construction materials and unsymmetrical placement of concrete. In no case it shall be considered less than 2 KN/m^2.

Load due to wet concrete shall be included under imposed load. Unit weight of wet concrete shall be considered as 26 KN/m^2 for load calculation purpose. Concrete should not be dropped from a free height greater than 1.1 m, nor should be allowed to accumulate on the formwork to a height more than three times the thickness of the slab, with a limit in area of 1 m^2. For any such situation if it be necessary to exceed these limitations, allowances for the additional loading should be considered in design. Accumulation of fresh concrete during construction shall be allowed only at pre planned locations.

6.1.3 Environmental Load

These loads include Wind load, Earthquake load and Snow load. Load shall be calculated as per relevant code (IS: 875/IS: 1893). Lateral force due to wind or seismic force shall subject to a minimum horizontal load amounts to 3% of vertical load. Shrinkage and early thermal movements in the freshly placed concrete should be assessed and accommodated in the design of formwork.

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Where supports cannot be fixed vertically due to any reason, the eccentricity of the loading so carried should also be taken into account as per clause No. 5.1.2 of IS 2750.

Design criteria as written in clause No. 5.1 to clause No. 5.2 of IS 2750 shall also be followed in addition to this clause.

6.2 Permissible stress

Permissible stresses shall be as per IS 800 in case of rolled section or IS 806 for tubular section. Bending and shear stress shall be checked for DL and combined action of DL, LL and environmental loads at all critical sections. In case of reusable components of steel, timber, etc, the values of permissible stresses shall be suitably reduced depending upon the number of uses and extent of deterioration as per guideline stipulated in clause No. 7.4.4 of IS 14687. Bearing Pressure on soil under base plate/ base shall not exceed 50 KN/m^2.

6.3 Deflection

In addition to deflection limit stipulated in clause No. 7.5 of IS 14687, vertical deflection (of members marked as ISMB150 or ISMC75 in drawing) should be limited to 12 mm or L/300, whichever is less (where L is the span length of the staging member).

7.0 MANUFACTURER CERTIFICATE

Manufacturer certificate with respect to steel tubes, fittings and prefabricated frames whenever asked by RCM/ Site- in- Charge shall be submitted as per guideline stipulated in clause No. 6 of IS 2750.

8.0 SAFETY PRECAUTIONS

Safety provisions should be considered as per clause No. 9.1 of IS 14687

9.0 REUSE AND MAINTENANCE OF SCAFFOLDING

Scaffolding which are to be reused shall be carefully cleaned and properly repaired between uses. Concrete or mortar film sticking to the form or the joining surface shall be completely removed after each use.

Formwork material shall be properly stored. The component shall be cleaned and painted periodically.

Threaded parts shall be oiled greased after thorough clearing and removal of dirt or slurry. Free movement of the telescopic components shall be ensured by periodic cleaning/oiling.

10.0 CHECKING OF SCAFFOLDING DURING CONSTRUCTION WORK

Formal checking as per clause No. 9.8 of IS 14687 should be exercised at site before and during concreting work. A filled watcher report as applicable to this specification as per Appendix-C of IS 14687 should be submitted by the contractor.

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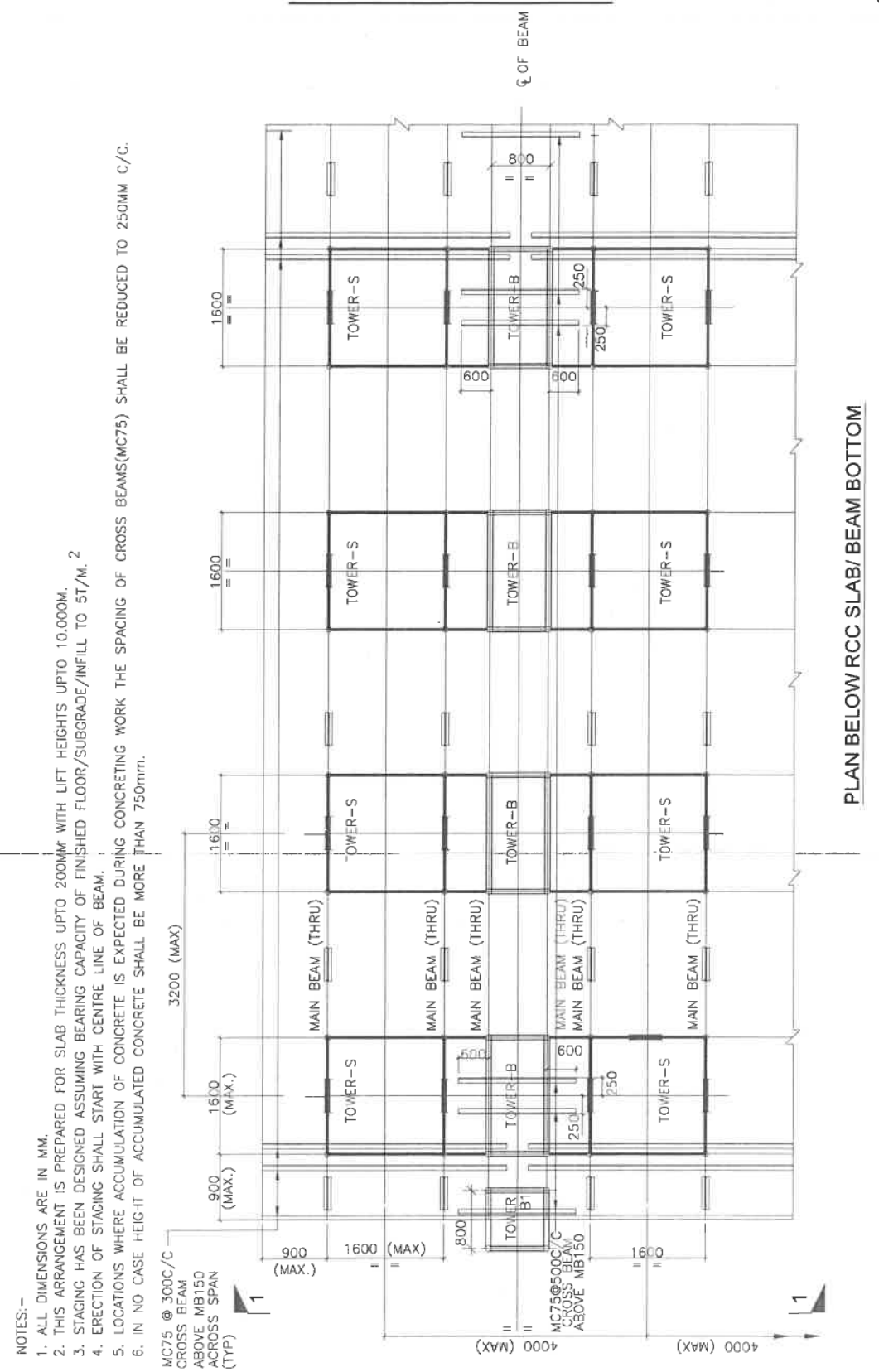
DETAILS OF SCAFFOLDING

ANNEXURE-I (Sh.1of 5)



NOTES:-

1. ALL DIMENSIONS ARE IN MM.
2. THIS ARRANGEMENT IS PREPARED FOR SLAB THICKNESS UPTO 200MM WITH LIFT HEIGHTS UPTO 10.000M.
3. STAGING HAS BEEN DESIGNED ASSUMING BEARING CAPACITY OF FINISHED FLOOR/SUBGRADE/INFILL TO 5T/M.^{2}
4. ERECTION OF STAGING SHALL START WITH CENTRE LINE OF BEAM.
5. LOCATIONS WHERE ACCUMULATION OF CONCRETE IS EXPECTED DURING CONCRETING WORK THE SPACING OF CROSS BEAMS(MC75) SHALL BE REDUCED TO 250MM C/C.
6. IN NO CASE HEIGHT OF ACCUMULATED CONCRETE SHALL BE MORE THAN 750mm.

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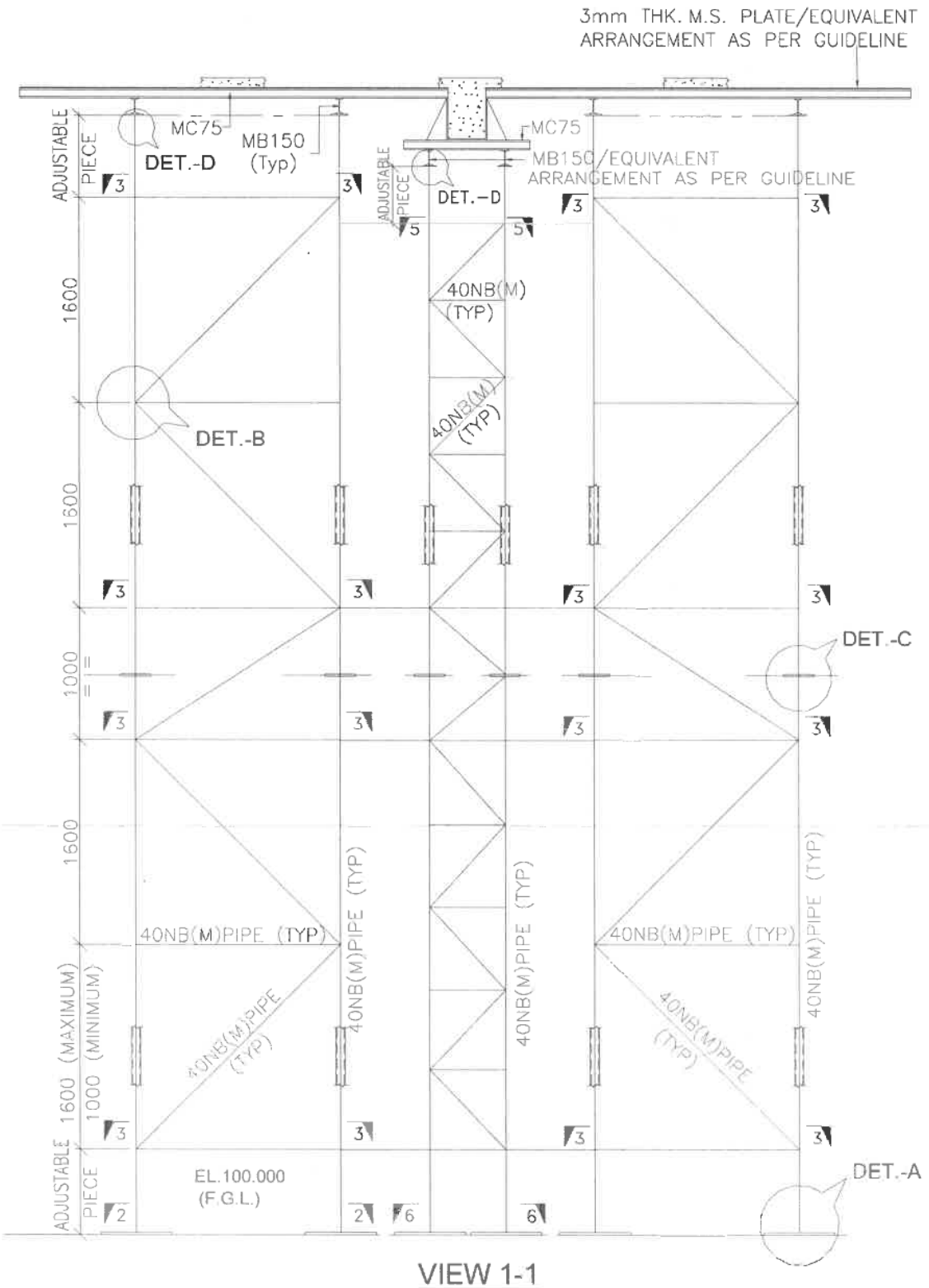
ANNEXURE-I (Sh.2 of 5)



VIEW 1-1

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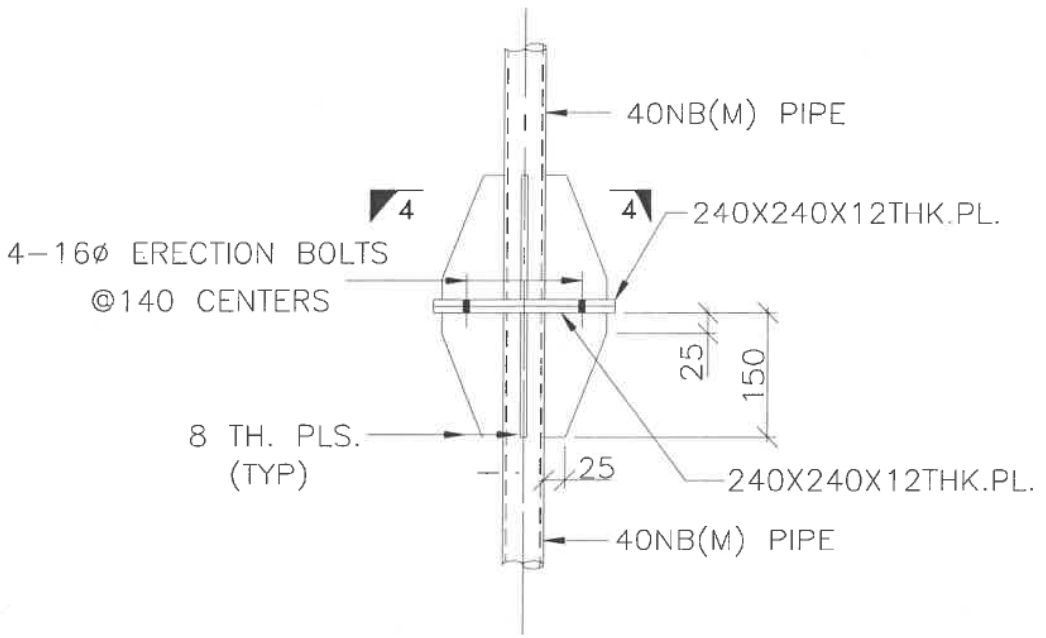
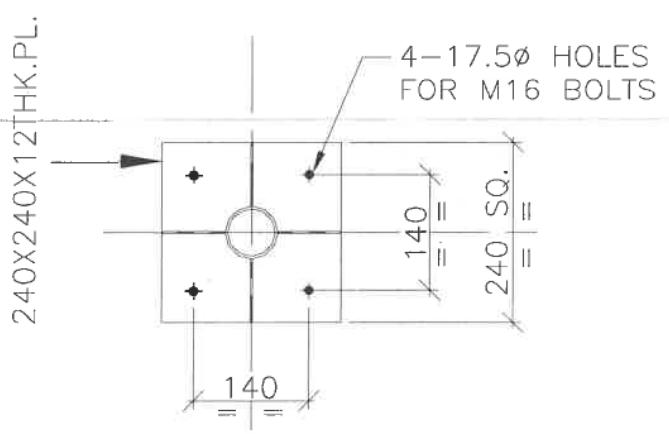
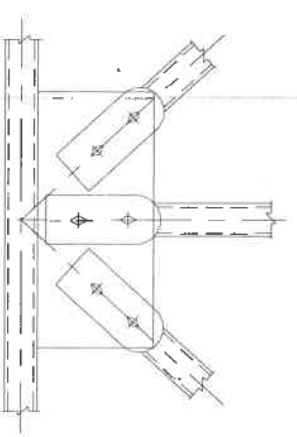
ANNEXURE-I (Sh.3 of 5)



DETAIL-C



VIEW 4-4



DETAIL-B

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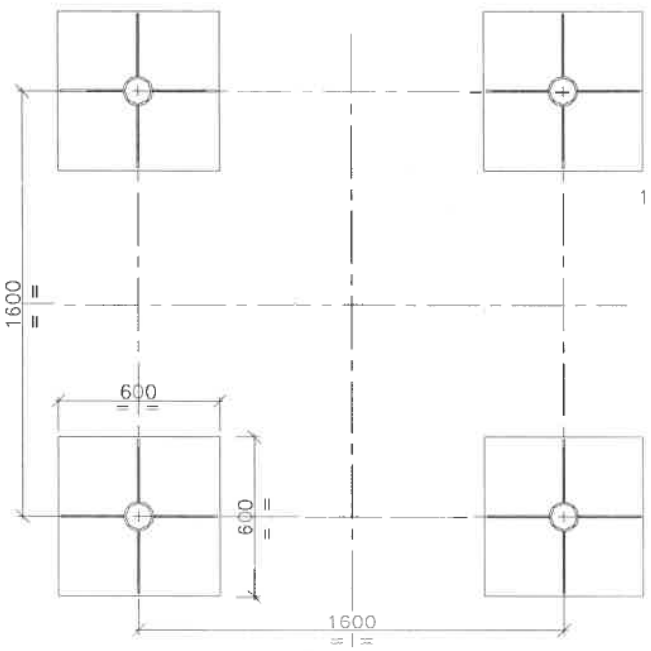
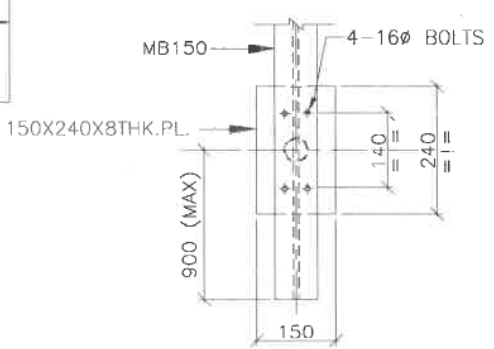
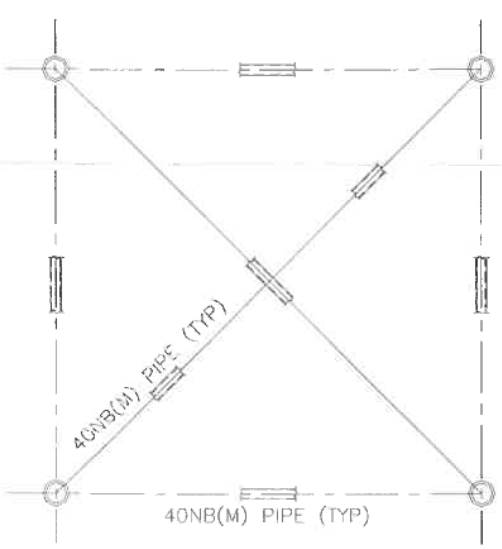
ANNEXURE-I (Sh.4 of 5)



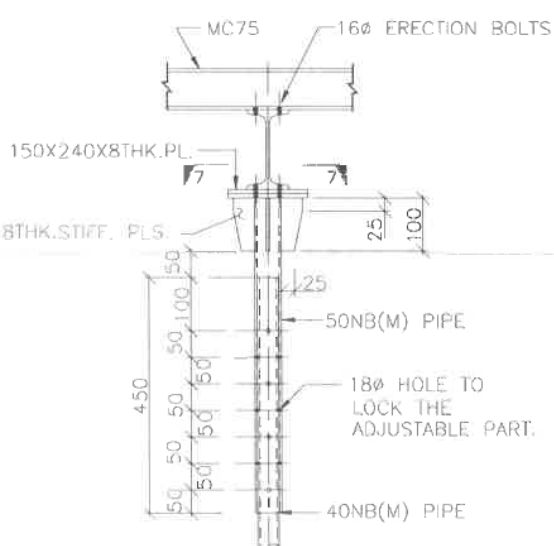
VIEW 2-2
PLAN OF BASE PLATE



VIEW 7-7



VIEW 3-3



DETAIL-D
SIMILAR FOR TOWER-S, B & B1

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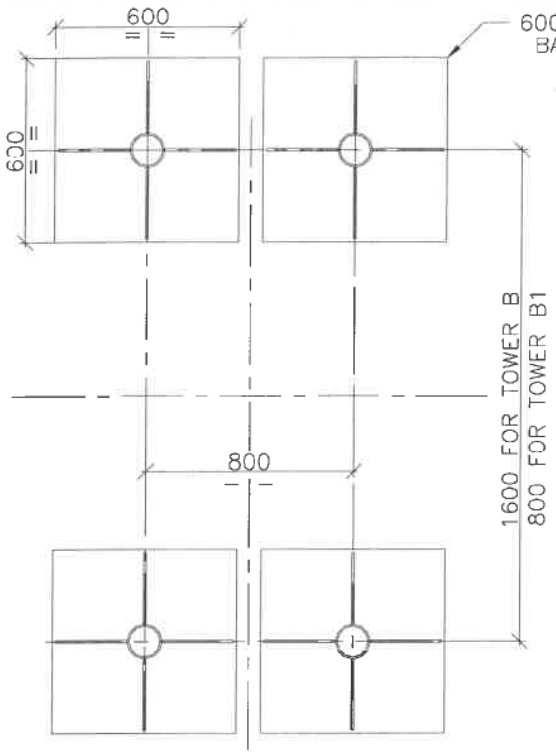
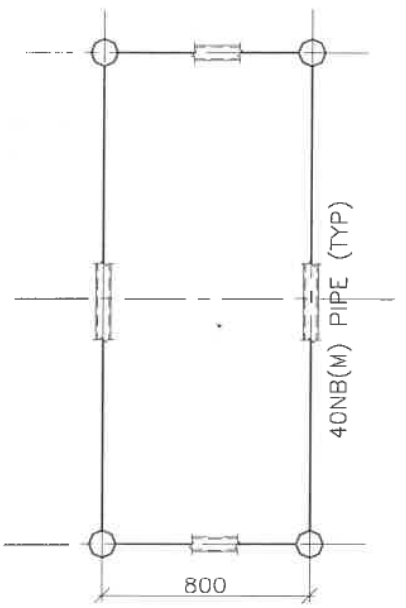
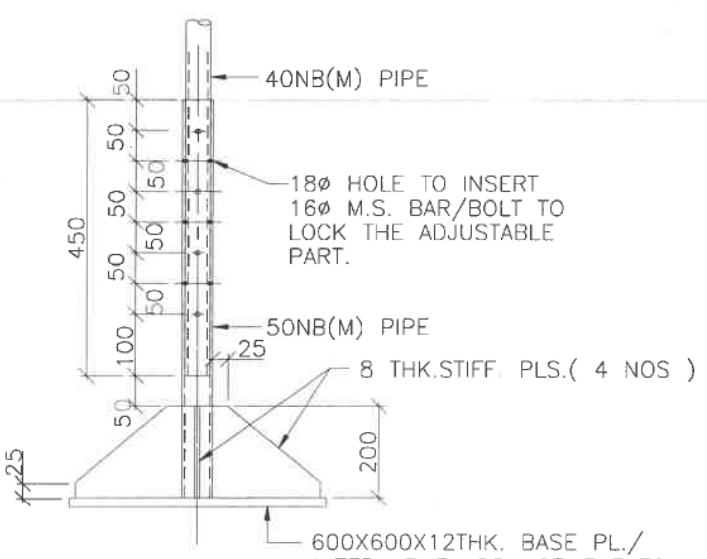
ANNEXURE-I (Sh.5 of 5)



VIEW 6-6
FOR TOWER B & B1



VIEW 5-5
FOR TOWER B & B1



DETAIL-A
SIMILAR FOR TOWER-S, B & B1

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उपस्कर एवं यंत्रों की स्थापना हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR ERECTION OF EQUIPMENT & MACHINERY

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	30.03.2019	Reaffirmed & Reissued	RJ	MI	RP	RKT
3	21.01.2013	Revised & Reissued	MA	RS	VK	DM
2	03.09.2008	Revised & Reissued	DM	PKR	AA	VC
1	30.05.2008	Revised & Reissued	DM	PKR	AA	VC
0	25.04.2001	Issued as Standard Specification	DM	AM	MR	MI

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Abbreviations:

ASME	:	American Society of Mechanical Engineers
EC	:	Erection Contractor
EIC	:	Engineer-in-charge
ELCB	:	Earth Leakage Circuit Breaker
GAD	:	General Arrangement Drawing
IS	:	Indian Standard
NDT	:	Non Destructive Testing
SS	:	Stainless Steel

General Engineering Standards Committee

Convenor : Ms R Priyamvada

Members : Mr BR Bhogal (Elect.)
Mr Rajan Srivastava (Strl.)
Mr RB Bhutda (EWS)
Mr Amrendra Kumar (Piping)
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Mr Amit Prakash (FEM)
Mr KJ Harinarayanan (SME)
Mr VK Tonger (Process-1)
Mr Satyabrata Biswas (Process-2)

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1.0 SPECIFICATION FOR ERECTION OF EQUIPMENT AND MACHINERY

1.1 Scope

This specification covers technical requirements for erection of all static and rotating equipment by erection contractor at site. This specification is applicable for all the erection tenders operated by EIL.

1.2 General

1.2.1 All necessary handling equipments, tools, tackles and precision instruments for carrying out the works as specified shall be provided by the Erection Contractor (EC) at his cost. EC must provide all tools and gauges for erection and alignment. Special tools, if any, received as part of machinery, will be given to EC for erection purposes, which shall be returned in good condition after use. Suitable deductions will be made by the Engineer-in-Charge (EIC) in case of loss or damage of the special tools. The value of such loss or damage will be decided by the EIC and EC shall be bound by such a decision.

1.2.2 Equipment Manufacturer's recommendations regarding preservation during storage at site and detailed specifications for the installation alongwith layout drawings, general arrangement/equipment outline drawings and sub-assembly drawings of the various equipment and machinery will be provided to EC during the performance of work. The requirements stipulated in these shall be fulfilled by EC in addition to what is stated in this specification. Erection shall be carried out as per the instructions and supervision of Machinery manufacturer's representative, wherever such supervisory services are applicable.

1.2.3 All the items of work covered in the tender shall be carried out as per this Specification and other details to be furnished to EC. However, EIC reserves the right to give additional/alternative specifications and instructions, at any time, for execution of any particular work and EC shall execute such works in accordance with such additional/alternative specifications and instructions of the EIC. Such a step taken by the EIC shall not constitute a breach of the contract.

1.3 Preparation for Erection

1.3.1 EC shall be responsible for organising the lifting of the equipment in the proper sequence, so that orderly progress of the work is ensured and access routes for erecting the other equipment are kept open.

Rigging procedure for all the major lifts (above 10 MT) and at maximum crane capacity shall be submitted by EC for the approval of EIC. However, approval to rigging procedure proposed by EC shall not relieve EC from his responsibility in following the proper lifting/erection methods on ensuring orderly.

1.3.2 Orientation of all foundations, elevations, length and disposition of anchor bolts and diameter of holes in the supports saddles shall be checked by EC, well in advance. Minor rectifications including chipping of foundations as the case may be, shall be carried out by EC after obtaining prior approval of EIC. EC shall also be provided with the necessary structural drawings and piping layouts etc. wherever required for reference. EC shall crosscheck such piping and structural drawings with actual construction at site and in case of any mismatch inform the EIC before taking up the erection.

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1.3.3 During the performance of the work, EC shall keep structures, materials or equipments adequately braced by guys, struts or otherwise approved means which shall be supplied and installed by EC as required till the installation work is satisfactorily completed. Such guys, shoring, bracing, strutting, planking supports etc. shall not interfere with the work of other agencies and shall not damage or cause distortion to other works executed by him or other agencies.

2.0 ERECTION OF COLUMNS, TANKS, VESSELS AND DRUMS ETC.

2.1 Scope of work of Erection Contractor

(a) Preparation of erection scheme and rigging procedure and obtaining its approval from EIC wherever necessary.

(b) Withdrawal of equipments from Owner's storage point, checking and reporting its conditions, transporting the same to EC's stores of work site including unloading etc.

(c) Erection on foundations furnished by Owner including aligning, levelling and grouting.

(d) Assembly and fixing of demisters, grids, internal distributors and other internal fittings in Columns, Vessels etc.

(e) Filling of Columns, Reactors, Vessels/ Drums etc. with Raschig rings, supporting elements, sand, concrete etc. as required.

(f) Welding of washers for equipments, erection of pipe davit & minor welding of their parts as per specifications and instruction of EIC.

(g) Assembly & erection of Agitator (Mixer) along with drive unit (Motor) including all accessories for vessels/drums/reactors (wherever indicated) as per specification drawings & instructions of EIC.

(h) Flushing, cleaning and drying of Columns, Vessels/Drums etc.

(i) Completing the equipments in all respects for commissioning the plant as per drawings, specifications & instructions of EIC.

(j) Any modification in the erected Columns, Reactors, Vessels/Drums to the complete satisfaction of EIC.

2.2 General Conditions of Erection

2.2.1 Unless otherwise specified Columns, Vessels, Drums etc. will be generally supplied to the Erection Contractor in single piece and EC will not be required to carry out any assembly or welding. In case column is supplied in multiple pieces and erection of the equipment is not possible in single piece, EC shall be responsible for lifting the pieces, for aligning, welding and hydrotest etc. in vertical position under the supervision of column Supplier (Fabricator). However, EIC shall be responsible for coordination between Erection Contractor & Fabricator. The schedule of quantities (SOQ) for equipment erection enclosed with the tender document outlines details of each equipment such as diameter, overall height, type of support (saddle/skirt/leg/bracket), position (horizontal or vertical) and approximate erection weight etc. However the erection elevation and location of equipment shall be as per the piping layout drawing enclosed with the tender.

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2.2.2 Rigging procedures and erection schemes for all the heavy lifts weighing 10 MT & above shall be prepared by EC and got approved by EIC. Approval by EIC shall not relieve EC of his responsibilities. The details to be submitted will include the location of equipment from where it will be lifted, location of crane(s), details of crane(s) (like configuration, boom length, operating radius, boom point elevation, clearance underside the boom and the equipment, lifting capacity, counter weights to be deployed, holds on any neighbouring foundations, structures, equipments etc.), the load chart of the crane(s), design of the lifting tackles like spreader beam, D-shackles, wire rope slings etc. Unless the erection scheme and rigging procedures are approved by EIC, erection of such equipments shall not be undertaken in any case by EC.

2.2.3 Before starting the erection of Columns, Vessels etc., top surface of the foundations is to be cleared/chipped, roughened to obtain proper bond, while grouting. Also the sleeves are to be cleaned before erecting the equipments. Line (orientation) and levels are to be marked on all the foundations to facilitate checking of alignment.

EC shall also check the correct elevation and orientation of civil, structural foundations, before proceeding with the erection work. Discrepancy, if any, shall be brought to the notice of EIC. However, minor rectifications and chipping of foundations upto a thickness of 15 mm in foundation height shall be carried out at no extra cost, by the EC. EC shall be responsible for supply of levelling plates, (if required) and shall carry out levelling of equipment under the directions of EIC.

2.2.4 While handling, transporting or erecting the equipments, care shall be taken not to damage the nozzles, instrument connections, structural clips etc. EC shall also take care of the orientation of the nozzles and other connections of the equipments while erecting the same and ensure compliance with the drawings and specifications supplied. Discrepancy, if any, in the number/orientation of the nozzles, cleats etc. should be brought to the notice of the EIC before actual erection is started.

2.2.5 Verticality of the Columns, Reactors/Vessels shall be checked with theodolites. After erection the equipment shall be levelled and properly aligned with necessary shims and wedges supplied by EC, at his cost. After the level, alignment and verticality etc. are checked and approved by EIC, EC shall carry out grouting.

2.2.6 EC shall produce recent test certificates of the slings which they will be using for erection work. However, retesting of the slings shall be done at site by EC at his cost, as and when required by EIC. The weights of test loads shall be as per IS-807. The test loads shall be supplied by EC at his cost. Tested slings will be punched for test loads and date of testing as directed by EIC.

2.2.7 EC shall also carry out the assembly, erection, levelling and alignment of all types of weir plates, baffles, distributors, collectors, spray nozzles, demisters, grids and other internal fittings etc. Work shall be carried out as per manufacturer's standards/specifications which shall be made available to EC at the time of erection. Raschig rings, molecular sieves, intalax saddles packing and other types of tower packings such as sand, catalyst etc. and SS wire mesh shall be loaded into sections of Vessels, Columns as per specifications and drawings. Details for internals to be installed by EC shall be as per separate schedule of quantities enclosed with the tender document. All packings except clay and lime stone shall be washed with water before filling. Bottom layers, if required, shall be arranged as directed and random filling shall be done afterwards with equipment filled with water. Installation of packings, shall be done only after flushing and cleaning of Columns/Vessels and completed to the satisfaction of EIC.

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2.2.8 EC shall carry out minor welding for attachment of prefabricated pipe davit parts such as rain covers, handles etc. with pipe davit, during or after erection of the same as per the manufacturer's specifications, at no extra cost to the Owner.

2.2.9 EC shall execute erection of wooden pillow for saddle support for cold horizontal vessels wherever necessary as indicated on the drawings/ EIL STD 7-12-0003 and as per the instructions of EIC.

2.2.10 EC shall execute assembly & erection of agitator/mixer along with drive unit including all accessories as per supplier's instructions, specification drawings & instructions of EIC.

2.3 Flushing & Cleaning of Columns, Vessels, Drums etc.

2.3.1 After the erection, alignment and grouting of these equipments are complete, flushing and cleaning shall be carried out by EC as per specifications and instructions of EIC.

2.3.2 After flushing, cleaning and draining, equipments shall be dried by compressed air at the pressure and for duration decided by the EIC. The Vessel interior shall be thoroughly inspected to the complete satisfaction of EIC before it is finally boxed up. Boxing up of manholes and handholes shall be leak proof. All joints which need remaking, shall be remade. Compressed air for drying shall be arranged by EC.

2.4 Inspection and Acceptance Limits for Level and Alignment

2.4.1 Co-ordinates of foundations/supporting structures/mounting holes etc. shall be checked with respect to the plot plans by EC.

2.4.2 Before equipments are placed on foundations, orientations shall be checked with respect to piping drawings.

2.4.3 When equipments are firmly bolted down but prior to grouting, verticality of all the Columns, vertical vessels etc. shall be checked by using theodolite. Tolerances for equipment after erection shall be as per EIL Standard 7-12-0001. The allowable deviation from plumb line shall be 1 mm per metre height, subject to maximum of 15 mm unless otherwise stated on the drawings.

2.4.4 Horizontal Vessels shall be checked for level across machined face of nozzle flanges with precision level.

2.5 Additional requirements for Underground buried vessels

2.5.1 **Underground vessels for operating temp upto 60°C**

The vessels shall be supplied at site with one coat of inorganic zinc silicate primer duly applied on its external surfaces as per Spec. 6-79-0020. All other works such as application of coaltar enamel, as per EIL Spec. 6-79-0020 and wrapping and coating as per EIL Spec. 6-79-0011 shall be carried out by EC. This shall include necessary materials, tools and tackles to complete the Job in all respect as per the instructions of EIC.

2.5.2 **Underground Vessels for operating temp. Above 60°C and upto 300°C**

The vessels shall be supplied at site with one coat of inorganic zinc silicate primer as per Spec. 6-79-0020 duly applied on its external surfaces. EC shall be required to carryout touch-up and repair of outside primer before erection of equipment.

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2.5.3 EC shall do the necessary excavation, backfilling and removal of surplus earth at the site as per the directions of the EIC. EC's rate shall include the excavation, blast cleaning, painting, wrapping by kraft paper, placing and fixing of Vessels, backfilling and removal of excess earth.

3.0 ERECTION OF MECHANICAL EQUIPMENT

3.1 Scope of Work of Erection Contractor

The scope of EC shall consist of withdrawal and transportation of equipments and accessories from Owner's stores to site, assembly of loose supplied components/parts erection of equipment on foundations, levelling, aligning and grouting, preparation of equipments for trial runs and hand over in fit condition for the start up of the plant as per instructions of EIC.

3.2 Details of Owner Supplied Equipments

Equipments to be erected shall be supplied by the owner. Equipments may be supplied in any of the following conditions.

- Single equipment such as filter, static mixer, silencer etc.
- Skid mounted equipment, fully assembled.
- Skid mounted equipment with some items supplied loose or as subassemblies involving interconnections also.
- System comprising of many equipments, skids with interconnected piping & hook up.

3.3 Technical Requirements

3.3.1 All equipment/machinery erection shall be done by experienced fitters. For this purpose EC shall employ an experienced erection supervisor and crew who have done similar jobs.

3.3.2 EC shall study the layout drawings, for the machineries and equipments with their auxiliaries, controls defining scope of supply.

3.3.3 Equipments shall be checked for any damages as a result of transport, handling and defects, if any, shall be reported to the EIC. Rectification of defects shall be carried out in accordance with approved procedure.

3.3.4 Correct procedures for handling of equipment & installation on the foundation shall be followed as given in the manufacturer's manual. In case of non-availability of such procedures, EC shall develop & submit handling procedures for all equipment weighing more than 10 metric tonnes. The handling procedure shall be approved by the EIC.

3.3.5 EC shall check the correctness of equipment foundations or supporting structures as per the drawings. Equipment/Skid foot print dimensions shall be verified to match with the foundation. Minor chipping of foundation, pockets if required shall be carried out by EC.

3.3.6 All accessories like pressure gauges, seal oil, cooling water & Lube oil headers etc., shall be tagged and separately kept in Contractor's stores till erection. All flanged connections and openings shall be kept blanked with dummies, plugs to prevent entry of foreign particles.

3.3.7 Equipments shall be installed on the foundations in proper sequence. Incase the equipments are delivered in subassemblies, EC shall do the assembly work as per manufacturer's instructions.

3.3.8 Equipments shall be installed in the correct orientation and alignment.

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3.3.9 After installation and levelling the equipment shall be grouted with the specified grouting applied to the baseplate and support.

3.3.10 EC shall remove all the packing and protective devices used during transport and handling from the equipment such as shock absorbent materials from machined faces, blocking of shafts or rolling bearings & restraining devices from instruments, safety devices and protective equipments.

3.3.11 After the grouting is set & cured, the foundation bolts shall be checked to make sure that they are in straight and vertical position and properly tightened. Shims, if used, shall be on either side of the foundation bolts.

3.3.12 Desiccant, catalyst where supplied loose shall be loaded on to the respective vessels in specified quantities as per the suppliers instructions.

3.3.13 Internals, where supplied loose shall be assembled as per the drawings and manufacturer's instructions.

3.3.14 Unless otherwise specified, all the instruments such as pressure gauges, sight glasses temperature recorders etc. including instrument panels, if any, supplied along with the equipment with necessary connections, shall be installed by EC as part of Equipment erection.

3.3.15 Equipments shall be checked for final cleanliness before boxing up.

3.3.16 Any interconnected piping & ducting shall be properly installed and supported. EC shall connect the gas, steam, air, utility piping, instruments, oil piping etc. as per manufacturer's drawings, specifications and instructions of the EIC.

3.3.17 Safety devices shall be correctly installed.

3.3.18 Ladders, platforms, walkways shall be correctly installed with handrails, and flooring shall be properly secured.

3.3.19 Field welding, where specified shall be in accordance with the specified procedures and NDT tests where specified shall be carried out. Results of NDT tests shall be recorded.

3.3.20 Equipment alignment & couplings shall comply with tolerances specified in manufacturer's drawings and manuals. Provisions of dowel pins or similar arrangements for retaining the alignment shall be carried out.

3.3.21 After the piping has been connected, the alignment shall be checked by EC again, to ensure that piping connections do not induce any undue stresses on the Equipments. After making necessary corrections on the piping, if any, realignment shall be done by EC to ensure that no undue stresses are induced on the equipment.

3.3.22 Painting, insulation & fireproofing where specified shall be carried out in accordance with the applicable specifications attached in the tender document.

3.3.23 Any alterations, deviations made during equipment erection with respect to manufacturer's drawings or instructions shall be duly recorded and approval shall be taken from the EIC.

3.3.24 Any special tools, tackles supplied along with the equipment and used during installation shall be returned to the stores through the EIC.

3.3.25 Any protection of the equipment after installation, if required shall be carried out in accordance of the instructions of the EIC.

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3.4 Trial Runs

3.4.1 Wherever specified, Machinery & Equipment erected & installed by EC under the supervision of Machinery/Equipment supplier shall be subjected to trial runs in accordance with clause 5.4 of this specification. Job specific trial run procedure, if specified, supersedes the trial run procedure as described in clause 5.4.

3.5 System Start-up

During this phase of work, EC shall provide as part of his work necessary skilled personnel as per requirement of EIC. Any defects noticed in the Equipment shall be made good by EC at his cost if such defects are attributable to him.

4.0 HEAT AND MASS TRANSFER EQUIPMENT

This section covers the minimum requirements for erection of the following equipment by the EC.

- Deaerator
- Trays/ Tower Internals and Tower Packings
- Separators and Internals
- Shell and Tube Heat Exchangers
- Double Pipe Exchangers
- Electric Heaters
- Plate Exchangers
- Plate Fin Exchangers
- Sulphur Recovery Unit Equipment like Combustion Chambers, Waste Heat Boilers, Sulphur Condensers, Incinerators, Burners, Etc.
- Waste Heat Recovery Units
- Desalters
- Vacuum Ejectors
- Ejector Condensers

4.1 Scope of Work of Erection Contractor

4.1.1 Preparation of erection scheme and rigging procedure and obtaining its approval from EIC wherever necessary.

4.1.2 Withdrawal of equipment from Owner's storage point, checking and reporting its conditions, transporting the same to EC's stores and work site including unloading etc.

4.1.3 Preparation of foundation by chipping & installation of base plates for foundations. Minor rectifications & chipping of foundations up to a thickness of 15 mm due to error in foundation height, shall be carried out by the EC at no extra cost

4.1.4 Before starting the erection, top surface of the foundations are to be cleaned/chipped/roughened to obtain proper bond while grouting. Line (Orientation) & Levels are also to be marked on the respective foundations prior to erection to facilitate checking of alignment.

4.1.5 Supply of necessary shims, levelling plates, wedges, sliding base plate.

4.1.6 Erection on foundations furnished by Owner including aligning, levelling and grouting.

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4.1.7 Assembly and fixing of trays, tower internals (distributor, bed limiter, support plate, chimney trays, vapour distributor etc.), demisters, grids, internal distributors and other internal fittings in columns, vessels etc.

4.1.8 Installation of transformers on desalters and their electrical connection to electrode grid etc.

4.1.9 Welding of chimney trays, lattice girders, beams etc. wherever required.

4.1.10 Carrying out minor adjustments, modifications, seal welding of seal plates etc. wherever necessary during installation.

4.1.11 Checking of installed trays & tower internals and filling of installation formats as referred in 6-14-0016.

4.1.12 Filling of columns, vessels/drums etc. with Raschig rings/Pall rings/ Structured packing, as required.

4.1.13 Welding of washers for equipment, erection of pipe davit & minor welding of their parts as per specifications and instruction of EIC.

4.1.14 Hydrotesting of shell and tube heat exchangers if the time gap between last hydrotest is more than six months or in case it is found to be necessary by EIC. Procedure is given in para 4.3 & 4.4 below. EC to note that any equipment which are refractory lined at shop shall not be hydrotested.

4.1.15 Flushing, cleaning and drying of equipment using compressed air and blinding to prevent ingress of rain, dust etc.

4.1.16 Installation of refractory lining, brick lining, ceramic boards etc., as per specifications, recommendations of manufacturer and instructions of EIC.

4.1.17 Mounting of instruments like safety valves, rupture disks, sight glasses etc as required.

4.1.18 Completing the equipment in all respects for the commissioning of the plant as per drawings, specifications & instructions of EIC.

4.1.19 Any modification in the equipment to the complete satisfaction of EIC.

4.1.20 In addition to the above EC may be called upon to do other jobs like rectification of defects etc. as per instructions of EIC.

4.2 General Conditions of Erection

4.2.1 All carbon steel components of trays/tower internals shall be cleaned to remove rust preventive coating.

4.2.2 All welding shall be done by qualified welders only. The electrodes/filler material to be used shall be compatible with the metallurgy of component and shall be used only after prior approval of EIC.

4.2.3 A proposed Welding Procedure Specification (WPS) shall be submitted to EIL/ Owner's Inspector for his approval. On approval, a Procedure Qualification Test (PQT) shall be conducted which shall be witnessed by EIL/Owner's Inspector. On acceptance of all tests as per ASME Section IX, a final WPS along with Procedure Qualification Record (PQR) shall be submitted. Production welding shall start only after approval of final WPS/PQR and

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qualification of welders as per ASME Section IX. EIL/Owner's Inspector may accept previously qualified WPS/PQR at his sole discretion.

4.2.4 Lattice girders wherever provided for supporting tray & tower internals have been designed in such a way that various components pass through column manway. Components/parts of lattice girders are to be welded inside the column as per respective drawings. EC shall also ensure that all parts of lattice girder are properly welded & levelness of the lattice girder shall be checked before & after the welding. The limits of levelness as mentioned in GA drawings shall be adhered to.

4.2.5 The rigging procedure shall include the following as a minimum:

Location of equipment from where it will be lifted, location of crane(s), details of crane(s) (like configuration, boom length, operating radius, boom point elevation, clearance underside the boom and the equipment, lifting capacity, counter weights to be deployed, holds on any neighbouring foundations, structures, equipment etc.), the load chart of the crane(s), design of the lifting tackles like spreader beam, D-shackles, wire rope slings etc. Unless the erection scheme and rigging procedures are approved by the EIC, erection of equipment shall not be undertaken in any case by the EC.

4.2.6 While handling, transporting or erecting the equipment, care shall be taken not to damage the nozzles, instrument connections, structural clips, refractory lining etc. EC shall also take care of the orientation of the nozzles and other connections of the equipment while erecting the same and ensure compliance with the drawings and specifications supplied. Discrepancy, if any, in the number/orientation of the nozzles, cleats etc. should be brought to the notice of the EIC before actual erection is started.

4.2.7 After erection, the equipment shall be levelled and properly aligned with necessary shims and wedges supplied by EC, at his cost. After the level, alignment and verticality etc. are checked and approved by EIC, EC shall carry out grouting.

4.2.8 EC shall produce recent test certificates of the slings which they will be using for erection work. However, retesting of the slings shall be done at site by the EC at his cost, as and when required by the EIC. The weights of test loads shall be as per IS-807. The test loads shall be supplied by EC at his cost. Tested slings will be punched for test loads and date of testing as directed by EIC.

4.2.9 EC shall also carry out the assembly, erection, levelling and alignment of all types of weir plates, baffles, distributors, collectors, spray nozzles, demisters, grids and other internal fittings etc. Work shall be carried out as per manufacturer's standards/specifications which shall be made available to EC at the time of erection. Raschig rings/Pall rings/Structured packing, molecular sieves, intalox saddles packing and other types of tower packing such as sand, catalyst etc. and SS wire mesh shall be loaded into sections of vessels, columns as per specifications and drawings. Details for internals to be installed by EC shall be as per separate schedule of quantities enclosed with the tender document. All packing except clay and lime stone shall be washed with water before filling. Bottom layers, if required, shall be arranged as directed and random filling shall be done afterwards with equipment filled with water. Installation of packing, shall be done only after flushing and cleaning of columns/vessels and completed to the satisfaction of EIC.

4.2.10 EC shall carry out minor welding for attachment of prefabricated pipe davit parts such as rain covers, handles etc. with pipe davit, during or after erection of the same as per the manufacturer's specifications, at no extra cost to the Owner.

4.2.11 EC shall install base plate over the sliding end foundation before erection of shell and tube exchangers.

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4.2.12 Levelling and plumbness shall be approved by EIC and shall be checked using theodolite before grouting and final finishing of the foundations. The record of the same shall be maintained.

4.2.13 EC to ensure that shell and tube exchangers shall be firmly bolted down to foundations at the fixed end. Further EC to ensure that foundation bolts at the sliding saddle end are at the centre of slotted holes & nuts at sliding end are only hand tightened. Projected bolt threads shall be properly protected by application of grease etc. to avoid rusting and for facilitating free movement of nuts.

4.2.14 EC shall ensure that no equipment is subjected to any corrosion during any stage during his period of work till handling over to EIC/Client.

4.2.15 Instruments, as required, shall be mounted by EC. On instructions of EIC, EC shall also remove and hand over the instruments to EIC for calibrations. During this period, EC shall cover all openings to protect the equipment.

4.2.16 Before transportation to site, EC shall check and report to EIC on the condition of equipment, specifically highlighting the nitrogen pressure indicated in the nitrogen gauges and the absence of blinds on any of the nozzles.

4.2.17 In case the shell and tube exchangers are to be stacked, but have been stored as single shells at the store, then EC shall erect the bottom most shell, then erect other shell(s) sequentially using the nozzle gaskets/bolting and saddle bolting supplied by owner. Additional shims, if necessary, shall be supplied by EC. If the exchangers do not have interconnecting nozzles, then nozzle elevations shall be maintained as per piping GAD.

4.2.18 All equipment, consumable and other accessories required for completion of the job shall be arranged by the EC. This would include but not limited to cranes, tools and tackles, manpower etc; machinery for cutting, grinding , drilling etc. of base plates; instruments like dumpy level, plumb lines, Engineer's levels, precision levels, theodolite, straight edges etc. for checking the alignment/erection accuracy, hydrostatic testing pumps, potable water for hydrotesting, necessary materials including making the arrangements for hydro-testing, hoses, compressed air supply, pressure gauge, sealing taps, blinds, shims and wedges for alignment etc.

4.2.19 EC shall execute the erection of wooden pillows for saddle supports for cold equipment as indicated in schedule of quantities, EIL standard 7-12-002 and instructions of EIC.

4.2.20 For bought out items like plate exchangers, plate fin exchangers, electric heater, etc. vendor's instructions shall be followed.

4.2.21 For erection of piping of ejector system, EC shall follow relevant erection specification of piping for the project.

4.2.22 EC shall check the health of the equipment refractory lined at shop on receipt and shall report any defect or damage in the same to EIC. During installation all precautions shall be taken to avoid any damage to refractory lining. Any damage to refractory during erection shall be repaired by EC at his own cost without loss of time.

4.2.23 Wherever equipment with refractory are bolted or welded at the girth joints, the gaps between the refractory shall be suitably filled with ceramic fiber of suitable grade as given in the drawings or other relevant documents of the equipment.

4.2.24 Refer section 1.0 (General) for additional requirements.

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4.3 Hydrotesting of Shell and Tube Exchangers including Condensers

4.3.1 These shall hydrotested at site using potable water. Hydrotesting of both shell and tube sides shall be carried out as per procedure given below or as per instructions of EIC. For exchangers fitted with SS bellow or SS part, potable water with max. 25 ppm chlorides shall be used for hydrotesting.

4.3.2 Suitable pump set, piping, test pressure gauges and other instruments, water-hoses, temporary gaskets, metallic blinds, bolts, nuts, consumable and other temporary arrangements and equipment for testing shall be provided by the EC at his cost. Test pressure gauges shall be calibrated by the EC and got approved from EIC.

4.3.3 Stacked exchangers shall be hydrotested in stacked conditions.

4.3.4 Test pressure shall be as indicated in the name plates mounted on each exchangers. Duration of hydrotest shall be at least one hour. Test pressures and duration of hydrotest may be reduced by EIC. Minimum test water temperature shall be 20°C.

4.3.5 Any defects noticed during hydrotesting shall be repaired by EC as per the procedure approved by EIC. Cost for rectifying defects, not attributable to the EC shall be paid separately.

4.3.6 No equipment shall in general form part of the piping loop during hydrotesting and shall be blinded off, except when instructed otherwise by EIC.

4.3.7 EC to take adequate care during pressurising & depressurising the equipment. EC shall also take care of any instruction given regarding hydrotest in the exchanger drawing.

4.4 Hydrotesting Procedure

4.4.1 Shell side & tube side shall be hydrotested separately, unless specified otherwise. If both sides are to be tested together, a warning plate would be fixed to the exchanger, and the instructions given therein are to be followed.

4.4.2 The side, shell or tube which ever to be tested at higher pressure shall be taken first.

4.4.3 During hydrotest all gasket joints should be checked for any leakage. In case of leakage from any gasket joint, bolting at that joint shall be further tightened following proper tightening sequence (bolts should not be overtightened or tightened by hammering). In case it is not possible to stop leakage by bolt tightening, drain the water in exchanger & replace gasket at that joint by new gasket (gasket will be supplied by owner). After replacing gasket exchanger must be again hydrotested with same procedure to ensure leak tightness.

4.4.4 In case of floating head heat exchangers, if it is found during hydrotest that the pressure is dropping, while the external gasketed joints are not leaking, this could be due to floating head gasket joint leakage. This shall be further investigated, by removing shell cover & pressurising tube side to check the floating head gasket joint leakage. In case of leakage observed at floating head flange joint, replace floating head gasket by new gasket. After replacing gasket exchanger must be again hydrotested first on tube side & then on shell side with same procedure to ensure leak tightness of gasket joints.

In case of heat exchangers with shell side hydrotest pressure higher than tube side, it is possible that above procedure (with tube side hydrotest to detect floating head gasket leakage) may not help. Absence of leakage during this test is not conclusive in such a case, as the shell side pressure was dropping during hydrotest. In such a case, floating head gasket shall in any case be replaced and then equipment retested to ensure leak tightness.

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4.4.5 When hydrotested as per above procedure after floating head gasket replacement, if it is observed that test pressure is still dropping, this could mean leakage from tube to tubesheet joint. For such cases matter shall be reported to EIC for further investigations/instructions.

4.5 Flushing & Cleaning

4.5.1 After the erection, alignment and grouting of these equipment are complete, and after hydrotest if any, flushing and cleaning shall be carried out by EC as per specifications and instructions of the EIC.

4.5.2 After flushing, cleaning and draining, equipment shall be dried by compressed air at the pressure and for duration decided by EIC. The equipment interior shall be thoroughly inspected to the complete satisfaction of EIC before it is finally boxed up. Boxing up of manholes and handholes shall be leak proof. All joints which need remaking, shall be remade. Compressed air for drying shall be arranged by EC at his cost.

4.6 Inspection and Acceptance Limits for Level & Alignment

4.6.1 Co-ordinates of foundations/supporting structures/mounting holes etc. shall be checked with respect to the plot plans by EC.

4.6.2 Before equipment are placed on foundations, orientations shall be checked with respect to piping drawings.

4.6.3 When equipment are firmly bolted down but prior to grouting, verticality of all equipment shall be checked by using theodolite. Tolerances for equipment after erection shall be as per EIL Standard 7-12-0001. The allowable deviation from plumb line shall be 1 mm per metre height, subject to maximum of 6 mm.

4.6.4 Horizontal equipment shall be checked for level across machined face of nozzle flanges with precision level.

4.6.5 Difference in elevation of centerline from one end to the other end shall not be more than 1 mm per meter and limited to ± 3 mm maximum. Further elevation difference shall be such as to ensure complete draining of equipment.

4.6.6 Survey of column inside and checking the levelness of support rings, location of bolting bars to ensure that the same are as per column drawings and within tolerances specified in standard 7-14-0001. In case these are not within permissible tolerances, the same shall be reported to EIC for necessary rectification/modification.

4.7 Safety, Health & Environment

EC shall install an exhaust fan for exhaling welding/ cutting fumes etc. and to maintain adequate oxygen level, before any work is started inside confined spaces (i.e. columns). Adequate ventilation shall be maintained at all times. Gas/LPG cylinders shall not be taken inside confined space. When a worker/supervisor enters a confined space, it shall be mandatory to have a second man as standby. Safety belts shall be worn while entering columns, if there is a danger of falling. All ladders/stair cases shall be in place before any item is offered to owner's inspectors. Rope ladders/scaffolding shall be provided inside the column in case tower internals are not easily approachable from column manhole. Low voltage (24 V) lamps equipped with guards shall be used to prevent accidental contact with bulb. All electrical connections shall be through ELCB's and proper earthing shall be ensured. Acids and other materials used for pickling shall be disposed off to a designated place as directed by owner/EIL. All statutory Regulations and owner's safety, health and environment requirements

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shall be complied with. Inspection aids for carrying out the inspection of internals shall also be provided.

5.0 ERECTION OF ROTATING EQUIPMENT

5.1 Scope of Work of Erection Contractor

The scope of work shall consist of transportation of Rotating Equipments and accessories from Owner's stores to site, assembly of sub-assemblies/parts, erection of Rotating Equipments on foundations, levelling, aligning and grouting, preparation of Rotating Equipments for trial runs, carrying out no load/trial runs, return of any unused material to the owners stores and hand over in fit condition for the start- up of the Plant, as per instructions of EIC.

Defects due to EC's fault noticed during trial runs shall be rectified by him. Schedule of Quantities, indicate estimated numbers, dimensions and weights of the Rotating Equipments. The actual data on dimensions and weights will be in the vendor data manuals.

The term 'Rotating Equipment' includes all pumps, compressors, steam & gas turbines, fans and blowers, diesel engine/steam turbine/gas turbine generator sets along with drivers accessories & auxiliary systems.

5.2 General Conditions of Erection

5.2.1 All Rotating Equipment erection shall be done by experienced fitters. For this purpose EC shall employ experienced and suitably qualified erection supervisor and crew who have done similar jobs.

5.2.2 The Rotating Equipment manufacturer's instructions as available regarding installation and trial runs will be passed on to EC during the course of work. The requirements prescribed therein shall be met in addition to what is stated in this specification. Erection shall be carried out as per instructions of the Rotating Equipment manufacturer's representative and under their supervision whenever the manufacturer is present at site. In all other cases instructions of the EIC, regarding procedure/sequence of erection shall be binding on EC.

5.2.3 For all Rotating Equipment, EC shall follow the proper sequence for assembly and erection. For Rotating Equipment received along with driver in coupled condition, the coupling bolts shall be dismantled by EC, and alignment shall be rechecked. Realignment, if required, shall be done before recoupling.

Where drivers and couplings are provided separately, drilling and tapping of holes in the base plates for fixing drivers, fixing of couplings on shafts, after enlarging the pilot bores to the correct size with key way etc. and dowelling including provision of dowel pins, alignment screws, jack-up screws or similar arrangements for retaining the alignment shall be carried out by EC as part of erection work. Shims & wedges as required for alignment shall be supplied by EC.

5.2.4 Process and utility (such as cooling water, steam flushing, quenching, lubricating oil, sealing etc.) connections connected with rotating equipment and its auxiliaries shall be fabricated and/or installed by EC from materials supplied by the Owner as per drawings, specifications and instructions of the EIC.

5.2.5 Piping and accessories supplied with the rotating equipment such as seal oil/Gas system, cooling water system & Lube oil system etc. shall be tagged separately and kept in EC's stores till erection. All flanged connections and openings shall be kept blanked with dummies/plugs to prevent entry of foreign matter.

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5.2.6 The local mounted instruments such as pressure gauges, sight glasses, temperature gauges etc. and Local instrument panels, if any, with necessary connections, shall be installed by EC as part of rotating equipment erection.

5.2.7 After initial alignment, the Rotating Equipments shall be properly grouted. Grouting shall be carried out as per this specification. Wherever grout holes are provides in the base plates, grout shall be filled through them also.

Epoxy grout where recommended by the rotating equipment manufacturer, shall be provided by EC and shall be as specified in this standard.

5.2.8 Alignment between the Driver and driven equipment shall be done without connecting the equipment nozzles to respective piping. After completion of alignment, the equipment shall be connected to Piping. After the piping has been connected, the alignment shall be re-checked by EC, to ensure that piping connections do not induce any undue stresses on the Rotating Equipments. After making necessary corrections on the piping, if any, re-alignment shall be done by EC and he will ensure that no undue stresses are induced on the Rotating Equipment.

5.3 Special Instructions

EC in addition to general instructions for erection as out lined in para 5.2 above, shall also follow the following special instructions.

5.3.1 Pumps

Depending upon the size of equipment, Pump train will be supplied for erection in any of the following modes :

(a) Pumps with drivers and accessories fully assembled on a common skid (Base plate).

(b) Pumps mounted on base plate and couplings and driver supplied loose in separate packs.

(c) Various major components such as pump, drivers, couplings, gear boxes & base plates auxiliary systems like lube, seal flush equipment in separate packs.

5.3.2 Reciprocating Type Compressors

5.3.2.1 Reciprocating compressors may be supplied for erection in knocked down condition in multiple packaged subassemblies such as frame assembly, distance pieces, fly wheels, cylinder block assemblies, valve assemblies etc. and other accessories such as, drivers, couplings, gear boxes (if any), control panels, gauge boards, coolers, lube oil systems, cooling water systems, etc. would be in separate packages.

Besides the above there would be other packages for loose supplied items such as instruments, pre-fabricated piping, and piping/tubing in commercial lengths.

Lifting devices for erection shall be arranged by EC depending on the weight of packages and elevation of installation.

5.3.2.2 In case of Rotating Equipments received in knocked down condition, the various parts shall be assembled as per instructions of the EIC and as per manufacturer's instructions. All parts of the Compressor shall be thoroughly cleaned with solvents to remove protective compounds if any, before assembly.

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5.3.2.3 The compressor, driver and other accessories shall be erected on their respective foundations and the compressor, couplings, gear box and driver shall be aligned and grouted as per the manufacturer's instructions and instructions of EIC and the manufacturers supervisor (when present). There-after all process and utility, drain & vent connections shall be completed as per the relevant drawings/instructions of equipment manufacturer and advice of EIC.

5.3.2.4 Final alignment shall be done after all the piping connections such as water, steam, drains and connection to coolers etc. are made. Tolerances for alignment shall be maintained as specified in the Manufacturer's Instruction Manual. To ensure that piping connections do not induce any undue stresses on the Rotating Equipment, the alignment shall be checked once again by EC after the piping has been connected. Any correction necessary for proper alignment shall be done by EC.

5.3.2.5 EC shall carefully study the vendor drawings, manuals and other data before start of the job to ensure correct erection, alignment and commissioning.

5.3.3 **Centrifugal Compressors & Expanders**

5.3.3.1 Centrifugal Compressors are supplied for erection in multiple packages such as,

- Compressor casings
- Drivers (Electrical motors, Steam/Gas turbines -♦)
  {♦ : Steam/Gas turbines would be further supplied in multiple packages}
- Base plates (or skids)
- Lube oil/control oil systems
- Sealing systems
- Air filters (for gas turbines & compressors for air service)
- Temporary strainers
- Couplings
- Gear boxes
- Coolers
- Gauge boards
- Control panels
- Lube & Seal Oil tanks
- Fire systems (for gas turbines)
- Condensers (for steam turbines)
- Condensate systems (for steam turbines)
- Loose supply items
- Pre-fabricated & Commercial lengths piping, tubing.
- Other miscellaneous packages

5.3.3.2 Other requirements shall be same as defined in para's 5.3.2.2 to 5.3.2.5 above.

5.4 Trial Runs of Machinery

5.4.1 Any construction defects shall be intimated to EIC before start-up. All protective and safety guards shall be installed and rotating equipment shall be checked for free movement by manual barring over. All foundation bolts and alignment shall be checked before starting the trial runs, if damaged, rotating equipment may have to be opened and repaired as directed by EIC. Prior to carrying out the trial runs, the rotating equipment will be subjected to necessary checks by the EIC and the trial runs shall be commenced only after the approval of the EIC.

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5.4.2 Unless otherwise specified, all the rotating equipment will be subjected to trial runs for a continuous operation of 72 hours. In case of motor driven rotating equipments, motors shall be decoupled and turned over to other agencies doing electrical work for testing and no load running of motors. After the no load runs of motors are satisfactorily completed, EC shall recouple the motors to the rotating equipment and recheck the alignment. The trial run of the rotating equipment shall be started only after the above is completed. EC shall provide, as part of his work, necessary skilled personnel (excluding the operating personnel) for conducting the trial runs round the clock during the trial runs period. The duration of trial run may be extended if it is considered necessary in the opinion of EIC and EC shall provide personnel for such extended period also. Final inspection of bearing etc. shall be carried out by EC after the Machinery had gone through the trial run and defects, if any, shall be made good for rendering the rotating equipment ready for start up.

5.4.3 During the trial runs, readings of bearing temperature, cooling water inlet and outlet temperatures, lube oil inlet/outlet temperature and pressure, rotating equipment discharge pressure and temperature, starting in current, no load/full load current etc. shall be recorded, wherever necessary, by EC. Trial reports shall be prepared in the approved proforma by EC containing all the above details and submitted to the EIC as part of completion documents.

5.4.4 EC shall also provide necessary improvised fencing and watch & ward personnel as safety measures during trial runs.

5.5 System Start up

During start-up, EC shall provide necessary skilled personnel as per requirement of EIC, to rectify defects noticed in the rotating equipment, if such defects are attributed to him.

6.0 EQUIPMENT GROUTING

All anchor bolt sleeves/pockets and space under Base plates/machine base frames/shoe plates, etc. shall be grouted with either free flow non shrink cementitious or epoxy grout as per the following categorisation:

Sr. No.	Type of Grout	Application
1	Non shrink cementitious grout	All static and rotating equipments, unless covered in 2) below, viz Static equipments like tall columns, vertical silo, blender etc. and horizontal vessel, drum, sphere, bullets, filter, heat exchangers, coolers etc. and other similar equipments, steel stack/chimney, furnace etc. Low frequency, medium frequency, high frequency rotating machines like compressors (centrifugal, reciprocating, diaphram, screw, gear type etc.). Induced draft fan, forced draft fan, air blowers, pumps (centrifugal, reciprocating, diaphram, gear type etc.), expanders, turbine, generator, diesel generator, air coolers (fin fan cooler) and other similar equipment. Machine like screen vibrator, extractor, centrifuge pulverizer, dryer, drop hammer, ball mill, crushers, bagging machine and general workshop equipment.
2	Epoxy grout	Specifically if requested by the Machine Vendor.

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6.1 Grout (Material)

All material used for grout shall be in EC's scope. Only approved grout material shall be used. EC shall submit details of grout materials for prior approval of EIC.

6.1.1 Non-Shrink Grout

Non-shrink grout shall be premix type of cementitious (cement pregraded fibre and additive) non-shrink, ready to use grout in dry powder form. It shall have free flow property when mixed with required quantity of water. It shall have initial setting time of 30 minutes.

It shall have the following features:

- Non corrosive to anchor bolts, base plate/saddle/frame, sliding plate.
- Not harmful to concrete and reinforcing steel.
- Non toxic
- Frost, oil and fire resistant
- Require normal curing
- Suitable to use under restraints and grout thickness required
- Expansive to counteract initial shrinkage
- Ensure high early strength without surface crack.
- Suitable for temperature of above 0 deg.C to 200 deg.C.
- Maximum flow distance is compatible to the dimensions of base plate/ saddle/frame.
- It should be resisted to the chemicals, gases etc. being handled in equipment/machines.

It should have the following physical properties:

-	Min. Compressive strength at	3 days	25 N/mm^2
		7 days	30 N/mm^2
		28 days	40 N/mm^2
-	Min. Tensile strength at	28 days	3.5 N/mm^2
-	Min. Bond strength at	7 days	12 N/mm^2
-	Max. Onstrained Expansion in	2 hours	4%
-	Min. Density		2000 kg/m^3

6.1.2 Epoxy Grout

Epoxy grout shall consist of epoxy resin base, hardener and filler component like graded and blended aggregate. Components of epoxy grout shall be of desired grade and mixed in proportion recommended by manufacturer such that it is injectable under base plate/frame/saddle etc., has low viscosity to meet the flow distances according to dimensions of base plate saddle/frame, it is suitable for the desired thickness, it is homogenous, free from segregation, attains high early and high final strength. It shall have minimum Pot life of 30 minutes. It shall have all the features as specified in clause 6.1.1 except for expansive properties.

It should have the following physical properties :

-	Min. compressive strength at	1 day	75 N/mm^2
		7 days	85 N/mm^2
-	Min. Flexural strength	7 days	25 N/mm^2

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6.2 Grouting (Placement)

6.2.1 Surface Preparation

Prior to positioning of equipment/machine etc. over concrete pedestal, foundation, slab, beam, etc. all laitance & loose material shall be removed by wire brushing & chipping. The bearing concrete surface shall be sufficiently levelled, hacked with flat chisels to make it rough, clean (using compressed air). Additional chipping, if required, to suit level of base plate and/or minimum thickness of grout shall also be done. In case of use of cementitious grout surface shall be thoroughly wet. All pockets for anchor bolts shall also be similarly cleaned. Any excess water shall be removed. In case of use of epoxy grout, it shall be ensured that surface/pocket to receive grout is totally dry. After erection, alignment/plumbing of equipment/machine in required level, orientation and plumb and installation of sliding plate. Forms shall be constructed around and joints made tight to prevent leakage of the grout.

6.2.2 Preparation of Grout

6.2.2.1 In case of premix type of grout water shall be added in required quantity as specified by supplier and/or EIC. Any specific instruction of manufacturer will be strictly followed.

6.2.2.2 In case of epoxy grout required quantity of all constituents shall be mixed in proportion recommended by manufacturer/supplier and/or EIC. All specific requirements of manufacturer/ supplier shall be strictly followed.

6.2.2.3 Required quantity of grout shall be made considering initial setting/pot life of grout. Any grout not used within initial setting time/pot life shall be rejected and in no case used for grouting.

6.2.3 Placement of Grout

6.2.3.1 Placing of grout shall be taken up only after level, orientation, alignment of equipment/machine has been approved by EIC and anchor bolts are placed in pocket.

6.2.3.2 In case of epoxy grout EC shall give details of grouting scheme and get approval of EIC.

6.2.3.3 The grout mixture shall be poured/injected continuously (without interruption till completion) by grouting pump/injecting gun from one side of base plate and spread uniformly with flexible steel strip and rammed with rods till the space is filled solidly and grout mixture carried to the other side of base plate and fill all pockets. Any specific requirement of manufacturer/ supplier shall be strictly followed. Epoxy grout shall be done by or under supervision of manufacturer/supplier and/or agency having adequate experience in this field as per direction of EIC.

Total work shall be done under supervision and direction of EIC and care shall be taken that alignment of equipment/machine is not disturbed.

6.2.3.4 Grout mixture shall be allowed to harden for a period of minimum 7 days or as required by manufacturer/supplier of grout and/or as decided by EIC. At the end of this period, the shims/edges/pack plate may be removed and anchor bolts tightened uniformly. Alignment of equipment/machine shall be rechecked and if found correct, the voids left by the removal of shims/wedges/pack plate (if removed) must be filled up with a similar mixture of grout. In case after checking, serious misalignment is indicated, the grout shall be removed completely and fresh grouting is done after making appropriate correction of alignment.

6.2.3.5 Minimum thickness of grout shall be 25mm for all types of grout and maximum thickness shall be 40mm for non-shrink grout. For epoxy grout the maximum thickness shall be as per manufacturer's recommendation and/or as specified in drawing.

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7.0 REFERENCE EIL STANDARDS/ SPECIFICATIONS

6-14-0003	Installation Procedure for Trays & Tower Internals
6-14-0011	Specification for Packing the Column
6-14-0016	Standard Specification for Review of Site Installation of Column Internals.
6-79-0011	Standard Specification for Corrosion Protection Tape Coating for Underground Steel Piping.
6-79-0020	Standard Specification for Surface Preparation and Protective Coating (New Construction)
7-12-0001	Vessel Tolerances.
7-12-0002	Support for Horizontal Vessel
7-12-0003	Wooden Pillow for Saddle Support
7-12-0004	Skirt Base Details
7-12-0024	Lifting Lug Top Head Type
7-14-0001	Construction Tolerance for Welded Supports for Tray / Tower Internals

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फ्लैंज जोड़ों के लिए बल-आघूर्ण (टॉर्क) तथा हाइड्रोलिक बोल्ट टेंशन के अनुप्रयोग हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR APPLICATION OF TORQUE AND HYDRAULIC BOLT TENSION FOR FLANGE JOINTS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	30-06-2021	Revised and reissued for Implementation	PVK	PG	VM	SM
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1	26-05-2008	Issued for Implementation	PG	KPS	AA	VC
0	15-05-2003	Issued for Implementation	PG	KPS	VC	SKG

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Abbreviations:

ASME	American Society of Mechanical Engineers
PMS	Piping Material Specification

General Engineering Standards Committee

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1.0 PURPOSE

The purpose of this specification is to describe the methodology for preparation of bolted flange joints by controlled bolt tightening during construction and commissioning stage of process plant piping. This specification shall be used in conjunction with the other process/project specific requirements and the licensor/vendor recommendations.

2.0 SCOPE

This specification covers ASME B16.5 and ASME B16.47 Series B bolted flanged joints, involving identical pair of flanges, which are tightened by means of either hydraulic bolt tensioning or calibrated torque wrenches.

3.0 REFERENCES

EIL Spec no. 6-44-0005 Rev 7	-	Standard Piping Material Specification
ASME B16.5	-	Pipe Flanges and Flanged Fittings (1/2" to 24" NPS)
ASME B16.47 Series B	-	Pipe Flanges and Flanged Fittings (26" to 60" NPS)
ASME B31.3	-	Process Piping
BP RP 42-2	-	British Petroleum Recommended Practice: Bolting for flange joints
ASME Section VIII Division 1 and Division 2	-	Boiler and Pressure Vessel Code

4.0 DEFINITIONS

None.

5.0 METHODOLOGIES AND CONTROL

5.1 Identification of joints for controlled bolt tightening

Controlled bolt tightening can be done either 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.

5.1.1 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 the category 'D' services. Category 'D' service is 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 equipments	(See Note-3 below)
25 mm and above, but less than 38 mm	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)

Note-1: Hydrogen Service

In absence of project specific definition, Hydrogen service may be defined as service in contact with Hydrogen or gaseous mixtures containing Hydrogen in which the partial pressure of Hydrogen is 7 bar (100 psi) abs. or more.

Note-2: Joints with leakage potential shall include

a) Joints involving tapped holes.
b) Joints not subjected to hydro test e.g. joints for equipment manholes, equipment mounted temperature, pressure and level instruments, line mounted temperature connections, on line instrument joints like control valves and safety valves, compressor volume bottles.
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.
d) Tie-in joints with other contractors and package vendors.
e) High temperature (above 371°C) joints in hydrocarbon services.

Note-3: Critical joints with the equipments shall include the inlet and the outlet flanges of pumps, compressors and turbines.

5.1.2 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 5.1.1 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. 5.1.1, shall not be considered for torque application.

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5.2 Pre-bolting Operations

5.2.1 Design

a) 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).

b) Stud bolts shall be longer by one diameter to suit the bolt tensioners for hydraulic bolt tensioning. Excess threads shall be protected by using nut, threaded cap etc. On bolts at ambient temperature duty the cap should have a grease nipple.

c) All flanges on hydrogen service must be left exposed unless otherwise agreed.

d) Interface joints shall be system pressure tested as per the relevant code to ensure their integrity.

5.2.2 General

a) Use of right type of gasket, fasteners etc. conforming to the specifications as per design and drawings should be ensured.

b) The Vickers hardness number of ring joint gaskets should be 30 to 40 less than that of the mating face of the flange.

c) All non-ring joint gaskets shall be replaced with the 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

d) Shop tested flange joints should not be disturbed at site. In case the joint is opened, the Contractor shall be responsible for final hook-up joints including bolt tensioning if applicable.

5.2.3 Visual inspection

a) Condition of flange faces should be checked. Those shall be free from dirt, scale, remnant gasket, and protrusions. Faces with pitting, indentations or radial tool marks, or scratches are not desirable. Surface finish should conform to specifications.

b) Flanges should be aligned properly. Flange faces shall be parallel and boltholes shall match so that the studs can be inserted freely.

c) 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.

d) Gasket position should be checked.

e) Studs and nuts shall be free from dirt, nicks, burrs and chips. Studs shall be straight and nuts shall turn freely on the stud.

f) No external load shall be used to align the flanges.

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5.2.4 Corrective measures

a) 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.

b) If necessary, gasket seating face should be cleaned using wire brush (SS bristles on alloy components) and/or suitable solvent.

c) Damaged gaskets shall be replaced.

d) If holding gasket in place after installation is a problem, a thin adhesive tape should be used along the outside edge of gasket.

5.2.5 Lubrication/anti-seize compound

a) Threads and nuts to flange contact face should be lubricated with suitable lubricant. Thread compound or lubricant, suitable for line temperature, may be used.

b) Gaskets should not be lubricated.

c) Lubricant shall not be applied on bolts, used in oxygen services.

d) Some of the types of lubricants used are as follows:

Molybdenum Lead oxide (graphite based)
Molykote G-n plus
Molykote P37
Molykote HSC Plus / Never Seez nickel special
API SA2
Molykote 1000
Machine oil
Graphite grease

5.2.6 Assembly

a) Suitable lubricant (refer cl. 5.2.5) to be applied to the threads and the face of the nut that contacts the flange.

b) Four studs should be placed in positions 1, 2, 3 and 4 according to "Stud Tightening Pattern" in Fig.1, as centring guides for the gasket.

c) Balance studs should be inserted next.

d) Nuts should be run down by hand in such a way that an equal number of threads project at each end.

5.2.7 Torque/tension calculation

a) Bolting load calculation and stress analysis used for computation of the listed tightening torque and tension values primarily follow the procedures outlined in ASME Section VIII Division 1/ Division 2.

b) Basic formulae used for torque calculation takes care of friction between bolt threads and nut threads as well as that between nut and back face of flange.

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c) A frictional co-efficient of 0.15 is assumed for calculation of torque values for the lubricant - graphite grease. When a lubricant with different co-efficient of friction (μ) is used, the calculated values get multiplied by the ratio μ/0.15. The approximate μ values of some of the lubricants are as follows:

Type of Lubricant	Co-efficient of friction (μ)
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

However, it is advisable to obtain the appropriate co-efficient of friction (μ) value from the lubricant manufacturer.

5.2.8 The PMS classes included in this specification are given in Table 3.

Table 3: PMS classes included in this specification

Sl. no	Piping class	Sl. no	Piping class	Sl. no	Piping class	Sl. no	Piping class
From Standard PMS (6-44-0005 rev 7)							
1	A1A	26	B1A	51	B6N	76	F2D
2	A2A	27	B2A	52	D1A	77	F2G
3	A4A	28	B4A	53	D2A	78	G2G
4	A6A	29	B5A	54	D4A		
5	A7A	30	B6A	55	D5A		
6	A8A	31	B9A	56	D9A		
7	A9A	32	B13A	57	D16A		
8	A11A	33	B16A	58	D19A		
9	A13A	34	B19A	59	D1D		
10	A15A	35	B32A	60	D2D		
11	A16A	36	B1D	61	D5D		
12	A19A	37	B5D	62	D5E		
13	A20A	38	B1E	63	D1K		
14	A32A	39	B3F	64	D2K		
15	A33A	40	B4F	65	E1A		
16	A4F	41	B4G	66	E2A		
17	A4G	42	B1K	67	E5A		
18	A1K	43	B2K	68	E9A		
19	A2K	44	B4K	69	E19A		
20	A6K	45	B5K	70	E5E		
21	A11K	46	B6K	71	F1A		
22	A1M	47	B1M	72	F2A		
23	A1N	48	B3M	73	F5A		
24	A4Y	49	B5M	74	F9A		
25	A33Y	50	B1N	75	F19A		

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5.2.9 Torque and tension values

Table 4 contains the tension and torque values to be used for bolt tightening of each bolt using hydraulic bolt tensioner and torque wrench respectively. These values are listed PMS class and flange size wise. The tension values specified are the target load per bolt intended after the bolt tensioning operation is complete. This means any allowance inherent in bolt tensioning equipment (viz. backlash etc.) shall also to be taken care of as recommended by the equipment manufacturer.

5.2.10 Notes to Torque and tension values in Table 4

a) The **maximum allowed** design pressure & temperature combination and test pressure values are listed in Table 4. These values corresponds to PMS rating table values, except as stated in c) below. **Recalculation** of torque and tension is necessary if the design condition exceeds these limits.

b) Values in the table are **not** valid if the design condition for pipe wall thickness calculation is lower than 80% of the class rating condition. **Recalculation** of torque and tension is necessary in such cases.

c) It may be noted that for the sizes above 24" and rating class above 150 (except Lists B-1 and B-2), the calculations are carried out for 80% of the pressure used for sizes up to 24".

d) Torque / tension computation of sizes and pipe thickness, which are not covered in the respective classes of the standard PMS, are carried out based on approximate calculated pipe thickness for the specified pressure and temperature condition.

e) The "Flange Std" column of table 4 is the standard rating class followed by a suffix. Suffixes to the rating class numbers denote the flange dimensional standard and are as follows:

S - ASME B16.5 B - ASME B16.47 Series B

f) The values in the tables are not valid for non-standard flanges or flanges conforming to any other dimensional standards, e.g., ASME B16.47 Series A, AWWA (American Water Works association) etc.

g) All pressure values are in kg/cm^2 (g) and all temperature values are in °C

h) Bolt tightening torque or tension values at equipment interface flanges, if specified by the equipment vendor, shall be used.

5.3 Bolting Operation

5.3.1 General

a) Categorisation of joints for tension or torque application shall be as per cl. 5.1.

b) Bolt tightening tension or torque value shall be as per cl. 5.2.9.

c) Guidelines and safety requirements provided by the manufacturer bolt tightening equipment should be followed.

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5.3.2 Hydraulic bolt tension application

a) Hydraulic pressure adequate to get the target bolt load can be calculated dividing the bolt load by the load cell hydraulic seal area. This pressure should be applied simultaneously to all load cells.

b) 4 load cells equally spaced should be used.

c) Nuts should be run down to flange surface manually.

d) Load cells should be shifted following the Criss-cross Pattern shown in Fig. 1 but in-groups of 4 bolts each (i.e. 1-2-3-4, 5-6-7-8, 9-10-11-12 etc.) and the tensioning of all bolts should be completed.

e) Tensioning operations should be repeated once again applying the same pressure.

5.3.3 Stud bolt torque application

a) Bolt torque application sequence shall be in accordance with "Criss-cross Stud Tightening Pattern" (Fig. 1).

b) Properly calibrated torque wrenches should be used.

c) Torque wrench should be held perpendicular to the axis of the bolt and if hydraulic wrench is used, it has to be ensured that it reacts against a rigid support parallel to the axis of bolt.

d) Torque should be applied using a minimum of following five steps:

i. All the nuts should be made snug tight with a short wrench (Criss-cross Pattern – Fig.1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

ii. Tightening to 30% of the final torque value (Criss-cross Pattern – Fig. 1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

iii. Tightening to 60% of the final torque value (Criss-cross Pattern – Fig.1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

iv. Tightening to the final torque value (Criss-cross Pattern – Fig. 1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

v. Tightening should be continued with the final torque in a clockwise manner (bolt to bolt) until no further rotation is observed.

e) In the event of nut seizure, the nut should be backed off and additional lubricant should be applied or the nut or/and bolt should be replaced, if necessary.

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5.3.4 Testing of joints

Checking up of the individual joints for any leak during system pressure testing should be carried out using special tapes, soap solutions.

6.0 RESPONSIBILITIES / APPROVALS

6.1 All procedures/documents to be used during Construction should be submitted by the Contractor to Engineer-in-charge at site in advance.

6.2 The equipment supplier shall be subjected to EIL/Owner approval.

6.3 The details of hydraulic tensioner equipment to be used for tightening shall be intimated to Engineer-in-charge before application.

6.4 Boxing up and tightening of flange joints shall be done by skilled technicians, qualified and approved by Contractor and EIL/Owner.

6.5 Any conflict between the requirements of this standard specification and applicable codes, licensor specification, standards, data sheets, drawings, requisitions etc. shall be referred to client/ consultant. Agency carrying out bolt tightening shall list and describe all the deviations from this standard specification and the related reference documents.

7.0 DOCUMENTATION

7.1 History sheet for flange joints shall be maintained as per Annexure-I.

7.2 Sequence of the activities involved for reopening/ making/ blinding/ de-blinding/ wedge opening of flange joints shall be as per Annexure-II.

7.3 All joints shall be boxed-up and the record shall be maintained of salient points and names of the persons involved in the execution/inspection of boxing-up operation.

7.4 All critical joints shall be boxed-up under the supervision of the Contractor's representative and EIL's Engineer-in-charge or his representative and separate records shall be maintained for such joints.

7.5 Box up records of interface joints and on-line instrument joints, like control valves, safety valves, turbine flow meters etc., which are not subjected to hydro test shall be maintained separately.

7.6 If mentioned in project specification, complete set of Bolt Tensioning Equipment/ Torque Wrenches shall be supplied by Contractor to the Owner, after commissioning of the plant, as mandatory spares.

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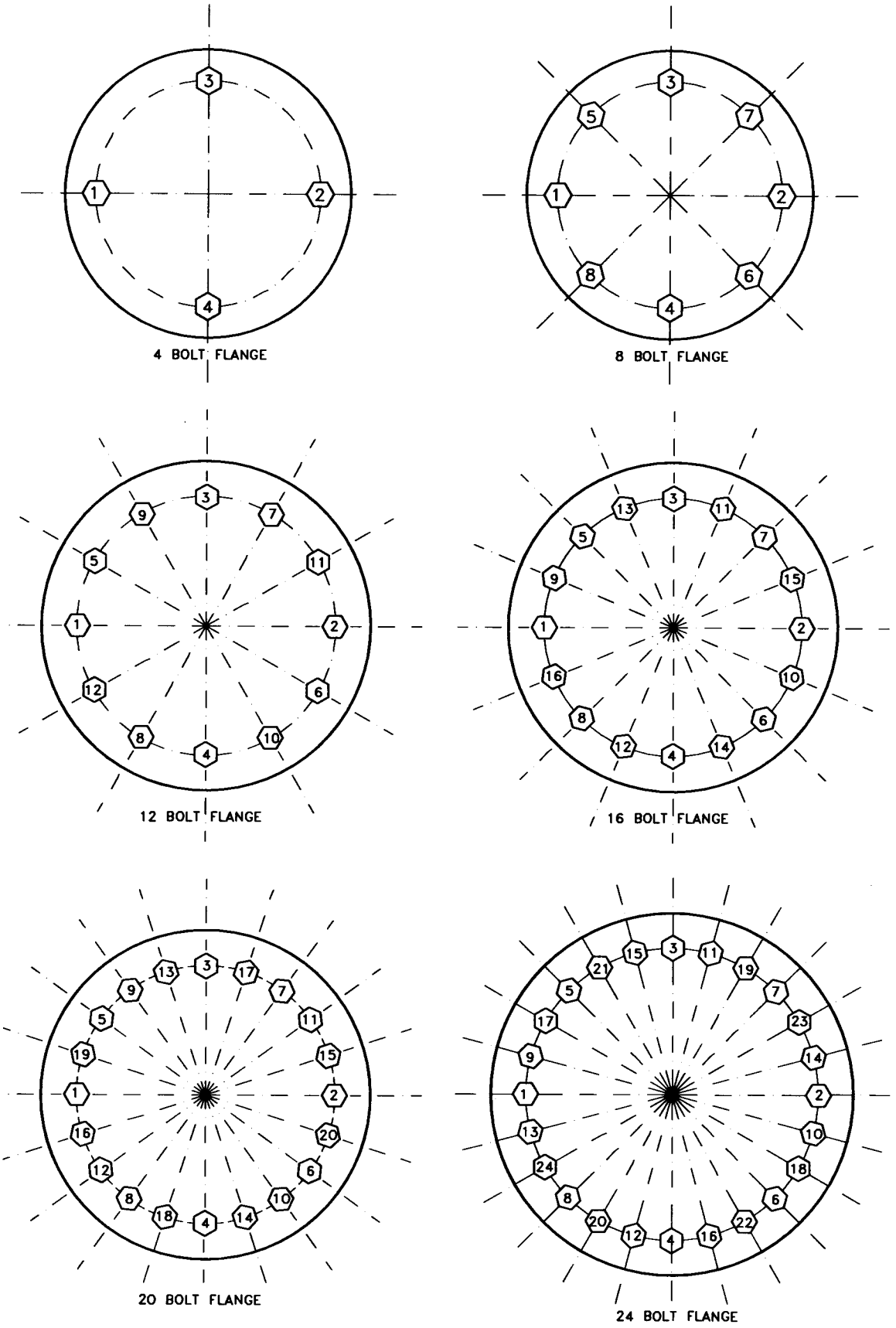

Figure 1 Typical "Criss-cross" Bolt tightening/Torque application pattern

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Table 4: Bolt Tension and Torque Values

Refer cl. 5.2.8, 5.2.9 and 5.2.10 for applicability of these values

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-1													
A1A	PMS rated Temperature / Pressure		371 / 7.73	Up to 48"	7.73	371	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	3/4	1/2	4	855	2.6
				A672 Gr. B60	7.73	371	30.05	150S	1	1/2	4	1027	3.1
A2A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150S	1-1/2	1/2	4	1597	4.8
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	2	5/8	4	2562	9.4
				A672 Gr. B60	7.73	371	30.05	150S	3	5/8	4	3020	11.1
A6A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	4	5/8	8	2471	9.1
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	6	3/4	8	3972	17.2
				A672 Gr. B60	7.73	371	30.05	150S	8	3/4	8	4931	21.3
A7A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	10	7/8	12	5135	25.5
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	12	7/8	12	5326	26.5
				A672 Gr. B60	7.73	371	30.05	150S	14	1	12	6249	35.2
A9A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150S	16	1	16	5999	33.8
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	18	1-1/8	16	8583	53.7
				A672 Gr. B60	7.73	371	30.05	150S	20	1-1/8	20	8583	53.7
A11A	PMS rated Temperature / Pressure		371 / 7.5	Up to 48"	7.73	371	30.05	150S	24	1-1/4	20	11379	78.3
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	26	3/4	36	4111	17.7
				A672 Gr. B60	7.73	371	30.05	150B	28	3/4	40	4111	17.7
A13A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150B	30	3/4	44	4385	18.9
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	32	3/4	48	4522	19.5
				A672 Gr. B60	7.73	371	30.05	150B	34	7/8	40	6274	31.2
A19A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150B	36	7/8	44	6274	31.2
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	38	1	40	7750	43.7
				A 672 Gr.B 60 Cl.22	7.73	371	30.05	150B	40	1	44	7750	43.7
					7.73	371	30.05	150B	42	1	48	7750	43.7
					7.73	371	30.05	150B	44	1	52	7750	43.7
					7.73	371	30.05	150B	46	1-1/8	40	11230	70.3
					7.73	371	30.05	150B	48	1-1/8	44	10570	66.2

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	30.05	150B	**50**	1-1/8	48	**10570**	**66.2**
					7.73	371	30.05	150B	**52**	1-1/8	52	**10240**	**64.1**
					7.73	371	30.05	150B	**54**	1-1/8	56	**10240**	**64.1**
					7.73	371	30.05	150B	**56**	1-1/8	60	**10240**	**64.1**
					7.73	371	30.05	150B	**58**	1-1/4	48	**13488**	**92.8**
					7.73	371	30.05	150B	**60**	1-1/4	52	**13488**	**92.8**
LIST A-2													
	PMS rated Temperature / Pressure		50 / 10.55	Up to 12"	10.55	186	15.80	150S	**1/2**	1/2	4	**684**	**2.1**
A4Y	A105	A307 GR.B	BUTYL RUBBER	API 5L GR.B PSL1	10.55	186	15.80	150S	**3/4**	1/2	4	**855**	**2.6**
					10.55	186	15.80	150S	**1**	1/2	4	**1027**	**3.1**
					10.55	186	15.80	150S	**1-1/2**	1/2	4	**1255**	**3.8**
					10.55	186	15.80	150S	**2**	5/8	4	**2013**	**7.4**
					10.55	186	15.80	150S	**3**	5/8	4	**2013**	**7.4**
					10.55	186	15.80	150S	**4**	5/8	8	**2013**	**7.4**
					10.55	186	15.80	150S	**6**	3/4	8	**3014**	**13.0**
					10.55	186	15.80	150S	**8**	3/4	8	**3014**	**13.0**
					10.55	186	15.80	150S	**10**	7/8	12	**4184**	**20.8**
					10.55	186	15.80	150S	**12**	7/8	12	**4184**	**20.8**
					10.55	186	15.80	150S	**14**	1	12	**5499**	**31.0**
					10.55	186	15.80	150S	**16**	1	16	**5499**	**31.0**
					10.55	186	15.80	150S	**18**	1-1/8	16	**7263**	**45.5**
					10.55	186	15.80	150S	**20**	1-1/8	20	**7263**	**45.5**
					10.55	186	15.80	150S	**24**	1-1/4	20	**9272**	**63.8**
LIST A-3													
	PMS rated Temperature / Pressure		204 / 14.06	Up to 48"	14.06	204	27.95	150S	**1/2**	1/2	4	**684**	**2.1**
A4A	A 350 GR.LF2 CL.1	A320 GR.L7	Spiral wound SS	A 333 GR.6	14.06	204	27.95	150S	**3/4**	1/2	4	**855**	**2.6**
				A 671 GR.CC60 CL.32	14.06	204	27.95	150S	**1**	1/2	4	**1027**	**3.1**
					14.06	204	27.95	150S	**1-1/2**	1/2	4	**1597**	**4.8**
					14.06	204	27.95	150S	**2**	5/8	4	**2562**	**9.4**
					14.06	204	27.95	150S	**3**	5/8	4	**3020**	**11.1**
					14.06	204	27.95	150S	**4**	5/8	8	**2471**	**9.1**
					14.06	204	27.95	150S	**6**	3/4	8	**3972**	**17.2**
					14.06	204	27.95	150S	**8**	3/4	8	**4931**	**21.3**

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					14.06	204	27.95	150S	10	7/8	12	5135	25.5
					14.06	204	27.95	150S	12	7/8	12	5326	26.5
					14.06	204	27.95	150S	14	1	12	6249	35.2
					14.06	204	27.95	150S	16	1	16	5999	33.8
					14.06	204	27.95	150S	18	1-1/8	16	8583	53.7
					14.06	204	27.95	150S	20	1-1/8	20	8583	53.7
					14.06	204	27.95	150S	24	1-1/4	20	11379	78.3
					14.06	204	27.95	150B	26	3/4	36	4111	17.7
					14.06	204	27.95	150B	28	3/4	40	4111	17.7
					14.06	204	27.95	150B	30	3/4	44	4385	18.9
					14.06	204	27.95	150B	32	3/4	48	4522	19.5
					14.06	204	27.95	150B	34	7/8	40	6274	31.2
					14.06	204	27.95	150B	36	7/8	44	6274	31.2
					14.06	204	27.95	150B	38	1	40	7750	43.7
					14.06	204	27.95	150B	40	1	44	7750	43.7
					14.06	204	27.95	150B	42	1	48	7750	43.7
					14.06	204	27.95	150B	44	1	52	7750	43.7
					14.06	204	27.95	150B	46	1-1/8	40	11230	70.3
					14.06	204	27.95	150B	48	1-1/8	44	10570	66.2
LIST A-4													
A8A	PMS rated Temperature / Pressure		65 / 19.17	Up to 6"	8.78	343	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	3/4	1/2	4	855	2.6
					8.78	343	30.05	150S	1	1/2	4	1027	3.1
A15A	PMS rated Temperature / Pressure		343 / 8.78	Up to 16"	8.78	343	30.05	150S	1-1/2	1/2	4	1597	4.8
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	2	5/8	4	2562	9.4
				A672 Gr. B60	8.78	343	30.05	150S	3	5/8	4	3020	11.1
A20A	PMS rated Temperature / Pressure		343 / 8.78	Up to 18"	8.78	343	30.05	150S	4	5/8	8	2471	9.1
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	6	3/4	8	3972	17.2
				A672 Gr. B60	8.78	343	30.05	150S	8	3/4	8	4931	21.3
A32A	PMS rated Temperature / Pressure		280 / 11.19	Up to 3"	8.78	343	30.05	150S	10	7/8	12	5135	25.5
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	12	7/8	12	5326	26.5
					8.78	343	30.05	150S	14	1	12	6249	35.2

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
A33A	PMS rated Temperature / Pressure		65 / 18.9	Up to 48"	8.78	343	30.05	150S	16	1	16	5999	33.8
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	18	1-1/8	16	8583	53.7
				IS-3589 GR.410	8.78	343	30.05	150S	20	1-1/8	20	8583	53.7
A33Y	PMS rated Temperature / Pressure		65 / 18.9	Up to 48"	8.78	343	30.05	150S	24	1-1/4	20	11379	78.3
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150B	26	3/4	36	4111	17.7
				IS-3589 GR.410	8.78	343	30.05	150B	28	3/4	40	4111	17.7
					8.78	343	30.05	150B	30	3/4	44	4385	18.9
					8.78	343	30.05	150B	32	3/4	48	4522	19.5
					8.78	343	30.05	150B	34	7/8	40	6274	31.2
					8.78	343	30.05	150B	36	7/8	44	6274	31.2
					8.78	343	30.05	150B	38	1	40	7750	43.7
					8.78	343	30.05	150B	40	1	44	7750	43.7
					8.78	343	30.05	150B	42	1	48	7750	43.7
					8.78	343	30.05	150B	44	1	52	7750	43.7
					8.78	343	30.05	150B	46	1-1/8	40	11230	70.3
					8.78	343	30.05	150B	48	1-1/8	44	10570	66.2
					8.78	343	30.05	150B	50	1-1/8	48	10570	66.2
					8.78	343	30.05	150B	52	1-1/8	52	10240	64.1
					8.78	343	30.05	150B	54	1-1/8	56	10240	64.1
					8.78	343	30.05	150B	56	1-1/8	60	10240	64.1
					8.78	343	30.05	150B	58	1-1/4	48	13488	92.8
					8.78	343	30.05	150B	60	1-1/4	52	13488	92.8
LIST A-5													
A16A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 Gr. B7M	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	3/4	1/2	4	855	2.6
				A672 Gr. B60	7.73	371	30.05	150S	1	1/2	4	1027	3.1
					7.73	371	30.05	150S	1-1/2	1/2	4	1597	4.8
					7.73	371	30.05	150S	2	5/8	4	2562	9.4
					7.73	371	30.05	150S	3	5/8	4	3020	11.1
					7.73	371	30.05	150S	4	5/8	8	2471	9.1
					7.73	371	30.05	150S	6	3/4	8	3972	17.2
					7.73	371	30.05	150S	8	3/4	8	4931	21.3
					7.73	371	30.05	150S	10	7/8	12	5135	25.5

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	30.05	150S	12	7/8	12	5326	26.5
					7.73	371	30.05	150S	14	1	12	6249	35.2
					7.73	371	30.05	150S	16	1	16	5999	33.8
					7.73	371	30.05	150S	18	1-1/8	16	8583	53.7
					7.73	371	30.05	150S	20	1-1/8	20	8583	53.7
					7.73	371	30.05	150S	24	1-1/4	20	11379	78.3
LIST A-6													
A4F	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.57	150S	1/2	1/2	4	798	2.4
	A182 Gr.F5	A193 Gr.B16	Spiral wound SS	A 335 GR.P5	7.73	371	30.57	150S	3/4	1/2	4	970	2.9
				A 691 GR.5Cr CL.42	7.73	371	30.57	150S	1	1/2	4	1141	3.4
					7.73	371	30.57	150S	1-1/2	1/2	4	1540	4.6
					7.73	371	30.57	150S	2	5/8	4	2745	10.1
					7.73	371	30.57	150S	3	5/8	4	3020	11.1
					7.73	371	30.57	150S	4	5/8	8	3020	11.1
					7.73	371	30.57	150S	6	3/4	8	5205	22.5
					7.73	371	30.57	150S	8	3/4	8	5274	22.8
					7.73	371	30.57	150S	10	7/8	12	6277	31.2
					7.73	371	30.57	150S	12	7/8	12	6277	31.2
					7.73	371	30.57	150S	14	1	12	8249	46.5
					7.73	371	30.57	150S	16	1	16	7249	40.9
					7.73	371	30.57	150S	18	1-1/8	16	11885	74.4
					7.73	371	30.57	150S	20	1-1/8	20	11554	72.4
					7.73	371	30.57	150S	24	1-1/4	20	14751	101.5
					7.73	371	30.57	150B	26	3/4	36	4109	17.7
					7.73	371	30.57	150B	28	3/4	40	4383	18.9
					7.73	371	30.57	150B	30	3/4	44	4520	19.5
					7.73	371	30.57	150B	32	3/4	48	4794	20.7
					7.73	371	30.57	150B	34	7/8	40	6847	34.0
					7.73	371	30.57	150B	36	7/8	44	7037	35.0
					7.73	371	30.57	150B	38	1	40	8748	49.3
					7.73	371	30.57	150B	40	1	44	8748	49.3
					7.73	371	30.57	150B	42	1	48	8498	47.9

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-7													
A4G	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.57	150S	1/2	1/2	4	798	2.4
	A182 Gr.F9	A193 Gr.B16	Spiral wound SS	A 335 GR.P9	7.73	371	30.57	150S	3/4	1/2	4	970	2.9
				A 691 GR.9Cr CL.42	7.73	371	30.57	150S	1	1/2	4	1255	3.8
					7.73	371	30.57	150S	1-1/2	1/2	4	1825	5.5
					7.73	371	30.57	150S	2	5/8	4	3203	11.8
					7.73	371	30.57	150S	3	5/8	4	3386	12.4
					7.73	371	30.57	150S	4	5/8	8	3386	12.4
					7.73	371	30.57	150S	6	3/4	8	5342	23.1
					7.73	371	30.57	150S	8	3/4	8	5342	23.1
					7.73	371	30.57	150S	10	7/8	12	7037	35.0
					7.73	371	30.57	150S	12	7/8	12	6847	34.0
					7.73	371	30.57	150S	14	1	12	8748	49.3
					7.73	371	30.57	150S	16	1	16	7999	45.1
					7.73	371	30.57	150S	18	1-1/8	16	12215	76.5
					7.73	371	30.57	150S	20	1-1/8	20	11885	74.4
					7.73	371	30.57	150S	24	1-1/4	20	15594	107.3
					7.73	371	30.57	150B	26	3/4	36	4383	18.9
					7.73	371	30.57	150B	28	3/4	40	4589	19.8
					7.73	371	30.57	150B	30	3/4	44	4726	20.4
					7.73	371	30.57	150B	32	3/4	48	5137	22.2
					7.73	371	30.57	150B	34	7/8	40	7132	35.5
					7.73	371	30.57	150B	36	7/8	44	7132	35.5
					7.73	371	30.57	150B	38	1	40	9123	51.4
					7.73	371	30.57	150B	40	1	44	9123	51.4
					7.73	371	30.57	150B	42	1	48	8998	50.7
LIST A-8													
A2K	PMS rated Temperature / Pressure		120 / 15.32	Up to 24"	15.32	120	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	15.32	120	29.00	150S	3/4	1/2	4	855	2.6
				A 358 GR.304	15.32	120	29.00	150S	1	1/2	4	1141	3.4
					15.32	120	29.00	150S	1-1/2	1/2	4	1597	4.8
					15.32	120	29.00	150S	2	5/8	4	2379	8.7
					15.32	120	29.00	150S	3	5/8	4	3203	11.8

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					15.32	120	29.00	150S	4	5/8	8	2837	10.4
					15.32	120	29.00	150S	6	3/4	8	4383	18.9
					15.32	120	29.00	150S	8	3/4	8	5068	21.9
					15.32	120	29.00	150S	10	7/8	12	5516	27.4
					15.32	120	29.00	150S	12	7/8	12	5896	29.3
					15.32	120	29.00	150S	14	1	12	7499	42.3
					15.32	120	29.00	150S	16	1	16	6749	38.1
					15.32	120	29.00	150S	18	1-1/8	16	9574	59.9
					15.32	120	29.00	150S	20	1-1/8	20	9574	59.9
					15.32	120	29.00	150S	24	1-1/4	20	12644	87.0
					15.32	120	29.00	150B	26	3/4	36	4109	17.7
					15.32	120	29.00	150B	28	3/4	40	4246	18.3
					15.32	120	29.00	150B	30	3/4	44	4383	18.9
					15.32	120	29.00	150B	32	3/4	48	4520	19.5
					15.32	120	29.00	150B	34	7/8	40	5896	29.3
					15.32	120	29.00	150B	36	7/8	44	5991	29.8
LIST A-9													
A1K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	7.73	371	29.00	150S	3/4	1/2	4	798	2.4
				A 358 GR.304	7.73	371	29.00	150S	1	1/2	4	913	2.7
A6K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1-1/2	1/2	4	1141	3.4
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	7.73	371	29.00	150S	2	5/8	4	2562	9.4
				A 358 GR.304L	7.73	371	29.00	150S	3	5/8	4	3020	11.1
A11K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	4	5/8	8	2471	9.1
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	7.73	371	29.00	150S	6	3/4	8	3972	17.2
				A 358 GR.304L	7.73	371	29.00	150S	8	3/4	8	4931	21.3
					7.73	371	29.00	150S	10	7/8	12	5135	25.5
					7.73	371	29.00	150S	12	7/8	12	5326	26.5
					7.73	371	29.00	150S	14	1	12	6249	35.2
					7.73	371	29.00	150S	16	1	16	5999	33.8
					7.73	371	29.00	150S	18	1-1/8	16	8583	53.7
					7.73	371	29.00	150S	20	1-1/8	20	8583	53.7
					7.73	371	29.00	150S	24	1-1/4	20	11379	78.3

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-10													
A1M	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F316	A193 GR.B7	Spiral wound SS	A 312 TP316	7.73	371	29.00	150S	3/4	1/2	4	798	2.4
				A 358 GR.316	7.73	371	29.00	150S	1	1/2	4	913	2.7
					7.73	371	29.00	150S	1-1/2	1/2	4	1141	3.4
					7.73	371	29.00	150S	2	5/8	4	2562	9.4
					7.73	371	29.00	150S	3	5/8	4	3020	11.1
					7.73	371	29.00	150S	4	5/8	8	2471	9.1
					7.73	371	29.00	150S	6	3/4	8	3972	17.2
					7.73	371	29.00	150S	8	3/4	8	4931	21.3
					7.73	371	29.00	150S	10	7/8	12	5135	25.5
					7.73	371	29.00	150S	12	7/8	12	5326	26.5
					7.73	371	29.00	150S	14	1	12	6249	35.2
					7.73	371	29.00	150S	16	1	16	5999	33.8
					7.73	371	29.00	150S	18	1-1/8	16	8583	53.7
					7.73	371	29.00	150S	20	1-1/8	20	8583	53.7
					7.73	371	29.00	150S	24	1-1/4	20	11379	78.3
LIST A-11													
A1N	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	24.26	150S	1/2	1/2	4	570	1.7
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	7.73	371	24.26	150S	3/4	1/2	4	798	2.4
				A 358 GR.316L	7.73	371	24.26	150S	1	1/2	4	913	2.7
					7.73	371	24.26	150S	1-1/2	1/2	4	1426	4.3
					7.73	371	24.26	150S	2	5/8	4	2562	9.4
					7.73	371	24.26	150S	3	5/8	4	3020	11.1
					7.73	371	24.26	150S	4	5/8	8	2471	9.1
					7.73	371	24.26	150S	6	3/4	8	3972	17.2
					7.73	371	24.26	150S	8	3/4	8	4931	21.3
					7.73	371	24.26	150S	10	7/8	12	5135	25.5
					7.73	371	24.26	150S	12	7/8	12	5326	26.5
					7.73	371	24.26	150S	14	1	12	6249	35.2
					7.73	371	24.26	150S	16	1	16	5999	33.8
					7.73	371	24.26	150S	18	1-1/8	16	8583	53.7
					7.73	371	24.26	150S	20	1-1/8	20	8583	53.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	24.26	150S	24	1-1/4	20	11379	78.3
LIST B-1													
B1A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	1/2	1/2	4	741	2.2
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	3/4	5/8	4	1373	5.0
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	1	5/8	4	1647	6.0
B2A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	1-1/2	3/4	4	2740	11.8
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	2	5/8	8	2105	7.7
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	3	3/4	8	3972	17.2
B5A	PMS rated Temperature / Pressure		230 / 43.66	Up to 24"	28.82	427	79.10	300S	4	3/4	8	5205	22.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	6	3/4	12	5205	22.5
				A 672 GR.B60 CL.32	28.82	427	79.10	300S	8	7/8	12	7608	37.8
B6A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	10	1	16	8748	49.3
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	12	1-1/8	16	11554	72.4
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	14	1-1/8	20	8913	55.8
B9A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	16	1-1/4	20	10958	75.4
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	18	1-1/4	24	11801	81.2
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	20	1-1/4	24	14330	98.6
B13A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	24	1-1/2	24	17849	144.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300B	26	1-1/4	32	13065	89.9
				A 672 GR.B60 CL.12	28.82	427	79.10	300B	28	1-1/4	36	13065	89.9
B19A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300B	30	1-3/8	36	15197	114.0
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300B	32	1-1/2	32	18487	150.1
				A 672 GR.B60 CL.22	28.82	427	79.10	300B	34	1-1/2	36	18168	147.5
B32A	PMS rated Temperature / Pressure		427 / 28.82	Up to 3"	28.82	427	79.10	300B	36	1-5/8	32	23630	206.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300B	38	1-5/8	36	25154	219.9
				A 672 GR.B60 CL.12	28.82	427	79.10	300B	40	1-5/8	40	24392	213.2
					28.82	427	79.10	300B	42	1-3/4	36	29631	277.5
LIST B-2													
B4A	PMS rated Temperature / Pressure		204 / 43.23	Up to 24"	28.82	427	79.10	300S	1/2	1/2	4	741	2.2
	A350 Gr.LF2 CL.1	A320 Gr.L7	Spiral wound SS	A333 Gr.6	28.82	427	79.10	300S	3/4	5/8	4	1373	5.0
				A671 Gr.CC60 CL.32	28.82	427	79.10	300S	1	5/8	4	1647	6.0
B16A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	1-1/2	3/4	4	2740	11.8
	A105	A193 Gr.B7M	Spiral wound SS	A106 Gr.B	28.82	427	79.10	300S	2	5/8	8	2105	7.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
				A672 Gr.B60 CL.22	28.82	427	79.10	300S	3	3/4	8	3972	17.2
					28.82	427	79.10	300S	4	3/4	8	5205	22.5
					28.82	427	79.10	300S	6	3/4	12	5205	22.5
					28.82	427	79.10	300S	8	7/8	12	7608	37.8
					28.82	427	79.10	300S	10	1	16	8748	49.3
					28.82	427	79.10	300S	12	1-1/8	16	11554	72.4
					28.82	427	79.10	300S	14	1-1/8	20	8913	55.8
					28.82	427	79.10	300S	16	1-1/4	20	10958	75.4
					28.82	427	79.10	300S	18	1-1/4	24	11801	81.2
					28.82	427	79.10	300S	20	1-1/4	24	14330	98.6
					28.82	427	79.10	300S	24	1-1/2	24	17849	144.9
					28.82	427	79.10	300B	26	1-1/4	32	13065	89.9
					28.82	427	79.10	300B	28	1-1/4	36	13065	89.9
					28.82	427	79.10	300B	30	1-3/8	36	15197	114.0
LIST B-3													
B1D	PMS rated Temperature / Pressure		538 / 15.11	Up to 24"	15.11	538	79.10	300S	1/2	1/2	4	741	2.2
	A182 Gr. F11 Cl. 2	A193 Gr. B16	Spiral wound SS	A335 Gr. P11	15.11	538	79.10	300S	3/4	5/8	4	1007	3.7
				A691 Gr.1.25Cr Cl.42	15.11	538	79.10	300S	1	5/8	4	1647	6.0
B5D	PMS rated Temperature / Pressure		538 / 15.11	Up to 24"	15.11	538	79.10	300S	1-1/2	3/4	4	3014	13.0
	A182 Gr. F11 Cl. 2	A193 Gr. B16	Spiral wound SS	A335 Gr. P11	15.11	538	79.10	300S	2	5/8	8	2196	8.1
				A691 Gr.1.25Cr Cl.42	15.11	538	79.10	300S	3	3/4	8	4794	20.7
B3F	PMS rated Temperature / Pressure		538 / 14.06	Up to 24"	15.11	538	79.10	300S	4	3/4	8	5205	22.5
	A 182 GR.F5	A193 GR.B16	Spiral wound SS	A 335 GR.P5	15.11	538	79.10	300S	6	3/4	12	5205	22.5
				A 691 GR5CR CL.42	15.11	538	79.10	300S	8	7/8	12	7228	35.9
B4F	PMS rated Temperature / Pressure		538 / 14.06	Up to 24"	15.11	538	79.10	300S	10	1	16	9498	53.6
	A 182 GR.F5	A193 GR.B16	Spiral wound SS	A 335 GR.P5	15.11	538	79.10	300S	12	1-1/8	16	11885	74.4
				A 691 Gr. 5CR CL.42	15.11	538	79.10	300S	14	1-1/8	20	9574	59.9
					15.11	538	79.10	300S	16	1-1/4	20	11801	81.2
					15.11	538	79.10	300S	18	1-1/4	24	12222	84.1
					15.11	538	79.10	300S	20	1-1/4	24	14751	101.5
					15.11	538	79.10	300S	24	1-1/2	24	17849	144.9
					12.09	538	63.28	300B	26	1-1/4	32	10958	75.4
					12.09	538	63.28	300B	28	1-1/4	36	10958	75.4

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					12.09	538	63.28	300B	30	1-3/8	36	12577	94.3
					12.09	538	63.28	300B	32	1-1/2	32	15937	129.4
					12.09	538	63.28	300B	34	1-1/2	36	15299	124.2
					12.09	538	63.28	300B	36	1-5/8	32	19819	173.2
					12.09	538	63.28	300B	38	1-5/8	36	22105	193.2
					12.09	538	63.28	300B	40	1-5/8	40	21343	186.5
					12.09	538	63.28	300B	42	1-3/4	36	26937	252.3
LIST B-4													
B1E	PMS rated Temperature / Pressure		538 / 18.63	Up to 24"	18.63	538	79.10	300S	1/2	1/2	4	855	2.6
	A 182 GR.F22 CL.3	A193 Gr. B16	Spiral wound SS	A335 Gr. P22	18.63	538	79.10	300S	3/4	5/8	4	1098	4.0
				A691 Gr.2.25Cr Cl.42	18.63	538	79.10	300S	1	5/8	4	1830	6.7
B4G	PMS rated Temperature / Pressure		538 / 17,92	Up to 24"	18.63	538	79.10	300S	1-1/2	3/4	4	3287	14.2
	A 182 GR.F9	A193 GR.B16	Spiral wound SS	A 335 GR.P9	18.63	538	79.10	300S	2	5/8	8	2288	8.4
				A 691 GR9CR CL.42	18.63	538	79.10	300S	3	3/4	8	4931	21.3
					18.63	538	79.10	300S	4	3/4	8	5342	23.1
					18.63	538	79.10	300S	6	3/4	12	5342	23.1
					18.63	538	79.10	300S	8	7/8	12	7418	36.9
					18.63	538	79.10	300S	10	1	16	9748	55.0
					18.63	538	79.10	300S	12	1-1/8	16	12215	76.5
					18.63	538	79.10	300S	14	1-1/8	20	10234	64.1
					18.63	538	79.10	300S	16	1-1/4	20	12644	87.0
					18.63	538	79.10	300S	18	1-1/4	24	13065	89.9
					18.63	538	79.10	300S	20	1-1/4	24	15173	104.4
					18.63	538	79.10	300S	24	1-1/2	24	18487	150.1
					14.90	538	63.28	300B	26	1-1/4	32	11801	81.2
					14.90	538	63.28	300B	28	1-1/4	36	11801	81.2
					14.90	538	63.28	300B	30	1-3/8	36	13625	102.2
					14.90	538	63.28	300B	32	1-1/2	32	17212	139.8
					14.90	538	63.28	300B	34	1-1/2	36	16574	134.6
					14.90	538	63.28	300B	36	1-5/8	32	21343	186.5
					14.90	538	63.28	300B	38	1-5/8	36	23630	206.5
					14.90	538	63.28	300B	40	1-5/8	40	22868	199.9
					14.90	538	63.28	300B	42	1-3/4	36	28733	269.1

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST B-5													
B6K	PMS rated Temperature / Pressure		427 / 24.25	Up to 24"	24.25	427	63.27	300S	1/2	1/2	4	570	1.7
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	24.25	427	63.27	300S	3/4	5/8	4	915	3.4
				A 358 TP304L CL.1	24.25	427	63.27	300S	1	5/8	4	1281	4.7
					24.25	427	63.27	300S	1-1/2	3/4	4	2192	9.5
					24.25	427	63.27	300S	2	5/8	8	1464	5.4
					24.25	427	63.27	300S	3	3/4	8	2466	10.6
					24.25	427	63.27	300S	4	3/4	8	2740	11.8
					24.25	427	63.27	300S	6	3/4	12	3150	13.6
					24.25	427	63.27	300S	8	7/8	12	4945	24.6
					24.25	427	63.27	300S	10	1	16	5249	29.6
					24.25	427	63.27	300S	12	1-1/8	16	7263	45.5
					24.25	427	63.27	300S	14	1-1/8	20	6933	43.4
					24.25	427	63.27	300S	16	1-1/4	20	8851	60.9
					24.25	427	63.27	300S	18	1-1/4	24	9694	66.7
					24.25	427	63.27	300S	20	1-1/4	24	11379	78.3
					24.25	427	63.27	300S	24	1-1/2	24	14662	119.1
LIST B-6													
B1K	PMS rated Temperature / Pressure		454 / 27.77	Up to 24"	5.97	704	75.93	300S	1/2	1/2	4	798	2.4
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	5.97	704	75.93	300S	3/4	5/8	4	1281	4.7
				A 358 TP304 CL.1	5.97	704	75.93	300S	1	5/8	4	1464	5.4
B2K	PMS rated Temperature / Pressure		120 / 40.14	Up to 24"	5.97	704	75.93	300S	1-1/2	3/4	4	2740	11.8
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	5.97	704	75.93	300S	2	5/8	8	2105	7.7
				A 358 TP316L CL.1	5.97	704	75.93	300S	3	3/4	8	3561	15.4
B4K	PMS rated Temperature / Pressure		704 /8.08	Up to 24"	5.97	704	75.93	300S	4	3/4	8	3972	17.2
	A 182 GR.F304H	A453 GR.660CL.A	Spiral wound SS	A 312 TP304H	5.97	704	75.93	300S	6	3/4	12	4109	17.7
					5.97	704	75.93	300S	8	7/8	12	6086	30.3
B5K	PMS rated Temperature / Pressure		704/8.08	Up to 24"	5.97	704	75.93	300S	10	1	16	7499	42.3
	A 182 GR.F304H	A453 GR.660CL.A	Spiral wound SS	A 312 TP304H	5.97	704	75.93	300S	12	1-1/8	16	9574	59.9
					5.97	704	75.93	300S	14	1-1/8	20	8253	51.7
					5.97	704	75.93	300S	16	1-1/4	20	10537	72.5
					5.97	704	75.93	300S	18	1-1/4	24	11379	78.3
					5.97	704	75.93	300S	20	1-1/4	24	12644	87.0

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					5.97	704	75.93	300S	24	1-1/2	24	15937	129.4
					4.78	704	60.74	300B	26	1-1/4	32	10537	72.5
					4.78	704	60.74	300B	28	1-1/4	36	11801	81.2
					4.78	704	60.74	300B	30	1-3/8	36	12577	94.3
					4.78	704	60.74	300B	32	1-1/2	32	15937	129.4
					4.78	704	60.74	300B	34	1-1/2	36	15937	129.4
					4.78	704	60.74	300B	36	1-5/8	32	19819	173.2
					4.78	704	60.74	300B	38	1-5/8	36	20581	179.9
					4.78	704	60.74	300B	40	1-5/8	40	19819	173.2
					4.78	704	60.74	300B	42	1-3/4	36	25142	235.5
LIST B-7													
B1M	PMS rated Temperature / Pressure		427 / 29.52	Up to 24"	26.66	538	75.95	300S	1/2	1/2	4	570	1.7
	A 182 GR.F316	A193 GR.B7	Spiral wound SS	A 312 TP316	26.66	538	75.95	300S	3/4	5/8	4	1373	5.0
				A 358 TP316 CL.1	26.66	538	75.95	300S	1	5/8	4	1373	5.0
B3M	PMS rated Temperature / Pressure		538 / 25.66	Up to 24"	26.66	538	75.95	300S	1-1/2	3/4	4	2192	9.5
	A 182 GR.F321	A453 GR.660CL.A	Spiral wound SS	A 312 TP321	26.66	538	75.95	300S	2	5/8	8	1556	5.7
				A 358 TP321 CL.1	26.66	538	75.95	300S	3	3/4	8	2603	11.2
B5M	PMS rated Temperature / Pressure		538 / 24.60	Up to 24"	26.66	538	75.95	300S	4	3/4	8	3972	17.2
	A 182 GR.F316H	A453 GR.660CL.A	Spiral wound SS	A 312 TP316H	26.66	538	75.95	300S	6	3/4	12	3972	17.2
					26.66	538	75.95	300S	8	7/8	12	5706	28.4
					26.66	538	75.95	300S	10	1	16	6999	39.5
					26.66	538	75.95	300S	12	1-1/8	16	8253	51.7
					26.66	538	75.95	300S	14	1-1/8	20	7593	47.5
					26.66	538	75.95	300S	16	1-1/4	20	9694	66.7
					26.66	538	75.95	300S	18	1-1/4	24	10537	72.5
					26.66	538	75.95	300S	20	1-1/4	24	12222	84.1
					26.66	538	75.95	300S	24	1-1/2	24	16256	132.0
					20.53	538	60.82	300B	26	1-1/4	32	10537	72.5
					20.53	538	60.82	300B	28	1-1/4	36	10537	72.5
					20.53	538	60.82	300B	30	1-3/8	36	11791	88.4
					20.53	538	60.82	300B	32	1-1/2	32	14981	121.6
					20.53	538	60.82	300B	34	1-1/2	36	14343	116.5
					20.53	538	60.82	300B	36	1-5/8	32	17913	156.6

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					20.53	538	60.82	300B	38	1-5/8	36	19056	166.6
					20.53	538	60.82	300B	40	1-5/8	40	18294	159.9
					20.53	538	60.82	300B	42	1-3/4	36	22897	214.4
LIST B-8													
B1N	PMS rated Temperature / Pressure		454 / 23.90	Up to 24"	23.90	454	63.27	300S	1/2	1/2	4	570	1.7
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	23.90	454	63.27	300S	3/4	5/8	4	915	3.4
				A 358 TP 316L CL.1	23.90	454	63.27	300S	1	5/8	4	1281	4.7
B6N	PMS rated Temperature / Pressure		427 / 24.25	Up to 24"	23.90	454	63.27	300S	1-1/2	3/4	4	2192	9.5
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	23.90	454	63.27	300S	2	5/8	8	1464	5.4
				A 358 TP 316L CL.1	23.90	454	63.27	300S	3	3/4	8	2466	10.6
					23.90	454	63.27	300S	4	3/4	8	2740	11.8
					23.90	454	63.27	300S	6	3/4	12	3150	13.6
					23.90	454	63.27	300S	8	7/8	12	4945	24.6
					23.90	454	63.27	300S	10	1	16	5249	29.6
					23.90	454	63.27	300S	12	1-1/8	16	7263	45.5
					23.90	454	63.27	300S	14	1-1/8	20	6933	43.4
					23.90	454	63.27	300S	16	1-1/4	20	8851	60.9
					23.90	454	63.27	300S	18	1-1/4	24	9694	66.7
					23.90	454	63.27	300S	20	1-1/4	24	11379	78.3
					23.90	454	63.27	300S	24	1-1/2	24	14662	119.1
LIST D-1													
D1A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	1/2	1/2	4	970	2.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	3/4	5/8	4	1373	5.0
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	1	5/8	4	2013	7.4
D2A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	1-1/2	3/4	4	4520	19.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	2	5/8	8	3112	11.4
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	3	3/4	8	5205	22.5
D5A	PMS rated Temperature / Pressure		230 / 86.96	Up to 24"	58.00	427	156.08	600S	4	7/8	8	7228	35.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	6	1	12	8998	50.7
				A 672 GR.B60 CL.32	58.00	427	156.08	600S	8	1-1/8	12	12875	80.6
D9A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	10	1-1/4	16	14751	101.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	12	1-1/4	20	14751	101.5
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	14	1-3/8	20	17294	129.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
D16A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	16	1-1/2	20	21037	170.8
	A105	A193 GR.B7M	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	18	1-5/8	20	27441	239.8
				A 672 GR.B60 CL.22	58.00	427	156.08	600S	20	1-5/8	24	26679	233.2
D19A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	24	1-7/8	24	34482	343.7
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	46.40	427	124.90	600B	26	1-5/8	28	25917	226.5
				A 672 GR.B60 CL.22	46.40	427	124.90	600B	28	1-3/4	28	28733	269.1
					46.40	427	124.90	600B	30	1-7/8	28	35527	354.2
					46.40	427	124.90	600B	32	2	28	39708	420.7
					46.40	427	124.90	600B	34	2-1/4	24	55895	661.6
					46.40	427	124.90	600B	36	2-1/4	28	49684	588.1
					46.40	427	124.90	600B	38	2-1/4	28	54342	643.2
					46.40	427	124.90	600B	40	2-1/4	32	51237	606.4
					46.40	427	124.90	600B	42	2-1/2	28	66195	865.9
LIST D-2													
D4A	PMS rated Temperature / Pressure		204 / 86.47	Up to 24"	86.47	204	147.05	600S	1/2	1/2	4	970	2.9
	A 350 GR.LF2 CL.1	A320 GR.L7	Spiral wound SS	A 333 GR.6	86.47	204	147.05	600S	3/4	5/8	4	1373	5.0
				A 671 GR.CC60 CL.32	86.47	204	147.05	600S	1	5/8	4	2013	7.4
					86.47	204	147.05	600S	1-1/2	3/4	4	4520	19.5
					86.47	204	147.05	600S	2	5/8	8	3112	11.4
					86.47	204	147.05	600S	3	3/4	8	5205	22.5
					86.47	204	147.05	600S	4	7/8	8	7228	35.9
					86.47	204	147.05	600S	6	1	12	8998	50.7
					86.47	204	147.05	600S	8	1-1/8	12	12875	80.6
					86.47	204	147.05	600S	10	1-1/4	16	14751	101.5
					86.47	204	147.05	600S	12	1-1/4	20	14751	101.5
					86.47	204	147.05	600S	14	1-3/8	20	17294	129.7
					86.47	204	147.05	600S	16	1-1/2	20	21037	170.8
					86.47	204	147.05	600S	18	1-5/8	20	27441	239.8
					86.47	204	147.05	600S	20	1-5/8	24	26679	233.2
					86.47	204	147.05	600S	24	1-7/8	24	34482	343.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST D-3													
D1D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	1/2	1/2	4	1084	3.3
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	3/4	5/8	4	1373	5.0
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	1	5/8	4	2196	8.1
D2D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	1-1/2	3/4	4	4246	18.3
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	2	5/8	8	3295	12.1
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	3	3/4	8	5342	23.1
D5D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	4	7/8	8	7798	38.8
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	6	1	12	9498	53.6
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	8	1-1/8	12	13535	84.8
					30.23	538	158.20	600S	10	1-1/4	16	16016	110.2
					30.23	538	158.20	600S	12	1-1/4	20	15594	107.3
					30.23	538	158.20	600S	14	1-3/8	20	18342	137.6
					30.23	538	158.20	600S	16	1-1/2	20	21674	176.0
					30.23	538	158.20	600S	18	1-5/8	20	28966	253.2
					30.23	538	158.20	600S	20	1-5/8	24	28203	246.5
					30.23	538	158.20	600S	24	1-7/8	24	36572	364.6
					24.19	538	126.56	600B	26	1-5/8	28	26679	233.2
					24.19	538	126.56	600B	28	1-3/4	28	30529	285.9
					24.19	538	126.56	600B	30	1-7/8	28	35527	354.2
					24.19	538	126.56	600B	32	2	28	40911	433.4
					24.19	538	126.56	600B	34	2-1/4	24	55895	661.6
					24.19	538	126.56	600B	36	2-1/4	28	49684	588.1
LIST D-4													
D5E	PMS rated Temperature / Pressure		538 / 37.61	Up to 24"	37.61	538	158.20	600S	1/2	1/2	4	1255	3.8
	A182 Gr. F22 Cl. 3	A193 Gr. B16	Spiral wound SS	A335 Gr. P22	37.61	538	158.20	600S	3/4	5/8	4	1556	5.7
				A 691 GR2.25CR CL.42	37.61	538	158.20	600S	1	5/8	4	2471	9.1
					37.61	538	158.20	600S	1-1/2	3/4	4	4657	20.1
					37.61	538	158.20	600S	2	5/8	8	3478	12.8
					37.61	538	158.20	600S	3	3/4	8	5479	23.7
					37.61	538	158.20	600S	4	7/8	8	7798	38.8
					37.61	538	158.20	600S	6	1	12	9748	55.0
					37.61	538	158.20	600S	8	1-1/8	12	13535	84.8

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					37.61	538	158.20	600S	10	1-1/4	16	16437	113.1
					37.61	538	158.20	600S	12	1-1/4	20	16437	113.1
					37.61	538	158.20	600S	14	1-3/8	20	19914	149.3
					37.61	538	158.20	600S	16	1-1/2	20	22949	186.3
					37.61	538	158.20	600S	18	1-5/8	20	29728	259.8
					37.61	538	158.20	600S	20	1-5/8	24	28966	253.2
					37.61	538	158.20	600S	24	1-7/8	24	38662	385.4
					30.09	538	126.60	600B	26	1-5/8	28	28203	246.5
					30.09	538	126.60	600B	28	1-3/4	28	32325	302.7
					30.09	538	126.60	600B	30	1-7/8	28	37617	375.0
					30.09	538	126.60	600B	32	2	28	43318	458.9
					30.09	538	126.60	600B	34	2-1/4	24	59000	698.3
					30.09	538	126.60	600B	36	2-1/4	28	52789	624.8
LIST D-5													
D1K	PMS rated Temperature / Pressure		454 / 55.54	Up to 24"	55.54	454	114.00	600S	1/2	1/2	4	627	1.9
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	55.54	454	114.00	600S	3/4	5/8	4	915	3.4
				A 358 TP304 CL.1	55.54	454	114.00	600S	1	5/8	4	1281	4.7
D2K	PMS rated Temperature / Pressure		120 / 80.12	Up to 24"	55.54	454	114.00	600S	1-1/2	3/4	4	2466	10.6
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	55.54	454	114.00	600S	2	5/8	8	1647	6.0
				A 358 TP304 CL.1	55.54	454	114.00	600S	3	3/4	8	3150	13.6
					55.54	454	114.00	600S	4	7/8	8	5135	25.5
					55.54	454	114.00	600S	6	1	12	6249	35.2
					55.54	454	114.00	600S	8	1-1/8	12	8913	55.8
					55.54	454	114.00	600S	10	1-1/4	16	9272	63.8
					55.54	454	114.00	600S	12	1-1/4	20	10115	69.6
					55.54	454	114.00	600S	14	1-3/8	20	12053	90.4
					55.54	454	114.00	600S	16	1-1/2	20	15299	124.2
					55.54	454	114.00	600S	18	1-5/8	20	19056	166.6
					55.54	454	114.00	600S	20	1-5/8	24	19056	166.6
					55.54	454	114.00	600S	24	1-7/8	24	25078	250.0
					44.44	454	91.20	600B	26	1-5/8	28	18294	159.9
					44.44	454	91.20	600B	28	1-3/4	28	20652	193.4
					44.44	454	91.20	600B	30	1-7/8	28	24033	239.6

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST E-1													
E1A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	1/2	3/4	4	2877	11.9
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	3/4	3/4	4	3698	15.3
				A 672 GR.B60 CL. 12	86.83	427	234.12	900S	1	7/8	4	4565	21.7
E2A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	1-1/2	1	4	6999	37.7
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	2	7/8	8	5135	24.4
				A 672 GR.B60 CL. 12	86.83	427	234.12	900S	3	7/8	8	6847	32.6
E5A	PMS rated Temperature / Pressure		230 / 130.63	Up to 24"	86.83	427	234.12	900S	4	1-1/8	8	8583	51.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	6	1-1/8	12	10234	61.3
				A 672 GR.B60 CL. 32	86.83	427	234.12	900S	8	1-3/8	12	15197	109.0
E9A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	10	1-3/8	16	16245	116.5
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	12	1-3/8	20	17294	124.1
				A 672 GR.B60 CL. 22	86.83	427	234.12	900S	14	1-1/2	20	21674	168.3
E19A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	16	1-5/8	20	26679	223.0
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	18	1-7/8	20	35527	338.8
				A 672 GR.B60 CL. 22	86.83	427	234.12	900S	20	2	20	40911	414.6
					86.83	427	234.12	900S	24	2-1/2	20	62301	779.5
					69.47	427	187.30	900B	26	2-1/2	20	60354	755.2
					69.47	427	187.30	900B	28	2-3/4	20	66799	915.6
					69.47	427	187.30	900B	30	3	20	77472	1152.8
LIST E-2													
E5E	PMS rated Temperature / Pressure		538 / 56.24	Up to 24"	56.24	538	237.28	900S	1/2	3/4	4	3150	13.0
	A182 Gr. F22 Cl. 3	A193 Gr. B16	RTJ - 5Cr-0.5Mo	A335 Gr. P22	56.24	538	237.28	900S	3/4	3/4	4	3835	15.8
				A 691 GR2.25CR CL.42	56.24	538	237.28	900S	1	7/8	4	5326	25.3
					56.24	538	237.28	900S	1-1/2	1	4	7749	41.8
					56.24	538	237.28	900S	2	7/8	8	5896	28.0
					56.24	538	237.28	900S	3	7/8	8	6467	30.7
					56.24	538	237.28	900S	4	1-1/8	8	9904	59.3
					56.24	538	237.28	900S	6	1-1/8	12	10894	65.3
					56.24	538	237.28	900S	8	1-3/8	12	16245	116.5
					56.24	538	237.28	900S	10	1-3/8	16	16770	120.3
					56.24	538	237.28	900S	12	1-3/8	20	17818	127.8
					56.24	538	237.28	900S	14	1-1/2	20	22949	178.2

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					56.24	538	237.28	900S	16	1-5/8	20	28203	235.8
					56.24	538	237.28	900S	18	1-7/8	20	36572	348.7
					56.24	538	237.28	900S	20	2	20	44521	451.1
					56.24	538	237.28	900S	24	2-1/2	20	68142	852.6
					56.24	538	189.83	900B	26	2-1/2	20	64248	803.9
					56.24	538	189.83	900B	28	2-3/4	20	73956	1013.8
					56.24	538	189.83	900B	30	3	20	83211	1238.2
LIST F-1													
F1A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	1/2	3/4	4	3014	12.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	3/4	3/4	4	3972	16.4
				A 672 GR.B60 CL.12	144.83	427	390.74	1500S	1	7/8	4	4945	23.5
F2A	PMS rated Temperature / Pressure		427 / 144.46	Up to 24"	144.83	427	390.74	1500S	1-1/2	1	4	7499	40.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	2	7/8	8	6467	30.7
				A 672 GR.B60 CL.22	144.83	427	390.74	1500S	3	1-1/8	8	12215	73.2
F5A	PMS rated Temperature / Pressure		230 / 217.79	Up to 24"	144.83	427	390.74	1500S	4	1-1/4	8	16016	105.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	6	1-3/8	12	19914	142.8
				A672 Gr. B60 Cl. 22	144.83	427	390.74	1500S	8	1-5/8	12	29728	248.5
F9A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	10	1-7/8	12	41797	398.5
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	12	2	16	43318	439.0
				A 672 GR.B60 CL.12	144.83	427	390.74	1500S	14	2-1/4	16	55895	632.8
F19A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	16	2-1/2	16	70089	877.0
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	18	2-3/4	16	85884	1177.3
				A672 Gr. B60 Cl. 22	144.83	427	390.74	1500S	20	3	16	103296	1537.0
					144.83	427	390.74	1500S	24	3-1/2	16	142889	2467.4
LIST F-2													
F2D	PMS rated Temperature / Pressure		538 / 75.93	Up to 24"	75.93	538	395.48	1500S	1/2	3/4	4	3972	16.4
	A 182 GR.F11 CL.2	A193 GR.B16	RTJ - 5Cr-0.5Mo	A 335 GR.P11	75.93	538	395.48	1500S	3/4	3/4	4	4931	20.4
				A 691 GR.1.25Cr CL.42	75.93	538	395.48	1500S	1	7/8	4	6277	29.8
					75.93	538	395.48	1500S	1-1/2	1	4	9248	49.9
					75.93	538	395.48	1500S	2	7/8	8	7037	33.5
					75.93	538	395.48	1500S	3	1-1/8	8	13205	79.1
					75.93	538	395.48	1500S	4	1-1/4	8	16858	110.9
					75.93	538	395.48	1500S	6	1-3/8	12	20962	150.4

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					75.93	538	395.48	1500S	8	1-5/8	12	30490	254.9
					75.93	538	395.48	1500S	10	1-7/8	12	41797	398.5
					75.93	538	395.48	1500S	12	2	16	46927	475.5
					75.93	538	395.48	1500S	14	2-1/4	16	55895	632.8
					75.93	538	395.48	1500S	16	2-1/2	16	72036	901.3
					75.93	538	395.48	1500S	18	2-3/4	16	88270	1210.0
					75.93	538	395.48	1500S	20	3	16	106165	1579.7
					75.93	538	395.48	1500S	24	3-1/2	16	146858	2535.9
LIST F-3													
F2G	PMS rated Temperature / Pressure		538 / 127.95	Up to 24"	127.95	538	395.48	1500S	1/2	3/4	4	3972	16.4
	A182 Gr. F91	A193 GR.B16	RTJ - 9Cr-1Mo	A 335 GR.P91	127.95	538	395.48	1500S	3/4	3/4	4	4931	20.4
				A 691 GR.P91 CL.42	127.95	538	395.48	1500S	1	7/8	4	6277	29.8
					127.95	538	395.48	1500S	1-1/2	1	4	9248	49.9
					127.95	538	395.48	1500S	2	7/8	8	7037	33.5
					127.95	538	395.48	1500S	3	1-1/8	8	13205	79.1
					127.95	538	395.48	1500S	4	1-1/4	8	16858	110.9
					127.95	538	395.48	1500S	6	1-3/8	12	20962	150.4
					127.95	538	395.48	1500S	8	1-5/8	12	30490	254.9
					127.95	538	395.48	1500S	10	1-7/8	12	41797	398.5
					127.95	538	395.48	1500S	12	2	16	46927	475.5
					127.95	538	395.48	1500S	14	2-1/4	16	55895	632.8
					127.95	538	395.48	1500S	16	2-1/2	16	72036	901.3
					127.95	538	395.48	1500S	18	2-3/4	16	88270	1210.0
					127.95	538	395.48	1500S	20	3	16	106165	1579.7
					127.95	538	395.48	1500S	24	3-1/2	16	146858	2535.9
LIST G-1													
G2G	PMS rated Temperature / Pressure		538 / 213.02	Up to 12"	213.02	538	510.00	2500S	1/2	3/4	4	5068	20.9
	A182 Gr. F91	A193 GR.B16	RTJ - 5Cr-0.5Mo	A 335 GR.P91	213.02	538	510.00	2500S	3/4	3/4	4	5479	22.6
				A 691 GR.P91 CL.42	213.02	538	510.00	2500S	1	7/8	4	7228	34.4
					213.02	538	510.00	2500S	1-1/2	1-1/8	4	13535	81.1
					213.02	538	510.00	2500S	2	1	8	9748	52.6
					213.02	538	510.00	2500S	3	1-1/4	8	15594	102.6
					213.02	538	510.00	2500S	4	1-1/2	8	24224	188.1

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure $kg/cm^2(g)$	Des Temp. °C	Test Pressure $kg/cm^2(g)$	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					213.02	538	510.00	2500S	6	2	8	46927	475.5
					213.02	538	510.00	2500S	8	2	12	46927	475.5
					213.02	538	510.00	2500S	10	2-1/2	12	70089	877.0
					213.02	538	510.00	2500S	12	2-3/4	12	95426	1308.1

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HISTORY SHEET FOR FLANGE JOINTS

Annexure - I

Project : _____
Unit : _____
System/Sub System Description : _____
Line No. : _____

Test loop No. : _____
ISO Drawing No.: _____
Connected P & ID No.: _____

Flange Joint No.	Flange Parallelity OK/Not OK		Flange Dia & Rating	Gasket		Studs *				Nuts		Torque Value	Bolt Tension Value	Flange joint Acceptance	
	Upstream	Down Stream		Spec.	OK/ Not OK	Size	Spec	Total Nos.	Accepted/ Nos Accepted	Spec.	Nos Accepted			Contractor	Owner/ EIL

* Special Care to be taken for tapped hole and it is to be certified by Contractor that full engagement of stud is there to the tapped hole. Contractor to carry out 100% verification

Acceptance by Licensor/Owner.

1. Pre-commissioning .....
   (Signature with Name and Date)
2. Commissioning .....
   (Signature with Name and Date)

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Annexure - II

SEQUENCE OF ACTIVITIES INVOLVED FOR REOPENING / MAKING / BLINDING / DEBLINDING / WEDGE OPENING OF FLANGE JOINTS

Sl. No.	Activity	Checked by Contractor (Signature)
1	Compliance of all check points.	
2	Availability and use of recommended tools i.e. Standard tools / Non-sparking tools/Pneumatic of Hydraulic torque wrench with suitable sockets and other accessories / Hydraulic bolt tensioner etc depending upon service pressure temperature rating of the line on which job is to be carried out.	
3	Skilled manpower with protective clothing, safety shoes etc.	
4	Proper access to flange joints for all bolts, proper scaffolding etc if required.	
5	Proper escape route	
6	Readiness of proper type, size & rating of blinds/gaskets/wedges & fasteners etc	
7	Loosening of the flange joints, starting from 6 '0' clock position (vertical joints)	
8	Check for leakage of any hot water / gas / steam / hydrocarbon etc and wait for depressurization of line, if any product leakage is observed.	
9	Complete opening of flange joint with recommended tools	
10	Removal of gasket / blind / wedge etc. and checking of old gaskets for improper loading from marking on gasket surface.	
11	Checking of old fasteners for proper metallurgy, sizing, length etc and ensure replacement of fasteners based on observations during final box up and also ensure that all fasteners to be of same size for uniform loading.	
12	Making gap in flange joints with proper tools (flange spreader etc.) For proper observations of gasket sitting area. Ensure proper cleaning of gasket seating surface with suitable non-sparking tools and inspection of gasket face.	
13	Ensure use of recommended gaskets of proper type and size for blinding / final box up	
14	Placing of fasteners in bottom half of flange joint (vertical joints).	
15	In case of blinding ensure that tail of the blind is vertically upward and blind is of proper size and not interfering with studs movement.	
16	Ensure proper placement of gasket on raised face/ring groove/serrated area.	
17	Ensuring slight tightening of studs in random in bottom half vertical joint(s) for holding of gasket in proper position	
18	Fixing all fasteners in position and tightening of nuts by hand to ensure uniform stud length on both sides.	
19	Tightening of all studs as per tightening sequence by recommended tools.	

ACCEPTANCE BY OWNER / EIL

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पाइपिंग के निर्माण के लिए वेल्डिंग विनिर्देश

WELDING SPECIFICATION FOR FABRICATION OF PIPING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	24/10/24	REVISED & REISSUED AS STANDARD SPECIFICATION	UTTAM	PRABHAKAR	R CHITARA	M NANDI
4	8/07/14	REVISED & REISSUED AS STANDARD SPECIFICATION	P CHOWDHARY	S GHOSAL	P P LAHIRI	S CHANDA
3	28/12/07	REVISED & REISSUED AS STANDARD SPECIFICATION	MPJ	VRK	VRK	VC
2	08/02/02	REVISED TO INCLUDE CHECK RADIOGRAPHY	GC	RN	TVD	
1	15/05/98	REVISED & REISSUED AS STANDARD SPECIFICATION	MPJ	TVD	JRP	AS
0	31/07/87	ISSUED AS STANDARD SPECIFICATION	TVD	TVD	JRP	AK

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ABBREVIATIONS

ASME	:	American Society of Mechanical Engineers
ASNT	:	American Society for Nondestructive Testing
AWS	:	American Welding Society
AUT	:	Automated Ultrasonic Testing
BPVC	:	Boiler & Pressure Vessel Code
CFH	:	Cubic Feet per Hour
DWDI	:	Double Wall Double Image
DWSI	:	Double Wall Single Image
GTA	:	Gas Tungsten Arc
GTAW	:	Gas Tungsten Arc Welding
IBR	:	Indian Boiler Regulations
IQI	:	Image Quality Indicator
NDT	:	Non Destructive Testing
PQR	:	Procedure Qualification Record
RT	:	Radiographic Testing
SMAW	:	Shielded Metal Arc Welding
SWSI	:	Single Wall Single Image
UTS	:	Ultimate Tensile Strength

Welding Standard Committee

Convenor : Mr. Rajesh Chitara (SMMS)

Members : Mr. Ayush Mathur (Project)
Mr. P Thulasimani (SCM-Inspection)
Mr. RK Medhavi (Project)
Mr. K Anjaneyulu (SMED)
Mr. RV Rao (Construction)
Dr. Arijit Roy (SMMS)
Mr. Prabhakar Chowdhary (SMMS)
Mr. Lokesh Singh Jangpangi (Piping)

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1.0 GENERAL

This specification shall be followed for the fabrication of all types of welded joints of piping system within the battery limits of the plant. This specification shall be used in conjunction with Welding Specification Charts for Piping.

The welded pipe joints shall include the following:

a) All pipe joints, longitudinal butt welds, circumferential butt welds and socket welds.

b) Attachments of forgings, flanges and other supports to pipes.

c) Welded manifold headers and other sub-assemblies.

d) Welded branch connections with or without reinforcing pads.

e) Joints in welded/fabricated piping components.

f) The attachments of smaller connections for vents, drain drips and other instrument tappings.

Any approval granted by the Engineer-in-Charge or Owner's inspector, shall not relieve the Contractor of his responsibilities and guarantee.

This specification shall not be applicable for welding of pipelines for transportation of liquid petroleum, gas and other similar products in onshore and offshore.

2.0 APPLICABLE CODES & STANDARDS

All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures unless otherwise specified in the EIL Standard Welding Specification Chart (6-77-0005) or Job Welding Specification Charts for Piping and the Technical Notes attached thereof. In the case of conflicting requirements, the requirements mentioned in Welding Specification Chart/Technical Notes shall be applicable.

i) ASME B31.3: Process Piping, ASME Code for Pressure Piping, B31

ii) ASME Boiler & Pressure Vessel Code, Sec II Part C: Specifications for Welding Rods, Electrodes and Filler metals.

iii) ASME Boiler & Pressure Vessel Code, Section V: Non destructive examination.

iv) ASME Boiler & Pressure Vessel Code, Section IX: Welding and Brazing Qualifications.

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

vi) 6-44-0016: Standard Specification for Non-Destructive Examination Requirements of Piping.

vii) 6-77-0005: Welding Specification charts for Piping Classes.

viii) API 582: Welding Guidelines for the Chemical, Oil, and Gas Industries.

ix) 5-1940-7040: Procedure for permitting Welding consumables.

In the event of any differences due to the additional requirements mentioned in this specification, over and above those obligatory as per codes, this specification shall be binding.

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3.0 BASE METAL

3.1 In general, use of carbon steel, alloy steel and stainless steel is envisaged. The details of the material specifications are given in the Welding Specification Chart.

3.2 The Contractor shall provide the manufacturer's test certificates for every batch of the materials supplied by him.

4.0 WELDING PROCESS

4.1 The welding processes to be employed are given in the Welding Specification Chart. In addition to Shielded Metal Arc Welding Process (SMAW) and Gas Tungsten Arc Welding Process (GTAW), Welding of various materials under this specification may be carried out using one or more of the following processes with the approval of the Engineer-in-Charge.

- Gas Metal Arc Welding (GMAW)
- Flux Cored Arc Welding (FCAW)
- Flux Cored Arc Welding (FCAW) - Orbital
- Submerged Arc Welding (SAW)

The limitations given in the API 582 for various welding processes shall be complied with.

4.3 The Welding procedure could be employed for a particular joint only after duly qualifying the welding procedure to be adopted. Previous qualified welding procedures may be permitted if agreed by the Engineer-in-charge.

4.4 FCAW with external gas shielding (FCAW-G) shall be used for pressure-retaining welds and structural welds. FCAW-G shall be used for filler and cap passes of butt welds.

4.5 GMAW process shall be used in Pulsed mode only for root pass welding of pipes.

5.0 WELDING CONSUMABLES

5.1 The Contractor shall provide, at his own expense, all the welding consumables necessary for the execution of the job such as electrodes, filler wires, argon etc. and these should bear the approval of the Engineer-in-Charge.

5.2 The welding electrodes and filler wires supplied by the Contractor shall conform to the class specified in the Welding Specification Chart. The materials shall be of the make approved by the Engineer-in-Charge. Usage of non-purge filler wires may be permitted only after taking approval in the Welding Specification Charts.

5.3 Electrode qualification test at site shall be done as per document number 5-1940-7040 and Welding specification chart for Piping, 6-77-0005. Electrode qualification test records should be submitted as per the Exhibit-A (attached) in respect of the electrodes tested by the Contractor, for obtaining the approval of the Engineer-in-Charge. It shall record the minimum test results required for classification of welding consumables as per ASME Section II part C.

5.4 The Contractor shall submit batch test certificates from the electrode manufacturers. All the test certificates shall be duly endorsed by the vendors/stockiest.

5.5 All electrodes shall be purchased in sealed containers and stored properly to prevent deterioration. Contractor shall use vacuum-packed electrodes for pressure-retaining welds for LTCS, Hydrogen, Amine, Caustic, NACE, Alloy steels, stainless steels, Non-ferrous alloys. The electrodes removed from the containers shall be kept in baking ovens at temperatures recommended by the electrode manufacturer. "Out of the oven time" of electrodes, before they are consumed, shall not exceed the limits recommended by the electrode manufacturer.

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The electrodes shall be handled with care to avoid any damage to the flux covering and proper records of both holding and baking time needs to be recorded by the Contractor.

5.6 All low hydrogen type of electrodes and others, shall be baked as per manufacturers recommendation and stored in holding ovens at temperature recommended by the manufacturer.

5.7 The electrodes, filler wires and flux used shall be free from rust, oil, grease, earth and other foreign matter which affect the quality of welding.

5.8 Tungsten electrodes used shall conform to ASME Sec.II C SFA 5.12 specification. Thoriated Tungsten electrodes shall not be permitted due to possible radiation hazard. Instead, ceriated Tungsten Electrodes (EWCe-2 or equivalent) shall be used for GTA Welding.

6.0 SHIELDING & PURGING GAS

6.1 Argon gas used in GTA welding shall be as per SFA 5.32 of ASME Section II part C. The purity of the gas shall be certified by the manufacturer. The rate of flow for shielding purposes shall be established through procedure qualification tests.

6.2 When GTAW process alone or a combination of GTAW and SMAW/FCAW/SAW processes is recommended for the production of a particular joint, the purging shall be maintained during the root pass and for the first filling pass to minimize oxidation on the inner side of the pipe, unless otherwise specified in Welding Specification Chart.

6.3 Initial purging shall be maintained for sufficient period of time so that at least 4-5 times the volume between the dams is displaced, in order to completely remove the entrapped air. In no case should the initial purging period be less than 10 minutes. High gas pressure should be avoided.

6.4 After initial purging, the flow of the backing gas should be reduced to a point where only a slight positive pressure prevails.

6.5 Gas backing (purging) is not required for socket type of welded joints.

6.6 Dams, used for conserving inert gas during purging, shall be removed after completion of the welding, and shall be accounted for. Wherever, removal of dams is not possible after welding, use of water-soluble dams should be made.

7.0 EQUIPMENTS & ACCESSORIES

7.1 All the equipment for performing the heat treatment, including transformers, thermocouples, pyro-meters, automatic temperature recorders (with suitable calibration arrangement etc.) shall be provided by the Contractor at his own expense along with certificate traceable to national /international standard.

7.2 Contractor shall make necessary arrangements at his own expense, for providing the radiographic equipment, radiographic films, processing equipment all other darkroom facilities and all the equipment/materials required for carrying out the dye-penetrant/magnetic particle test/ultrasonic testing.

7.3 Contractors shall use only calibrated panels and digital recorders for carrying out PWHT activities.

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8.0 EDGE PREPARATION

8.1 General

The edges to be welded shall be prepared to meet the joint design requirements by any of the following methods recommended:

(a) Carbon Steel
Gas cutting, machining or grinding methods shall be used. After gas cutting, oxides shall be removed by chipping or grinding.

(b) Low Alloy Steels (containing up to 5% Chromium).
Gas cutting, machining or grinding methods shall be used. After gas cutting, machining or grinding shall be carried out on the cut surface.

(c) High alloy steel (> 5% Chromium) and stainless steels, nickel alloys:
Plasma cutting, machining or grinding methods shall be used. After plasma cutting, cut surfaces shall be machined or ground smooth.

8.2 The beveled edges shall be masked with tape after fit-up. The welding shall preferably be completed within a week after fit-up.

8.3 Cleaning

(a) The ends to be welded shall be properly cleaned to remove paint, oil, grease, rust, oxides, sand, earth and other foreign matter. The ends shall be completely dry before the welding commences.

(b) On completion of each run, craters, welding irregularities, slag etc., shall be removed by grinding and chiseling. Wire brushes used for cleaning stainless steel joints shall have stainless steel wires and the grinding wheels used for grinding stainless steel shall be of a suitable type. Separate grinding wheels and wire brushes shall be used for carbon steels and stainless steels. Mixing of usage of carbon steel grinding wheels on stainless steels is not permitted.

9.0 ALIGNMENT & SPACING

9.1 Components to be welded shall be aligned and spaced as per the requirements laid down in applicable code. Special care must be taken to ensure proper fitting and alignment when the welding is performed by GTAW process. Flame heating for adjustment and correction of ends is not permitted unless specifically approved by the Engineer-in-Charge.

9.2 A wire spacer of suitable diameter may be used for maintaining the weld root opening while tacking, but it must be removed after tack welding and before laying the root bead.

9.3 For pipes of wall thickness 5 mm and above, the ends to be welded shall be secured in position with the aid of couplers, yokes and 'C' clamps, to maintain perfect alignment. Yokes shall be detached after the completion of weld, without causing any surface irregularity. Any irregularity caused on the pipe surface must be suitably repaired to the satisfaction of the Engineer-in-Charge.

9.4 Tack welds, for maintaining the alignment, of pipe joints shall be made only by qualified welders using approved WPS. Since the tack welds become part of the final weldment they shall be executed carefully and shall be free from defects. Defective tack welds must be removed prior to the actual welding of the joints.

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9.5 Tacks should be equally spaced. Minimum number of tacks shall be:

3 tacks - for 2 1/2" and smaller dia. pipes.
4 tacks - for 3" to 12" dia. pipes.
6 tacks - for 14" and larger dia. pipes.

9.6 Welding shall commence only after approval of fit-up by the Engineer-In-Charge.

10.0 WEATHER CONDITIONS

10.1 The parts being welded and the welding personnel should be adequately protected from rain and strong winds. In the absence of such a protection no welding shall be carried out.

10.2 During field welding, particular care shall be exercised to prevent any air current affecting the welding process.

11.0 WELDING TECHNIQUE

11.1 Root Pass

(a) Root pass shall be made with electrodes/filler wires recommended in the welding specification chart. For fillet welding, root welding shall be done with consumables recommended for filler passes. The preferred size of the electrodes is 2.5 mm diameter (12 SWG) but in any case not greater than 3.25 mm (10 SWG).

(b) Upward technique shall be adopted for welding pipe held fixed with its axis horizontal.

(c) The root pass of butt joints should be executed so as to achieve full penetration with complete fusion of the root edges. Weld projection inside the pipe shall be as per applicable code. It shall be limited 3mm max. when the applicable code does not place any restriction.

(d) Any deviation desired from the recommended welding technique and electrodes indicated in the welding specification chart should be adopted only after obtaining express approval of the Engineer-in-Charge.

(e) Root welding shall be uninterrupted. No joint shall be left alone after the root pass. Hot pass shall be deposited prior to stoppage of work.

(f) While the welding is in progress care should be taken to avoid any kind of movement of the components, shocks, vibrations and stresses to prevent occurrence of weld cracks.

(g) Peening shall not be used.

11.2 Joint Completion

(a) Joint shall be completed using the class of electrodes, recommended in the Welding Specification Chart. Size of the electrode shall not exceed 4 mm in diameter for stainless steels and alloy steels used for low temperature applications.

(b) Two weld beads shall not be started at the same point in different layers.

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(c) Butt joints shall be completed with a cover layer that would affect good fusion at the joint edges and a gradual notch free surface.

(d) Each weld joint shall have a workmanship like finish. Weld identification work shall be stamped clearly at each joint, just adjacent to the weld. Metal stamping shall not be used on thin pipe having wall thickness less than 3.5mm. Suitable paint shall be used on thin wall pipes for identification.

(e) Rust preventive/protective painting shall be done after the weld joint has been approved.

11.3 Dissimilar Welds

(a) Where welds are to be produced between carbon steels (P No. 1) and alloy steels (P No. 4, 5A, 5B), preheat and post weld heat treatment requirements shall be those specified for corresponding alloy steels. The preferred filler wire/electrodes shall correspond to ER70S-2 or E-7016/7018 type.

(b) For welds between two dissimilar Cr-Mo low alloy steels (P No. 4, 5A, 5B), preheat and post weld heat treatments shall be those specified for higher alloy steel and electrodes preferred shall match steel of lower alloy content. For dissimilar metal welds between 9Cr-1Mo-V (P No. 15E) and lower-alloy steel (e.g 2.25Cr-1Mo)/carbon steel, Cr-Mo (P No. 5B) to carbon steel (P No.1), consideration should be made to insert a small transition piece (e.g 2.25Cr-1Mo, 5Cr-0.5Mo) to allow a lesser gradient in the chemical composition.

(c) For carbon steel or alloy steel to stainless welds, use of filler wire/electrodes E/ER-309/ERNiCr-3/E Ni Cr Fe-3/ENiCrMo-3 shall be made. E/ER-309 shall not be used above design temperature of 315°C. The welding procedure, electrodes/filler wires to be used shall be approved by the Engineer-in-Charge.

(d) Dissimilar metal welds joining carbon steels and low alloy steel to stainless or nickel base alloys shall be avoided in the severe thermal cycling service and in sour services.

12.0 HEAT TREATMENT

12.1 Preheating and Interpass Temperature

a) No welding shall be performed without preheating the joint to 10°C (50°F) when the ambient temperature is below 10°C.

b) Preheating and Interpass temperature requirements for the various materials shall be as per the Welding Specification Chart attached.

c) Preheating shall be performed using resistance or induction heating methods. Preheating by gas burners, utilizing oxy-acetylene or oxy-propane gas mixtures, with neutral flame may also be carried when permitted by the Engineer-in-Charge.

However, preheating in lieu of PWHT carried out in carbon steel piping above 25 mm thickness shall be done using coil heating and monitored using thermocouples.

d) Preheating shall extend uniformly to at least three times the thickness of the joint, but not less than 50 mm, on each side of the weld.

e) Preheating temperature shall be maintained over the whole length of the joint during welding. Temperature recorders shall be provided by the Contractor to record the

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temperature during alloy steel welding. For carbon steel piping, preheat temperature shall be ensured by use of temperature indicating crayons, pyrometers or other suitable means. Digital hand-held contact thermocouples are preferred over crayons for austenitic stainless steels, DSS, and nickel alloys.

f) If a welding is interrupted for more than 3 minutes without maintenance of minimum preheat before a minimum of 10mm deposits or 25% of the total joint thickness is completed (whichever is less), surface NDE shall be performed before welding is restarted.

12.2 Post Heating

In case of alloy steel materials (P-Nos. 5B, 15E), if a weld joint is not completed on the same day or the postweld heat treatment is not performed immediately after welding, the weld joint and adjacent portion of pipe, at least 50 mm on either side of weld, shall be uniformly heated to 350°C for 1 hour per inch with 1 hour minimum and then wrapped with mineral wool before allowing it to cool to room temperature. Post-weld heat treatment as specified in the Welding Specification Chart shall be carried out later on.

12.3 Post-Weld Heat Treatment (PWHT)

a) Post-weld heat treatment, wherever required for joints between pipes, pipes and fittings, pipe body and supports shall be carried out as per the welding specification chart, applicable codes standards and the instructions of the Engineer-in-Charge. In this regard, procedure qualification shall be done before carrying out PWHT on production welds.

b) The Contractor shall submit for the approval of the Engineer-in-Charge, well before carrying out actual heat treatment, the details of the post-weld heat treatment procedure as per Exhibit B attached, that he proposes to adopt for each of the materials/assembly/part involved.

c) Post-weld heat treatment shall be done in a furnace or by using an electric resistance or induction-heating equipment, as decided by the Engineer-in-Charge.

d) While carrying out local post-weld heat treatment, technique of application of heat must ensure uniform temperature attainment at all points of the portion being heat-treated. Care shall be taken to ensure that width of heated band over which specified post-weld heat treatment temperature attained is at least that specified in the relevant applicable standards/codes. Control of temperature shall be done using microprocessor/computer-controlled system.

e) Throughout the cycle of heat treatment, the portion outside the heated band shall be suitably wrapped under insulation so as to avoid any harmful temperature gradient at the exposed surface of pipe. For this purpose, temperature at the exposed surface should not be allowed to exceed 50% of the peak temperature.

f) The temperature attained by the portion under heat treatment shall be recorded by means of thermocouple pyrometers. Adequate number of thermocouples should be attached to the pipe directly at equally spaced location along the periphery of the pipe joint. Minimum number of thermocouples required different pipe diameters is given in the table below. However, the Engineer-in-Charge can increase the required number of thermocouples to be attached if found necessary.

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Pipe outside diameter, inch	No. of thermocouples
Up to 6"	1
8" - 10"	2
12" - 20"	3
24" - 36"	4
42" - 54"	5
56" - 92"	8
104"	10

g) Automatic temperature recorders, which have been suitably calibrated, shall be employed for measuring & recording temperature. The time-temperature graph shall be submitted to Engineer-in-Charge immediately on completion of Stress Relieving Cycle. The calibration record of each recorder should be submitted to the Engineer-in-Charge prior to starting the heat treatment operations and his approval should be obtained.

h) Manufacturer's test certificate shall be submitted for the thermocouples materials and record shall be maintained by the Contractor.

i) Immediately on completion of the Heat Treatment, the Post-Weld Heat Treatment charts/records along with the hardness test results on the weld points, wherever required as per the Welding Specification Chart, shall be submitted to Engineer-in-Charge for his approval.

j) Each weld joint shall bear a unique identification number, which shall be maintained in the piping sketch to be prepared by the Contractor. The weld joint identification number should appear on the corresponding post weld heat treatment charts. The chart containing the identification numbers and piping sketch shall be submitted to the Engineer-in-Charge in suitable folders.

13.0 CLEANING OF THE WELD JOINT

All weld joints shall be free from adherent weld spatters, slag, swarf, dirt or foreign matter. This can be achieved by brushing. For stainless steels, brushes with only stainless-steel bristles shall be used.

14.0 INSPECTION AND TESTING

14.1 General

(a) The Owner's inspector shall have free access to all concerned areas, where the actual work is being performed. The contractor shall also accord the Owner's Inspector all means and facilities necessary to carry out inspection.

(b) The Owner is entitled to depute his own inspector to the shop or field where prefabrication and erection of pipe lines is in progress for (but not limited to) the following objectives:

i) To check the conformance to relevant standards and suitability of various welding equipments and the welding performance.

ii) To witness the welding procedure qualification.

iii) To witness the welder performance qualification.

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iv) To check whether shop/field welding being executed is in conformity with the relevant specifications and codes of practice followed in piping construction.

(c) Contractor shall intimate sufficiently in advance the commencement of qualification tests, welding works and acceptance tests, to enable the Owner's inspector to be present to supervise them, as decided by the Engineer-In-Charge.

14.2 Welding Procedure Qualification

(a) Welding procedure qualification shall be carried out in accordance with the applicable requirements of ASME Sec. IX latest edition and/or other applicable codes and the job requirements.

(b) The contractor shall submit the welding procedure specification in format as per Exhibit-C (attached) immediately after the receipt of the order. For shop/field welding, WPS format given in ASME Section IX may also be used.

(c) Owner's inspector will review, check and approve the welding procedure submitted and shall release the procedure for qualification tests. The procedure qualification test shall be carried out by the Contractor at his own expense. A complete set of test results in the format as per Exhibit-D (attached) or ASME Section IX shall be submitted to the Owner's inspector for his approval immediately after completing the procedure qualification test and at least 2 weeks before the commencement of actual work. For shop welding, PQR format given in ASME Section IX may also be used.

(d) Standard test as specified in the code shall be carried out in all cases. In addition to these tests, other tests like macro/micro examination, hardness tests, dye penetrant examination, Charpy V-notch, Corrosion tests etc. shall be carried out on specimens depending upon the type of base material, operating conditions and requirements laid down in the detailed drawings, specifications and welding charts. It shall be the responsibility of the Contractor to carry out all the tests required to the satisfaction of the Owner's inspector.

(e) Contractor may submit old PQR conducted at other sites under EIL supervision. Engineer-In-Charge may permit the use of old PQR if found acceptable.

14.3 Welder's Qualification

(a) Welders shall be qualified in accordance with the ASME Section-IX or other applicable codes. The Owners inspector reserves the right to witness the test and certify/approve the qualification of each welder separately. Only those welders who have been approved by the Owner's Inspector shall be employed for welding. Contractor shall submit the welder qualification test reports in the format as per Exhibit-E (attached) and obtain express approval before commencement of work. It shall be the responsibility of Contractor to carry out qualification tests of welders. For welding of the steam piping, falling under the purview of Indian Boiler Regulations, only those welders with IBR Certification, qualified by Boiler Inspectorate, and acceptable to the local Boiler Inspector authority shall be employed.

(b) The welders shall always have in their possession, an identification card containing information contained in Exhibit-G and shall produce it on demand by the Engineer-In-Charge or his representative. It shall be the responsibility of the Contractor to issue the identify cards after it has been duly certified by the, owner's Inspector.

(c) No welder shall be permitted to work without the possession of the identify card.

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(d) If a welder is found to perform a type of welding or in a position for which he is not qualified, he shall be debarred from doing any further work. All welds performed by an unqualified welder shall be cut and redone by a qualified welder at the expense of the Contractor

14.4 Visual Examination

Visual Examination of all welds shall be carried out as per the latest editions of the applicable codes and EIL Standard 6-44-0016. All finished welds shall be visually inspected for parallel and axial alignment of the work, excessive reinforcement, concavity of welds, shrinkage cracks, inadequate penetration, unrepaired burn-through, under cuts, dimensions of the weld, surface porosity and other surface defects. Undercutting adjacent to the completed weld shall not exceed the limits specified in the applicable standard/code.

14.5 Radiographic Examination

(a) Radiography shall be carried out by Conventional radiography or Close proximity radiography or Computed Radiography (CR) using Phosphor Imaging Plate (IP) as described in ASME Section V Article 2 Mandatory Appendix VIII. The details of the Computed Radiography is covered in Annexure J. Digital Radiography (DR) as described in ASME Section V Article 2 Mandatory Appendix IX may be permitted for vendor shop weld inspection after review and approval of the procedure by EIL Inspector or Owner's Third Party Inspector (TPI).

(b) The extent of Radiography shall be as per the EIL Standard NDT specifications (6-44-0016) or job specification given elsewhere in the Tender. For field weld joints, Contractor shall propose among suitable Radiographic methods given in clause 14.5 (a) depending on the actual field condition for approval of Engineer-in-charge. For welds between dissimilar materials, the extent of Radiographic Examination shall be the more stringent of the two recommended for the materials being welded. Wherever random Radiography is called for, in a particular piping class, the dissimilar materials weld joints shall essentially be included.

(c) The Radiographic Examination procedures shall be submitted by the contractor as per Exhibit-F for approval from the Owner's Inspector prior to employment. A person qualified to ASNT Level-II or ASNT Level-III in Radiographic testing shall prepare the procedure. The Radiography Procedure shall be established to demonstrate that the required sensitivity can be consistently achieved under the most unfavorable parameters (e.g. source to film distance, geometric unsharpness, thickness etc.). The radiographic technique and procedure adopted shall conform of the requirements mentioned in Article 2 as well as Article 22 of ASME Section V. The IQI sensitivity obtained shall be equal to or better than the requirements mentioned in Article 2 of ASME Section V. Source side penetrameter shall be used in establishing radiographic procedure/ technique. The acceptance criteria shall be as per the relevant codes of Fabrication and overriding requirements if mentioned elsewhere in the technical specifications of the contract. The Contractor shall be responsible for carrying out Radiography; rectification of defects and re-radiography of welds repaired/rectified at his cost.

(d) Depending on the site condition, decision to use close proximity radiography shall be taken by Engineer-in-charge. Close Proximity Radiography (CPR) with conventional film radiography or Computed Radiography shall be used. The cordoning distance for close proximity radiography shall be 4 to 5 meters maximum. The permissible maximum pipe thickness and minimum pipe size shall be 12 mm and 3" respectively for use of Close Proximity Radiography.

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(e) Type of Radiation source and film to be used shall be as per Exhibit-H for carrying out radiographic examination. However, if specifications (as given elsewhere in the contract) for some critical material require usage of X-Ray Radiation, then Radiography shall be done using X-Rays only.

(f) The Contractor shall fulfill all the statutory and owner's safety requirements while handling X-ray and Gamma-ray equipment.

(g) In case of random radiography, the joints for Radiography shall be selected by the Owner's Inspector and the Radiography shall be performed in his presence, if he instructs the contractor to do so. The contractor shall furnish all the radiographs, to the Owner's Inspector immediately after processing along with evaluation by a person qualified to ASNT Level-II in Radiographic testing, inline with Article 2 of ASME Section V. The certificate of ASNT/ISNT Level II qualification of the NDT personnel shall be submitted to owner's inspector for his approval prior to start of job.

(h) The Contractor shall provide the Owner's Inspector, all the necessary facilities at site such as a dark room with controlled temperature, illuminator (viewer) suitable for varying densities, a duly calibrated electronic densitometer with batteries, magnifying glass, tracing papers, ruler, marking pencils etc. to enable him to review the radiographs.

(i) For each weld performed by a welder found unacceptable, two additional checks shall be carried out on welds performed by the same welder. This operation is iterative and the of two additional welds for each weld deemed unsatisfactory shall be continued till such time that two consecutive welds of satisfactory quality are found for every defective weld.

(j) The Contractor shall carry out these additional radiographic testing at his own expense. To avoid the possibility of too many defective welds by a single welder remaining undetected for a long period to time, the Contractor shall promptly arrange for Radiographic Examination so that there is no accumulation of defective joints.

14.5.1 Check shots

(a) Owner / Engineer-in-charge or his representative shall select 5% of the total number of weld joints accepted in first attempt in radiography for check shots. CONTRACTOR shall take check shot in one segment instead of all segments of each selected joints if agreed by the Engineer-in-charge.

(b) Weld profiles of check shots shall be compared with weld profile observed in the earlier Radiographs. In the event of any one variation in the check shots and earlier Radiographs, contractor shall re-shoot the entire lot of joints radiographed by particular Radiography agency on the particular date. All the re-shot films shall be compared with the originally submitted films.

14.6 Liquid Penetrant and Magnetic Particle Examination

(a) Whenever such tests are specified, the tests shall be carried out on joints chosen by the Owner's inspector, as per ASME Section V article 6 and 7 respectively. The tests are to be performed by a person possessing a valid ISO/ASNT/ISNT Level-II qualification in the method being used.

(b) For austenitic stainless steels and other nonmagnetic materials, liquid (dye) penetrant test shall be carried out. For carrying out this test, the materials shall be brought within a temperature limit of 15^0 to 50^0C.

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14.7 Ultrasonic examination (UT)

(a) Ultrasonic testing (UT) can be used in place of radiographic examination when permitted by ASME B31.3 with prior approval of Engineer-in-charge.

(b) The Ultrasonic testing procedure to be adopted shall be submitted by the CONTRACTOR in line with EXHIBIT-I and get it approved from EIL/OWNER.

(c) The CONTRACTOR shall make all the arrangements for the Ultrasonic Testing of work at his expense. The CONTRACTOR shall furnish all the reports to the EIL/OWNER, immediately after examination together with the corresponding interpretation reports on the approved format. The details of the AUT reports along with the joint identification number shall be duly entered in a register and signed by the CONTRACTOR and submitted to the EIL/OWNER for approval. The EIL/OWNER will review all the Ultrasonic Testing records of welds and inform the CONTRACTOR to those welds, which are unacceptable. The decision of the COMPANY shall be final and binding in this regard.

(d) In addition, Radiography examination shall be carried out when in the opinion of EIL/OWNER, Radiography inspection is required to confirm or clarify defects indicated by Ultrasonic examination.

(e) The ultrasonic testing system used for inspecting welds shall be approved by EIL/OWNER.

14.8 Hardness Test

Hardness requirements for welds shall be as per the Welding Specification Chart/Non-Destructive Examination Specification attached elsewhere in the contract. Hardness testing shall be carried out by Vickers Hardness Tester during welding procedure qualification and shall be cross sectional. For production welds, hardness testing shall be carried out by portable digital hardness testers. Poldi hardness tester shall not be permitted. Contractor shall produce documentary evidence/calibration certificate to the Owner's Inspector and obtain approval of the hardness testing equipment. Contractor shall mobilize standardized test block with hardness value punch and calibration certificate. Digital hardness tester shall be checked prior to each shift using standardized test block.

14.9 Proof Tests

Hydrostatic and pneumatic tests shall be performed as per the requirements laid down by respective flushing and Testing specification/applicable codes to demonstrate the soundness of the welds. The tests shall be conducted after fulfilling the requirement of visual examinations, radiography etc., and after the entire work has been certified by the Owner's inspector to be fit for being subjected to such tests.

15.0 REPAIRS OF WELDS

(a) No repair shall be carried out without prior permission of the Owner's inspector.

(b) Repairs and/or work of defective welds shall be done in time to avoid difficulties in meeting the construction schedules.

(c) Defects ascertained through the inspection methods, which are beyond acceptable limits shall be removed after the joint is completely radiographed by the process of chipping and grinding. The repaired welds shall be subjected, as a minimum requirement to the same testing and inspection requirements as the original weld.

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(d) The number of times repair welding can be permitted for the same weld shall be governed by the standard specification, 6-44-0016.

(e) When the entire joint is judged unacceptable, the welding shall be completely cut and edges suitably prepared as per required alignment tolerances. The rewelded joint shall again be examined following standard practices.

(f) After attending repairs for alloy steel (P No.4, 5) joints, full joint to be re-radiographed after completion of PWHT.

16.0 DOCUMENTS TO BE SUBMITTED BY CONTRACTOR (4 COPIES EACH)

(a) Electrode and Welding Consumable Qualification Records as per Exhibit-A, for the Welding Consumables tested and approved for the work.

(b) Batch Test Certificates, for the Electrodes used, obtained from the Electrode Manufacturers.

(c) Proposed Heat Treatment Procedure as per Exhibit-B.

(d) Heat Treatment Charts.

(e) Weld joint hardness test results.

(f) Welding Procedure Specifications as per Exhibit-C immediately after receipt of the order.

(g) Welding Procedure Qualification records as per Exhibit-D.

(h) Welder Performance Qualification records as per Exhibit-E immediately after conducting Welder Qualification Tests.

(i) Radiography Procedure as per Exhibit-F and other NDT procedures.

(j) Radiographic test Report along with Radiographs and other NDT reports.

(k) Piping Sketch (Isometric) giving all the details regarding the pipe specifications, welded joints, joints radiographed magnetic particle, tested, ultrasonic tested, penetrant tested, joints heat treated, WPS used, welders identification number, etc.

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EXHIBIT – A: ELECTRODE QUALIFICATION TEST RECORD

Date:

Test started on:

Test completed on:

A: DETAILS

CONTRACTOR

Tested at (Site name)

Code of Reference (used for testing) :

Special Requirements (if any) :

Sl. No.	Classification of electrode	Size of electrode	Batch no.	Manufacturer name/brand/date of manufacture	Intended for welding in position	Remarks

B : All-weld Tensile Test

Base Material used :

Buttering used : Yes/No

Pre-heat temperature :

Inter-pass temperature :

Post weld heat treatment details :

Visual examination :

Radiographic examination results :

Tensile test results :

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Sl.No.	Batch no./ identification no.	Size of electrode	Current & polarity	UTS		YS		% elongation		Remarks
				As per code	Actual	As per code	Actual	As per code	Actual	

C. Impact Test Results

Test Temperature : Notch in :

Type of Specimens (Charpy) : Size of Specimens :

Sl.No.	Batch no./ identification no.	Size of electrode	Current & polarity	Impact value							Remarks
				As per code, max./avg.	1	2	3	4	5	Average	

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D. Chemical Analysis Results

Sl.No.	Batch no./ identification no.	Size of electrode	Current & polarity		% C	% Mn	% Si	% P	% S	% Cr	% Ni	% Mo	% V	others	Remarks
				As per code											
				Actual											
				As per code											
				Actual											

E. Fillet Weld Test Results :

Base Materials :

Sl. No.	Batch no./ identification no.	Size of electro de	Current & polarity	Welding position	Visual	Macro	Fracture	Remarks
				Horizontal				
				Vertical				
				Overhead				
				Horizontal				
				Vertical				
				Overhead				

F. Other Test Results :

1. Transverse tensile test :

In combination with :

Base material used :

Position of welding :

Preheat temperature :

Post weld heat treatment :

Radiography :

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	Identification No.	U.T.S.	Fracture in	Remarks

2. Guided Bend Test :

Position	Identification No.	Root, Face or Side Bend	Remarks
	1		
	2		
	3		
	4		
	5		

G. Any other tests :

H. Conclusions :

PREPARED BY	REVIEWED BY	APPROVED BY
(CONTRACTOR)	(CONTRACTOR)	(EIL/OWNER)

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EXHIBIT – B: STRESS RELIEF HEAT TREATMENT PROCEDURE

LSTK CONTRACTOR : _____

Name of the Heat treater : _____

Name of the Project : _____

Specification /Reference No. :

Line no./Joint No.

1. General Details — Other Details

Name of the Equipment : _____

Type of Heating : Elec. Res./ Induction (Tick mark applicable method)

Maximum Permissible Temp at Uncovered Parent Metal _____

Width of heated band _____
Width of Insulation _____

Material : _____

No. of Themo couples (dia wise) _____

Type of Thermo couples _____

3. Heat Treatment Cycle Details

Charging Temp °C _____
Rate of heating °C /Hr. _____
Soaking Temperature, °C _____
Soaking Time, Hrs. _____
Rate of Cooling °C /Hr. _____
Method of Cooling _____

4. Other details, if any _____

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EXHIBIT – C: FORMAT FOR WELDING PROCEDURE SPECIFICATION (WPS)

Company Name _____ By _____

Welding Procedure Specification No. _____ Date _____ Supporting PQR No. (S) _____

Revision No. _____ Date _____

Welding Process (es) _____ Type (s) _____
(Automatic, Manual, Machines or Semi Auto)

JOINTS

Joint Design _____
Backing (Yes) _____ (No) _____
Backing Material (Type) _____
Sketches Production Drawings. Weld Symbols Written
Description should show the general arrangement of the parts to be welded. Where applicable, the root specing and the details of weld groove may be specified.
(At the option of the Manufacturer sketches may be attached to illustrate joint design weld layers and bead sequence e.g. for notch toughness procedures, for multiple process procedures, etc.)

BASE METALS

P.No. _____ Group No. _____ to P. No. _____ Group No. _____

OR

Specification type and grade _____
to Specification type and grade _____

OR

Chem. Analysis and Mech. Prop. _____
to Chem. Analysis and Mech. Prop. _____
Thickness Range :
Base Metal : Groove _____ Fillet _____
Deposited Weld Metal : Groove _____ Fillet _____
Pipe Dia Range : Groove : _____ Fillet _____
Other _____

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FILLER METALS

F.No. _____ Other _____
A.No. _____ Other _____
Spec. No. (SFA) _____
AWS No. (Class) _____
Size of filler metals _____
_____
(Electrodes, Cold Wire, Hot Wire etc.)
Electrode-Flux (Class) _____
Flux Trade Name _____
Consumable Inset _____
Each base metal/filler metal combination should be recorded individually.

WPS NO. _____ Rev. _____

POSITIONS:	**POSTWELDED HEAT TREATMENT**
Position (s) of Groove _____ Welding Progression : UP ____ Down ____ Position (s) of Fillet _____	Temperature Range _____ Time Range _____
PREHEAT Preheat Temp. Min. _____ Interpass Temp. Max. _____ Preheat Maintenance _____	**GAS** Shielding Gas (es) _____ Percent Composition (mixtures) _____ _____ Flow Rate _____ Gas Backing _____ Trailing Shielding Gas Composition _____

ELECTRICAL CHARACTERISTICS

Current AC or DC _____ Polarity _____
Amps (Range) _____ Volts (Range) _____
(Amps and volts range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below).

Tungsten Electrode Size and Type _____
(Pure Tungsten, 2% Ceriated, etc)
Mode of Metal Transfer for GMAW _____
(Spray arc, short circuiting arc, etc.)
Electrode Wire feed speed range _____
_____

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TECHNIQUE

String or Weave Bead _____

Orifice or Gas Cup Size _____

Initial and Interpass Cleaning (Brushing, Grinding, etc.) _____

_____

Method of Back Gouging _____

Oscillation _____

Contact Tube to Work Distance _____

Multiple or Single Pass (per side) _____

Multiple or Single Electrodes _____

Travel Speed (Range) _____

Peening _____

Other _____

Weld Layer(s)	Process	Filler Metal		Current		Volt Range	Travel Speed Range	Others
		Class.	Dia.	Type Polarity	Amp. Range			
								e.g. Remarks, Comments, Hot wire Addition, Technique Torch Angle, etc.

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EXHIBIT-D: FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)

RECORD OF ACTUAL CONDITIONS USED TO WELD TEST COUPON

Company Name _____
Procedure Qualification Record No. _____ Date _____
WPS No. _____

Welding Process (es) _____
Types (Manual, Automatic, Semi-Auto) _____
_____

JOINTS

Groove Design of Test Coupon

(For combination qualification the deposited weld metal thickness shall be recorded for each Filler metal or process weld)

_____

BASE METALS Material Sepc. _____ Type of Grade _____ P.No. _____ to P.No. _____ Thickness of Test Coupon _____ Diameter of Test Coupon _____ Other _____	**POSTWELD HEAT TREATMENT** Temperature _____ Time _____ Other _____ _____ _____
FILLER METALS Weld Metal Analysis A No. _____ Size of Filler Metal _____ Filler Metal F.No. _____ SFA Specification _____ AWS Classification _____ Other _____	**GAS** Type of Gas/Gases _____ Composition of Gas Mixture _____ Other _____ _____ _____
POSITION Position of Groove _____ Weld Progression (Uphill, Downhill) _____ Other _____ _____	**ELECTRICAL CHARACTERISTICS** Current _____ Polarity _____ Amps. _____ Tungsten Electrode Size _____ Other _____
PREHEAT Phreheat Temp. _____ Interpass Temp. _____ _____	**TECHNIQUE** Travel Speed _____ String or Weave Bead _____ Oscillation _____ Multipass or Single Pass (per side) _____ Single or Multiple Electrodes _____ Other _____

SHEET 1 OF 3

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TENSILE TEST

Specimen No.	Width	Thickness	Area	Ultimate total force, kgf	Ultimate tensile stress, Kgf/mm^2	Type & location of failure

GUIDED BEND TESTS

Type of Figure No.	Result

TOUGHNESS TESTS

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Value	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break

FILLET WELD TEST

Result - Satisfactory : Yes _____ No ____ Penetration into Parent Metal : Yes ___ No. ____

Marco - Results _____

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OTHER TESTS

Type of Test _____

Deposit Analysis _____

Other _____

_____

Welder's Name _____ Clock No. _____ Stamp No. _____

Test Conducted by _____ Laboratory Test No. _____

We certify that the statements in this record are correct and test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

Date _____ Manufacturer _____

By _____

(Detail of record of tests are illustrative only and may be moulded to conform to the type and number of tests required by codes and specifications).

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EXHIBIT – E: FORMAT FOR MANUFACTURER'S RECORD FOR WELDER OR WELDING OPERATOR QUALIFICATION TESTS

Welder Name _____ Check No. _____ Stamp. No. _____

Using WPS No. _____ Rev. _____

The above welder is qualified for the following ranges

Variable	Record Actual Values Used in Qualification	Qualification Range
Process	_____	_____
Process Type	_____	_____
Backing (metal, Weld metal, flux, etc)	_____	_____
Material Spec.	_____ to _____	_____ to _____
Thickness		
Groove	_____	_____
Fillet	_____	_____
Diameter		
Groove	_____	_____
Fillet	_____	_____
Filler Metal		
Spec. No.	_____	_____
Class	_____	_____
F. No.	_____	_____
Position	_____	_____
Weld Progression	_____	_____
Gas Type	_____	_____
Electrical Characteristics	_____	_____
Current	_____	_____
Polarity	_____	_____

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Guided Bend Test Results

Type and Fig. No.	Result

Radiographic Test Results
For alternative qualification of groove welds by radiography

Radiographic Results _____

Fillet Weld Test Results

Fracture Test (Describe the location, nature and size of any crack or tearing of the specimen___
Length and Per Cent of Defects _____ inches _____ %
Macro Test - Fusion _____
Appearance - Fillet Size (ing) _____ x _____ Convexity or Concavity _____
_____

Test Conducted by _____ Laboratory - Test No. _____

We certify that the statements in this record are correct and that the test welds were prepared. Welded and tested in accordance with the requirements of Section IX of the ASME Code.

Date _____ Organization _____
By _____

(Details of record tests are illustrative only and may be modified to conformation to the type & number of tests required by the Code).

Note: Any essential variables in addition to those above shall be recorded.

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EXHIBIT – F: RADIOGRAPHIC PROCEDURE QUALIFICATION RECORD FOR PIPE WELDING

1. Location
2. Date of Testing
3. Name of the LSTK CONTRACTOR/Agency
4. Material: Carbon steel/Alloy Steel/Stainless Steel

4 A. Technique: DWSI/SWSI/DWDI

5. Diameter & Thickness:
6. Type of Weld Joint:
7. Radiation Source:
8. Intensifying Screens/Lead Screens:
9. Geometric Relationship:
10. Limit of Film Coverage:
11. Film Type and Make:
12. Exposure Time:
13. Processing:
14. Density:
15. Sensitivity:

16.* Type of penetrameter: (Source side)

17.* Type of penetrameter: (Film side)

Signature of LSTK CONTRACTOR/Agency with Seal

Approval of OWNER/ PMC's Inspector

* Ref. Para regarding recommended practice on placement of penetrameters Article 22, SE 142, ASME Sec. V.

* For "Random Radiography" lines placement of penetrameters as per Article 2, ASME, Sec. V is permitted.

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EXHIBIT – G: WELDER'S IDENTIFICATION CARD

1.	Name:
2.	Identification:
3.	Date of Testing:
4.	Process
5.	Thickness range
6.	Diameter range
7.	P. No.
8.	Date of approval of welding
9.	Position(s)

Photograph

Approved by:

Employer's Signature with Seal

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EXHIBIT – H: Type of Source and Films to be used for RADIOGRAPHY

NOMINAL WALL THICKNESS (T) IN mm		SHOP WELDED JOINTS		IN-SITU WELDS	
		SOURCE	FILM : CEN Class	SOURCE	FILM : CEN Class
T > 19	All Materials	Gamma Ray	C 5	Gamma Ray	C 5
8 ≤ T < 19	Carbon Steel	Gamma Ray	C 4	Gamma Ray	C 4
	All other materials	Gamma Ray	C3	Gamma Ray	C 3
< 8	Carbon Steel Other than Inspection Class IV *	Gamma Ray	C 3	Gamma Ray	C3/C1
	All other materials and Carbon Steel of Inspection Class IV *	X-Ray	C 4	X-ray with C4 or Equivalent to be used. Gamma Ray (Se 75 Source only) with C3/C2 Equivalent may be allowed only if in the assessment of the owner's inspector, Joints are inaccessible for X-ray equipment and radiographic sensitivity is achieved.	

Note: Integral to above table

1) Films slower than the above may have to be used, if required radiographic sensitivity is not achieved consistently.

* Piping classes where 100% RT is specified. Refer Std. Spec. No. 6-44-0016

COMPARISON OF FILMS FROM DIFFERENT MANUFACTURERS

CEN Classification	KODAK	AGFA	FUJI
---	CX	D8	---
C5	AA400	D7	IX100
C4	T200	D5	IX80
C3	MX125	D4	IX50
C2	M100	D3	---
C1	DR50	D2	IX25
---	SR**	---	---

** *Special films, extremely fine grain & very high resolution*

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EXHIBIT – I: ULTRASONIC TESTING (UT)

1.0 INTRODUCTION

2.0 REFERENCE DOCUMENTS

3.0 AUT SYSTEM

4.0 COUPLANTS

5.0 CALIBRATION/DEMONSTRATION BLOCK

6.0 CALIBRATIONS

7.0 PROCEDURE

8.0 TRAINING AND QUALIFICATION

9.0 EVALUATION AND ACCEPTANCE CRITERIA

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1.0 INTRODUCTION

The specification shall be applicable for Automated Ultrasonic Testing (AUT) system or Semi-Automated Ultrasonic Testing suitable for full penetration butt-welds of piping. The system shall incorporate Phased array probes and Time of Flight Diffraction (TOFD) probes plus pulse echo probes. The procedure shall evaluate the performance of Phased Array Ultrasonic examination instruments and system. This specification is intended to be used on thickness of 8.0 mm and greater. TOFD probes shall be used above 12mm thickness. Lesser thicknesses may be tested using the standard practice if the technique can be demonstrated to provide adequate protection on mockups of the same wall thickness and geometry.

2.0 REFERENCE DOCUMENTS

The latest edition with addendum of the following standards shall be referred here:

a) ASME B31.3 – Process piping
b) ASME Section V- Non Destructive Examination (Latest edition)
c) ASNT SNT-TC-1A - Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

3.0 AUT SYSTEM

3.1 Instrument Requirement

The ultrasonic examination shall be performed using a system employing automated/ semi-automated scanning with computer-based data and analysis abilities.

The instrument shall be capable of real-time sectorial scan (also called an S-scan) image during scanning to assure that proper data has been collected, generating and displaying sectorial-scan image, which can be stored and recall for subsequent review.

The system shall provide an adequate number of examination channels to ensure the complete volumetric examination of the weld through the thickness in one circumferential scan.
The instrument linearity should be such that the accuracy is within 5%.

Each examination channel should be selective for pulse-echo or through transmission mode gate position and length for a minimum of two gates and gain.

TOFD techniques & B-scan mapping should be available to improve characterization. Recording thresholds should be selectable to display signals between 0 and 100% of full screen height for simple amplitude and transit time recording and it should be from 0 to 100% for B-scan or mapping type recording of data. Two recordable signals output per gate should be available being either analog or digital and representative of signal height and time of flight. Measuring distance accuracy of circumferential weld shall be within 1.0 cm from zero (0) position.

Electronic noise shall be lower than acoustical noise in all channels for the probes and sensitivities to be used during inspection. The signal to noise ratio for each channel during examination shall be at least $\geq$ 20 dB for shear waved probes.

The Contractor shall provide the detail information of the equipment like model, trade name, software used to the OWNER/EIL.

3.2 Probes

The phased array search unit frequency shall be between 1 MHz and 10 MHz depending on material type and thickness. The Contractor shall provide the detail information of the probe frequency, no. of elements, size, pitch etc. to the OWNER/EIL.

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3.3 Wedge

Phased array wedges shall be of a design to accommodate phased array search unit. Nominal refracted-wedge angles shall be possible from 35 to 75 degrees to ensure 100 % coverage of the weld and heat affected zone. The Contractor shall provide the detail information of the wedge to the OWNER/EIL.

3.4 Encoder

The encoder shall be capable of permitting a scan resolution of 1.0mm as minimum.

4.0 COUPLANT

The couplant shall be obtained by using a medium suitable for the purpose. It shall be suitable for the temperature used. The couplant, including additives, shall not be detrimental to the material being examined. Couplants used on nickel base alloys shall not contain more than 250 ppm of sulfur. Couplants used on austenitic stainless steel shall not contain more than 50 ppm of halides (chlorides plus fluorides). A method should be employed to determine that constant coupling is achieved during examination. An examination of the test piece with its surface wiped dry should produce a record showing an absence of the couplant recording signal.

The same couplant shall be used during calibration and examination.

5.0 CALIBRATION/DEMONSTRATION BLOCK

5.1 Calibration/Demonstration Block Material

5.1.1 Material selection

The material from which the qualification and calibration blocks are fabricated shall be of the same product form and material specification or equivalent P-number grouping as one of the materials being examined.

5.1.2 Heat treatment

The calibration and qualification blocks shall receive at least the minimum tempering treatment required by the material specification for the type and grade. If the calibration and qualification blocks contains welds other than cladding, and the component weld at the time of the examination has been heat treated, the block shall receive the same heat treatment.

5.1.3 Reflectors

a) Calibration blocks reflectors: Side drilled holes shall be used to confirm adequate sensitivity settings.

b) Demonstration blocks reflectors: Surface and sub-surface notches

5.1.4 Quality of calibration and demonstration blocks

Prior to fabrication, the block material shall be completely examined with a straight beam search unit. Areas that contain an indication exceeding the remaining back-wall reflection shall be excluded from the beam paths required to reach the various calibration reflectors.

5.1.5 Cladding

When the component material is clad, the block shall be clad by the same welding procedure as the production part. It is desirable to have component materials, which have been clad before the dropouts, or prolongations are removed. When the cladding is deposited using an automatic welding process, and, if due to block size, the automatic welding process is impractical, deposition of clad may be by the manual method.

5.1.6 Surface roughness of calibration and demonstration blocks

The roughness of the Demonstration and calibration surfaces of the blocks shall be representative for the scanning surface of the components to be examined.

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5.2 Calibration Blocks

5.2.1 Standard block
IIW V1 calibration block or V2 or equivalent calibration block are a recognized test reference for sweep range scale, index point of shear wave transducer, and refracting angle.

5.2.2 Calibration reference block
Reference block shall be made with notch and side-drilled hole as per ASME Section V article 4, Fig.T-434.2.1 and Fig.T-434.3 and shall be used for gain calibration and construction of reference curves. The reference calibration block shall be a section of pipe of the same nominal and schedule and normally be manufactured from the actual material examined and have approved dimensions.

5.2.3 Non-piping Calibration block
The basic calibration block configuration and reflectors shall be as shown in ASME Section V article 4, Fig.T-434.2.1. The block size and reflector locations shall be adequate to perform calibrations for the beam angles used.

5.2.4 Piping Calibration block
The basic calibration block configuration and reflectors shall be as shown in ASME Section V article 4, Fig.T-434.3. The block size and reflector locations shall be adequate to perform calibration for the beam angles used.

5.2.5 Block Curvature
The block curvature shall be as per ASME Section V article 4.

5.3 Demonstration Block

5.3.1 Preparation
A demonstration block shall be prepared by welding or, provided the acoustic properties are similar, the hot isotactic process (HIP) may be used.

5.3.2 Thickness
The demonstration block shall be within 25% of the thickness to be examined. For welds joining two different thickness of material, demonstration block thickness shall be based on the thinner of the two materials.

5.3.3 Weld joint configuration
The demonstration blocks weld joint geometry shall be representative of the production joints details.

5.3.4 Flaw location
Unless specified otherwise by the referencing Code Section, the demonstration block which three EDM notches oriented and major groove faces. The flaws shall be located at or adjacent to the blocks groove faces as follows:

(a) One surface flaw on the side of the block representing the component O.D. surface
(b) One surface flaw on the side of the block representing the component I.D. surface
(c) One subsurface flaw

When the scan plan to be utilized subdivides a weld into multiple examination zones, a minimum of one flaw per zone is required.

5.3.5 Flaw Size
Demonstration block flaw sizes shall be based on the demonstration block thickness and shall be no larger than that specified by the referencing Code Section.

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(a) Maximum acceptable flaw height for material less than 1 in. (25 mm) thickness, or
(b) 0.25 aspect ratio acceptable flaw for material equal to or greater than 1 in. (25 mm) thickness based on the demonstration block

5.3.6 Single I.D. / O.D. flaw alternative
When the demonstration block can be scanned from both major surfaces during the qualification scan [e.g., joint I.D. and O.D. have a similar detail, diameter of curvature is greater than 20 in. (500 mm), no cladding or weld overlay present, etc.], then only one surface flaw is required.

5.3.7 One-sided exams
When, due to obstructions, the weld examination can only be performed from one side of the weld axis, the demonstration block shall contain two sets of flaws, one set on each side of the weld axis. When the demonstration block can be scanned from both sides of the weld axis during the qualification scan(e.g., similar joint detail and no obstructions), then only one set of flaws is required.

6.0 CALIBRATION

6.1 General Calibration Requirements

1) Ultrasonic system: Calibration
Calibration shall be performed for complete ultrasonic system and shall be done prior to examination in the desired thickness range.
2) The surface condition of the calibration block shall be similar to that on which production test will be performed with respect to the surface geometry and cladding.
3) Same couplant shall be used for calibration as well as production testing.
4) Contact wedges, if used, shall be same for the calibration as well as for the production testing.
5) Any control, which affects instrument linearity (e. g. Filters, reject, or clipping), shall be in the same position for calibration, calibration checks, instrument linearity checks and examination.
6) Focal-Law: The focal law to be used during the examination shall be used for calibration.
7) Beam Calibration
All individual beams used in the examination shall be calibrated to provide measurement of distance and amplitude correction over the sound path employed in the examination. This shall include applicable compensation for wedge sound path variations and wedge attenuation effects.
8) The maximum temperature difference between test blocks and examination surface shall not exceed 14°C.

6.2 PA Instrument Linearity

The following requirements shall be met at intervals not to exceed one year or prior to first use thereafter.

1) Screen height linearity: The PAUT equipment's screen height linearity shall be evaluated in accordance with Mandatory Appendix I of ASME Sect. V, Art.4.

2) Amplitude control linearity: The PAUT equipment's amplitude control linearity shall be evaluated in accordance with Mandatory Appendix II of ASME Sect. V, Art.4 for each pulse-receiver circuit
3) Equipment linearity shall be such that accuracy of indicated amplitude or time is ±5% of actual full scale amplitude or time.

6.3 Phased array system calibration

Calibration shall be performed from the surface of the calibration block which corresponds to the component surface to be examined. System calibration shall include the complete

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ultrasonic system. Screen distance calibration shall be at least 1-1/2 "veepaths"(also known as skip) for the minimum angle that will be used during the examination.

The system shall be calibrated for velocity and wedge delay calibration, sensitivity calibration, Time Corrected Gain (TCG) calibration. Encoder calibration and confirmation of sensitivity.

The system shall require re-calibration due any of the following conditions:
1) Search unit transducer or wedge change.
2) Search unit cable or length change.
3) Ultrasonic instrument change.
4) Change in examination personnel.
5) Change in type of power source.

7.0 PROCEDURE

7.1 Safety

At first, safety supervisor or technician should be confirmed regarding safety matters before starting examination. Those are included mainly of scaffolding, ladder, lighting, electric conditions and personnel safety equipments have been checked by themselves as followed Project Safety Regulation. If there is not clear for safety questions for personnel, equipment and examination, the technician has right to stop his job whenever.

7.2 A detailed Automated Ultrasonic examination procedure shall be prepared and qualified for each wall thickness and joint geometry to be examined prior to the start of any NDT work. Repair procedure shall be separately qualified for each joint geometry. The procedure as a minimum shall include the following:

Scope; equipment; probe type and details; surface preparation, cleaning and couplant; technique sheet for each technique specified (number of techniques to be sufficient to cover all type of joints to be covered by the procedures scope); material; weld material (if different); sketch showing joint configuration, beam coverage; extent of scan; scanning pattern; material thickness and curvature; calibrations and frequency; means of setting and scanning sensivity levels and DAC curves; flaw location and size evaluation; acceptance criteria; reporting format; operator qualifications.

7.3 Lamination Check

A-UT shall be performed using a device employing automatic computer based data acquisition. The straight beam material examination (T-472 of Section V, Article 4) for reflectors that could interfere with the angle beam examination shall be performed:
a) Manually,
b) As part of a previous manufacturing process, or
c) During the A-UT examination provided detection of these reflectors is demonstrated.
d) The coverage shall be included minimum 100mm from centerline of welding.

7.4 Examination Coverage

The required volume of the weld and base material to be examined shall be scanned using a linear scanning technique with an encoder. Each linear scan shall be parallel to the weld axis at a constant standoff distance with the beam oriented perpendicular to the weld axis.

The ultrasonic examination area shall include the volume of the weld, plus the lesser of 25mm (1 in.) or "t" on each side of the weld.

A documented examination strategy or scan plan shall be provided, showing transducer placement, movement, and component coverage, that provides a standardized and repeatable methodology for weld acceptance. The scan plan shall also include ultrasonic beam angle

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used, beam directions with respect to weld centerline, and pipe volume examined for each weld. The documentation shall be made available to the owner's Inspector.

7.5 Examination side

Basically shall be examined on the both sides of welding line axis but can be examined from one side in case of another side is not available access under full coverage volume condition.

7.6 Surface condition

The contact surface shall be cleaned of weld spatter, dirt, pitting, rust and/or any other impurities or roughness that will interfere with the free movement of the ultrasonic transducers or would prevent adequate transmission of ultrasound. Prior to inspection the NDT technician shall judge the suitability of the surface and when required remedial action shall be taken.

7.7 Scanning

1) The search unit shall be maintained at a fixed distance from the weld axis by a fixed guide or mechanical means.

2) The examination angle(s) for E-scan and range of angles for S-scan shall be appropriate for the joint to be examined.

3) Scanning speed shall be such that data drop-out is less than 2 data lines per inch (25mm) of the linear scan length and that there arr no adjacent data line skips.

4) For E-scan techniques, overlap between adjacent active apertures (i.e., aperture incremental change) shall be a minimum of 50% of the effective aperture height.

5) For S-scan techniques, the angular sweep incremental change shall be a maximum of 1 deg or sufficient to assure 50% beam overlap.

6) When multiple linear scan are required to cover the required volume of weld and base material, overlap between adjacent linear scans shall be a minimum of 10% of the effective aperture height for E-scan or bean width for S-scan

7) Each scan shall have an overlap of minimum 1 in. (25 mm) - (in case of re-acquisition of missing or poor data line etc.)

8) TOFD channel

The TOFD gate start will be set 1 µSec before the arrival of the lateral wave and should extend up to the first back wall echo to achieve full cover of wall thickness.

7.8 Data Recording

A-scan data shall be recorded in an unprocessed form with on threshold, at a minimum digitization rate of five times the examination frequency, and recording increments of a maximum of

a) 0.04 in. (1 mm) for material < 3 in. (75 mm) thick

b) 0.08 in. (2 mm) for material ≥ 3 in. (75 mm) thick

7.9 Reflectors Transverse to the Weld Seam

As an alternate to line scanning, a manual angle beam examination may be performed for reflectors transverse to the weld axis. Manual angle beam UT shall be accordance with manual ultrasonic examination procedure based on (T-472 of Article 4, ASME Sec V).

7.10 Re-examination

1) Re-examination for repaired welds shall follow the same condition (same examination method, same acceptance criteria) as for the original weld.

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2) The additional testing shall be extent a length at least equal to 1 in.(25 mm) from the both end of repaired area.

3) Additional NDT methods of UT and MT shall be carried out to make ensure for the repaired area

8.0 TRAINING AND QUALIFICATION

All Inspectors of the EIL/OWNER (EIL/OWNER) shall be imparted training at the CONTRACTOR's cost. The inspector shall be provided complete awareness and knowledge regarding the equipment, limitations, capabilities complete range, method of operation, calibration, scanning, including development of suitable procedure, training on variables effecting the system performance and interpretation of results.

The Ultrasonic lead operator performing the examination shall be qualified in accordance with the EIL/OWNER's written practice, ASNT-TC-1A, ASME B31 Case 181-1. The minimum qualification of person interpreting the collected data shall be a ASNT Level III.

Only qualified UT personnel trained in the use of the equipment and who have demonstrated the ability to properly acquire examination data, shall conduct production scan.

Scanner technician, Band setter, scribe line technician shall have sufficient experience and capabilities to perform their duties to the satisfaction of AUT operator.

9.0 EVALUATION AND ACCEPTANCE CRITERIA

9.1 Evaluation

9.1.1 Data analysis criteria

Reflectors exceeding the limits in either a) or b) below, as applicable, shall be investigated to determine whether the indications originates from a flaw or is a geometric indication in accordance with Para. 9.1.3 (Flaw sizing) below.

a) For amplitude-based techniques, the location, amplitude, and extent of all reflectors that produce response greater than 20% of the reference level shall be investigated.

b) For non-amplitude based techniques, the location and extent of all images that have an indicated length greater than the limits, as applicable, shall be investigated.

9.1.2 Geometric

Ultrasonic indications of geometric and metallurgical origin shall be classified as follows:

1) Indications that are determined to originate from the surface configurations(such as weld reinforcement or root geometry) or variations in metallurgical structure of materials (such as cladding to base metal interface) may be classified as geometric indications, and

a) Need not be characterized or sized.
b) Need not be compared
c) Location shall be recorded

2) The following steps shall be taken to classify an indication as geometric:

a) Interpret the area containing the indication;
b) Plot and verify the indication coordinate, provide a cross-sectional display showing the indication position and surface discontinuity such as root or counter bore; and
c) Review fabrication or weld preparation drawings.

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3) Alternatively other NDE methods or techniques may be applied to classify an indication as geometric (e.g. alternative UT beam angles, radiography, ID and/or OD profiling).

9.1.3 Flaw sizing

The dimensions of the flaw shall be determined by the rectangle that fully contains the area of the flaw.

Flaw Sizing - Reflectors determined to be flaws shall be sized in accordance with a procedure demonstrated to size similar flaws at similar material depths. A flaw may be sized by manually analysis the data using sizing techniques that have been demonstrated on the calibration block. The dimension of the flaw shall be determined by the size of the rectangle that fully contains the area of the flaw.

9.1.4 Flaw evaluation

Flaws shall be evaluated for acceptance using the applicable criteria of ASME B31.3 Appendix R.

9.2 Acceptance criteria

Weld quality shall be judged on the basis of the acceptability criteria mentioned in ASME B31.3 Appendix R.

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EXHIBIT – J: COMPUTED RADIOGRAPHY

1.0 DIGITAL RADIOGRAPHY- INTRODUCTION

2.0 REFERENCE DOCUMENTS

3.0 DIGITAL RADIOGRAPHY SYSTEM

4.0 SYSTEM CHARACTERIZATION

5.0 QUALIFICATION PLANS44

6.0 TECHNIQUES

7.0 FILE FORMAT AND STORAGE

8.0 PERSONNEL REQUIREMENTS

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1.0 COMPUTED RADIOGRAPHY- INTRODUCTION

The minimum requirements for Computed radiography using phosphor image plates (films) is covered here. It is the CONTRACTOR'S responsibility to arrange and maintain Computed Radiographic System as required by this specification.

2.0 REFERENCE DOCUMENTS

The latest edition with addendum of the following standards shall be referred here:

a) ASME Section V, Mandatory Appendix VIII- Non Destructive Examination, Radiography using Phosphor Imaging Plate.
b) ASTM E2446- Practice of classification of computed Radiography system.
c) EN 14784-1: Industrial COMPUTED Radiography with storage Phosphor imaging plate.
d) ASNT SNT-TC-1A - Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

3.0 COMPUTED RADIOGRAPHY SYSTEM

3.1 Integral Image plate scanner and eraser unit Image plate scanner and eraser are single unit and integral. Scanner will be able to scan different sizes of imaging plates. Scanner will be able to provide simultaneous multi-scanning feature. Scanning speed will be 100 plates per hour for 3 X 12 @ 50 microns or better. Scanner will be able to provide flat horizontal transport system.

3.2 Imaging Plates/Cassettes

3.2.1 Image plates/Cassettes should have electron beam cured protection layer. Certification shall be as per EN 14784-1. Image plates and scanner, eraser & cassettes will be suitable for Radiography using X-ray, Ir-192, Selenium and Cobalt-60.

3.2.4 Images obtained by computer Radiography will give equivalent or better results in terms of shape/size, geometrical unsharpness and back scattering.

3.2.5 The offered image plates will not get exposed/deteriorated due to exposure to sunlight, room light etc.

3.2.6 No dark room will be used for handling & removing image plates from covers/cassettes, scanning & erasing. All the work will be done under tube lights illuminated ventilated room. The image plates should not have effect of such use on quality/results produced.

3.2.7 Image plate sizes shall be as per weld joint size.

3.2.8 Normally 50, 60 and 100 micron of IP plates are used for inspection of weld joints depending on type of energy source. 50 microns is used for X-ray and selenium source, 60 microns for IR-192 and 100 microns for Co-60 energy source. Different combination of IP plate and energy source may be used as advised by the IP plate manufacturer depending upon the job thickness and achievement of sensitivity. CONTRACTOR shall consider this clause as guideline only and select right combination of IP plate and source type after establishing the Digital Radiography procedure.

3.3 Software & High performance Laptop (Computer)

3.3.1 Software shall be user friendly and rugged. Software should be powerful to acquire, review, report and archive inspection data which should be compatible with Windows XP/Vista operating systems.

Line Profile - Software for image assessment should be capable of generating a line profile. This should include the ability to generate a line profile of a variable width specified by the user in order to be able to perform the testing specified in ASTM E2737.

Bad Pixel Presentation – Software for image assessment should be capable of turning on and off the display of bad pixels on demand by the user.

Image Enhancements – Software should have the capability of display images without image enhancements and then allow the user to apply filters, edge enhancements or contrast enhancements as desired.

Preservation of Original Data – Software should retain the original data if image enhancements are applied.

It should have wall thickness measurement tools and software.

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3.3.2 Software should be capable of saving images in a DICONDE compliant file format in accordance with ASTM E2339.

3.3.4 Generation of reports in Microsoft word and excels formats. System should be capable of saving data in DVDs.

4.0 SYSTEM CHARACTERIZATION

4.1 Prior to the approval of any item specific techniques, the system should be characterized to establish the capabilities of the system and determine the baseline for system performance. If any key components of a system are replaced, such as IP type, scanner model, scanner settings, software, etc; then this system characterization testing should be repeated.

4.2 *System Performance Baseline* - This system characterization should utilize Image Quality Indicators (IQIs) for quantitative measurement of *key system performance parameters.* The IQIs and test articles for this testing should be selected based upon materials and geometries that are representative of the system's intended application. The level III radiographer is responsible for developing the testing procedures for determining the system performance baseline. Equipment manufacturer assistance may be taken if required.

4.3 *Multiple Focal Spots* - Systems which have multiple focal spots that will be used for inspection should test system performance for each focal spot that will be used.

5.0 QUALIFICATION PLANS

5.1 CONTRACTOR is responsible for development and documentation of the qualification plans.

5.2 The qualification plans should include the following minimum details:

System configuration: The qualification plan(s) should include a complete and accurate listing of the CR inspection equipment. This should be a detailed listing of the CR system components by manufacturer, model and serial numbers. The software list should include details of software which is being used as part of the inspection process and its version information. This listing should be updated when key components are replaced or the system is modified.

Procedures – The qualification plan(s) should include a listing of the procedures used for operation, calibration and maintenance of the equipment.

Range of Items – The qualification plan(s) should specify the items, devices, materials, components, etc. that are covered by the qualification plan. This listing should identify specific items that are covered by the plan

Defects Covered – The qualification plan(s) should specify the types of defects that will be covered by the inspection. Whenever possible, the defects should be described quantitatively such as specifying the minimum dimensions for length, width and depth of cracks for specific materials.

Technique Verification Requirements – The qualification plan(s) should include a description of how the technique or techniques will be verified and the frequency of the verification. This includes a description and the quantity of the samples used for the technique verification and what IQIs and/or RQIs will be used.

Data Format and its Storage – The qualification plan(s) should include and documented about data format and its storage along with integrity & retrievability.

Revision – A qualification plan should be revised whenever any component specified above is changed.

6.0 TECHNIQUES

6.1 All techniques should be covered by a qualification plan approved by the level III radiographer.

6.2 *Filters and Collimators* – The written technique should specify the thickness, material and location of any beam hardening filters. The technique should also specify if a collimator is used to tighten the beam spread and the setting or position of the collimator if adjustable.

6.3 *Representative Quality Indicators* - Image quality indicators used shall be similar to conventional radiography as per this document.

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6.4 Type of radiation source shall be as per EXHIBIT-H in this document. Other radiation source might be used in consultation of CR System manufacturer considering energy level.

6.5 Filter Screens - Filter screens should be in intimate contact with the imaging plate with the exception of a thin layer or coating to prevent direct contact between the lead and the imaging plate.

6.6 *Backscatter* - Back filter screens should be used for protection from backscattered radiation. Lead or other suitable material should be used behind the imaging plate to prevent scattered radiation.

6.7 Viewing Adjustments – Standard digital image viewing software allows adjustment of Window/Level and Zoom. The technique should specify if these parameters may be adjusted during image assessment and the allowable range of adjustment.

6.8 Image Enhancements – All automated and manually applied image enhancements which manipulate the digital data, including digital filters, contrast or edge enhancements, etc. should be specified in the written technique unless specified in a system's operation procedure that is approved by the level III radiographer. Any manually controlled image enhancements specified in the technique should include the range of adjustment that is allowed.

6.9 Gray Value Range – Techniques should specify an acceptable gray value range of the area of interest, similar to a film density value used in film radiography. In addition, the gray value on the IQI should be within +/- 15% of the gray value as the area of interest.

6.8 Image Storage – The format for file storage should be specified in the written technique unless specified in a systems operation procedure that is approved by the level III radiographer.

6.9 Technique Verification– All techniques should be verified prior to approval by the level III radiographer. The verification should simulate the inspection as closely as is practical. This verification should ensure that the technique and inspection process are capable of detecting all defects specified in the inspection criteria and should be witnessed by a CLIENT representative.

6.10 Verification Personnel – During the validation, the inspection process should be performed by the same personnel who will be performing the inspection once the technique has been approved. The level III radiographer should witness the validation.

6.11 Written Technique – The technique used for the verification should be documented prior to the start of the verification. Changes made to the technique during the verification process may require the verification to be restarted at the discretion of the level III radiographer and/or CLIENT representative.

6.12 Samples for Demonstration - The preferred method of verification utilizes real or simulated defects (RQIs) in a blind test. At a minimum, the verification should be done using production representative samples.

7.0 FILE FORMAT AND STORAGE

7.1 *DICONDE* - Software should be capable of saving images in a DICONDE compliant file format in accordance with ASTM E2339. The full bit depth of the image should be retained in the saved image. Images should be saved in a lossless format.

7.2 *DVD* - Systems should be capable of saving data to DVDs. CDs may be used for smaller inspections; however, any inspection that cannot fit onto a single CD should be submitted on a DVD. DVDs used for submittal of images to the CLIENT should be write-once (DVD-R or DVD+R).

7.3 *DICONDE Headers* - Information stored in the DICONDE headers should contain as a minimum:-

- Detector manufacturer and model
- Viewing software and version number
- Pixel pitch (in microns)
- Part Name, such as nomenclature
- Part Identification, such as DODIC or drawing number
- Lot Number
- Date of Inspection
- Inspecting Activity

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7.4 Data Archival - Data should be archived in a secure location for the minimum duration specified in the contract.

7.5 Digital Annotation - If digital labeling is used, it should not permanently alter the nature of the image or hinder interpretation of an area within the image.

8.0 PERSONNEL REQUIREMENTS

Personnel should be trained and certified in accordance with an approved as established by ASNT-TC-1A or NAS-410. As a minimum, Level II and III individuals shall have 40 hours of training and 1 month of practical experience in the digital imaging process technique.

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SPECIFICATION FOR QUALITY MANAGEMENT SYSTEM REQUIREMENTS FROM BIDDERS / SUPPLIERS / CONTRACTORS

Rev. No.	Date	Purpose	Prepared by	Checked by	Approved by: Standards Committee Convener	Approved by: Standards Bureau Chairman
3	29-09-2025	General Revision	QMS Standards Committee	QMS Standards Committee	AK	MN
2	12-06-2020	General Revision	QMS Standards Committee	QMS Standards Committee	SKB	SKS
1	12-03-2015	General Revision	QMS Standards Committee	QMS Standards Committee	MPJ	SC
0	04-06-2009	Issued as Standard Specification	QMS Standards Committee	QMS Standards Committee	SCT	ND

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Abbreviations:

EIL	Engineers India Limited
ISO	International Organization for Standardization
MR	Material Requisition
PO	Purchase Order
PR	Purchase Requisition
QMS	Quality Management System

QMS Standards Committee

Convener: Mr. Anil Kumar

Members: Mr. Himangshu Pal (SCM-Inspection)
Mr. Ravindra Kumar (Const.)
Mr. Vinod Kumar (CQA)
Mr. Swapnil Vaishnav (Projects)
Mr.Vijay Kumar Garg (SCM)
Mr.Raju Kumar Pandey (Equipment Division)

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1.0 SCOPE

This specification establishes the Quality Management System requirements to be met by BIDDER for following purpose:

- QMS requirements to be met by suppliers/contractors after award of work/duringcontract execution.

2.0 DEFINITIONS

2.1 Bidder

For the purpose of this specification, the word "BIDDER" means the person(s), firm, company or organization who is under the process of being contracted by EIL / Owner for delivery of some products (including service).The word "Bidder" is considered synonymous to supplier, contractor or vendor.

2.2 Project Quality Plan (PQP)

Document tailored from Standard Quality Management System Manual of BIDDER, specifying how the quality requirements of the project will be met.

2.3 Owner

Owner means the owner of the project for which services / products are being purchased and includes their representatives, successors and assignees.

3.0 REFERENCE DOCUMENTS

- Specification for Documentation Requirements from Contractors (Doc. No. 6-78-0002)
- Specification for Documentation Requirements from Suppliers (Doc. No. 6-78-0003)

4.0 QUALITY MANAGEMENT SYSTEM – GENERAL

Unless otherwise agreed with EIL / Owner, the BIDDER proposed quality system shall fully satisfy all relevant requirements of ISO 9001 "Quality Management Systems – Requirements."Evidence of compliance shall be current certificate of quality system registration to ISO 9001 or a recent compliance audit recommending registration from a certification agency.The quality system shall provide the planned and systematic control of all quality related activities for execution of contract.Implementation of the system shall be in accordance with BIDDER'S Quality Manual and PROJECT specific Quality Plan.

5.0 QUALITY SYSTEM REQUIREMENTS

5.1 BIDDER shall prepare and submit for review / record, Project Quality Plan / Quality Assurance Plan for contracted scope / job.The BIDDER'S Quality Plan shall address all of the applicable elements of ISO 9001, identify responsible parties within BIDDER'S organization, for the implementation / control of each area, reference the applicable procedures used to control / assure each area, and verify the documents produced for each area.The Project Quality Plan shall necessarily define control or make reference to the relevant procedures, for design and engineering, purchase, documentation, record control, bid evaluation, inspection, production/manufacturing, preservation, packaging and storage, quality control at construction site, pre-commissioning, commissioning and handing over (as applicable) in line with contract requirement and scope of work.

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5.2 BIDDER shall identify all specified or implied statutory and regulatory requirements and communicate the same to all concerned in his organization and his sub contractor's organization for compliance.

5.3 BIDDER shall deploy competent and trained personnel for various activities for fulfilment of PO / contract.BIDDER shall arrange adequate infrastructure and work environment to ensure that the specification and quality of the deliverable are maintained.

5.4 BIDDER shall do the quality planning for all activities involved in delivery of order.The quality planning shall cover as minimum the following:

- Resources
- Product / deliverable characteristics to be controlled.
- Process characteristics to ensure the identified product characteristics are realized
- Identification of any measurement requirements, acceptance criteria
- Records to be generated
- Need for any documented procedure

The quality planning shall result into the quality assurance plan, inspection and test plans (ITPs) and job procedures for the project activities in the scope of bidder. These documents shall be submitted to EIL/Owner for review/approval, before commencement of work.

5.5 Requirements for sub-ordering of outsourced items /sub-contracting / purchasing of services specified in MR/ contract / tender shall be adhered to. In general all outsourced items will be from approved vendors of EIL. Wherever requirements are not specified, or approved sub vendors do not exist, the sub-contractor shall establish and maintain a system for purchasing / sub-contracting to ensure that purchased product / service conforms to specified requirements in concurrence with EIL / Owner.Criteria for selection of sub-contractor, evaluation, re-evaluation, maintenance of purchasing data and verification of purchased product (sub-contractor services), constitute important components of this requirement.

5.6 BIDDER shall plan and carry production and service provision under controlled conditions.Controlled conditions shall include, as applicable

a) the availability of information that describes the characteristics of the product
b) the availability of work instructions
c) the use of suitable equipment
d) the availability and use of monitoring and measuring devices
e) the implementation of monitoring and measurement
f) the implementation of release, delivery and post-delivery activities

5.7 BIDDER shall validate any processes for production and service provision where resulting output cannot be verified by subsequent monitoring and measurement. This includes any process where deficiencies become apparent only after the product is in use or service has been delivered.

5.8 BIDDER shall establish a system for identification and traceability of product / deliverable throughout product realization.Product status with respect to inspection and testing requirements shall be identified.

5.9 BIDDER shall identify, verify, protect and safeguard EIL / Owner property (material / document) provided for use or incorporation into the product.If any Owner / EIL property is lost, damaged or otherwise found to be unsuitable for use, this shall be reported to the EIL / Owner.

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BIDDER shall ensure the conformity of product / deliverable during internal processing and delivery to the intended destination.Requirements mentioned in the MR/ tender shall be adhered to.

5.10 BIDDER shall establish system to ensure that inspection and testing activities are carried out in line with requirements.Where necessary, measuring equipment shall be calibrated at specified frequency, against national or international measurement standards; where no such standard exists, the basis used for calibration shall be recorded.The measuring equipment shall be protected from damage during handling, maintenance and storage.

5.11 BIDDER shall ensure effective monitoring, using suitable methods, of the processes involved in production and other related processes for delivery of the scope of contract.

5.12 BIDDER shall monitor and measure the characteristics of the product/deliverable to verify that product requirement has been met.The inspection (stage as well as final) by BIDDER and EIL / Owner personnel shall be carried out strictly as per the approved ITPs or ITPs forming part of the contract.Product release or service delivery shall not proceed until the planned arrangements have been satisfactorily completed, unless otherwise approved by relevant authority and where applicable by Owner / EIL.

5.13 BIDDER shall establish and maintain a documented procedure to ensure that the product which does not conform to requirements is identified and controlled to prevent its unintended use or delivery

5.14 All non-conformities (NCs) / deficiencies found by the BIDDER'S inspection / surveillance staff shall be duly recorded, including their disposal action shall be recorded and resolved suitably.Effective corrective actions shall be implemented by the BIDDER so that similar NCs including deficiencies do not recur.The BIDDER shall take appropriate actions to address the Risks and Opportunities in the project.

5.15 All deficiencies noticed and reported by EIL / Owner shall be analysed by the BIDDER and appropriate corrective actions shall be implemented.BIDDER shall intimate EIL / Owner of all such corrective action implemented by him.

5.16 BIDDER should follow the standards, specifications and approved drawings. Concessions/Deviations shall be allowed only in case of unavoidable circumstances. In such situations Concession/deviation request must be made by the BIDDER through online system of EIL vendor portal for document exchange. URL of EIL vendor portal for document exchange is http://edocx.eil.co.in/vportal. BIDDER shall have documented procedure for control of documents.

5.17 All project records shall be carefully kept, maintained and protected for any damage or loss until the project completion, then handed over to EIL / Owner as per contract requirement (Refer Specification Nos. 6-78-0002 - Specification for Documentation Requirements from Contractors and 6-78-0003 - Specification for Documentation Requirements from Suppliers), or disposed as per relevant project procedure.

6.0 AUDITS

BIDDER shall plan and carry out the QMS audit for the job. Quality audit program shall cover design, procurement, construction management and commissioning as applicable including activities carried out by sub-vendors and sub-contractors. This shall be additional to the certification body surveillance audits carried out under BIDDER'S own ISO 9001 certification scheme.

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The audit programs and audit reports shall be available with bidder for scrutiny by EIL / Owner.EIL or Owner's representative reserves the right to attend, as a witness, any audit conducted during the execution of the WORKS.

In addition to above, EIL, Owner and third party appointed by EIL/Owner may also perform Quality and Technical compliance audits.BIDDER shall provide assistance and access to their systems and sub-contractor / vendor systems as required for this purpose.Any deficiencies noted shall be immediately rectified by BIDDER.

7.0 DOCUMENTATION REQUIREMENTS

BIDDER shall submit following QMS documents immediately after award of work (Within one week) for record / review by EIL / Owner/ TPIA(Third Party Inspection Agency), as applicable:

- Organization chart (for complete organization structure and for the project)
- Project Quality Plan/Quality Assurance Plan
- Job specific Inspection Test Plans, if not attached with PR
- Job Procedures
- Inspection/Test Formats

In addition to above QMS documents, following documentation shall be maintained by the BIDDER for submission to EIL / Owner on demand at any point of time during execution of the project:

- Quality Manual
- Certificate of approval for compliance to ISO9001 standard
- Procedure for Control of Non-conforming Product
- Procedure for Control of Documents
- Sample audit report of the QMS internal and external audits conducted during last one year
- Customer satisfaction reports from at least 2 customers
- Project QMS audit report
- Technical audit reports for the project
- Corrective action report on the audits

Documents as specified above are minimum requirements. BIDDER shall submit any other document/data required for completion of the job as per EIL/Owner instructions.

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SPECIFICATION FOR DOCUMENTATION REQUIREMENTS FROM CONTRACTORS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
					Approved by	
3	29-09-2025	General Revision	QMS Standards Committee	QMS Standards Committee	AK	MN
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0	04-06-2009	Issued as Standard Specification	QMS Standards Committee	QMS Standards Committee	SCT	ND

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Abbreviations:

DEC	Detailed Engineering Contractor
DCI	Document Control Index
EIL	Engineers India Limited
EPCC	Engineering Procurement Construction Contract
FOA	Fax of Acceptance
IC	Inspection Certificate
IRN	Inspection Release Note
ITP	Inspection and Test Plan
LOA	Letter of Acceptance
LSTK	Lumpsum Turnkey
ODC	Over Dimension Consignment
PMC	Project Management Consultancy
QMS	Quality Management System
URL	Universal Resource Locator

QMS Standards Committee

Convener: Mr. Anil Kumar

Members:
Mr. Himangshu Pal (SCM-Inspection)
Mr. Ravindra Kumar (Const.)
Mr. Vinod Kumar (CQA)
Mr. Swapnil Vaishnav (Projects)
Mr.Vijay Kumar Garg (SCM)
Mr.Raju Kumar Pandey (Equipment Division)

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Annexures:

S. No.	Title	Doc. No.
1.	Format for completeness of Final Documentation	Format No. 3-78-0004

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1.0 SCOPE

This specification establishes the Documentation Requirements from Contractors.

All documents/data against the Tender / Contract shall be developed and submitted to EIL/Owner by the contractor for review / records, in line with this specification.

2.0 DEFINITIONS

2.1 Contractor

For the purpose of this specification, the word "CONTRACTOR" means the person(s), firm, company or organization who has entered into a contractwith EIL / Owner for delivery of some products and services.The word is considered synonymous to bidder, supplier or vendor.

2.2 Owner

Owner means the owner of the project for which services / products are being purchased and includes their representatives, successors and assignees.

3.0 REFERENCE DOCUMENTS

- Specification for Quality Management System Requirements from Bidders (Doc. No. 6-78-0001)

4.0 DOCUMENTATIONAND DATA REQUIREMENTS

4.1 Order Acknowledgement and Assigning Project Manager

After placement of order, Contractor shall acknowledge order through V-Portal within 7 days of receipt of FOA/PO. Contractor shall assign a Project Manager for that order though online portal and provide requisite details. Project Manager details shall include e-mail address, mailing address, mobile/telephone nos., fax nos. and name of Project Manager. All the system generated emails pertaining to that order shall be sent to the assigned Project Manager.

4.2 Documents/Data to be submitted by the Contractor

4.2.1 The contractor shall submit the documents and data against the Tender/Contract as per the list specified in respective Tender/Contract.

4.2.2 Review of the contractor drawings / Documents by EIL would be only to review the compatibility with basic designs and concepts and in no way absolve the contractor of his responsibility/contractual obligation to comply with Tender/Contract requirements, applicable codes, specifications and statutory rules/regulations. Any error/deficiency noticed during any stage of manufacturing/execution/ inspection / installation shall be promptly corrected by the contractor without any extra cost or time, whether or not comments on the same were received from EIL during the drawing review / inspection stage.

4.2.3 Unless otherwise specified, submission of documents for Review/Records shall commence as follows from the date of Fax of Intent /Letter of Intent/ Fax of Acceptance (FOA)/ Letter of Acceptance (LOA):

QMS	-	1week
Document Control Index	-	2weeks
Other Documents/Drawings	-	As per approved Document Control Index

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4.2.4 Documents as specified in Tender/Contract are minimum requirements.Contractor shall submit any other document/data required for completion of the job as per EIL/Owner instructions.

4.3 Style and Formatting

4.3.1 All Documents shall be in ENGLISH language and in M.K.S System of units.

4.3.2 Before submitting the drawings and documents, contractor shall obtain the title block from EIL and ensure that the following information are properly entered in each drawing:

- Tender Number
- Name of Equipment / Package
- Equipment / Package Tag No.
- Name of Project
- Owner
- Main Contractor (if work is sub-contracted)
- Drawing / Document Title
- Drawing / Document No.
- Drawing / Document Revision No. and Date

4.4 Review and Approval of Documents by Contractor

4.4.1 All the Drawing/Documents shall be reviewed, checked, approved and duly signed/stamped by contractor before submission.Revision number shall be changed during submission of the revised contractor documents and all revisions shall be highlighted by clouds. Whenever there is a requirement of any sub- contractor/DEC drawings to be reviewed by EIL, the same shall be submitted by the contractor duly reviewed, approved and stamped by the sub- contractor/DEC and the contractor.Direct submission of sub- contractor's drawings without contractor's approval shall not be entertained.

4.5 Transportation Plan

Transportation Plan for Over Dimensional Consignments (ODC), if any, shall be submitted within 2 weeks of receiving FOA / LOA, for approval. Unless otherwise mentioned, consignments with parameters greater than following shall be considered as over dimensional.

Dimensions : 4 meters width x 4 meters height x 20 meters length

Weight : 32 MT (Metric Ton)

Dimensions and weight provided above are inclusive of all nozzles, attachments, transportation saddles etc.

Physical Route survey for ODC movement shall be submitted to EIL within 8 weeks of receiving FOA / LOA.

4.6 Document Category

Following review codes shall be used for review of contractor Drawings/Documents:

Code 1 - No comments. Proceed withManufacture/ Fabrication/ Constructionas per the document.

Code 2 - Proceed with Manufacture/Fabrication/Constructionas per commented document.Revised document required.

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Code 3 - Document does not conform to basicrequirements as marked.Resubmitfor review.

Code R - Document is retained for Records. Proceed withManufacturing/ fabrication as per Tender/ ContractRequirement.

Code V - Void, Document is returned as invalid.

Document is marked as Void under following conditions:

a) Wrong item drawing uploaded.
b) Superseded or obsolete submission.
c) Duplicate submission.
d) Out of sequence submission.
e) Mismatch in document name and title under which document uploaded.
f) Document not legible.
g) For PMC projects, document not signed and stamped by contractor and DEC

4.7 Methodology for Submission of Documents to EIL/Owner

4.7.1 Document Control Index (DCI)

Contractor shall create and submit Document Control Index (DCI) for review based on PO/PR/MR along with schedule date of submission of each drawing/document on EIL Vendor Portal.The DCI shall be specific with regard to drawing/document no. and the exact title. Proper sequencing of the drawings/documents should be ensured in schedule date of submission.

4.7.2 Submission of Drawings/Documents / Data

Drawings/documents, data and DCI shall be uploaded on the EIL VendorPortal. The detail guidelines for uploading documents on EIL Vendor Portal are available on following URL:

http://edocx.eil.co.in/vportal

4.7.3 Statutory Approvals

Wherever approval by any statutory body is required to be taken by Contractor, the Contractor shall submit copy of approval by the authority to EIL.

4.7.4 Schedule and Progress Reporting

Contractor shall submit monthly progress report (MPR) and updated procurement, engineering and manufacturing status (schedule vs. actual) and highlight constraints, if any, along with action plan for mitigation, to the EIL / Owner by 1st week of every month. One month Look-ahead schedule including the mobilization plan shall be submitted within 2 weeks from FOA / LOA.In case of exigencies, EIL/Owner can ask for report submission as required on weekly/fortnightly/ad-hoc basis depending upon supply status and contractor shall furnish such reports promptly without any price implication.Format for progress report shall be submitted by the contractor during kick off meeting or within one week of receiving FOA/LOA, whichever is earlier.

Contractor shall submit progress reports including Daily Progress Reports (DPR) through planning portal. “EIL CP Contractor Daily Update System” available in following url: https://www6.eil.co.in/CDUS/

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4.7.5 Quality Assurance Plan/Inspection and Test Plan

Inspection and test plans attached if any, to the tender are generic and indicative only. Immediately after receipt of the order, contractor shall submit within one week of receiving FOA/LOA, job specific ITPs based on the indicative ITPs. Further, contractor shall also submit Quality Assurance Plan for project activities in the scope of contract, starting from manufacturing to handing over/ commissioning, these plans shall cover/identify the activities, relevant procedure, if any, code of conformance, resources for performance and checking/monitoring, approval requirements and authority, records to be generated and audit scope by EIL/Owner.

For EPCC/LSTK/Package contracts, the contractor shall prepare a list of items/ equipment and their inspection categorization plans for all items included in the scope of supply immediately after receipt of order and obtain approval for the same from EIL. The items shall be categorized into different categories depending upon their criticality for the scope of inspection of TPIA and/or EIL.

4.7.6 Inspection Release Note (IRN)/ Inspection Certificate (IC)

Contractor shall ensure that all documents viz. documents reviewed, manufacture's test certificate etc., mentioned in Inspection Release Note(IRN), issued by EIL/third party against the materials supplied by contractor, are sent to EIL along with the IRN.

IRN/ IC shall be issued by EIL Inspector/ third party inspection agency only after all the drawings/documents as per DCI are submitted and are accepted under review code-1& code R. Material/Equipment dispatch from contractor's/sub vendor's works shall not commence till above condition is met.

Note 1: Nonfulfilling above requirement shall result into appropriate penalty or with- holding of payment as per conditions of Tender/Contract.

Note 2: For items where IRN/IC is issued by TPIA, supplier to ensure that following as a minimum must be mentioned by TPIA in IRN/IC

a) Tender document number
b) List of drawings / documents with EIL approval code
c) Tests witnessed, documents reviewed
d) Compliance statement by TPIA that product meets the requirement as specified in EIL standard specifications, Inspection Test Plan / Quality Assurance Plan (QAP) and approved documents.

4.7.7 Pre-Commissioning& Commissioning Activities Management System (PCAMS)

Pre-Commissioning& Commissioning activities management system software shall be followed for Mechanical completion, check listing of loops, punch points, hydro test and issue of Formats during the Pre-Commissioning and Commissioning activities and the same can be accessed on following URL

https://pcams.eil.co.in/

4.8 Final Documentation

4.8.1 As built Drawings

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Minor Shop/Site changes made by contractor after approval of drawings under 'Code 1' by EIL and deviations granted through online system, if any, shall be marked in hard copies of drawings which shall then be stamped 'As-built' by the contractor.These 'As-built' drawings shall be reviewed and stamped by EIL Inspector/Site engineer/TPIA also, as the case may be. Format for completeness of final documents (Format No. 3-78-0004) is attached with this specification.Contractor shall prepare scanned images files of all marked – up 'As – built' drawings. Simultaneously contractor shall incorporate the shop/site changes in the native soft files of the drawings also.

4.8.2 As built Final Documents

As built final documents shall be submitted as listed in Tender/Contract

4.8.3 Packing/Presentation of Final Documents

Final Documents shall be legible photocopies in A4, A3 size only.Drawings will be inserted in plastic pockets (both sides transparent, sheet thickness minimum 0.1 mm) with an extra strip of 12 mm wide for punching so that drawings are well placed.

Final Documentation shall be bound in hard board plastic folder(s) of size 265 mm x 315 mm (10½-inch x 12½-inch) and shall not be more that 75 mm thick. It may be of several volumes and each volume shall have a volume number, index of volumes and index of contents of that particular volume.Where numbers of volumes are more, 90mm thickness can be used.Each volume shall have top Poly Vinyl Chloride (PVC) sheet of minimum 0.15 mm thick duly fixed and pressed on folder cover and will have 2 lever clips.In case of imported items documents, 4 lever clip shall also be accepted.All four corners of folders shall be properly metal clamped.Indexing of contents with page numbering must be incorporated by contractor.Spiral/Spico bound documents shall not be acceptable.As mentioned above, books should be in hard board plastic folders with sheets punched and having 2/4 lever clips arrangement.

Each volume shall contain on cover a title block indicating Tender No., name of project, name of customer, package equipment tag no. & name (if applicable).Each volume will have hard front cover and a reinforced spine to fit thickness of book.These spines will also have the title printed on them.Title shall include also volume number (say 11 of 15) etc.

4.8.4 Submission of Soft copies

Contractor shall submit to EIL, the scanned images files as well as the native files of drawings/documents, along with proper index.

In addition to hard copies, contractor shall submit soft copies of all the final drawings and documents in pen drive or any other specified medium with proper identification tag, all text documents prepared on computer, scanned images of all important documents (not available as soft files), all relevant catalogues, manuals available as soft files (editable copies of drawings/text documents, while for catalogues/manuals/proprietary information and data PDF files can be furnished). All soft files shall be appropriately named, systematically indexed, and duly bookmarked in PDF format to facilitate ease of reference and access.

All the above documents shall also be uploaded on the EILVendor Portal and if applicable on Client Server also.

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4.8.5 Completeness of Final Documentation

Contractor shall get the completeness of final documentation verified by EIL/TPIA and attach the Format for Completeness of Final Documentation (Format No. 3-78-0004) duly signed by EIL or TPIA as applicable to the final document folder.

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COMPLETENESS OF FINAL DOCUMENTATION

Name of Supplier/Contractor	:	
Customer	:	
Project	:	
EIL's Job No.	:	
Purchase Order No./ Contract No.	:	
Purchase Requisition No./ Tender No.	:	Rev. No.:
Name of the Work/ Equipment	:	
Tag. No.	:	
Supplier's/ Contractor's Works Order No.	:	

Certified that the Engineering Documents/ Manufacturing & Test Certificates submitted by the supplier (as per Index sheet mentioned in Annexure-1) are complete in accordance with the Vendor Data Requirements of Purchase Requisition / Tender.

Signature	: …….	Signature	: …….
Date	: …….	Date	: …….
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……
	Supplier/Contractor		EIL/TPIA

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Annexure-1

Final Documentation Index Sheet			
PR/PO/Tender No.		Revision No.	
Serial No.	Document Title	Page/ Folder No.	No. of Pages

Signature	: ……	Signature	: ……
Date	: ……	Date	: ……
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……

Supplier / Contractor

EIL / TPIA

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SPECIFICATION FOR DOCUMENTATION REQUIREMENTS FROM SUPPLIERS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
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Abbreviations:

DCI	Document Control Index
EIL	Engineers India Limited
EPS	Electronic Procurement System
FOA	Fax of Acceptance
IC	Inspection Certificate
IRN	Inspection Release Note
ITP	Inspection and Test Plan
LOA	Letter of Acceptance
LR	Lorry Receipt
MR	Material Requisition
ODC	Over Dimension Consignment
PO	Purchase Order
PR	Purchase Requisition
PVC	Polyvinyl Chloride
QAP	Quality Assurance Plan
QMS	Quality Management System
RPO	Regional Procurement Office
TPIA	Third Party Inspection Agency
URL	Universal Resource Locator
V-Portal	Vendor Portal

QMS Standards Committee

Convener: Mr. Anil Kumar

Members:
Mr. Himangshu Pal (SCM-Inspection)
Mr. Ravindra Kumar (Const.)
Mr. Vinod Kumar (CQA)
Mr. Swapnil Vaishnav (Projects)
Mr.Vijay Kumar Garg (SCM)
Mr.Raju Kumar Pandey (Equipment Division)

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Annexures:

S. No.	Title	Doc. No.
1.	Format for completeness of Final Documentation	Format No. 3-78-0004

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1.0 SCOPE

This specification establishes the Documentation Requirements from Suppliers.

All documents/data against the PO / PR / MR shall be developed and submitted to EIL/Owner by the suppliers for review / records, in line with this specification.

2.0 DEFINITIONS

2.1 Supplier

For the purpose of this specification, the word "SUPPLIER" means the person(s), firm, company or organization who has entered into a contract with EIL / Owner for delivery of some products and/orservices.The word is considered synonymous to bidder, contractor or vendor.

2.2 Owner

Owner means the owner of the project for which services / products are being purchased and includes their representatives, successors and assignees.

3.0 REFERENCE DOCUMENTS

- Specification for Quality Management System Requirements from Bidders (Doc. No. 6-78-0001)

4.0 DOCUMENTATION REQUIREMENTS

4.1 Order Acknowledgement and Assigning Project Manager

After placement of order, Supplier shall acknowledge order through V-Portal within 7 days of receipt of FOA/PO. Supplier shall assign a Project Manager for that order though online portal and provide requisite details. Project Manager details shall include e-mail address, mailing address, mobile/telephone nos., fax nos. and name of Project Manager. All the system generated emails pertaining to that order shall be sent to the assigned Project Manager.

4.2 Documents/Data to be submitted by the Supplier

4.2.1 The Supplier shall submit the documents and data against the PO/PR/MR as per the list given in respectivePO/PR/MR.

4.2.2 Review of the supplier drawings/ documents by EIL would be only to review the compatibility with basic designs and concepts and in no way absolve the supplier of his responsibility/contractual obligation to comply with PR requirements, applicable codes, specifications and statutory rules/regulations.Any error/deficiency noticed during any stage of manufacturing/execution/inspection/ installation shall be promptly corrected by the supplier without any time and cost implications, irrespective ofcomments on the same were received from EIL during the drawing review stage or not.

4.2.3 Unless otherwise specified, submission of documents for Review/Records shall commence as follows from the date of Fax of Intent /Letter of Intent/ Fax of Acceptance (FOA)/ Letter of Acceptance (LOA):

QMS	-	1week
Document Control Index	-	2weeks
Other Documents/Drawings	-	As per approved Document Control Index

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4.2.4 Documents as specified in PO/PR/MR are minimum requirements.Supplier shall submit any other document/data required for completion of the job as per EIL/Owner instructions.

4.3 Style and Formatting

4.3.1 All Documents shall be in ENGLISH language and in M.K.S(Meter-Kilogram-Second) System of units.

4.3.2 Before forwarding the drawings and documents, contractor shallobtain the title block from EIL and ensure that the following information are properly mentioned in each drawing:

- Purchase Requisition Number
- Name of Equipment / Package
- Equipment / Package Tag No.
- Name of Project
- Client
- Drawing / Document Title
- Drawing / Document No.
- Drawing / Document Revision No. and Date

4.4 Review and Approval of Documents by Supplier

4.4.1 All, the Drawing/Documents shall be reviewed, checked, approved and duly signed/stamped by supplier before submission.Revision number shall be changed during submission of the revised supplier documents and all revisions shall be highlighted by clouds. Whenever the supplierrequires any sub-supplier drawings to be reviewed by EIL, the same shall be submitted by the supplier duly reviewed, approved and stamped by the supplier.Direct submission of sub-supplier's drawings without contractor's / suppliers' approval shall not be entertained.

4.5 Document Category

Following review codes shall be used for review of supplier Drawings/Documents:

Code 1 - No comments. Proceed with Manufacture / Fabrication / Construction as per the document.

Code 2 - Proceed with Manufacture / Fabrication / Construction as per commented document. Revised document required.

Code 3 - Document does not conform to basic requirements as marked.Resubmitfor review.

Code R - Document is retained for Records. Proceed with Manufacturing / fabrication as per Tender/ ContractRequirement.

Code V - Void, Document is returned as invalid.

Document is marked as Void under following conditions:

a) Wrong item drawing uploaded.
b) Superseded or obsolete submission.
c) Duplicate submission.
d) Out of sequence submission.
e) Mismatch in document name and title under which document uploaded.
f) Document not legible.
g) For PMC projects, document not signed and stamped by contractor and DEC

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4.6 Methodology for Submission of Documents to EIL/Owner

4.6.1 Document Control Index (DCI)

Supplier shall create and submit Document Control Index (DCI) forreview based on PO/PR/MR along with schedule date of submission of each drawing/document on EIL Vendor Portal.The DCI shall be specific with regard to drawing/document no. and the exact title. Proper sequencing of the drawings/documents should be ensured in schedule date of submission.

4.6.2 Submission of Drawings/Documents / Data

Drawings/documents, data and DCI shall be uploaded on the EIL Vendor Portal as per approved DCI. The detailed guidelines for uploading documents on EIL VendorPortal are available on URL:**http://edocx.eil.co.in/vportal**

4.6.3 Statutory Approvals

Wherever approval by any statutory body is required to be taken by Supplier, the Supplier shall submit copy of approval by the authority to EIL.

4.6.4 Manufacturing Schedule

Supplier shall prepare milestone based(milestones such as document submission, sub ordering, manufacturing, Inspection, dispatches, etc.) manufacturing schedule for the order, to meet delivery as per FOA/PO terms. Supplier shall submit manufacturing schedule to concerned Regional Procurement Office (RPO) of EIL, with a copy to Head office monitoring team/Owner for review within 7 days from date of FOA/PO.Same shall be uploaded in the EPS portal of EILi.e.,https://www6.eil.co.in/epsinspection/supp

4.6.5 Schedule and Progress Reporting

Supplier shall submit Monthly Progress Report(MPR) on or before the 9th of every monthindicating following milestone-based progress details as minimum:

- Drawing submission and approval status and schedule for submission of revised drawing / fresh Drawing requiring approval as per approved DCI
- Sub-ordering plan/details for all major items indicating item description, sub-order number, Date of sub-ordering, sub-vendor name, Location, contractual delivery data and expected delivery dates at main vendor's shop and other critical details requiring timely receipt of sub-ordered items at shop.
- Shop manufacturing progress indicating major milestone progress, in case of missing any milestone date, catch up plan for the same and expected dispatch date from shop and expected delivery date at site.
- Area requiring special attention/concern and proposed action plan to resolve the same.

First Monthly Progress Report (MPR) shall be submitted within2 weeks from FOA/LOA.In case of exigencies, EIL/Owner can ask for report submission as required on weekly/fortnightly/ad-hoc basis depending upon supply status and supplier shall furnish such reports promptly without any price implication.Format for progress report shall be submitted by the Supplier during kick off meeting or within 2 weeks of receiving FOA/LOA, whichever is earlier.

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4.7 Inspection and Testing

4.7.1 Quality Assurance Plan/Inspection and Test Plan

If Inspection and test plans (ITP)are attached with MR/PR same shall be followed along with additional tests requirement (if any) mentioned in MR/ PR. However for cases wherein EIL Standard ITPs not available/ have not been attached with MR/PR, Supplier shall submit within one week of receiving FOA/LOA, the Quality Assurance Plan for inspection & testing at various stages of production, quality control records for critical bought out items/ materials and site assembly & testing as may be applicable to the specific order and obtain approval from concerned Regional procurement Office of EIL/third party inspection agency, as applicable.

For Package equipment contracts, the supplier shall prepare a list of items/ equipment and their inspection categorization plan for all items included in the scope of supply immediately after receipt of order and obtains approval for the same from EIL. The items shall be categorized into different categories depending upon their criticality for the scope of inspection of TPIA and/or EIL.

4.7.2 Inspection Requirements:

Supplier shall perform internal inspection as per ITP/ approved QAP at their works based on approved documents/drawings. Upon satisfactory internal inspection, supplier shall raise inspection call through Inspection call Module of EPS (https://www6.eil.co.in/epsinspection) to concerned Regional Procurement Office (RPO) of EIL/ TPIA/ Owner with advance notice as per contractalong with Internal test reports. Where inspection is not in the scope of EIL and is carried out by nominated Third Party Inspection agency (TPIA), Inspection Release Note (IRN) issued by the nominated TPIA along with Manufacturer's Test Certificate (MTC) shall be uploaded in EIL EPS Portal (https://www6.eil.co.in/epsinspection).

All changes w.r.t. PR shall be recorded through agreed variations or Concessions & Deviations. Conflict, if any, between PR / Job specifications and approved drawings, shall be brought to the notice of EIL / owner bythe supplier/ contractor. Decision of EIL / owner will be binding on the supplier and to be complied without time and cost implications.

Identified bought out items/ raw material shall be procured under TPIA as per ITP.

4.7.3 Inspection Release Note (IRN)/ Inspection Certificate (IC)

IRN/ IC shall be issued by EIL Inspector/ third party inspection agency on successful inspection, review of test reports/ certificates as per specifications &ITP/ agreed quality plan (as applicable) and only after all the drawings/documents as per DCI are submitted and are accepted under review code-1or code R. Supplier shall ensure that necessary documents/manufacturing and test certificates are made available to EIL/TPIA as and when desired.

Note 1: Non fulfilling above requirement shall result into appropriate penalty or with- holding of payment as per conditions of PO/PR/MR.

Note 2: For items where IRN/IC is issued by TPIA, supplier to ensure that following as a minimum must be mentioned by TPIA in IRN/IC:

a) PR document number
b) List of drawings/documents with EIL approval code
c) Tests witnessed, documents reviewed

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d) Compliance statement by TPIA that product meets the requirement as specified in EIL PR, standard specifications, Inspection Test Plan/QAP and approved documents.

4.8 Transportation Plan

Transportation Plan for Over Dimensional Consignments (ODC), if any, shall be submitted within 2 weeks of receiving FOA/LOA, for approval. Unless otherwise specified, consignments with parameters greater than following shall be considered as over dimensional.

Dimensions : 4 meters width x 4 meters height x 20 meters length

Weight : 32 MT (Metric Ton)

Dimensions and weight provided above are inclusive of all nozzles, attachments, transportation saddles etc.

Physical Rout survey for ODC movement shall be submitted to EIL within 8 weeks of receiving FOA / LOA.

4.9 Dispatch Details

Upon receipt of IRN/IC from EIL inspector/TPIA, supplier shall dispatch items within 2 days. Item wise dispatch details shall be uploaded in EIL's EPS module within 24 hours of any item dispatched from shop, indicating PR item no, Quantity dispatched, Transporter's name, LR Number/ LR date.

4.10 Vendorshall ensure timely uploading of Manufacturing Schedule, Monthly Progress Report,Inspection Certificate (IRN)issued by the TPIA (as applicable for PO where Inspection is under nominated Third Party Inspection Agency)and updation ofitem wise dispatch details in EPS portal of EIL (https://www6.eil.co.in/epsinspection).

4.11 Final Documentation

4.11.1 Supplier shall prepare final documents in line with VDR(Vendor Document Requirements) attached with PR/Tender. A copy of final document along with filled in Format for Completeness of Final Documentation (Format No. 3-78-0004) to be submitted to EIL Inspector/TPIA for review & approval within 2 weeks from dispatch. Upon receipt of EIL/TPIA endorsement on Completeness of Final Documents, supplier shall submit soft/hard copies of Final documents to EIL/Owner in requisite quantity as per PO/PR details, along with covering letter. A copy of covering letter to be submitted to the concerned Regional Procurement Office (RPO) of EIL/Owner.

4.11.2 As Built Drawings

Minor Shop changes made by Supplier after approval of drawings under 'Code 1' by EIL and deviations granted through online system, if any, shall be marked in hard copies of drawings which shall then be stamped 'As-built' by the supplier.These 'As-built' drawings shall be reviewed and stamped by EIL Inspector/TPIA.Supplier shall prepare scanned images files of all marked – up 'As – built' drawings. Simultaneously Supplier shall incorporate the shop changes in the native soft files of the drawings also.

4.11.3 Packing/Presentation of Final Documents

Final Documents shall be legible photocopies in A4, A3 size only.Drawings will be inserted in plastic pockets (both sides transparent, sheet thickness minimum 0.1 mm) with an extra strip of 12 mm wide for punching so that drawings are well placed.

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Final Documentation shall be bound in Hard board Plastic folder(s) of size 265 mm x 315 mm (10½-inch x 12½-inch) and shall not be more that 75 mm thick. It may be of several volumes and each volume shall have a volume number, index of volumes and index of contents of that particular volume.Where number of volumes are more, 90mm thickness can be used.Each volume shall have top PVC sheet of minimum 0.15 mm thick duly fixed and pressed on folder cover and will have 2 lever clips.In case of imported items documents, 4 lever clip shall also be accepted.All four corners of folders shall be properly metal clamped.Indexing of contents with page numbering must be incorporated by supplier.Spiral/Spico bound documents shall not be acceptable.As mentioned above, books should be in hard board plastic folders with sheets punched and having 2/4 lever clips arrangement.

Each volume shall contain on cover a Title Block indicating package Equipment Tag No. & Name, PO/Purchase Requisition No., Name of Project and Name of Customer.Each volume will have hard front cover and a reinforced spine to fit thickness of book.These spines will also have the title printed on them.Title shall include also volume number (say 11 of 15) etc.

4.11.4 Submission of Soft Copies

Supplier shall submit to EIL, the scanned images files as well as the native files of drawings/documents, along with proper index.

In addition to hard copies, Supplier shall submit soft copies of all the final drawings and documents in pen drive or any other specified medium with proper identification tag, all text documents prepared on computer, scanned images of all important documents (not available as soft files), all relevant catalogues, manuals available as soft files (editable copies of drawings/text documents, while for catalogues/manuals/proprietary information and data, PDF files can be furnished). All soft files shall be appropriately named, systematically indexed, and duly bookmarked in PDF format to facilitate ease of reference and access.

All the above documents shall also be uploaded on the EILVendor Portal and if applicable on Client Server also.

4.11.5 Completeness of Final Documentation

Supplier shall get the completeness of final documentation verified by EIL/TPIA,as applicable, and attach the Format for Completeness of Final Documentation (Format No. 3-78-0004) duly signed by EIL Inspector or TPIA as applicable to the final document folder.

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COMPLETENESS OF FINAL DOCUMENTATION

Name of Supplier/Contractor	:	
Customer	:	
Project	:	
EIL's Job No.	:	
Purchase Order No./ Contract No.	:	
Purchase Requisition No./ Tender No.	:	Rev. No.:
Name of the Work/ Equipment	:	
Tag. No.	:	
Supplier's/ Contractor's Works Order No.	:	

Certified that the Engineering Documents/ Manufacturing & Test Certificates submitted by the supplier (as per Index sheet mentioned in Annexure-1) are complete in accordance with the Vendor Data Requirements of Purchase Requisition / Tender.

Signature	: ……	Signature	: ……
Date	: ……	Date	: ……
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……
	Supplier/Contractor		EIL/TPIA

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Annexure-1

Final Documentation Index Sheet			
PR/PO/Tender No.		Revision No.	
Serial No.	Document Title	Page/ Folder No.	No. of Pages

Signature	: ……	Signature	: ……
Date	: ……	Date	: ……
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……

Supplier / Contractor

EIL / TPIA

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वैसल्स, पाइपिंग तथा इक्वीपमैंट के शीतल इन्स्यूलेशन हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR COLD INSULATION OF VESSELS, PIPING AND EQUIPMENT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
1	30-11-2021	REVISED & ISSUED AS STANDARD SPEC.	PP	BS	PS	SM
0	15-07-2020	ISSUED AS STANDARD SPEC.	PP	BS	PS	SM

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Abbreviations:

ASTM	:	American Society for Testing and Materials
CG	:	Cellular Glass
CUI	:	Corrosion Under Insulation
DFT	:	Dry Film Thickness
ESCC	:	External Stress Corrosion Cracking
GI	:	Galvanized Iron
IS	:	Indian Standard
ITP	:	Inspection Test Plan
PIR	:	Rigid Poly Isocyanurate
PUF	:	Poly Urethane Foam
S.S.	:	Stainless Steel
SWG	:	Standard Wire Gauge

Definitions**:**

Ambient temperature:	Unless otherwise mentioned, ambient temperature referred in this specification shall mean 30^0C
Cold service:	Operating temperature below ambient up to minus (-) 200 deg C is considered as cold service
Dual service:	Operating temperature ranging from minus (-) 200 to + 350 deg C is considered as dual service

Refractory & Insulation Standards Committee

Convenor : Mr Prasenjit Saha

Members :
Mr Biswarup Sarkar
Mr P. Pal
Mr Udayan Chakravarty (Piping)
Mr Prag Goel (Fired Heaters)
Mr Ayush Mathur (Projects)
Mr Tarun Kumar (Equip Div)
Mr Neeraj Mathur (Inspection)
Dr Arijit Roy (Materials & Corrosion)
Mr Neeraj Rai (Pipeline)
Mr Ravindra Kumar (Construction)

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1.0 SCOPE

This specification shall be applicable for external insulation for cold conservation of above ground piping, vessels, tanks, pumps, exchangers, instrument connections at units and off-sites having operating (process fluid) temperature between below ambient to minus (-) 200°C and dual temperature services operating between (-) 200°C to +350°C.

Exclusion: This specification shall not apply to licensed units, where licensor's insulation standard/ specification is applicable.

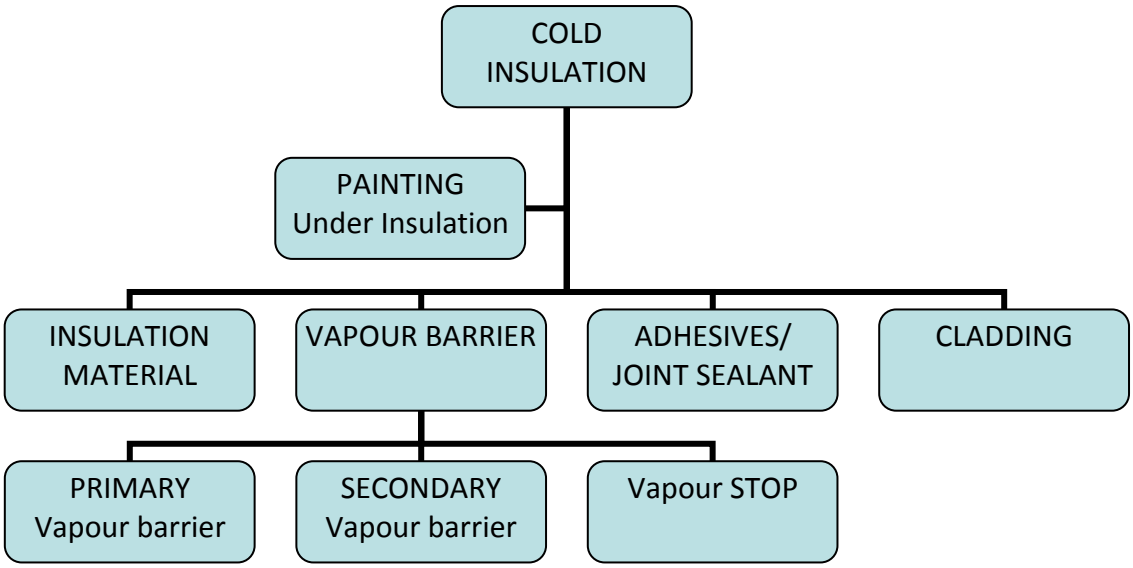
2.0 GENERAL

2.1 Cold insulation is provided to meet any of the following or combination of the below mentioned objectives:

a) Maintain low temperature/ limit heat gain (cold conservation) for process control
b) Prevent/ control surface condensation and ice formation
c) Personal protection from cold burn below minus (-) 10^0C

2.2 Insulation system for cold service shall essentially be VAPOUR TIGHT such that water in any form including moisture present in air is prevented from entering into the insulation. This is achieved by proper selection of insulation material that has almost zero or negligible water vapour permeability and effective designing the insulation system by layering and use of vapour barrier to stop ingress of moisture through insulation joints.

2.3 A cold insulation system shall have following major components. Insulation material is the primary component in the system. Selection of other components such as vapour barrier, adhesives, joint sealants etc. are dependent on the insulation material.



2.4 Insulation design and application shall be as per details provided in this specification. However, for any typical details of any vessel part not covered in this specification, intended insulation practice shall be submitted by the contractor for approval of owner/ Engineer in charge. The details shall include the following as minimum:

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a) Removable insulation housings
b) Flashing details
c) Additional Insulation supports
d) Vessel head insulation supports
e) Expansion joints
f) Vessel insulation details
g) Exchanger removable housings
h) Machinery removable housings etc.

2.5 Extent of Insulation

2.5.1 Items Requiring Insulation

a) Items requiring insulation are specified in the piping line schedule and equipment/vessel/heat exchanger data sheets.

b) All attachments and projections such as vessel supports, structural steel attached to vessels, piping hanger/ supports, instrument lead lines, branch lines like vents, drains and instrument connections connected directly to cold insulated piping, vessels and equipment shall be cold insulated up to a distance of four (4) times the adjoining insulation thickness (or 300mm whichever is greater). Insulation design & thickness same as the main piping/ equipment shall be applied to the attachments/ extensions.

a) All flanged joints, manhole covers, etc. shall be cold insulated with removable box insulation. Valves and fittings shall be same insulation as that of the adjoining piping.

2.5.2 Items Not Requiring Insulation

a) Bonnet of valves above the packing glands.

b) Display of nameplates, stampings, inspection code etc. in any vessel/ equipment shall be specially designed and insulated so that the display is not covered by insulation.

2.6 Codes & Standards

2.6.1 Latest issue of the codes/standards prevailing on last submission date of the tender shall be applicable.

2.6.2 Specific technical requirement mentioned over and above the standards/ code shall be followed irrespective of code requirement. In case of difference, if any between technical requirement of code and the current specification, stringent of the two shall apply.

2.7 General Requirements

2.7.1 Protection of Materials During Storage

Insulation materials must be protected against any damage, from delivery to finish cladding. Decking and covering with tarpaulins alone are not considered sufficient protection from weather for any length of time and shall not be permitted. Insulation material slabs and sections shall be stored on a flat surface in a horizontal position. Insulation material shall never be stacked directly on the ground. The contractor shall make own arrangement for covered storage for insulation materials as directed by the Engineer-in-Charge.

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2.7.2 Protection of Partially Completed Jobs

Precautions must be taken to ensure that each day's work is adequately protected during erection and before being left over-night to prevent seepage of water into the materials and getting trapped. The system shall be protected by tarpaulins, water shed and other protective means.

2.7.3 Hydrostatic Test

Insulation shall be applied on vessels, heat exchangers, piping and other equipment only after successful completion of hydrostatic test.

2.7.4 Co-ordination with Other Agencies

Contractor shall work in close co-ordination with the erection Contractor. Wherever temporary supports are provided the contractor shall remove these and provide necessary insulating blocks (wood/PUF etc.) as per support standard or as specified in the bid package/tender.

3.0 INSULATION MATERIALS

Insulation material shall be selected primarily based on range of service temperature and other parameters like desired thermal performance, fire protection requirement etc.

PIR (poly-isocyanurate rigid foam) is the most common material used for cold insulation, but other materials like cellular glass, aerogel etc. are also used in cold insulation for specific advantages of thermal conductivity or fire resistivity. Following materials options are considered in this standard for cold service for the temperature ranges mentioned below. ASTM grades, referred shall indicate the general classification and minimum requirement, the material shall meet respective specified technical parameters as given in this specification.

TEMPERATURE RANGE	INSULATION MATERIAL	ASTM GRADE		THERMAL CONDUCTIVITY # W/mK	FIRE RESISTIVITY $ (ASTM E84)
(-) 180 to (+) 120 ^{0}C	PIR foam	C-591 Gr-2, Type-II		0.026 (at 10^{0}C)	25
(-) 200 to (+) 427 ^{0}C	CELLULAR GLASS	C-552 Gr-6		0.043 (at 10^{0}C)	5
(-) 196 to (+) 125 ^{0}C*	AEROGEL	C-1728	Type-I Grade 1B	0.017 (at 24^{0}C)	25
			Type-IV Grade 1A	0.022 (at 24^{0}C)	25

Indicative values for comparison, vary with density, grade and temperature
$ Indicative value, lower the value, better is the fire resistivity
* Type-IV Grade 1A is suitable up to 250 deg C

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3.1 Preformed Polyisocyanurate Rigid Foam (PIR)

3.2 PIR rigid foam shall be performed into free rise buns made from HCFC free chemicals and then cut into required shape/ pipe sections using a CNC machine. Material shall be chemically inert, moisture free, rot and vermin proof not disintegrate, settle, change its form or composition in a detrimental way while in service. PIR rigid foam shall conform to general classification of ASTM C591 Grade-2 Type-II and meet the following specification:

Characteristics		Value	Remarks
Temperature range of use ***(Note-1)***		(-) 180 to (+) 120 ^{0}C	
Bulk density (kg/m3) ASTM-C302/ ASTM -D1622/ IS-11239		40 min	Batch test ***(Note-3)***
Closed Cell content (%) ASTM D-6226 Procedure-2 / IS-11239 Part-5		95 min	
Chloride content (ppm) ASTM C 871, Procedure 2		60 max	
pH (ASTM C 871)		6-7	
Horizontal burning (IS11239, Part-12)		25 max	
Water vapour transmission (ng/Pa-s-m) ASTM E-96 method-A at 23°C & 50% RH		5.1 max	
Compressive strength at 10% deformation (kPa), ASTM D 1621		240 min.	
Flame spread Index (ASTM E84)		25 max	Type test ***(Note-4)***
Tensile Strength (kPa) at (-)165°C ASTM D-1623		265 min	
Linear thermal expansion coefficient (-)165°C to 23 deg C (ASTM D-696)		70 x10^{-6}/K max	
E-modulus, at (-)165°C (MPa) ASTM-D1623		16 max	
Cryogenic Thermal Stress Resistance (CTSR) ***(Note-2)***		≥ 1.5	
Thermal conductivity of 180 days aged sample at mean temp (W/mK) ASTM C-177	(+)10 deg C	0.026 max	
	(-) 20 deg C	0.027max	
	(-) 80 deg C	0.025 max	
	(-)120 deg C	0.019 max	

Note-1: For services (-) 50 to (+) 120°C, moulded pipe sections are acceptable. CTSR and relevant properties need not be tested

Note-2: CTSR = σ_t x (1-δ) / (E x α x ΔT) ≥ 1.5, where
σ_t = the average value of the tensile strength
δ = the Poisson's ratio of the material (0.4)
E = the average value of the tensile modulus
α = the average linear thermal expansion coefficient of the insulation materials
ΔT= the temperature difference between service temperature and ambient

Note-3: Supplier shall provide test certificate for each production Batch.

Note-4: Type test certificate no older than 2 years shall be acceptable.

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3.3 In-situ PUR

This is a two component polyurethane rigid foam (slow rise expansion), consisting of one component MDI (Di-phenyl methane-4,4'di-isocyanate) and one component of a polyol blend. The material will have equivalent property as that of PIR (see 3.1), but formed by in-situ injection foaming. After curing the system converts into a rigid cellular polyurethane based plastic foam with a 95% closed cell structure, in accordance with ISO 4590 and manufactured without the use of blowing agents that contain CFC's or HCFC's and with an Ozone Depleting Potential (ODP) of zero (0).

There is certain degree of uncertainty associated with quality of PUR obtained through in-situ foaming. The foaming process depends on many factors like substrate temperature, ambient temperature, humidity etc. Before every injection, the procedure for in-situ injection needs to be demonstrated through a mock up for achievement of optimum quality.
Despite taking all measures, the PUR so formed may have unidentified defects like holiday/ void etc., hence shall only be used in a very limited way for insulation of valves/ flanges where other insulation by prefabricated rigid PIR is not possible.

In-situ foaming is NOT to be used as replacement for preformed rigid PIR.

3.4 Cellular Glass

Cellular glass shall conform to general classification of ASTM C552 Type-II, Grade-6, supplied/ fabricated into pipe sections contour of the substrate as per ASTM C1639 from a proven manufacturer and shall meet the following minimum technical specification:

Characteristics		Values	Remarks
Temperature range of use		(-) 200 to (+) 427 ^{0}C	
Density(kg/m^3), min. (ASTM C303)		98	Batch test ***(Note-1)***
Compressive Strength (kPa) (ASTM C165), min.		414	
Flexural strength (kPa), ASTM C203, min.		283	
Water absorption (Volume %), max., (ASTM C240)		0.5	Type test ***(Note-2)***
Water Vapour Permeability, ng/Pa.s.m (ASTM E96)		0.007	
Closed cell content		100	
Surface burning characteristics, ASTM E84			
Flame spread index, max		5	
Smoked developed index, max.		0	
Thermal conductivity , w/mK (ASTM C518/ASTM C177)	(+)10 deg C	0.046	Batch test ***(Note-1)***
	(-) 18 deg C	0.042	
	(-) 73 deg C	0.033	
	(-)101 deg C	0.030	
Dimensional tolerance		ASTM C1639	

Note-1: Supplier shall provide test certificate for each production Batch.
Note-2: Type test certificate no older than 2 years shall be acceptable.

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3.5 Flexible Aerogel Insulation

Flexible aerogel insulation is a composite of an amorphous silica-based aerogel, a fibrous carrying media, or reinforcements, or a combination thereof shall conform to general classification of ASTM C1728 and meet the following properties:

Properties		Values		Remarks
ASTM Grade / Type		Type-I Grade 1B	Type-IV Grade 1A	
Temperature range of use		(-)196 to (+)125 ^{0}C	(-)196 to (+)250 ^{0}C	
Density (kg/m3) ASTM C303		80-180	160-240	Batch test ***(Note-1)***
Compressive Strength (kPa), min, at 10% deformation (ASTM C165)		34.5	34.5	
Linear shrinkage at maximum exposure temperature for 24h , max, % (ASTM C356) in length & width		2	2	
Water absorption, max, % by weight		8	8	
Water vapour absorption, by weight, max %, (ASTM C1104/ C1104M)		5	5	
Thermal conductivity (W/mK) at mean temperature (°C) (ASTM C177)	-129	0.014	0.015	
	-73	0.015	0.017	
	-17	0.016	0.020	
	24	0.017	0.022	
Flame spread index (ASTM E84) , max Smoke developed index (ASTM E84) , max		25 50	25 50	Type test ***(Note-2)***

Note-1: Supplier shall provide test certificate for each production Batch.
Note-2: Type test certificate no older than 2 years shall be acceptable.

3.6 Selection of Insulation Material

3.6.1 PIR is the most commonly available cold insulation material. Unless otherwise specified, preformed PIR rigid foam shall be used as default cold insulation material in the temperature range (-) 200 to (+) 120 ^{0}C.

3.6.2 Cellular glass shall be chosen where any one of the following conditions is a requirement:

a) Dual temperature service, where upper limit of the exposure exceeds (+) 120 ^{0}C
b) Fireproofing (epoxy intumescent or vermiculite) to be applied over insulation
c) Insulation needs to be fire safe

3.6.3 Use of cellular glass can be optimized in a fire safe cold insulation requiring 75mm or higher thickness by combination lining with inner PIR and outer 50mm cellular glass.

3.6.4 Flexible aerogel blanket can also be a useful for small diameter pipes (< 2 inch NB) where use of rigid PIR may have application constraint and flexible aerogel may have specific advantage of lesser application time.

3.6.5 In-situ PUR may be used for insulation of irregular shape like valves and flanges. But, shall NOT be used as a replacement of PIR where rigid PIR foam is specified.

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3.6.6 Valves and flanges in cold service for which insulation clearance is usually granted late and insulation activity becomes a bottleneck for plant commissioning, combination lining with inner flexible aerogel blanket and outer in-situ PUR could be advantageous. In such cases, commissioning activity may proceed with flexible aerogel applied over the valves and flanges (which can be done faster) followed by in-situ forming of PUR.

3.7 Insulation Thickness

Insulation thickness and thickness for inner and outer insulation for combination lining shall be specified in schedule of rate / equipment datasheet.

Unless otherwise specified, layering of insulation as given below shall be followed for insulation system with PIR/ Cellular glass:

Insulation thickness (mm)	Number of layers
≤ 75	Single layer
76-150	Two layers
>150	Three layers

Flexible aerogel blanket normally comes in thin blankets of 5-20mm thickness, hence multiple layers will be used.

3.8 Form of Insulation

Cellular glass shall be fabricated as per ASTM C1639.

Preformed rigid insulation blocks of PIR shall be cut from buns in the contour of pipe section / surface profile of the equipment using CNC machine. Half sections or radial sections shall have longitudinal and circumferential faces flat and smooth so as to match with the other half/ section. Ends of the preformed half sections shall be flat and perpendicular to the center line.

Application	Sections
Pipes up to 12 inch NB	Two half sections
>12 inch up to 20 inch NB	Max 3 radial sections
>20 inch NB	Max 4 radial sections
Equipments, Vessel shells	Machine cut radial sections in required contour of the substrate/ underneath layer
Vessel heads	Manually cut slabs contoured to the profile of vessel heads is acceptable

Moulded sections made by forming into mould may be used for application temperature (-) 50 to (+) 120°C. Tolerances for moulded sections shall be as under:

Outside diameter	-0%, + 5%
Concentricity	± 3% O.D.
Bore	+ 2mm, -0 mm
Length, width and thickness of slabs	± 2mm

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4.0 ANCILLARY MATERIALS

Cold insulation system with PIR/ Cellular glass shall have the following ancillary components:

Primary components	Secondary components	Adhesives & Sealant	Other ancillaries
• Pipe support • Primary vapour barrier • Vapour stop • Weather protection Jacket	• Secondary vapour barrier • Glass cloth fabric • Painting • Contraction joint	• Adhesive • Joint sealant	• Adhesive tape • Band • Butyl Rubber Sheet • Wire netting

4.1 Pipe Supports

Cradle type cold support shall be used for piping.

Pipe supports shall be in high density PUF (polyurethane foam). Thickness & layering shall be same as that of insulation design of the respective the pipe diameter, supplied in pipe sections. PUF pipe support shall meet the minimum technical specification given below.

Characteristics		**Types** *(See Note below)*	
Bulk Density($kg/m^{3)}$ (ASTM D1622) min.		240	320
Thermal conductivity (ASTM C177) W/mK, max.	at +20°C	0.040	0.050
	at 0°C	0.036	0.046
	at -40°C	0.034	0.044
	at -80°C	0.031	0.040
Compressive Strength, MPa at 23°C in all directions, (ASTM D 1621) min.		3.0	6.0
Tensile Strength, MPa at 23°C in all directions (ASTM D 1623) min.		3.0	4.9
Closed Cell content , % , (ASTM D 6226 procedure-2		95	
Water Vapour Permeability, g/m2.h ASTM E-96 method-A at 23°C and 50% RH, min.		0.8	
Water absorption % (by Volume) max.(ASTM D2842)		5	
Linear Coefficient of thermal expansion max.,/°K (ASTM D 696) between 23°C and -165°C		$70x10^{-6}$	
Chlorides, ppm, (ASTM C 871, procedure 2)		60	
pH values, (ASTM C 871)		6-7	
Combustibility / fire resistance, ASTM E84		FSI < 25	

Note:

1. *Density of PUF support and length of the sections shall be specified in engineering standard elsewhere in the tender.*

2. *Unless otherwise specified, PUF pipe supports 240 kg/m3 may be used for 12 inches NB or below and 320 kg/m3 shall be used for above 12 inches NB.*

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3. *High density Pipe support for cyclic service shall be selected based on the following:*

   a) *High density PUF shall be suitable for temperature range (-) 200 to (+) 100 ^{0}C.*
   b) *For temperature up to (+) 125 ^{0}C, high density pipe support shall be made in PIR with equivalent physical properties as that of high density PUF.*
   c) *For temperature exceeding (+) 125 ^{0}C, composite pipe supports (outer layer High density PUF + inner layer suitable load bearing temperature membrane like Perlite block) may be used subject to approval of owner/ Engineer in charge.*

4.2 Isolation Block

Support structures / equipment legs for cold vessels shall be isolated from foundation / main structure by means of hard wood OR high density PUF of 500 kg/m3.

4.3 Primary Vapour Barrier

Primary Vapour barrier is a very important component in cold insulation. All cold insulations, irrespective of insulation type and service temperature shall have a thick mastic (min 1.5mm when dry) 'Primary Vapour Barrier' over outermost insulation layer, underneath weather barrier jacket (cladding).

Primary vapour barrier shall be chlorosulfonated polyethylene (hypalon) rubber based fire retardant elastomeric polymer mastic, compatible with base insulation, stable in the range of minus (-)40 to (+)100^{0}C. The mastic is applied in two coats reinforced with glass fiber cloth sandwiched between two coats. When cured, the film shall be durable, have good tensile strength and puncture resistance, shall not wrinkle or crack when exposed to the limiting temperatures for 3 hours.

Industry benchmark for Primary Vapour Barrier is **Foster make 60-38/39**. Proposed materials shall be technically equivalent and shall have proven reference for use in a temperature range and shall meet the minimum technical requirement given below:

Characteristics	Parameter	Remarks
Consistency	Thixotropic soft paste	
Water vapour permeance	0.02 metric perms (max) with DFT 1.2-1.3mm as per ASTM E-96 procedure-E	Type test ***(Note-1)***
Combustibility/ fire resistance	FSI (flame spread index) ≤ 25 as per ASTM E-84, tested on a 6.3mm inorganic reinforced cement board with DFT 1.1-1.2 mm	

Note-1: Type test certificate from reputed international laboratories, no older than 2 years shall be acceptable

4.4 Vapour Stop

Vapour stops are used in cold insulation with an objective to create containment so that in the event the insulation is damaged, water ingresses if any remains in that containment zone. Vapour stop is applied across the insulation thickness at regular intervals and stops such propagation. In piping, vapour barrier needs to be used on both sides of pipe support, for equipment / vessels, it shall be applied at support locations, where chances of crack is more due to differential movement of vessel and support structures. Vapour stop is a thick mastic (min 1.5 mm when dry) similar to primary vapour barrier with improved flexibility, tensile

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strength and cryogenic resistance. It is a two component butyl rubber based elastomeric mastic suitable for temperature range of minus (-) 196 to (+)82^{0}C, shall be suitable for application to PIR foam, cellular glass, fibrous glass and aerogel insulations. The mastic is applied in two coats reinforced with glass fiber cloth sandwiched between two coats. When cured, the film shall be durable, have good tensile strength and puncture resistance, shall not wrinkle or crack when exposed to the limiting temperatures for 3 hours.

Industry benchmark for Primary Vapour Barrier is **Foster make 90-66**. Proposed materials shall be technically equivalent and shall have proven reference for use in a temperature range and shall meet the minimum technical requirement given below:

Characteristics	Parameter	Remarks
Consistency	Thixotropic soft paste	
Water vapour permeance	0.007 metric perms (max),as per ASTM F-1249 with DFT 0.5-0.6mm	Type test ***(Note-1)***
Tensile strength (of cured dry film)	> 8 kg/cm^2 as per ASTM-D412 measured with 1.2 mm dry film	

Note-1: Type test certificate from reputed international laboratories, no older than 2 years shall be acceptable

4.5 Secondary Vapour Barrier

Cold insulation for service temperature below (-) 50 ^{0}C shall have an additional membrane 'secondary vapour barrier' between the outermost layer and next insulating layer. Secondary vapour barrier shall be a multiplex laminated foil (~50 micron thickness) consisting of one aluminium foil (25µ) sandwiched between two 12µ polyester films). Materials shall have following characteristics:

Characteristics	Values
Service temperature range (°C)	-60 to 120
Volumetric mass (kg/dm^3)	1.93
Tensile Strength, MPa	100
Yield Strength, N/cm	70
Tear resistance, g/mm	400
Water Vapour Permeability, ASTM E96 Procedure E (Metric perms)	0.0007

4.6 Glass Cloth / Fabric

The glass cloth to be used for vapour barrier/ vapor stop reinforcement shall be prepared from E-glass and open weave 10 mesh. Glass Cloth having glass fibre thickness of 5 mils, 18x12 threads per 25mm and weight 80g/m^2 or in case of synthetic fabric same shall have weight 30g/m^2 and 20x10 threads per 25mm. Other types if specified by mastic manufacturer shall be subject to review and approval by Engineer-in-charge.

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4.7 Cryogenic Adhesive

Adhesives are used for bonding of insulation sections to the substrate and shall be essentially compatible with the base insulation material and suitable for the temperature range to which it is exposed. Typical technical requirement of adhesive for PIR shall meet the following characteristics given below. For cellular glass insulation, compatibility or specific products shall be recommended/ confirmed by the cellular glass supplier.

Application temperature	Characteristics
Ambient to (-) 50 deg C	Synthetic rubber/ resin based or Thermo setting two component solvent free urethane based, suitable for the temperature range to which it is exposed, have average 38% volume solid as per ASTM D1644 and Leachable chlorides max 90 ppm as per ASTM C871
(-) 51 to (-) 100 deg C	
Below minus (-) 100 deg C	Chemically cured epoxy based, in three components, have > 99% volume solid as per ASTM D1644

4.8 PU Adhesive

High density PUF pipe supports shall be installed to the cradle with a PU adhesive. Typical technical requirement of PU adhesive shall meet the following characteristics given below

Application temperature	Characteristics
Ambient to (-) 50 deg C	Synthetic rubber/ resin based or Thermo setting two component solvent free urethane based, suitable for the temperature range to which it is exposed, have average 38% volume solid as per ASTM D1644 and Leachable chlorides max 90 ppm as per ASTM C871

4.9 Joint Sealant for Insulation Blocks

The joint sealant for joints between insulation blocks shall be compatible with the base insulation material and suitable for the temperature range to which it is exposed. Typical material and technical requirement for PUR/PIR insulation system is specified below. For cellular glass insulation, compatibility or specific products shall be recommended/ confirmed by the cellular glass supplier

General Characteristics	Combustibility/ fire resistance	Water vapour permeance (max)
Average 82% volume solid as per ASTM D2369	Flame spread and fuel contribution negligible when used as 3.2 mm wide sealant between joints of incombustible insulation blocks	Negligible when measured across 3.2 mm wide sealant between joints of impermeable insulation blocks

4.10 Contraction Joints

Contraction joints shall be provided in the insulation. At contraction joint location, provision shall be made in the metal cladding to accommodate contraction of pipe or vessel.
The material to be used in the contraction joints shall be light weight fiber glass blanket. The material shall have the following properties:

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Properties	Values
Density (kg/m^3), ASTM D1622	23-24
Compressive strength (kPa), at 10% deformation at 24°C, ASTM C165	0.215
Thermal conductivity (W/mK) at 25°C, max, ASTM C177	0.034
Leachable chlorides content (mg/kg), max, ASTM C-871	10
pH, ASTM C-871	6-10.5

Typical contraction joint requirements are specified below:

a) Contraction joints shall be provided at regular intervals depending on pipe or vessel material contraction/expansion co-efficient and design temperature. Unless otherwise specified, contraction joints shall be provided in all insulations exposed to (-) 40°C and below at intervals of 6m on straight run of pipes or vessels.

b) Contraction joints in horizontal vessel insulation shall be close to support points while on vertical pipes & vessels, the same shall be provided at support ring location and at an interval of 4.0m straight run. Both longitudinal and circumferential joints in insulation shall be staggered.

c) A contraction joint shall consist of 12mm gap in the Insulation, loosely packed with filler material (refer section painting & ancilliaries) to a depth of 6mm less than the adjacent insulation thickness. The outer 6 mm shall be filled up with Joint Sealer and finished smooth with adjacent insulation surface and applied a butyl rubber membrane overlapping 75mm onto adjacent insulations (after the sealer has cured). Expansion /contraction joint details in insulation for 'horizontal & vertical pipes' & for 'expansion bellows' are illustrated in the insulation diagrams.

4.11 Weather Protection Jacket

Unless otherwise mentioned, aluminium cladding shall be used as weather protection jacket over insulation. Aluminium cladding shall be ASTM C1729, class A having polysurlyn lamination on inside surface and shall meet the requirements of ASTM B209 alloy 3003 H14.

For **fire safe insulation**, cladding shall be of stainless steel as per ASTM A167 / A240 type 304 or aluminized steel as per ASTM A463, type 2, coating designation T2-100 with polysurlyn lamination on inside surface.

Cladding metal sheets (all types) shall have minimum thickness as below:

Item	Insulation O.D (mm)	Thickness (SWG)
Pipe, Vessels and equipment	< 500	26
Pipe, Vessels and equipment	> 500	24
Valves, flanges and foot traffic areas	-	22

4.12 Joint Sealant for Joints of Metal Cladding

The technical requirement and typical material for joint sealant of metal cladding (aluminium and stainless steel) is specified below.

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General Characteristics	Combustibility/ fire resistance	Water vapour permeance (max)
Average 52% volume solid as per ASTM C461	FSI (flame spread index) ≤ 20 as per ASTM E-84, tested on a 6.3mm inorganic reinforced cement board with DFT ~2mm	0.0092 metric perms (as per ASTM F-1249 with DFT 2.8mm)

4.13 Sealing Tape for Secondary Vapour Barrier

Sealing tape shall be a three layer laminated foil (~50 micron thickness) made of aluminium & polyester (25µ aluminum foil sandwiched between two 12µ polyester films. Material shall have following properties.

Total thickness exclusive of adhesive layer	50 µm
Temperature range	+120°C to -45°C
Volumetric mass	1.93 kg / dm³
Water vapour permeability in acc. with ASTM E 96, procedure E (37.8°C, 90% R.H.)	Max. 10.10-6 g / (m².h.mmHg)

4.14 Under Insulation Painting

Equipments and piping shall be protected from corrosion by providing appropriate painting under insulation, as per applicable painting specification for the project.

4.15 Adhesive Synthetic Tape

The tape used to secure the inner layers of polyisocyanurate shall be by pressure sensitive glass fiber reinforced tape. The tape shall have the following characteristics:

a) Materials: Glass fibre-reinforced synthetic tape

b) Dimensions: width min.30mm and thickness min. 0.14mm.

c) Adhesiveness: 200gr/mm^2

Adhesive tapes shall be spaced as follows:

To Secure Insulation	Spacings (mm)
OD of insulation Upto 250mm (10 inch).	300
Over 250mm (10 inch).	200

4.16 Bands

Band to secure last layer of insulation materials shall be stainless steel to ASTM A-167 Type 304. Banding to secure the weatherproof jacketing shall be stainless steel to ASTM A-167 Type 304 or 316. For aluminium cladding, aluminium band (Aluminium 99.5, temper H14) in accordance with ASTM B-209M shall be used. The band shall be 20 mm width x 24 SWG.

4.17 Butyl Rubber Sheet

Butyl rubber membrane, comply to ISO 188-aging of thickness 1.2 and width 20 mm shall be used as flexible covering over contraction joint for weather barrier.

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5.0 APPLICATION

5.1 Surface Preparation and Under Insulation Coating / Wrapping

Ingress of rain water and corrosive products or condensation of water vapour in the insulation may cause severe CUI (corrosion under insulation) and ESCC. The surfaces of piping, vessels & equipments valves etc. on which cold insulation is to be applied shall be free of dust, loose paint or any other foreign matter. The surface irregularities shall be filled up with the approved filler. Anticorrosive coating/ under insulation coating shall be applied over the carbon/Alloy Steel surfaces to be insulated and allowed to dry before application of insulation. Paint system shall be as per applicable for the project. Austenitic stainless steel especially 300 and 400 series are susceptible for external stress corrosion cracking (ESCC). For to avoid ESCC in stainless steel as an alternative of coating, 0.1mm thick aluminium foil can be wrapped with an overlap of 50mm. Overlap joint shall be sealed with barium chromate sealer or self- adhesive (chloride free) aluminum tape at the edge of foil. Foil shall be secured in position either by pressure sensitive tape or aluminium band.

5.2 Insulation Layer Application and Securement (General)

a) Before application of insulation, surfaces shall be clean, dry, and free from oil, grease and dirt. Individual pieces of insulating material shall fit closely, both together and to the surface being insulated. The least number of pieces possible shall be used, and joints between individual pieces shall be staggered.

b) There shall be no gap or cavities between individual pieces of insulation blocks. Adjacent sections of rigid cold insulation materials shall be buttered together with a flexible joint sealant

c) Based on the operating temperature and insulation thickness insulation application can be single layer application or multilayer application. If total insulation thickness exceeds 75 mm, multilayer structures of insulating material shall be used. Layers shall be approximately equal in thickness, and no single layer shall exceed 75 mm.

i) Single Layer Insulation

Insulation blocks cut into appropriate width suitable for handling but not less than 300mm in contour of the surface profile installed on to the surfaces of vessels/piping/equipment adhering to each other with applicable joint sealer and secured in position by SS-304 bands. There shall be no through joints and the insulation shall not be bonded to the vessel.

ii) Multilayer Insulation

The inner layer of insulation shall be bonded to the vessel with cryogenic adhesive. Subsequent layers of insulation shall be bonded to the preceding layer, with the applicable adhesive. The joint sealer shall be applied to the ends and edges of all sections, including those in the inner most layers to seal all joints. Care shall be taken to ensure that the adhesive is evenly spread over the entire surface of the application and the insulation is closely butted to each other both longitudinally and circumferentially. Longitudinal and circumferential joints shall be staggered by approximately 50% of lag or section size. Inner layers of insulation shall be secured with self adhesive tape and final shall be secured with metallic band.

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iii) The securement for insulation by means of metallic band shall be as follows:

To Secure Insulation	Spacings (mm)
Pipe work OD of insulation Upto 250mm (10 inch).	225
Over 250mm (10 inch).	300
Vessels, equipment	300

In case of securement of inner layer insulation by self adhesive tape, the spacing shall be followed as:

To Secure Insulation	Spacings (mm)
OD of insulation Upto 250mm (10 inch NB).	300
Over 250mm (10 inch NB).	200

iv) Projections (e.g., lifting lugs, supports, etc.) shall be insulated with the same thickness of insulation as that specified for the body of the process equipment. The insulation shall extend down the projection as far as required by the process.

5.3 Application of Piping Insulation

a) Horizontal and Vertical Piping

Insulation shall be applied on after ensuring that piping to be insulated is properly installed, supported and tested. Refer insulation diagrams at end of this specification.

The insulation shall be applied to pipes in half round sections in reasonably handy sizes.

The inner layer of insulation shall be bonded to the piping with applicable adhesive. Subsequent layers of insulation shall be bonded to the preceding layers with the above adhesive. Joint sealer shall be applied to the ends and edges of all sections for sealing all longitudinal and circumferential joints. Adhesive shall be applied evenly and the half sections shall be closely butted to each other both longitudinally and circumferentially.

All the insulation layers except the final shall be secured in position by pressure sensitive tape, while the final layer shall be secured with metallic bands.

Insulation of piping shall be stopped short of flanges to allow for withdrawal of bolts. For fittings, the insulation shall be completed by applying cut segments of the same insulation sections used for pipes. In case of vertical piping insulation support/spacer rings shall be provided at an interval of 4.0m (if other insulation supports do not already exist on the pipe) as illustrated in diagrams at end of this specification.

b) Pipe Supports & Hangers

In all the supporting arrangements of both horizontal and vertical piping, dry hard wood pipe support bearing blocks coated with fire retardant paint/mastic or PUF, as applicable, shall be used. Metal cradles, metal pipe supports and hangers shall be attached to outside of the pipe support bearing blocks and not directly to bore pipe. Provision shall be made to prevent seepage of water into the insulation from pipe hangers.

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c) Flanges & Valves

i) Lining with PIR

Removable covers shall be provided over all flanges and valves. Insulation shall be performed as per the details are illustrated in diagrams at end of this specification. Loose fill mineral wool backed up by slab insulation of thickness equal to that an adjacent pipe shall be applied.

As an alternative to slab insulation, injection foaming by in-situ PUR is also acceptable. Metallic covers over the valves and flanges shall be fitted with quick release clips. This application shall be proposed for each case by the insulation contractor and approved by the Engineer-in-Charge.

ii) Combination lining with flexible aerogel + PUR

Wherever combination lining with aerogel is used, valves and flanges shall first be applied with a flexible aerogel blanket and proceed with commissioning activity. Remaining of the insulation matched with adjacent piping is installed by in-situ PUR injection foaming within metal cladding.

iii) Refrigerant Traced Lines

When lines are traced with one or more tracers, insulation shall be of sufficient size to house the assembly without distortion or damage to the insulation.
The refrigerant traced assemblies shall be first wrapped with specified wire netting, thus ensuring tracer pipe wearing tightly against the line refrigerant – traced. Application of insulation for piping are illustrated in diagrams at end of this specification.

5.4 Insulation Application on Vertical Vessel

a) Shell (Cylindrical)

Insulation blocks cut into appropriate width suitable for handling but not less than 300mm in contour of the surface profile to be applied resting onto the supports with joints tightly butted, staggered & adhering to each other with applicable adhesive and secured in position by circumferential metallic bands at a pitch of 300 mm. Care shall be taken to ensure that no air pockets are formed in the finished insulation.

b) Top Heads

Shaped insulation blocks cut into appropriate width suitable for handling shall be installed on top head, banded and butted tightly to each other. Insulation may be held in position by making use of galvanized iron floating ring (25mm x 0.6mm) placed over the insulation and positioned in the centre of the head so as not to touch the nozzle at the vortex. The insulation shall be held in position by use of radial metallic bands, one end of which shall be fastened to floating ring and the other end shall be anchored to the band(s) placed around the cylindrical section close to the head. Radial bands shall be spaced on 300mm centres measured around the circumference of the vessel.

c) Bottom Heads

In all the skirt supported vessels, insulation supports are provided inside the skirt as indicated in the equipment drawings, illustrated in diagrams at end of this specification

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Floating ring and wire loops around the nozzle and bands shall be used to support downward facing of insulation. Such a floating ring shall be positioned centrally around the nozzle but over the insulation by radial bands anchored to the lagging support angle ring fixed inside the skirt at a pitch of 300mm measured over the support angle ring.

If nozzle is not existing, metallic bands shall be stretched across the bottom head and anchored with lagging support angle ring inside the skirt.

5.5 Insulation Application on Horizontal Vessel

Insulation blocks cut into appropriate width suitable for handling but not less than 300mm in contour of the surface profile to be applied in close contact with the faces to be insulated and held in position metallic bands at a pitch of 300mm. Where more than one layer is required, each layer shall be banded separately.

Insulation sections on the vessel heads shall be secured in position by metallic bands stretched across the heads and anchored to circumferential metallic band(s) on the shell near the heads. Anchoring of bands measured on the circumference of shell shall be of a pitch of 300mm max. Method of application of insulation are illustrated in diagrams at end of this specification.

5.6 Insulation Application on Tank

Material and method of application for tanks shall be the same as specified for vessels.

5.7 Insulation Application on Spherical Vessels

Insulation of spherical vessels shall be performed as illustrated in diagrams at end of this specification. Shaped insulation to fit curvature of sphere shall be bonded to the vessel with applicable adhesive. All insulation joints shall be sealed with applicable joint sealer. The inner layer of insulation shall be held in position by 20mm x 20 SWG aluminium bands of 300mm max. centres of the equator. These bands are tied up with suitable rings. The bands being staggered on successive layers and the clips of the bands being recessed into the insulation.

5.8 Application of Primary Vapour Barrier

Cold insulation shall essentially have a thick mastic coating (min 1.5mm when dry) as ‘primary vapour barrier’ applied over external surface of the insulation underneath weather barrier jacket (cladding). The mastic shall be applied in two coats reinforced with glass fiber cloth to obtain the specified dry film thickness.

Primary vapour barrier mastic shall be supplied in two sheds. One shed shall be used for the first coat and the other shed for second coat. The first coat shall be applied to a wet thickness that contributes half of the required thickness by trowel or other method as may be specified by the supplier to a smooth finish by covering the insulation joints. At insulation terminations, including those at flanges, the primary vapour barrier shall extend at least 75 mm beyond the edges of the insulated section onto adjacent uninsulated equipment/ piping.

The fabric (glass cloth) shall be embedded in the wet tack layer such that no wrinkles are formed and all joints have a minimum overlap of at least 50 mm. Apply the second coat (of other shed) after a time gap recommended by the mastic supplier (usually within 2 hours) to a smooth finish fully embedding the fabric and to the required thickness to obtain required DFT.

When cured, the layer shall be durable and have good dry film strength and puncture resistance. Minimum technical requirement for primary vapour barrier is specified below. The total dry layer thickness shall conform to the layer thickness specified by the supplier. There

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shall not be any cracks, holes, thin spots or open joints in the vapour barrier, which shall be applied such that no part of the insulation material is uncovered. The connections with protrusions and in corners shall be carefully finished.

5.9 Application of Secondary Vapour Barrier

At an operating temperature of -50°C or below, in addition to primary vapour barrier, the multiplex foil as a secondary vapour barrier shall be applied between the outermost layer and the next insulation layer. The foil shall be cut to size correctly and shall be installed with dots of adhesive at the surface, tightly stretched and without air inclusions. The joint shall be sealed with multiplex tape of aluminium/polyester.

5.10 Application of Expansion / Contraction Joints

When specified on a pipe line or vessel drawing or where deemed necessary to allow movement and contraction of the pipe or vessel without producing random cracking of the insulation, contraction joints shall be provided in the insulation. At contraction joint location, provision shall be made in aluminium cladding to accommodate contraction of pipe or vessel.

The following steps shall be taken:

a) Both longitudinal and circumferential joints in insulation shall be staggered.

b) Contraction joints shall be provided at an interval depending on pipe or vessel material contraction/expansion co-efficient and temperature. Unless otherwise specified contraction joints shall be provided at an interval of 6.0m on straight run of pipes or vessels operating at temperatures (-) 40°C & below.

c) Contraction joints in horizontal vessel insulation shall be close to support points while on vertical pipes & vessels, the same shall be provided at support ring location and at an interval of 4.0m straight run.

d) A contraction joint shall consist of 12mm gap in the Insulation with staggered joints, compressed (minimum compression 50%) with resilient blanket, butyl rubber at the vapor barrier joint and sliding weather barrier sheet at the jacketing joint.

e) The butyl rubber sheet will be centrally positioned and bonded by compatible adhesive and secured on both sides by stainless steel bands.

Expansion/contraction joint details in insulation for 'horizontal & vertical pipes' & for 'expansion bellows' are illustrated in diagrams at end of this specification.

5.11 Application of Finishing Layer

To protect the primary vapor barrier against mechanical damage and influence of weather a finishing layer shall be installed. The following types of finishing layers can be applied:

Appropriate metal cladding system shall be selected depending upon the requirement. The metal cladding shall be constructed such that any condensation (moist) can drain from the cladding. The cladding is fastened with stainless steel bands. For aluminium cladding aluminium bands may be used. All the longitudinal and circumferential joints having an overlap of minimum 50mm. Unless otherwise specified the metal sheeting shall be secured in position by means of bands as per mentioned below mentioned spacing:

To Secure Metal Cladding	Spacing (mm)
Pipe OD up to 250mm	225
Pipe OD over 250mm	300
Vessels and equipment and all tankage	425

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All longitudinal and circumferential joints of metal sheeting shall be sealed with suitable approved non-hardening elastomeric mastic sealer.
For horizontal vessel and piping all the longitudinal joints with overlap shall be kept below the horizontal plane passing through the axis of the vessel to prevent water or other spillage from entering into the insulation. At horizontal piping, in the middle between two supports, at the lowest point , drain holes shall be provided, min 1 hole/6 m, dia 10mm and at the lowest point of vertical bends, connections etc.

The securement of metal sheeting in case of horizontal vessel dish heads, vertical vessels top/bottom heads and spherical vessels shall be carried out as under:

a) Horizontal Vessels

Jacketing for dished heads shall be fabricated from radial segments with the radial overlap of minimum 50mm. The sheeting shall be secured in position by radial tensioned metallic bands stretched over the heads. One end of each band is anchored to the circumferential band(s) on the shell while the other is fastened (pop riveted) to 6mm dia. floating rod ring which can be replaced by 6mm thick strip (G.I.) rolled in the form of a ring. Radial metallic bands, measured over the circumference of shell, shall be at a pitch of 300mm.

b) Vertical Vessels

i) Top Heads
Insulation shall be covered with flat jacket fabricated in segmental form with lapped joints properly sealed with approved mastic sealer. Over-lapping of sheet metal joints shall not be less than 50mm. Jacket shall be secured in position by radial tensioned metallic bands anchored to the circumferential band(s) of vessel on one side and fastened to 6mm dia. floating rod ring, centralized at the vortex of head on the other side. 6mm thick metallic (G.I.) strip rolled into a ring can be a substitute for 6mm dia. Rod. Pitch of radial bands measured over the circumferential bands of shell shall be max. 300mm.

ii) Bottom Heads

Metal sheeting shall be installed exactly in the same manner as indicated for top heads.

iii) Spherical Vessels

Jecketing of each hemisphere of spherical vessel shall be done with metal sheets placed horizontally and a thick circumferential tensioned band (6mm thick) shall be used at the equator to hold the radial metallic bands.

6.0 MISCELLANEOUS ASPECTS

6.1 Insulation of Piping at or Below Ground Level and Likely Hood of Foot Traffic

Material of insulation shall be preformed sections of Polyurethane/Cellular glass. Application of insulation shall be same as piping except that instead of providing metallic cladding over the final layer of vapour barrier.

Bituminized self finishing roofing felt shall be wrapped over the final layer of vapour barrier after it has fully dried, with an overlap of minimum 50mm both on longitudinal and

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circumferential joints. The roofing felt shall be secured with the specified galvanized iron wire netting, laced with 20 SWG galvanized iron wire.
3mm thick Bitumen Emulsion mastic shall be applied for water and weather proofing.
When bitumen emulsion has completely dried, the surfaces shall be painted with two coats of bitumen based aluminium paint.

6.2 Cold Insulation with Acoustic Service

In case of dual service requirement such as thermal insulation as well as acoustic, insulation system shall have features of both insulation system and needs to be especially designed to meet required objectives. Cold insulations shall be installed first meeting technical requirement (except cladding/ jacketing), above which the acoustic insulation shall be installed with appropriate cladding/ jacketing of acoustic insulation.

6.3 Protection of Materials During Storage

Insulation materials must be protected against any damage, from delivery to finish cladding. Decking and covering with tarpaulins alone are not considered sufficient protection from weather for any length of time and shall not be permitted. Insulation material slabs and sections shall be stored on a flat surface in a horizontal position. Insulation material shall never be stacked directly on the ground. The contractor shall provide covered storage for insulation materials as directed by the Engineer-in-Charge.

6.4 Protection of Partially Completed Job

All precautions shall be taken to ensure that each day's work is vapour sealed and cladded during erection and before being left over-night to prevent seepage of water into the materials and getting trapped. The system shall be protected by tarpaulins, water shed and other protective means.

6.5 Hydrostatic Test

Insulation shall be applied on vessels, heat exchangers, piping and other equipment only after successful completion of hydrostatic test. In case insulation work starts before completion of hydrostatic test, all welded and mechanical joints shall be left exposed for testing and subsequently insulated after successful completion of the hydrostatic test.

6.6 Flashing

All openings through insulation finish shall be flashed weather tight particularly where connections are not insulated. Flashing shall be carried out as per details are illustrated in diagrams at end of this specification. Skirt supported vessels shall have the skirt insulated inside and outside for at least 600mm below the tangent line or such that temp. of adjacent non insulated surfaces of the skirt shall not be below dew point. Proper flashing and sealing shall be done on skirt where insulation and subsequent metal finish terminates as are illustrated in diagrams at end of this specification.

6.7 Exchanger Insulation

Exchanger shells except for channels and channel covers shall be insulated and weather proofed as specified for vessels. Exchanger channels and channel covers including flange bolting shall be insulated with removable aluminium covers lined with insulation slabs of required thickness.

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6.8 Machinery

In general, removable aluminium boxes lined with slab insulation of required thickness shall be used for insulation of machinery after giving a coat of anticorrosive paint. The contractor shall submit details of individual pieces of equipment depending on the nature of items to be insulated to the Engineer-in Charge of site for approval.

7.0 QUALITY CONTROL REQUIREMENTS

Insulation system should be applied as per approved drawings/sketches, installation procedure and quality plan.

7.1 Qualification of Application Crews

Contractor's credential shall be approved by engineer in-charge of insulation work. The application crew must be fully trained work force. Mock-up of insulation application shall be carried out at site, resembling the actual insulation application. Mock-up application and applicator shall be certified by Owner/Engineer in charge.

7.2 Installation Schedule and Condition

Insulation shall be installed after hydrostatic testing and inspection. Insulation shall be protected from weather before and during installation.

7.3 Inspection

Inspection shall be carried out on materials and applications during execution of work to ensure compliance with the specifications. The contractor shall prepare Inspection test plan (ITP) identifying inspection stages, hold/ witness points, inspection frequency etc. and submit for approval of Owner/Engineer in charge. The engineer in-charge may finalize the same with consultation of HO specialist. If so desired by engineer-in charge, HO specialist may assist inspection of insulation work at critical stages.

7.4 Safety

The insulation contractor shall provide adequate protective appliances like hand gloves, masks, glasses etc. to the workmen carrying out the insulation work, to protect them from inhaling and touching insulation dust and fibers.

7.5 Guarantee for Supply and Installation Quality

Contractor shall ensure supplied materials conform to the technical requirements of this specification and relevant standards / codes applicable for the job. The insulation and ancillary materials shall be procured fresh for the project. Use of excess material from other site which does not have proper traceability shall not be allowed. It is the responsibility of insulation contractor to ensure adequate precautions are taken against damage and deterioration during sourcing, transportation and storage of insulation materials.

For major insulation materials like PIR, cellular glass, aerogel and vapour barriers, vapour stop etc. batch and type test certificates as applicable shall be submitted. For ancillary materials like glass cloth, sealants, tapes, foil etc. and metal cladding may be accepted based on supplier's compliance certificate.

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Any deviations shall be clearly stated and work shall proceed only after the deviations are approved by competent authority. The workmanship in execution of the insulation works shall be in accordance with sound engineering practice.

8.0 REFERENCES

Following standards have been referred while preparation of the standard:

CINI	CINI manual for industrial insulation
ASTM A240	Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet and strip for Pressure Vessels
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

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ASTM C553	Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial & Industrial Applications
ASTM C585	Standard Practices for Inner & Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe & Tubing
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 E96	Standard test methods for Water vapor transmission of materials
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM C1728	Standard Specification for Flexible Aerogel Insulation
ASTM C1729	Standard specification for aluminium jacketing for insulation
IS 11239	Methods of Test for Rigid Cellular Thermal Insulation materials

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9.0 INSULATION DIAGRAMS

The drawings/ sketches are primarily for insulation system with base insulation PIR/CG. Specific insulation system/ requirement if any from insulation manufacturer, shall be submitted by contractor for approval by owner/ Engineer in charge. The attached sketches describe general arrangement of insulation material, ancillaries and cladding. Difference if any on material type & quality between sketch and the description elsewhere in this specification/ SOR, later shall apply

S.No.	Description	Drawing
1	Vertical vessels- cold insulation with metal jacketing on shell top & bottom heads	DRAWING. No. 01
2	Horizontal vessels -cold insulation with metal jacketing	DRAWING. No. 02
3	Cold insulation for Spherical Vessels	DRAWING. No. 03
4.	Typical single layer cold insulation on pipes	DRAWING. No. 4.1
5.	Typical double layer cold insulation on pipes	DRAWING. No. 4.2
6.	Support ring for vertical insulated piping	DRAWING. No. 05
7.	Method of insulating feet of vessels	DRAWING. No. 06
8.	Typical insulation details for horizontal flange box	DRAWING. No. 7.1
9.	Typical insulation details for vertical flange box	DRAWING. No. 7.2
10.	Typical insulation details for valves box (horizontal)	DRAWING. No. 8.1
11.	Typical insulation details for valves box (vertical)	DRAWING. No. 8.2
12.	Insulation details for manholes	DRAWING. No. 09
13.	Typical contraction joint details for piping	DRAWING. No. 10.1
14.	Contraction joint – mechanical expansion joint	DRAWING. No. 10.2
15.	Contraction joint – vertical vessels	DRAWING. No. 10.3
16.	Supports for block insulation	DRAWING. No. 11.1
17.	Clips on heads and inside skirt for block insulation	DRAWING. No. 11.2
18.	Detail of spacer ring	DRAWING. No. 12
19.	Refrigerant tracing insulation	DRAWING. No. 13
20.	Method of Lagging Flanged Joints of Vessels	DRAWING. No. 14.1 & 14.2
21.	Method of Insulating Vessel Skirt (Alternative for Half or Full Insulation of Skirt)	DRAWING. No. 15
22.	Typical insulation details for pipe support	DRAWING. No. 16.1
23.	Typical insulation details for pipe hanger support	DRAWING. No. 16.2
24.	Typical details for vapor stop at flanges and valves	DRAWING. No. 17
25.	Typical details at insulation termination	DRAWING. No. 18
26.	Typical details for vessel lifting lugs	DRAWING. No. 19
27.	Typical insulation details for T-pieces (single layer	DRAWING. No. 20.1
28.	Typical insulation details for T-pieces (multiple layers)	DRAWING. No.20.2
29.	Typical insulation details for eccentric reducer	DRAWING. No.21.1
30.	Typical insulation details for concentric reducer	DRAWING. No.21.2

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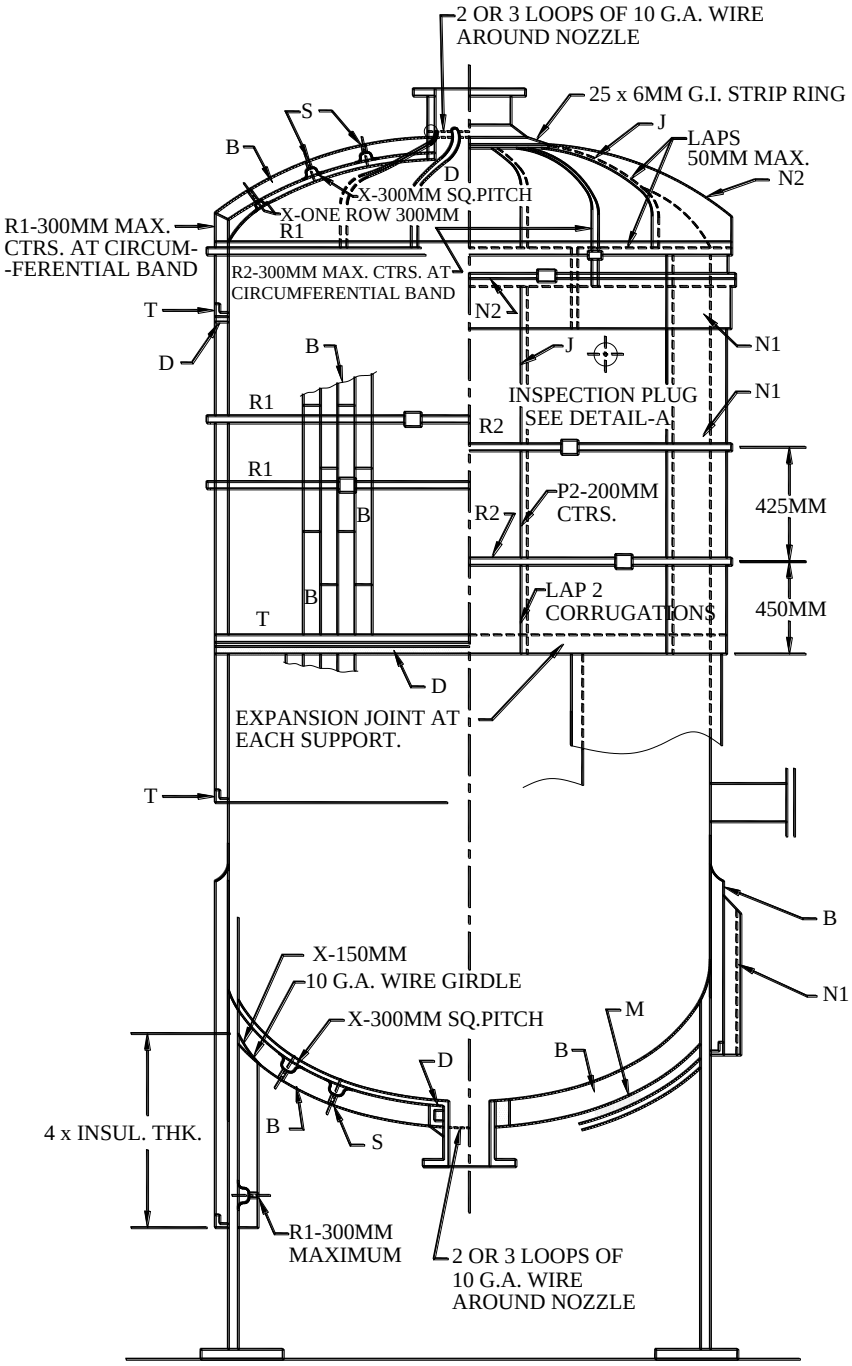

B - BLOCK INSULATION

D - LOOSE MINERAL FIBRE

J - LAP SEALER

M - WIRE MESH-LACE EDGES WITH 16 G.A. WIRE

N1 - WEATHER PROOFING

N2 - WEATHER PROOFING

R1 - BANDS AT 225MM

R2 - BAND

S - 10 G.A. WIRE TIES TO BE USED FOR VESSEL SUBJECT TO HEAT DEFROSTING

T - ANGLE RING SUPPORT & LUGS SEE SEE DRAWING NO.-11.1 ON SHT.28 OF 32

X - CLIPS. SEE DRAWING NO.-11.2 ON SHT. 28 OF 32

VERTICAL VESSELS- COLD

INSULATION WITH METAL JACKETING ON SHELL TOP & BOTTOM HEADS

DRAWING NO. - 01

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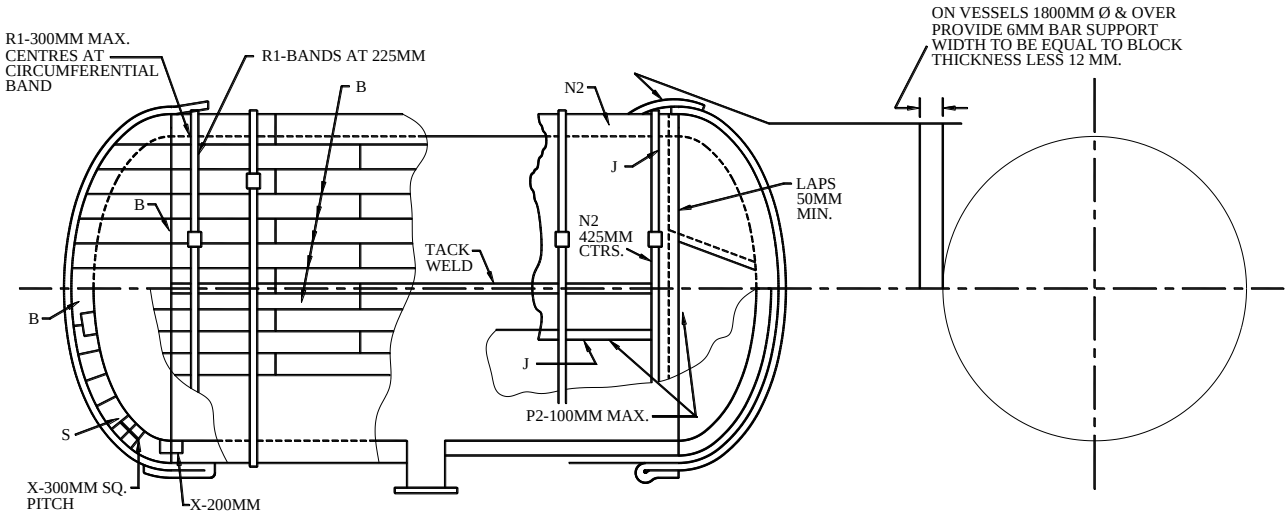

FOR S, B, N1, N2, R1, R2 & J REFER SHT. 17 OF 32

HORIZONTAL VESSELS - COLD INSULATION WITH METAL JACKETING

DRAWING NO.-02

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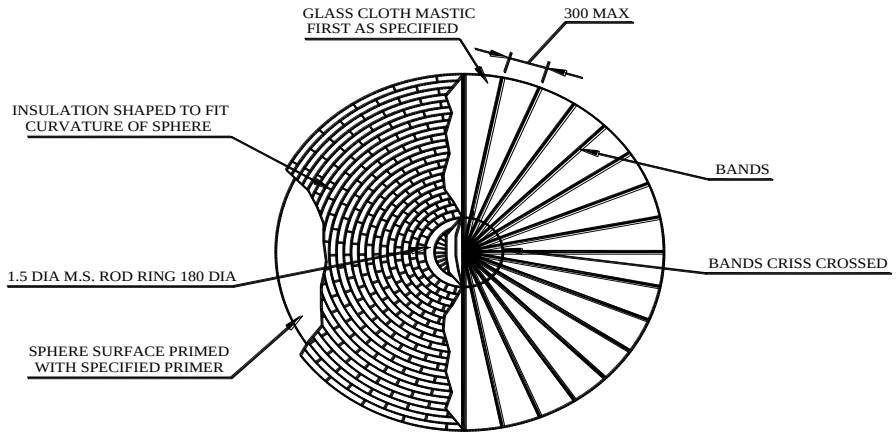
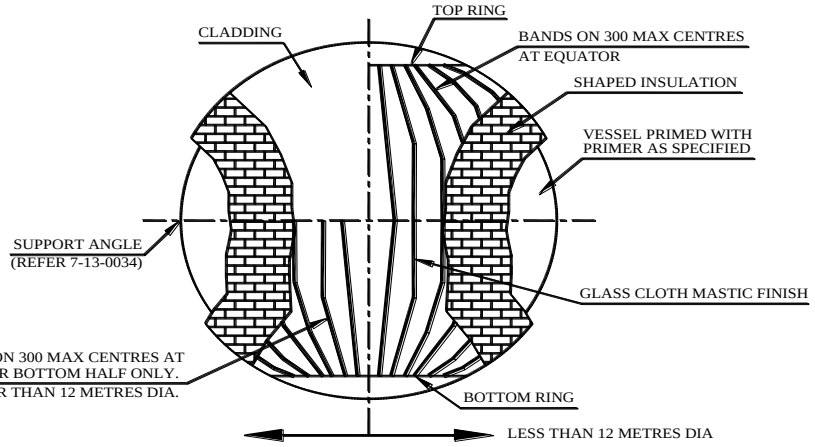


BOTTOM VIEW



ELEVATION VIEW

FIG.3-1 MULTI-LAYER APPLICATION

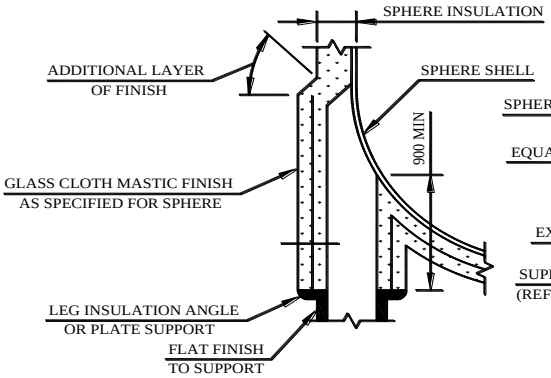
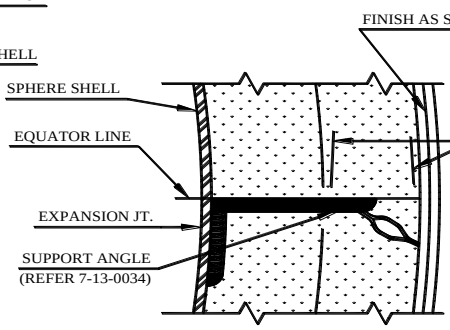


FIG.3-2 LEG INSULATION DETAIL



ADDITIONAL LAYER OF FINISH
300 MIN. WIDTH

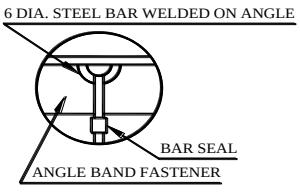


FIG.3-3 INSULATION DETAIL NEAR SUPPORT ANGLE

NOTE: FOR DETAILS OF INSULATION SUPPORTS REFER STD. NO: 7-13-0034

COLD INSULATION FOR SPHERICAL VESSELS
DRAWING No.-3

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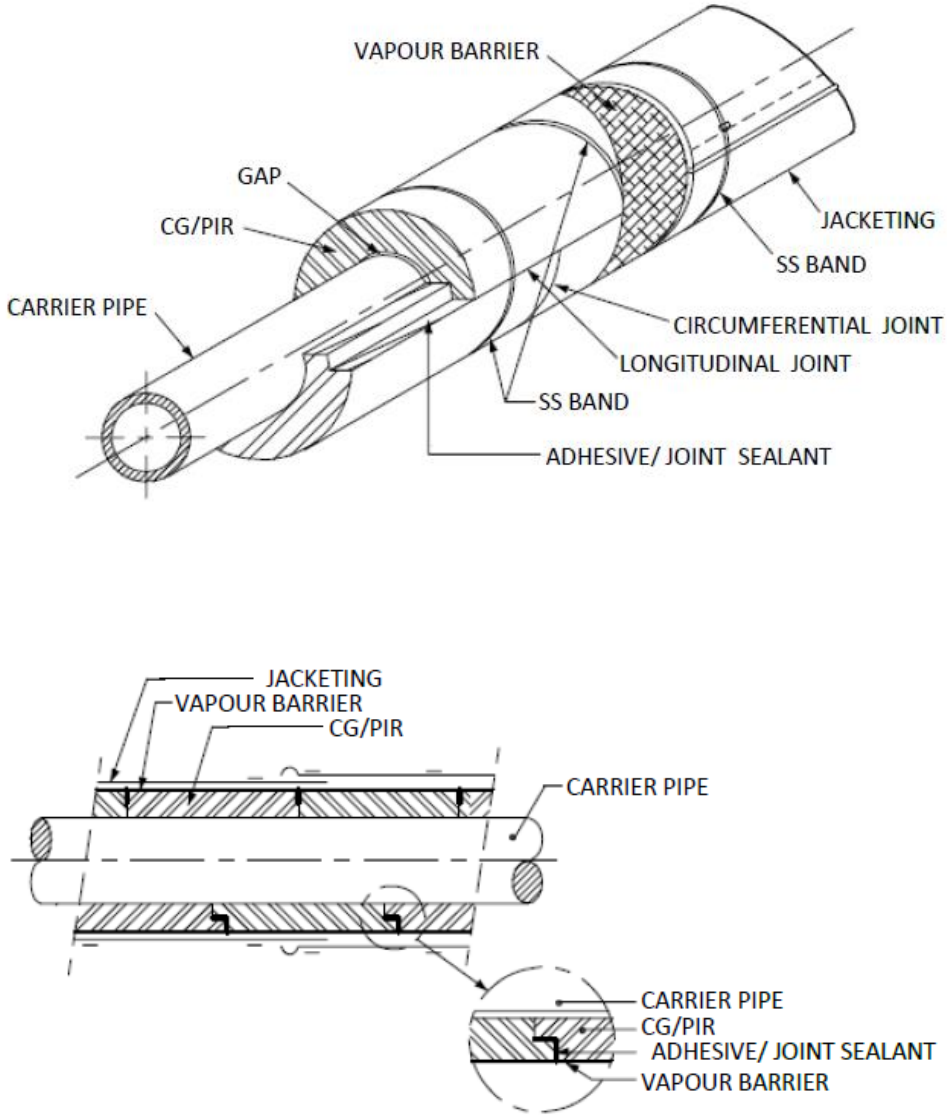

TYPICAL SINGLE LAYER COLD INSULATION ON PIPES

DRAWING NO.-4.1

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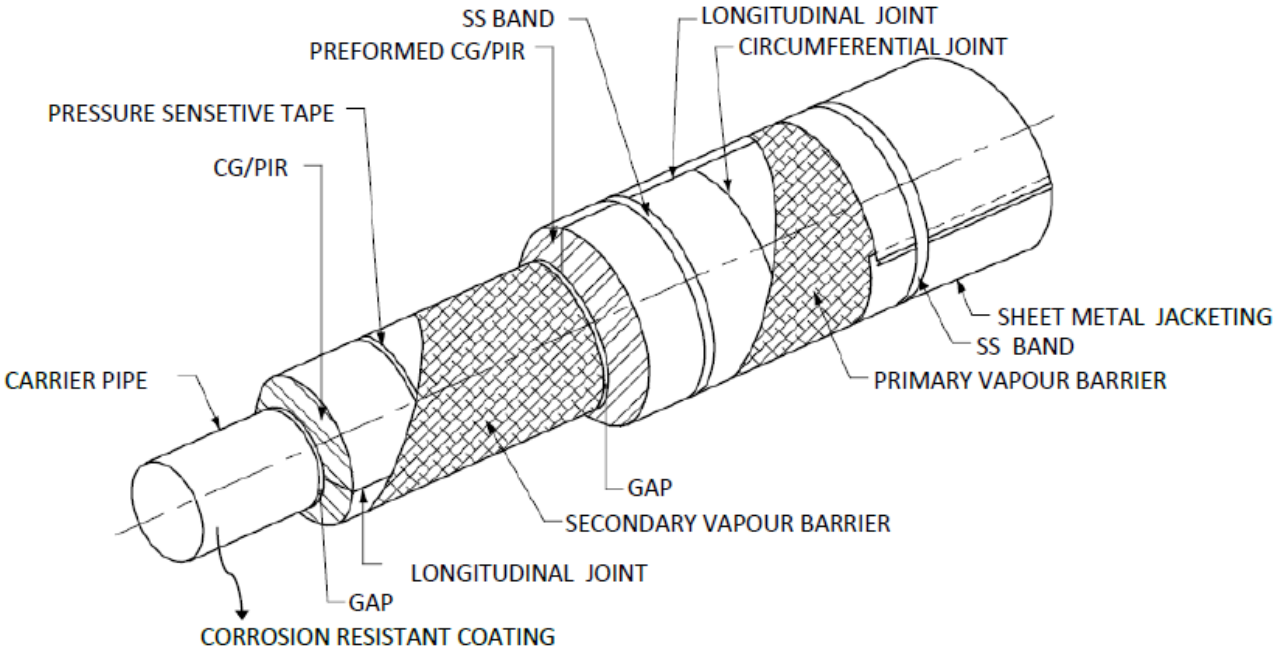

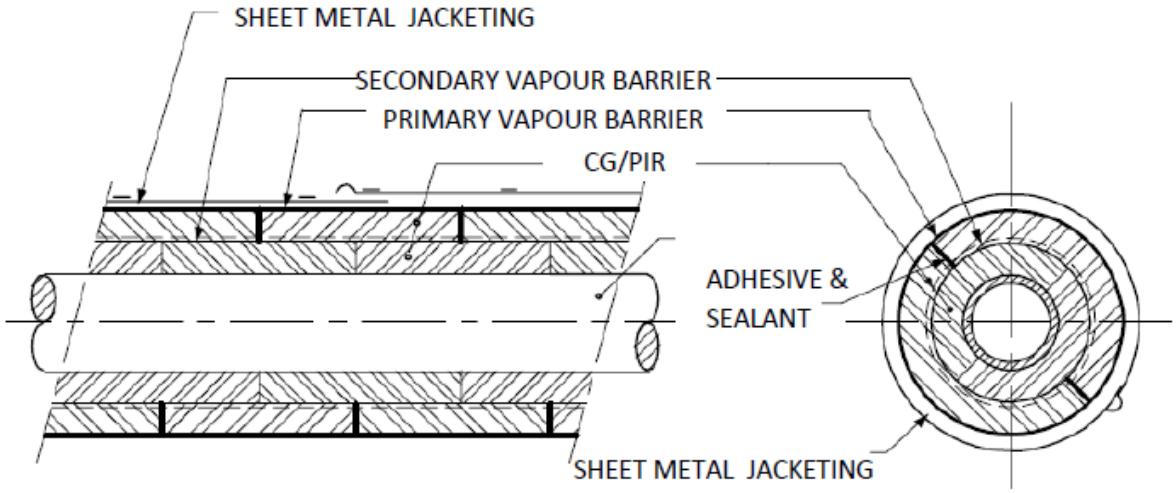

TYPICAL DOUBLE LAYER COLD INSULATION ON PIPES

DRAWING NO.-4.2

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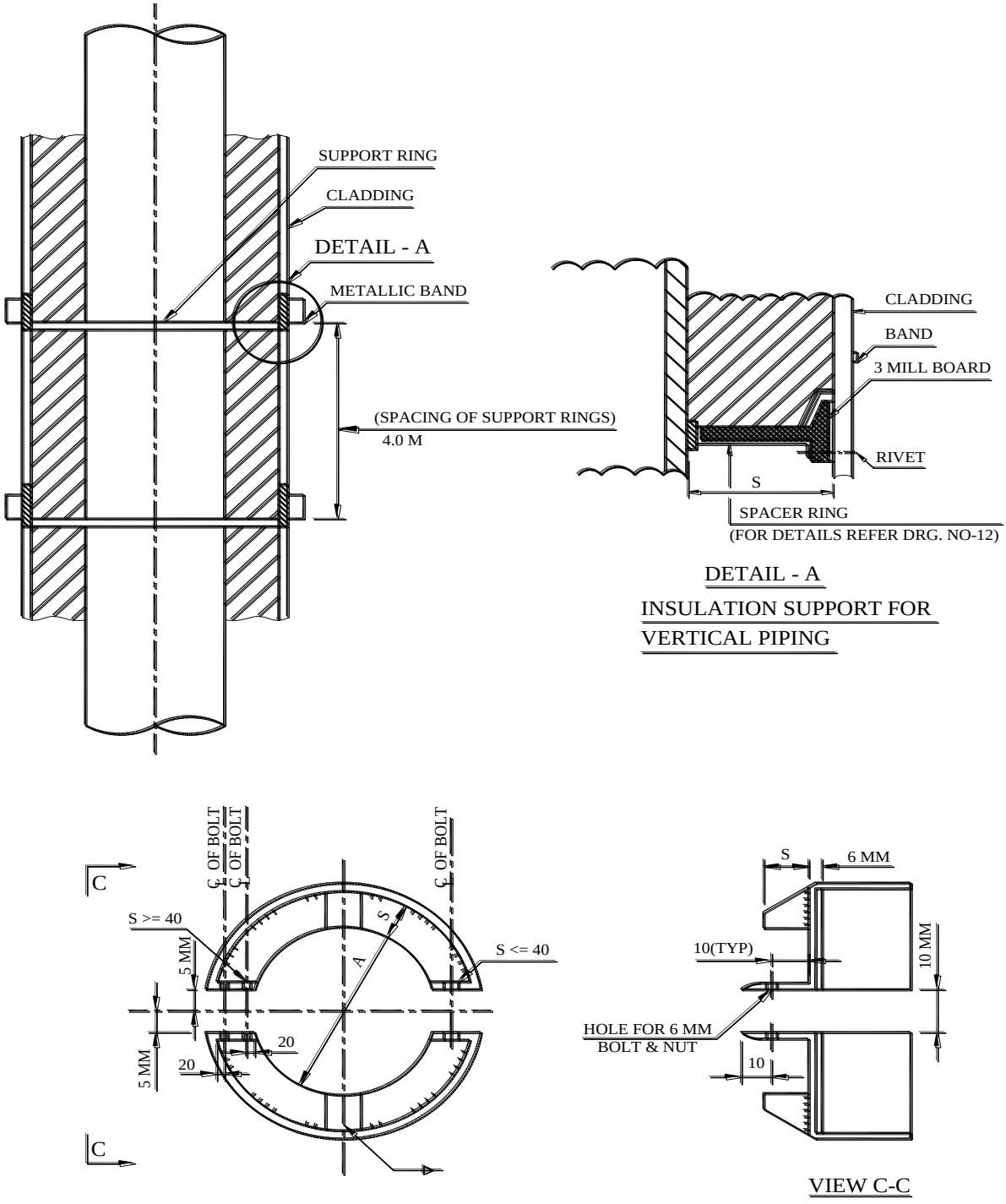

LEGEND:

A DIMENSIONS TO MATCH O.D. OF PIPE OR O.D. OF VESSEL

S INSULATION THICKNESS

SUPPORT RING FOR VERTICAL INSULATED PIPING

DRAWING NO.5

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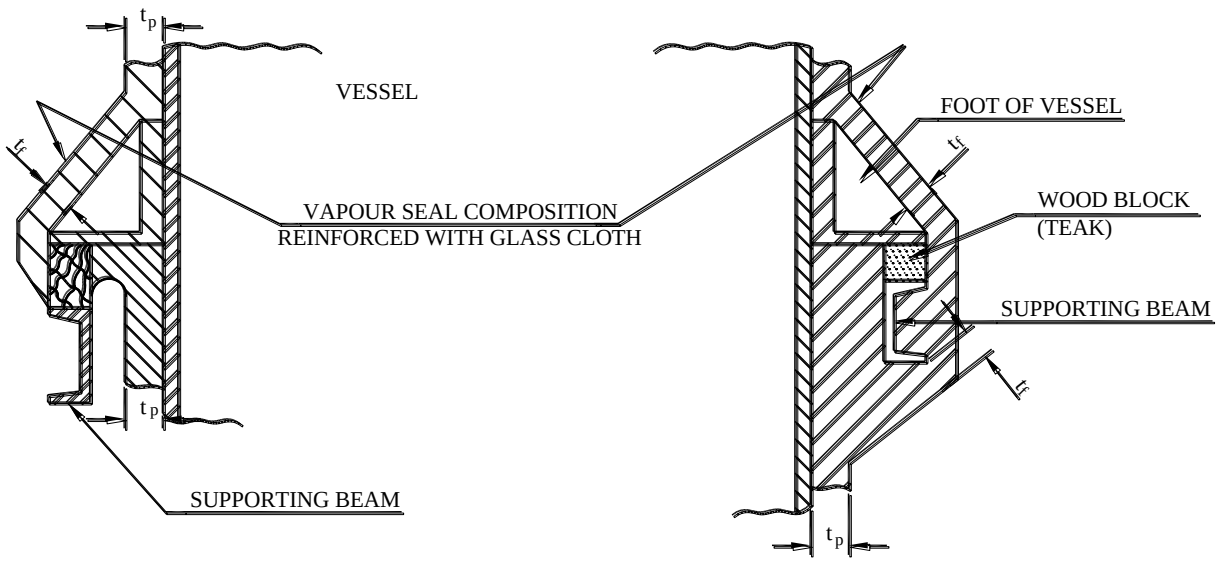
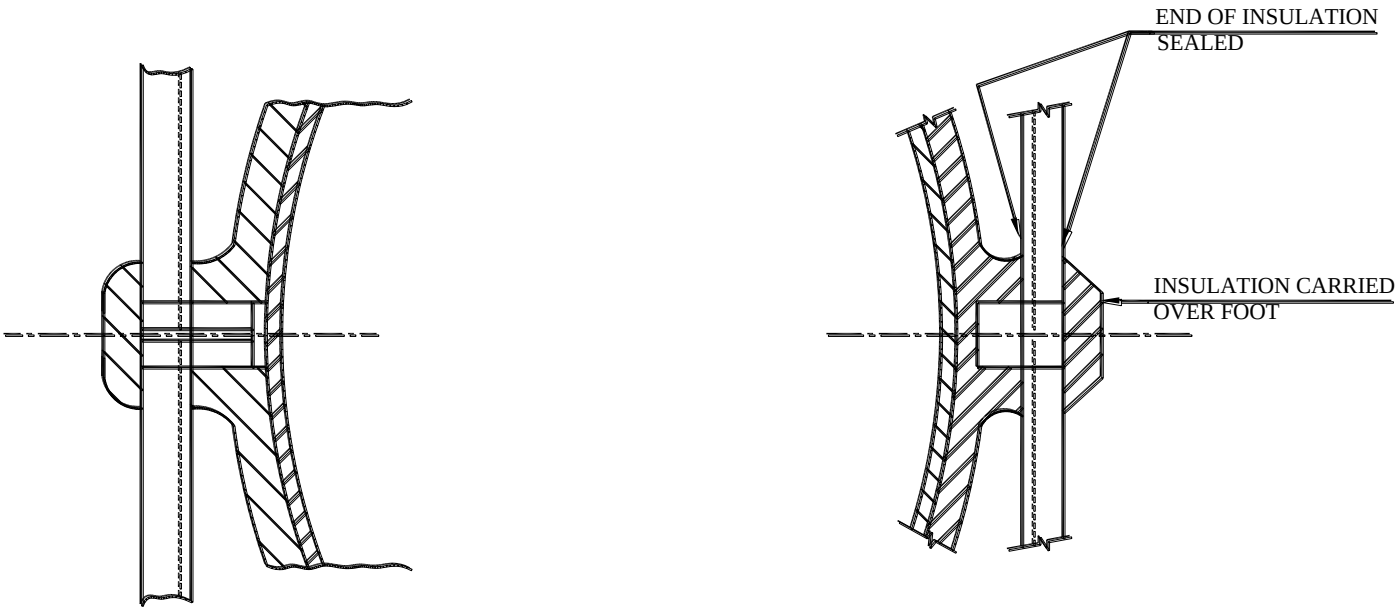


NOTE : ALL CORNERS MUST BE ROUNDED. MINIMUM RADIUS 25 MM.



t_p = THICKNESS OF VESSEL INSULATION
$t_f = t_p$ t_f = 100 MM WHERE t_p IS BETWEEN 100 MM & 125 MM.

METHOD OF INSULATING FEET OF VESSELS

DRAWING NO.-06

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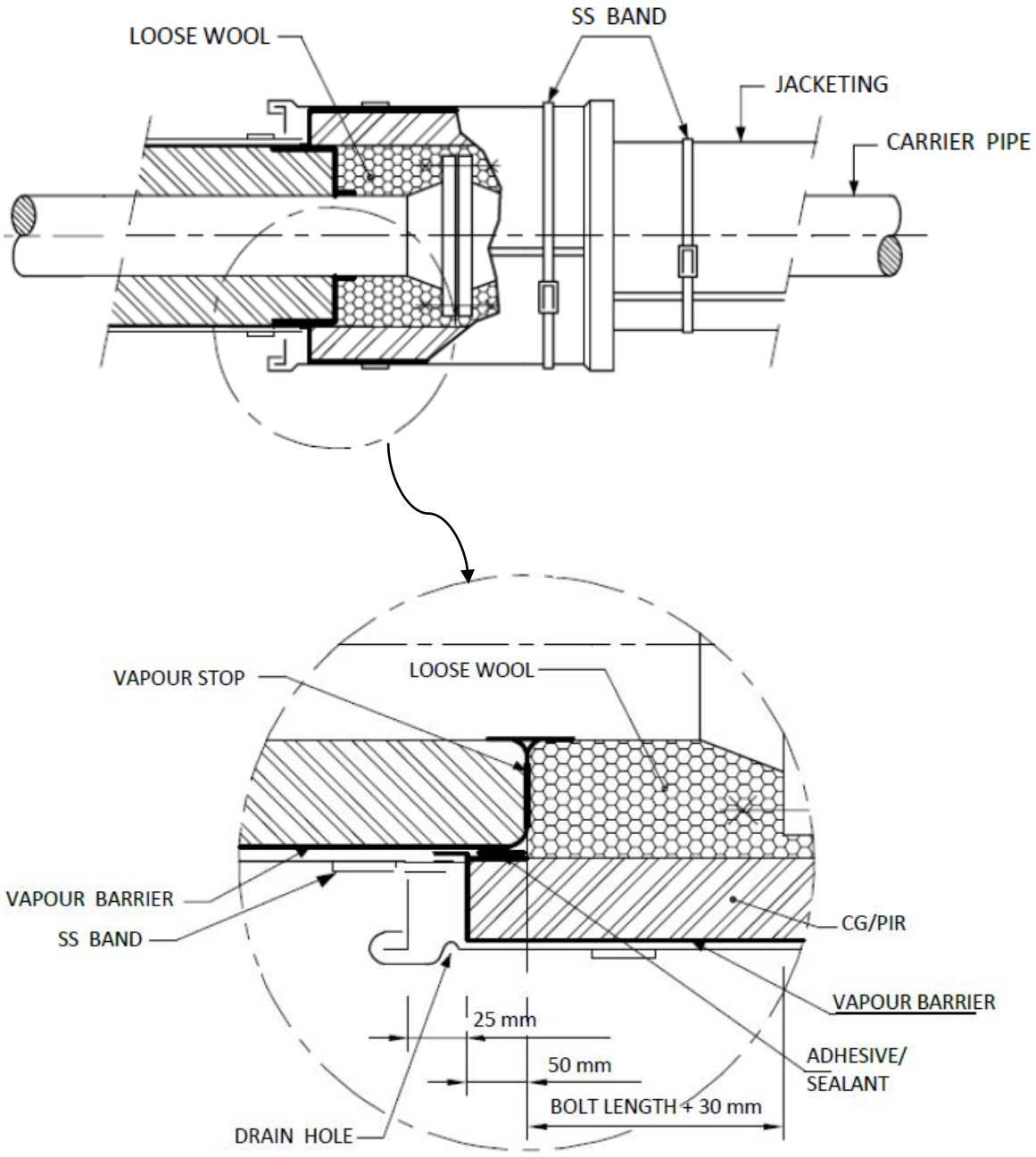

TYPICAL INSULATION DETAILS FOR HORIZONTAL FLANGE BOX

DRAWING NO.-7.1

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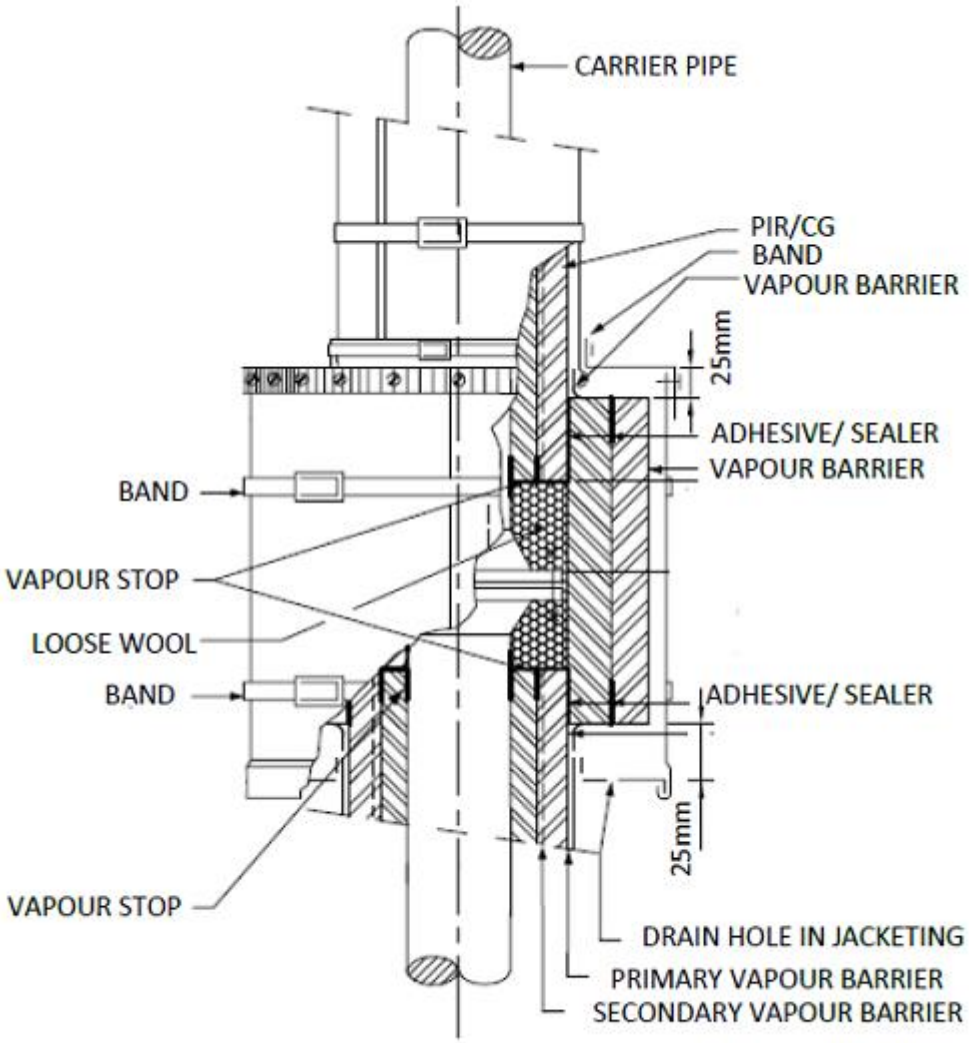

TYPICAL INSULATION DETAILS FOR VERTICAL FLANGE BOX

DRAWING NO.-7.2

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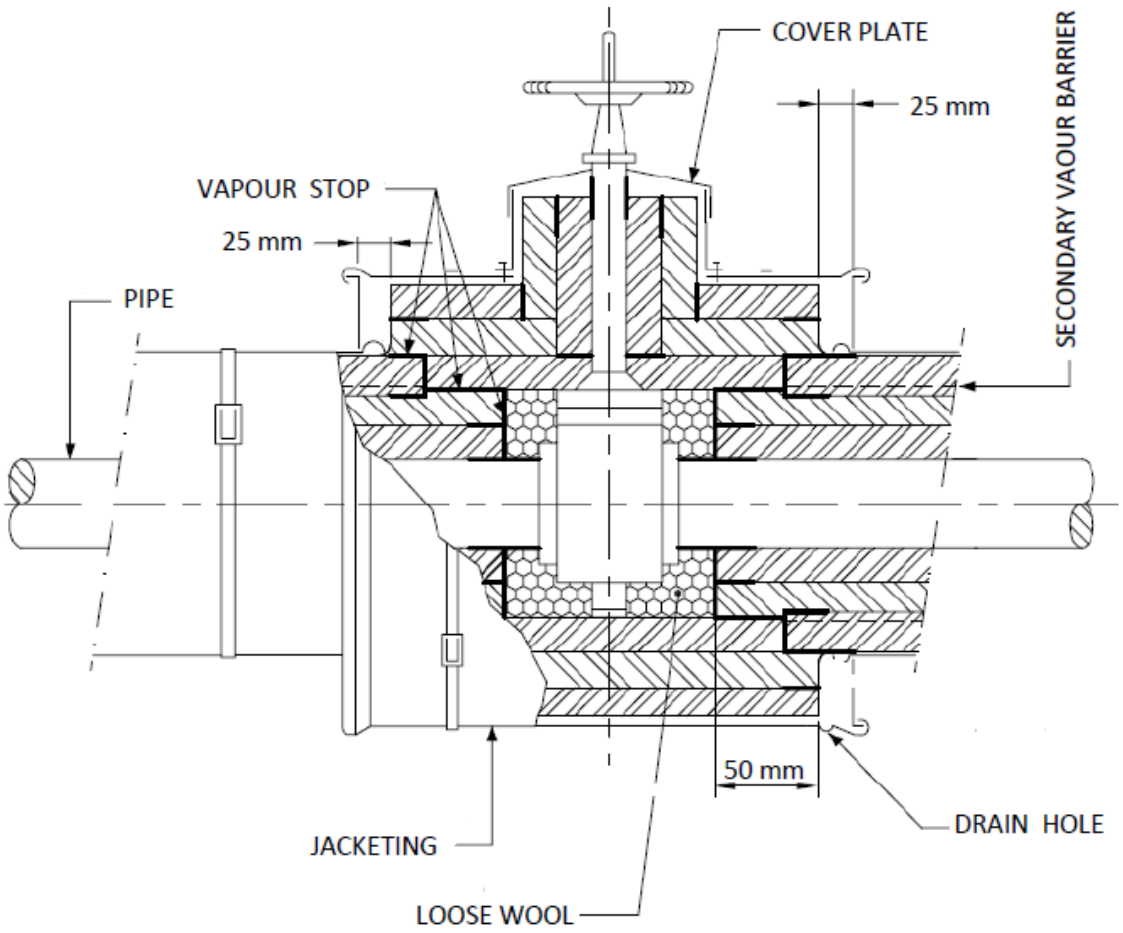

TYPICAL INSULATION DETAILS FOR VALVES BOX (HORIZONTAL)

DRAWING NO.-8.1

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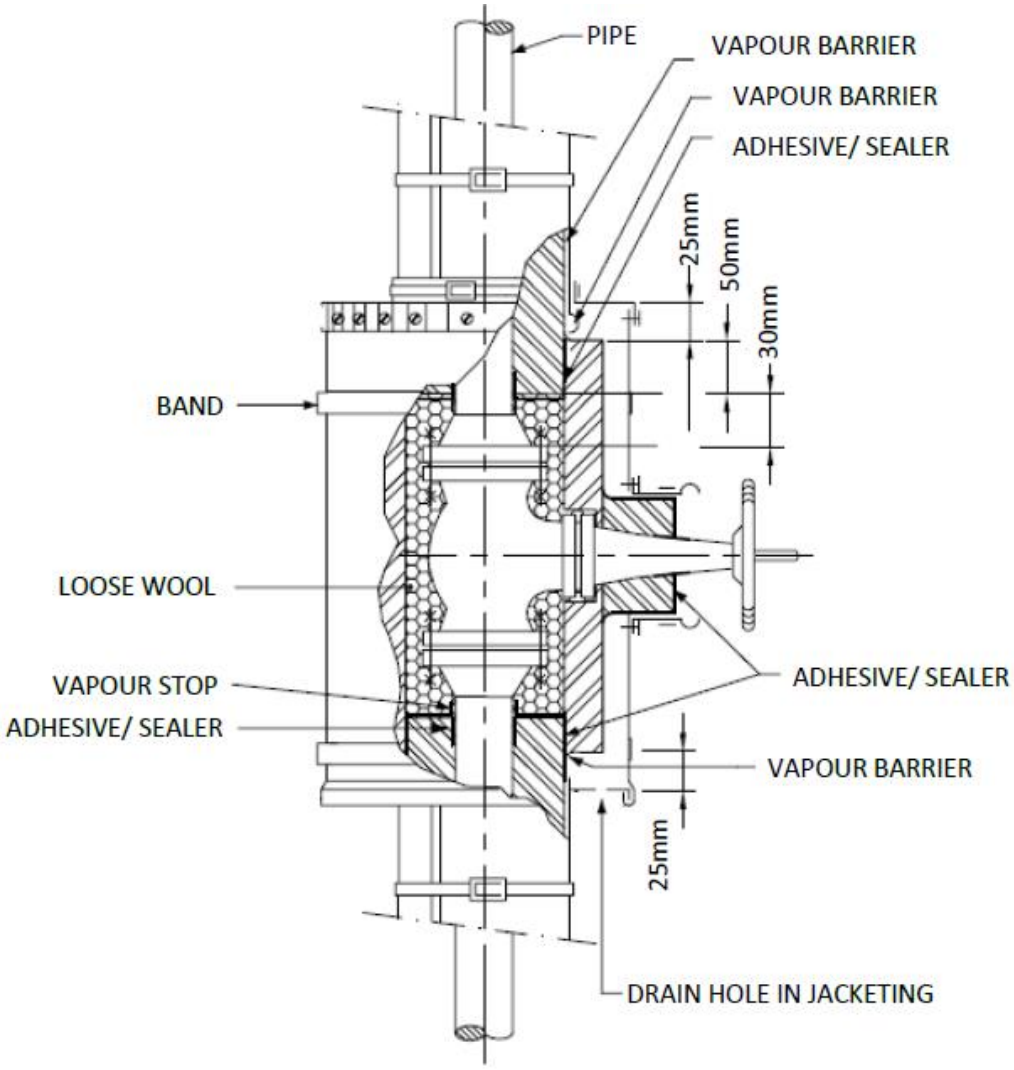

TYPICAL INSULATION DETAILS FOR VALVES BOX (VERTICAL)

DRAWING NO.-8.2

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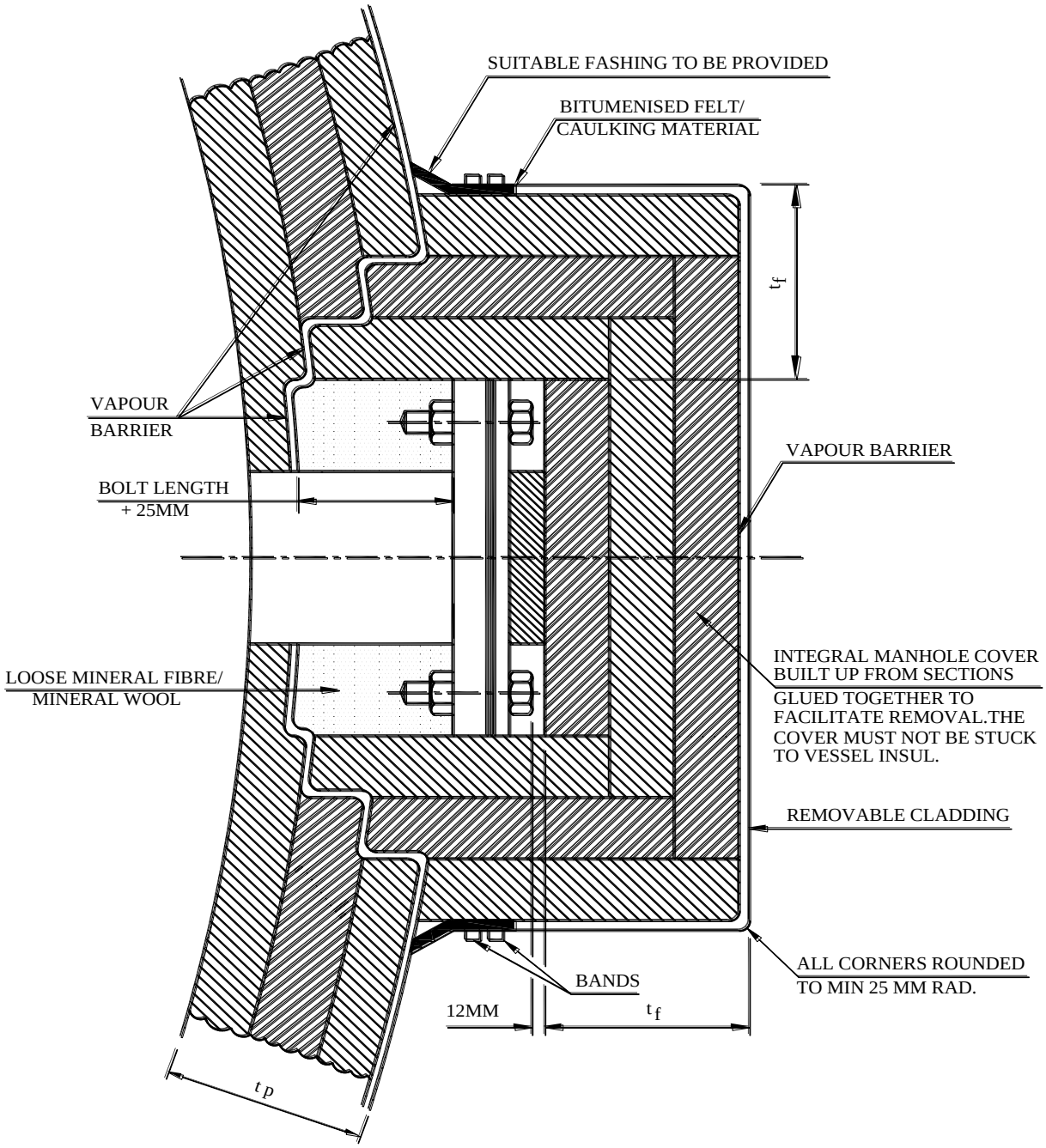

t_p = THICKNESS OF LAGGING IN VESSELS

t_f = THICKNESS OF LAGGING IN FLANGES

t_f = t_p + 25 MM WHERE t_p >125 MM
t_f = 100 MM WHERE t_p IS BETWEEN 100 MM & 125 MM
t_f = t_p WHERE t_p <100 MM

INSULATION DETAILS FOR MANHOLES

DRAWING NO.-09

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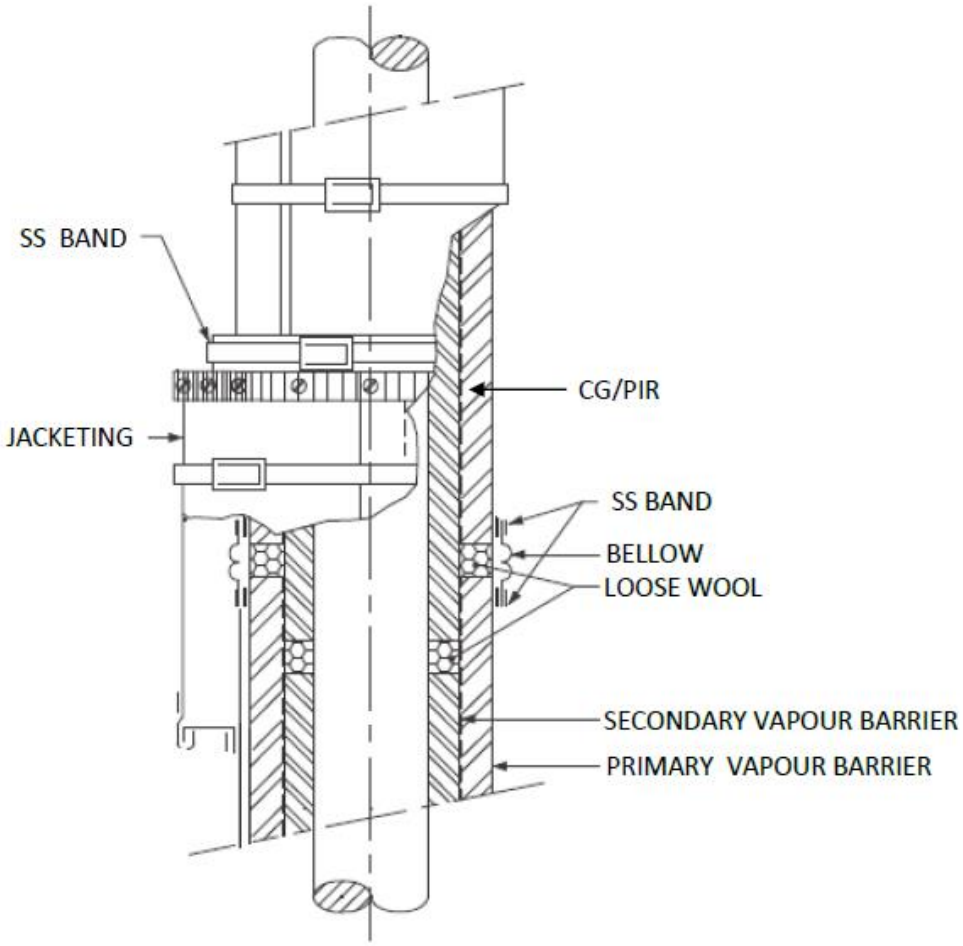

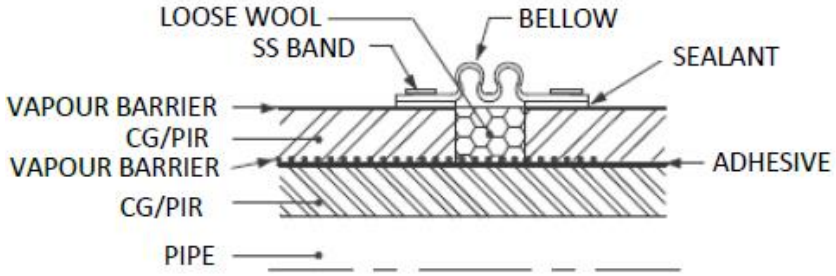

TYPICAL CONTRACTION JOINT DETAILS FOR PIPING

DRAWING NO.-10.1

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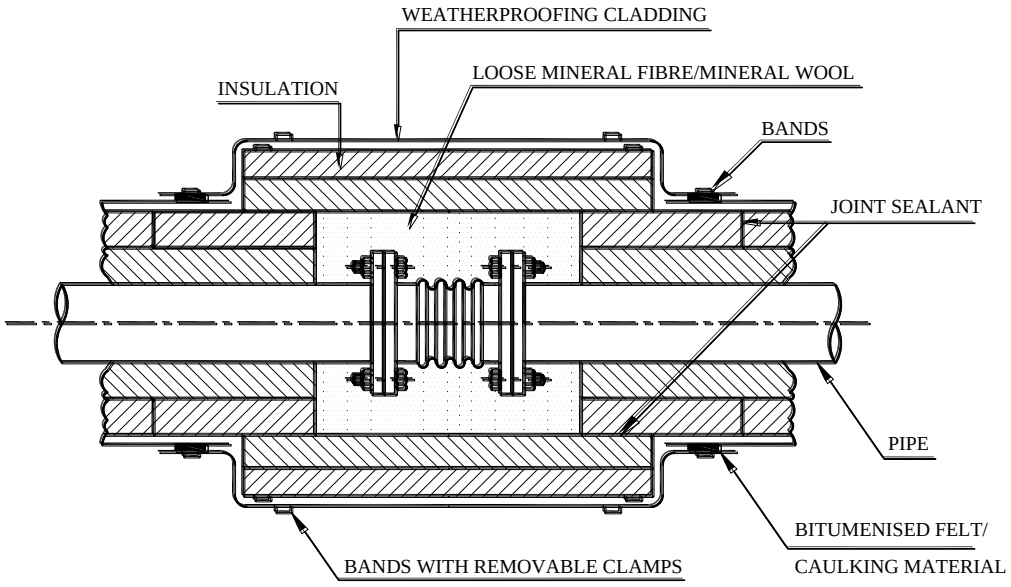
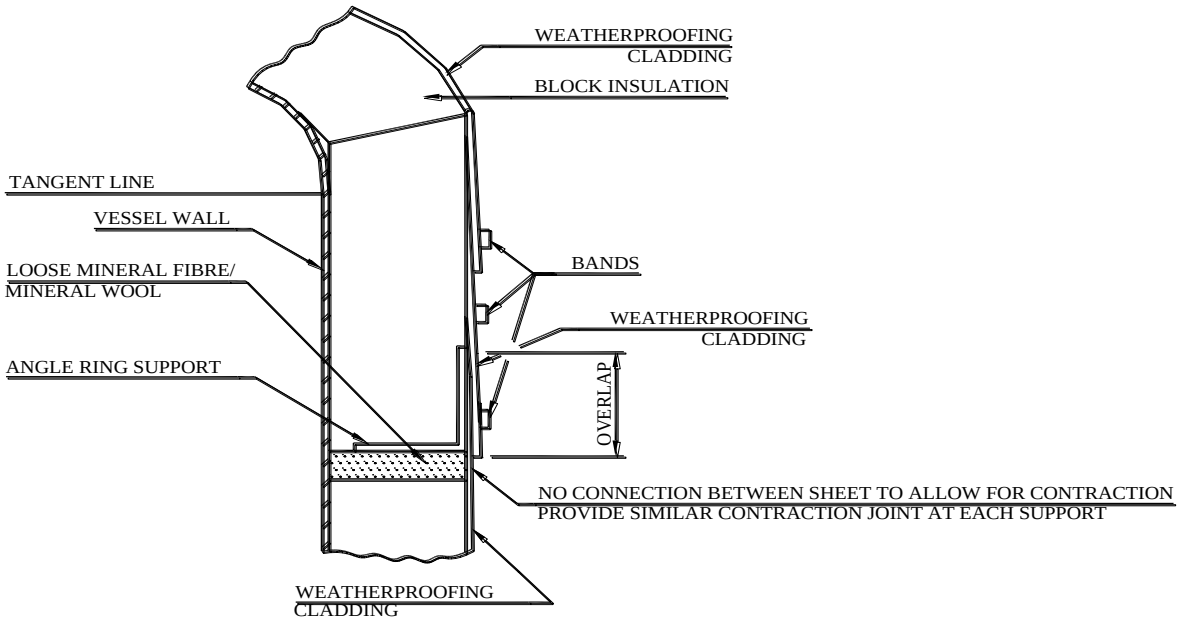


CONTRACTION JOINT – MECHANICAL EXPANSION JOINT

DRAWING NO.-10.2



CONTRACTION JOINT – VERTICAL VESSELS

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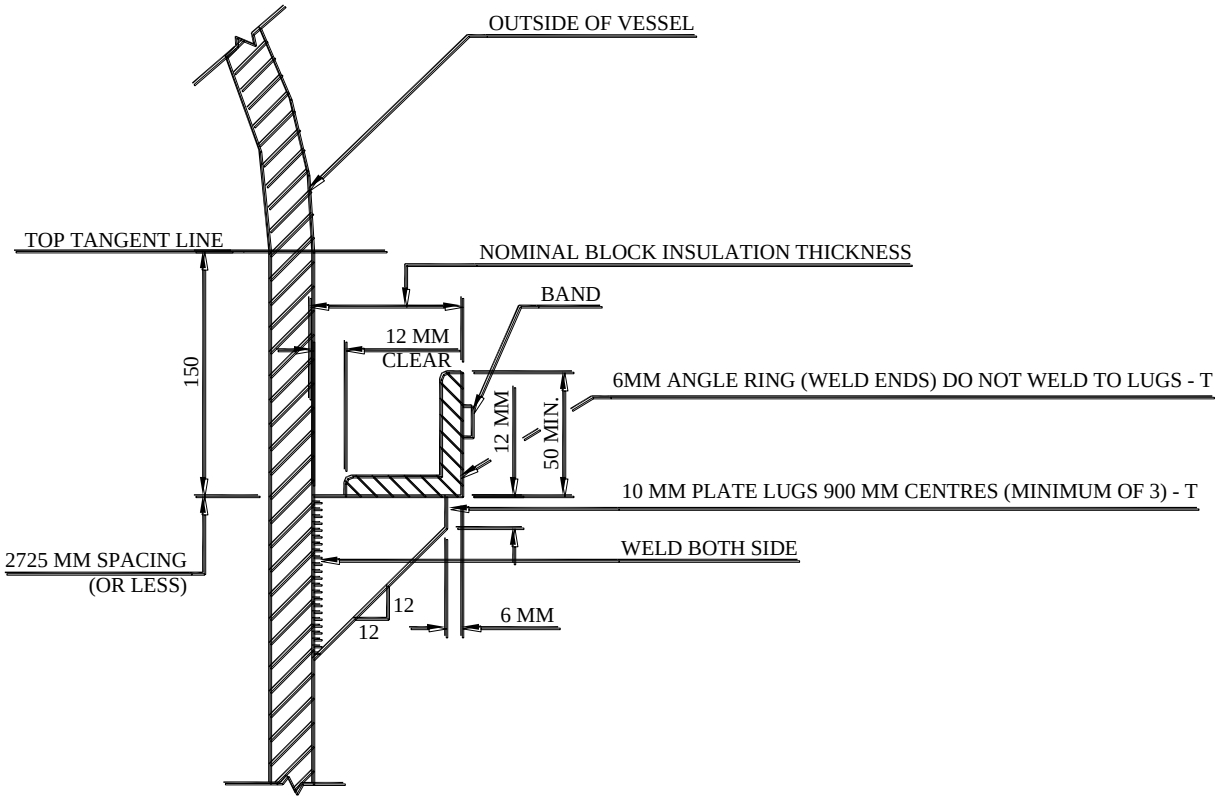
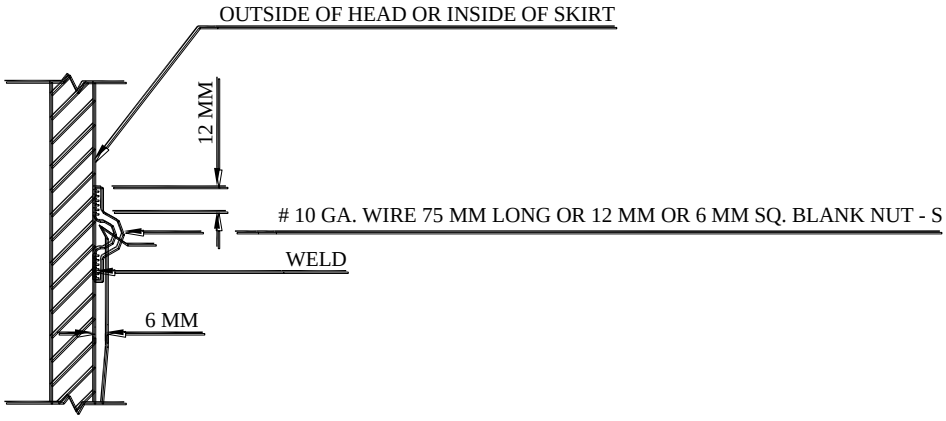


SUPPORTS FOR BLOCK INSULATION

DRAWING NO.-11.1



CLIPS ON HEADS AND INSIDE SKIRT FOR BLOCK INSULATION

DRAWING NO-11.2

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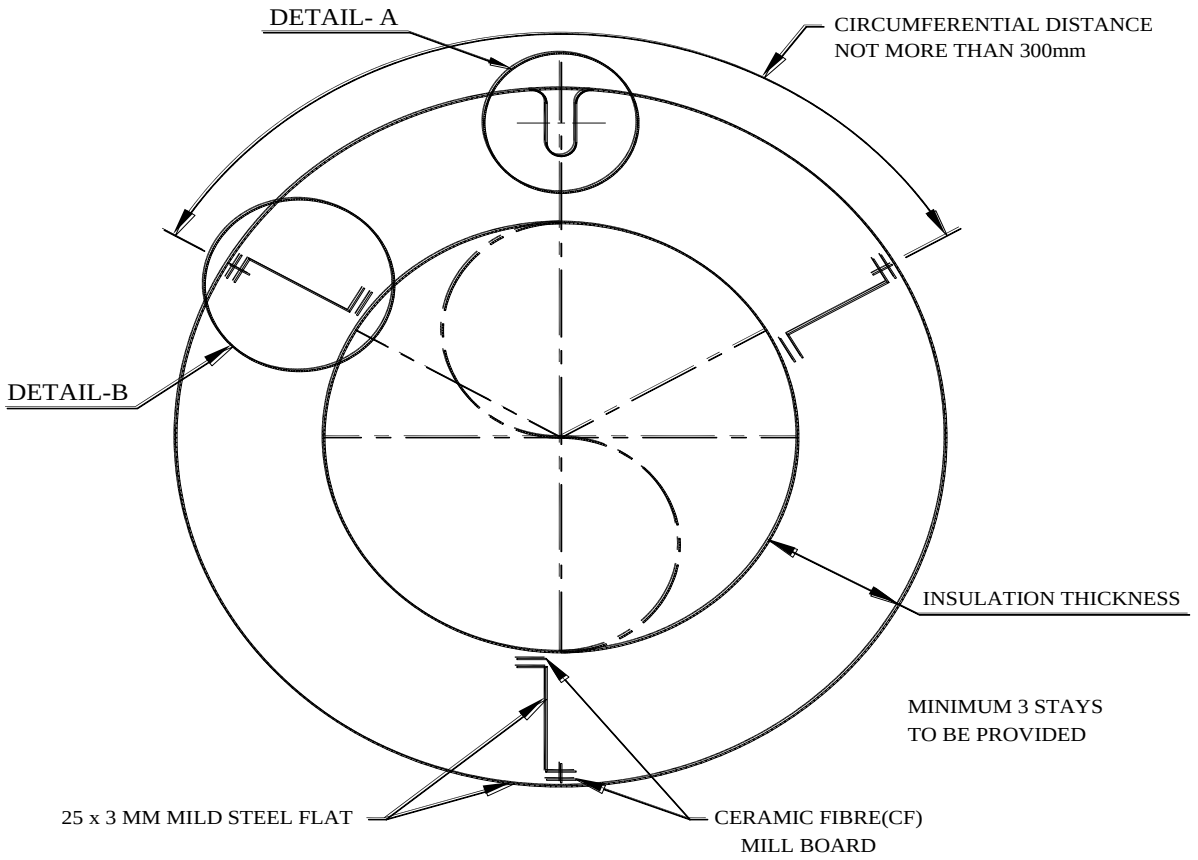

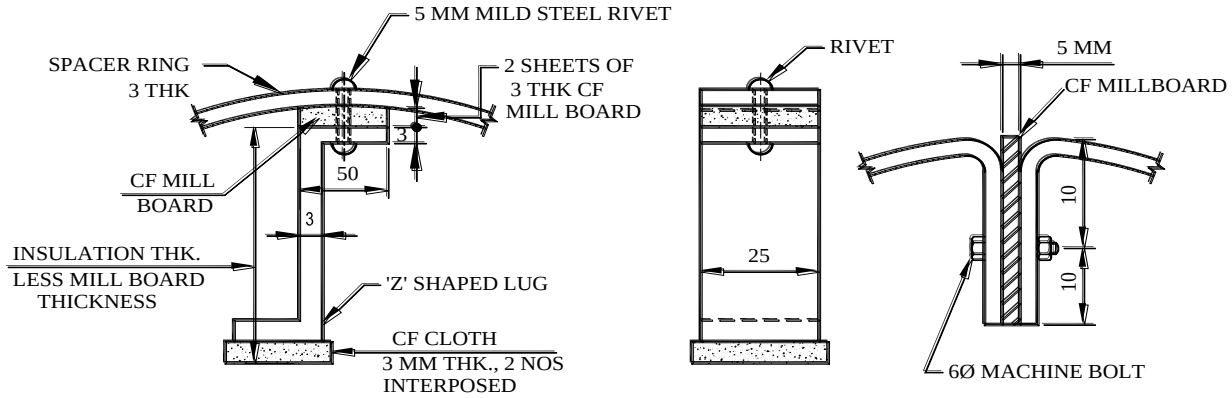

DETAIL - B

DETAIL - A

DETAIL OF SPACER RING

DRAWING NO.-12

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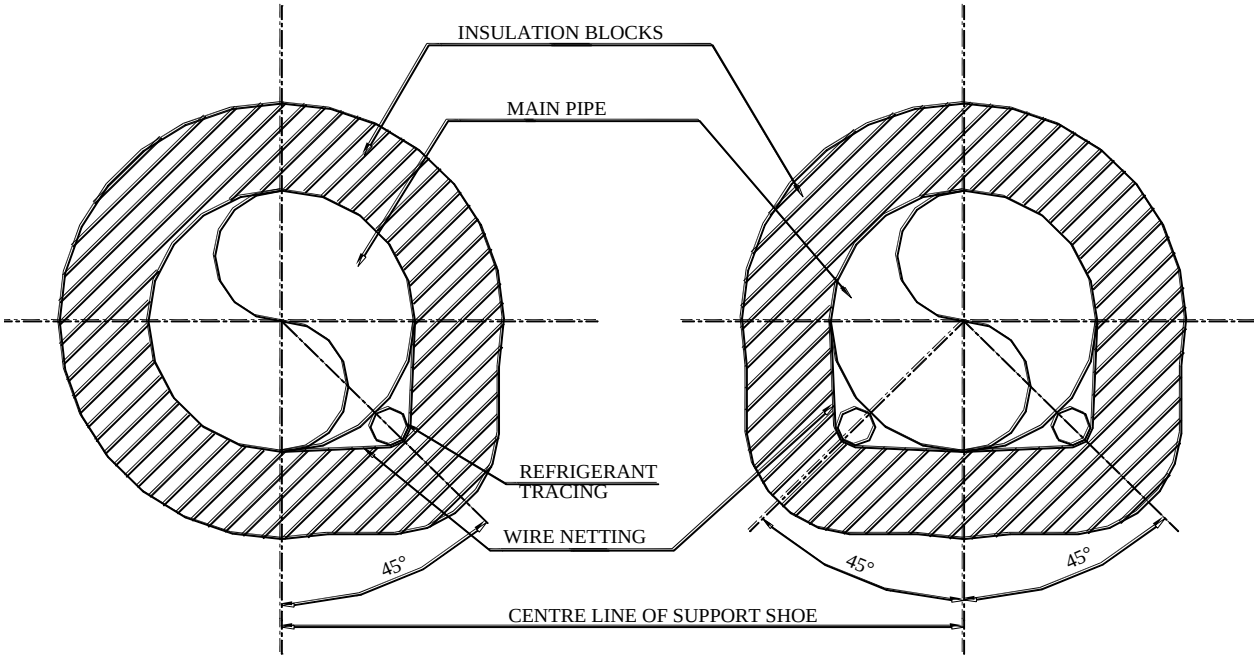
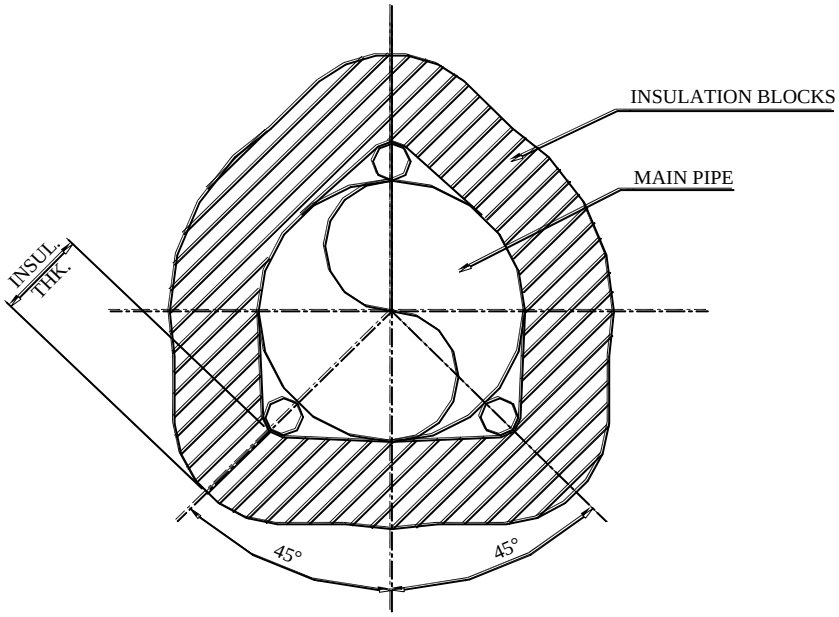


SINGLE TRACER DETAIL

DOUBLE TRACER DETAIL



TRIPLE TRACER DETAIL

REFRIGERANT TRACING INSULATION

DRAWING NO.-13

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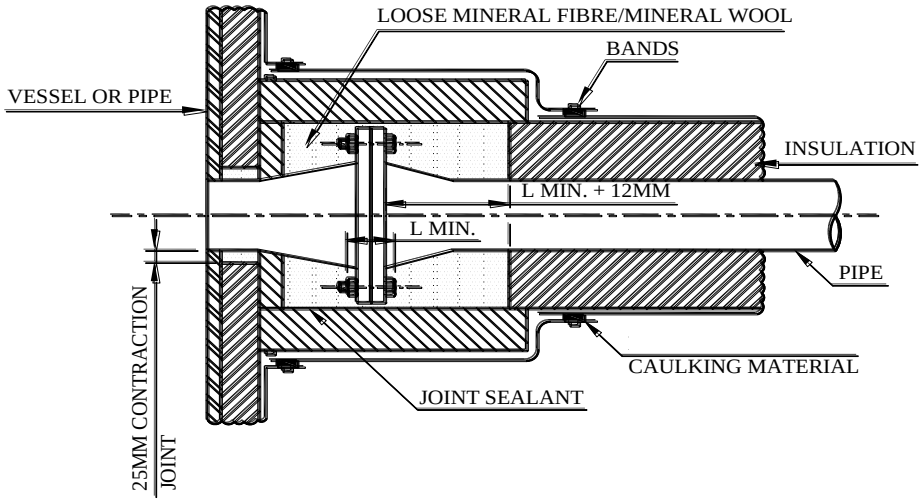
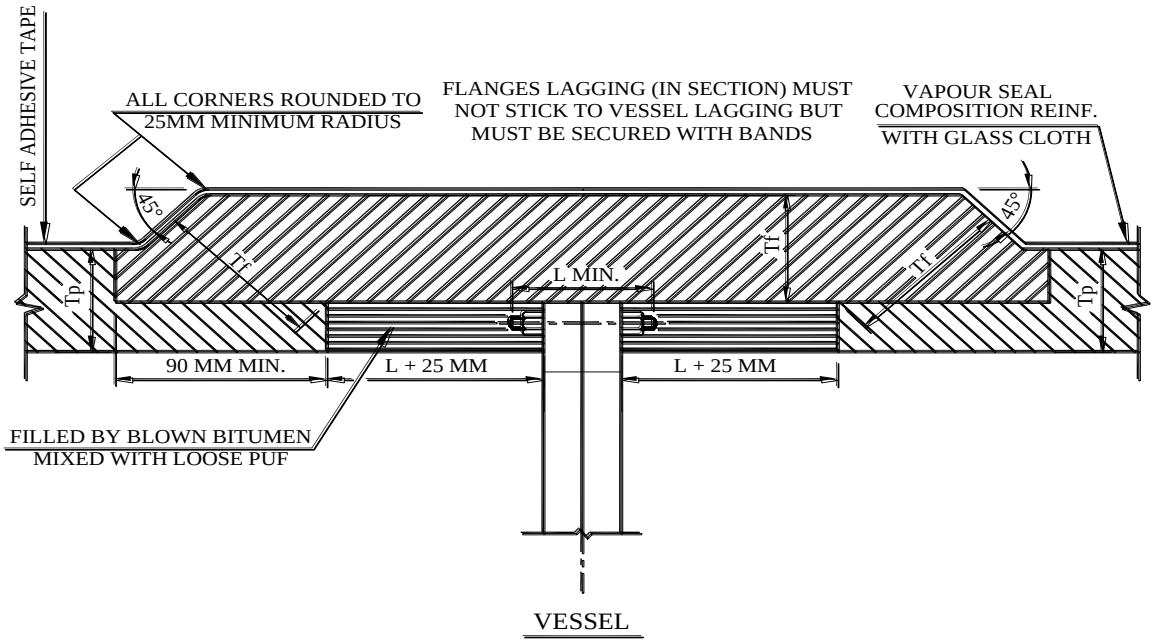


DRAWING NO.-14.1



Tp = THICKNESS OF LAGGING ON PIPE OR VESSEL SHELL PLATE AND END PLATE

Tf = THICKNESS OF LAGGING ON PIPE FLANGE OR VESSEL FLANGE

Tf = Tp - 25 MM WHERE Tp>= 125 MM

Tf = 100 MM WHERE Tp IS BETWEEN 100 & 125 MM

Tf = Tp WHERE Tp <=100 MM

DRAWING NO.-14.2

METHOD OF LAGGING FLANGED JOINTS OF VESSEL

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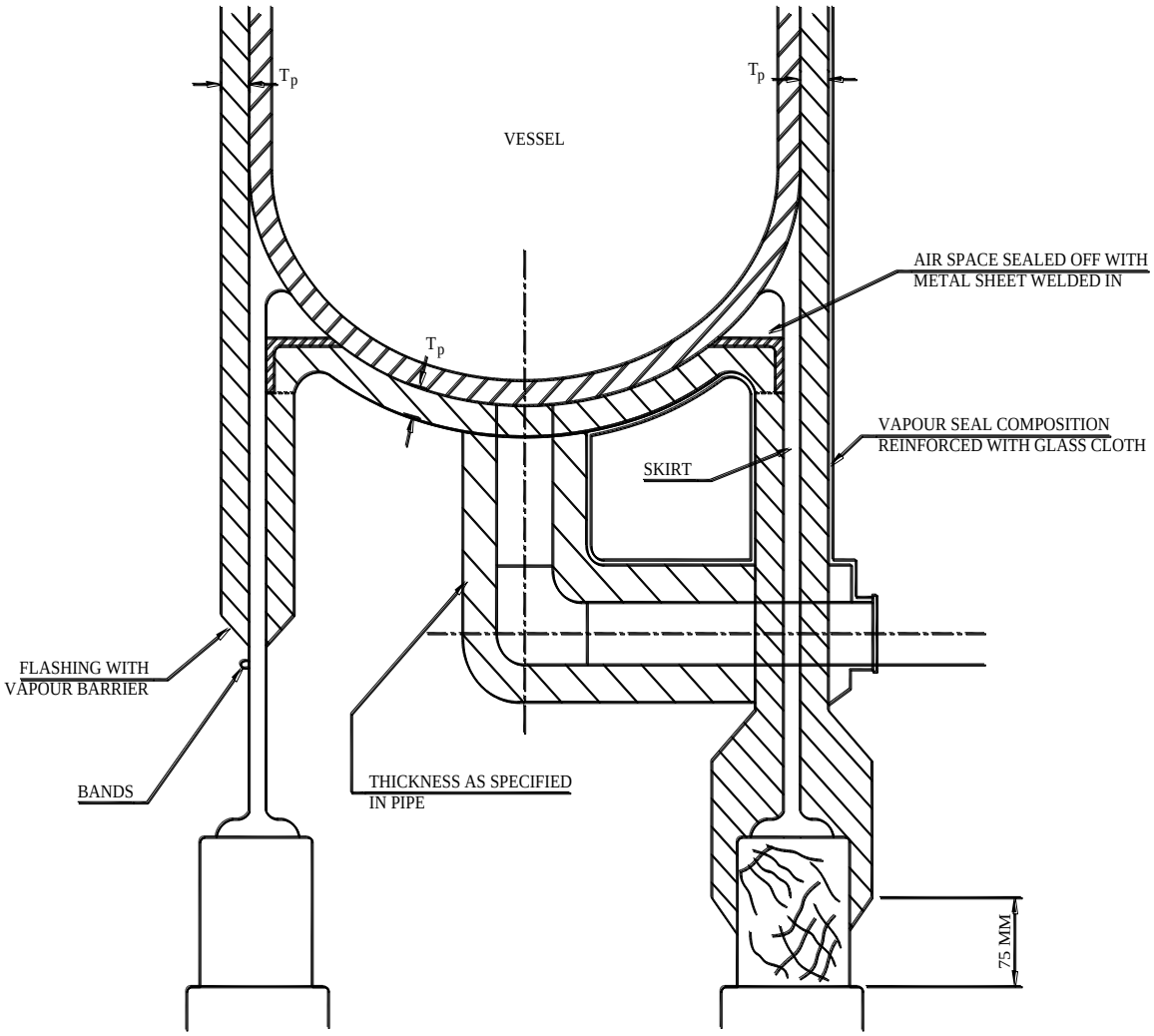

WOOD BLOCKS TO BE COATED ALL OVER WITH ADHESIVE BEFORE ASSEMBLY

T_p = THICKNESS OF VESSEL INSULATION

METHOD OF INSULATING VESSEL SKIRT

(ALTERNATIVE FOR HALF OR FULL INSULATION OF SKIRT)

DRAWING NO.-15

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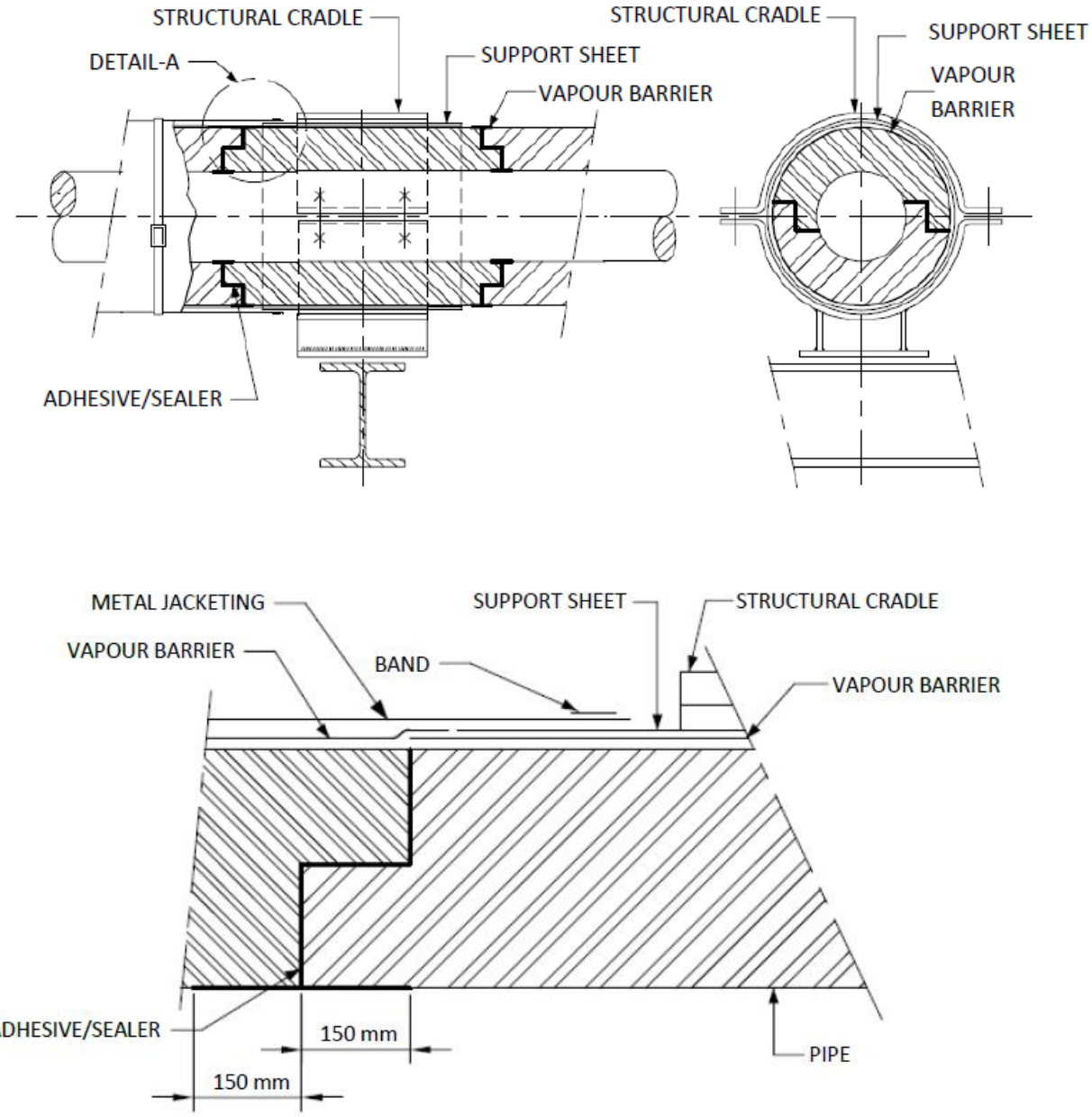

DETAIL-A

TYPICAL INSULATION DETAILS FOR PIPE SUPPORT

DRAWING NO.-16.1

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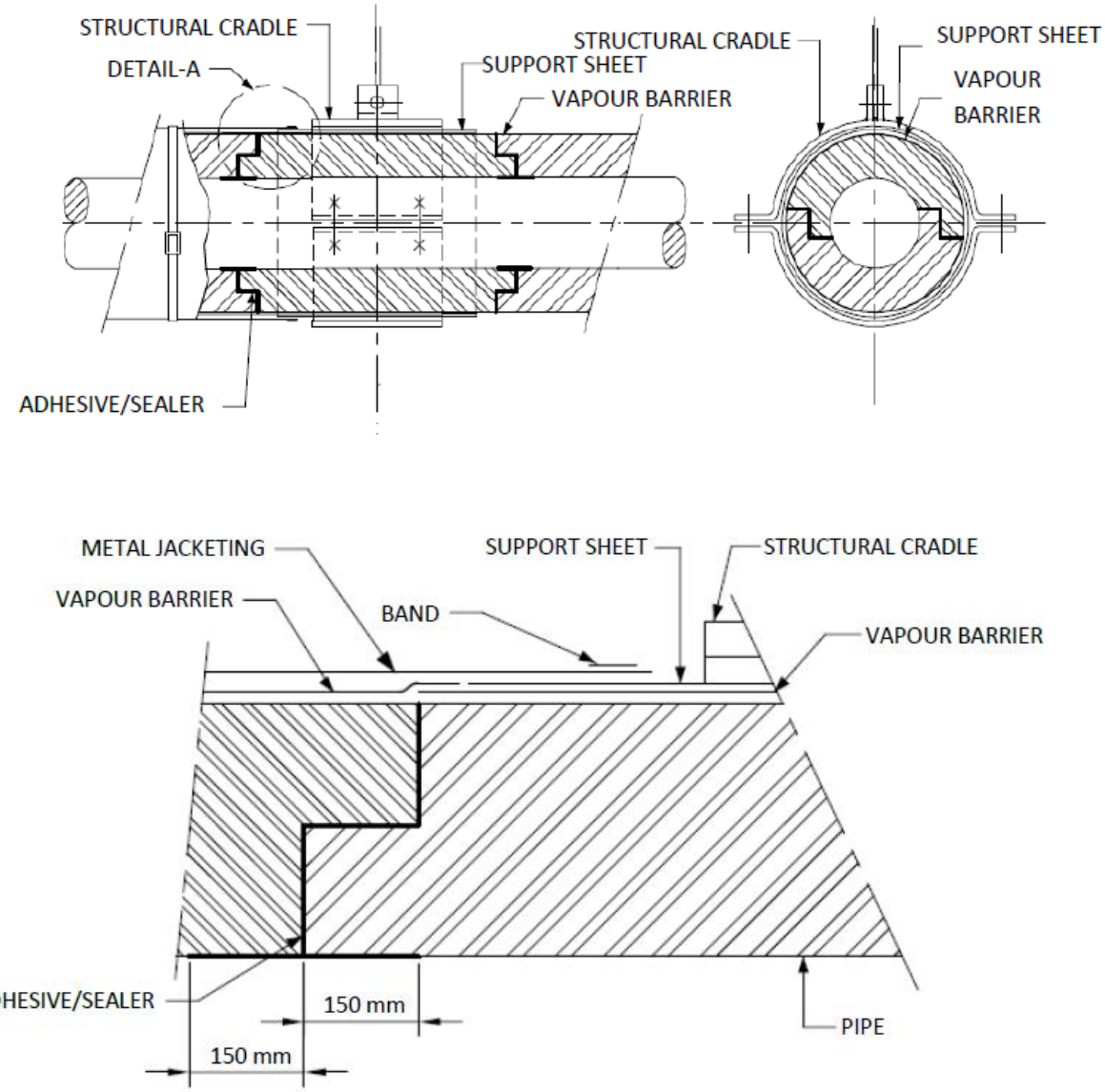

DETAIL-A

TYPICAL INSULATION DETAILS FOR PIPE HANGER SUPPORT

DRAWING NO.-16.2

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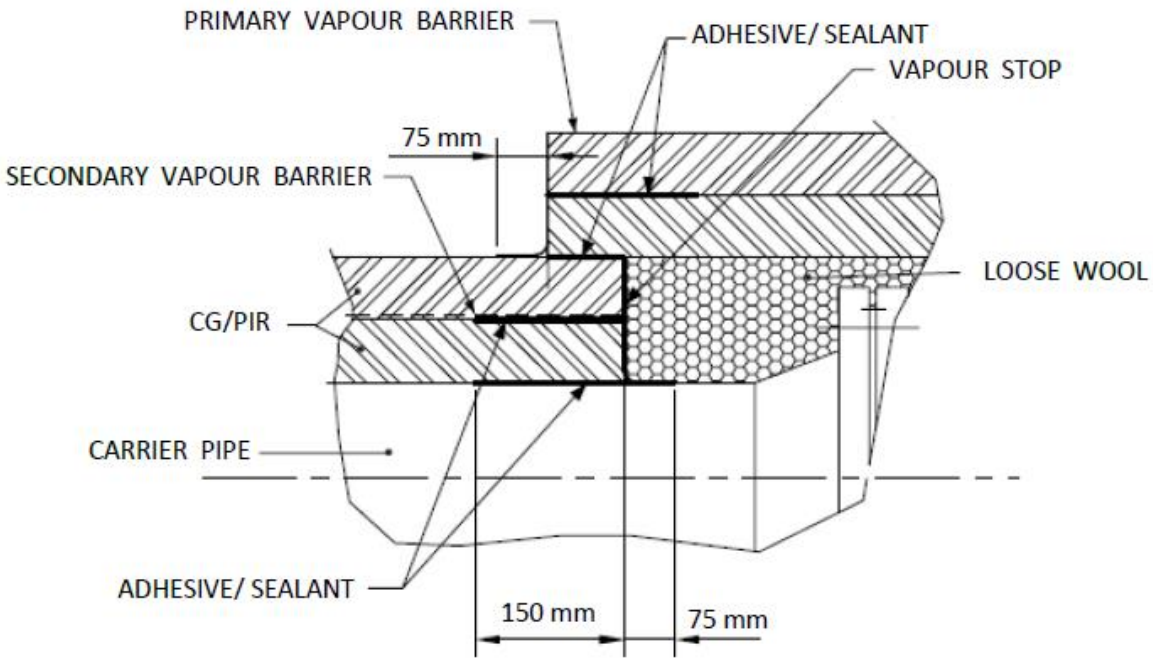
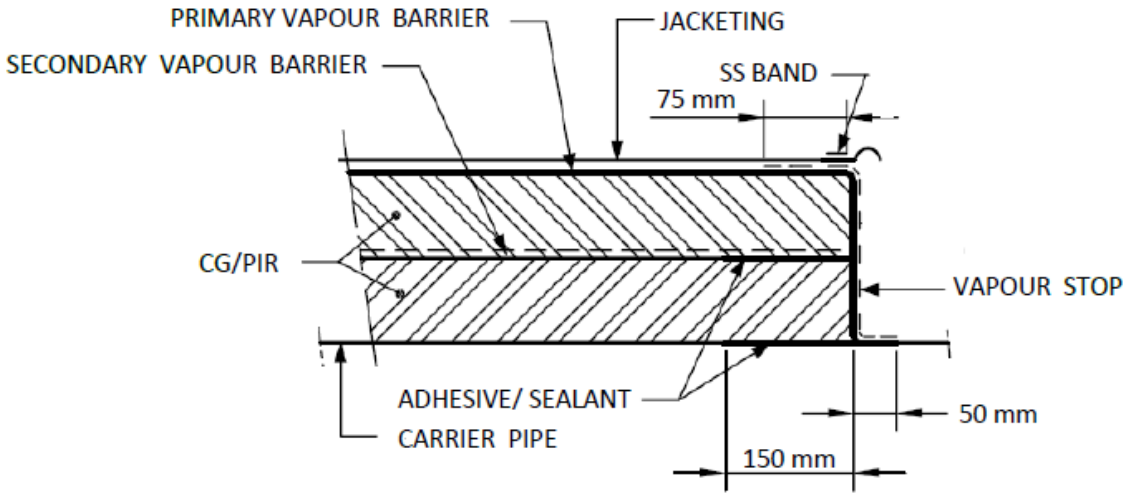


TYPICAL DETAILS FOR VAPOR STOP AT FLANGES AND VALVES

DRAWING NO.-17



TYPICAL DETAILS AT INSULATION TERMINATION

DRAWING NO.-18

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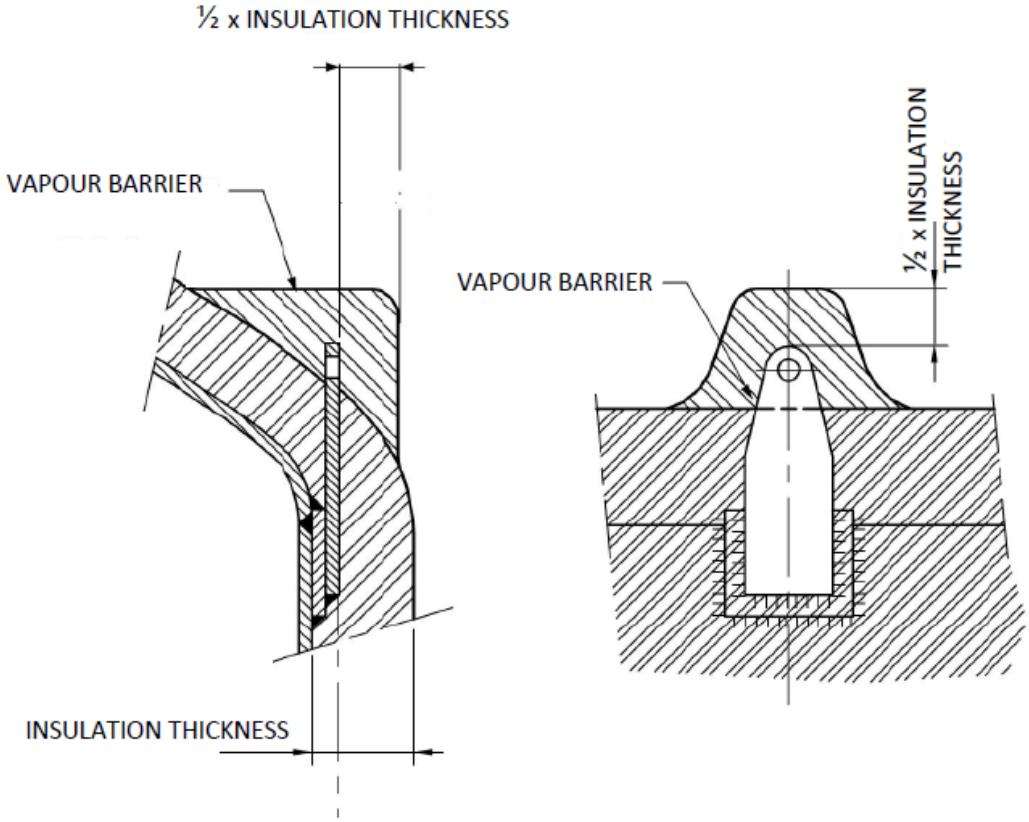

TYPICAL DETAILS FOR VESSEL LIFTING LUGS

DRAWING NO.-19

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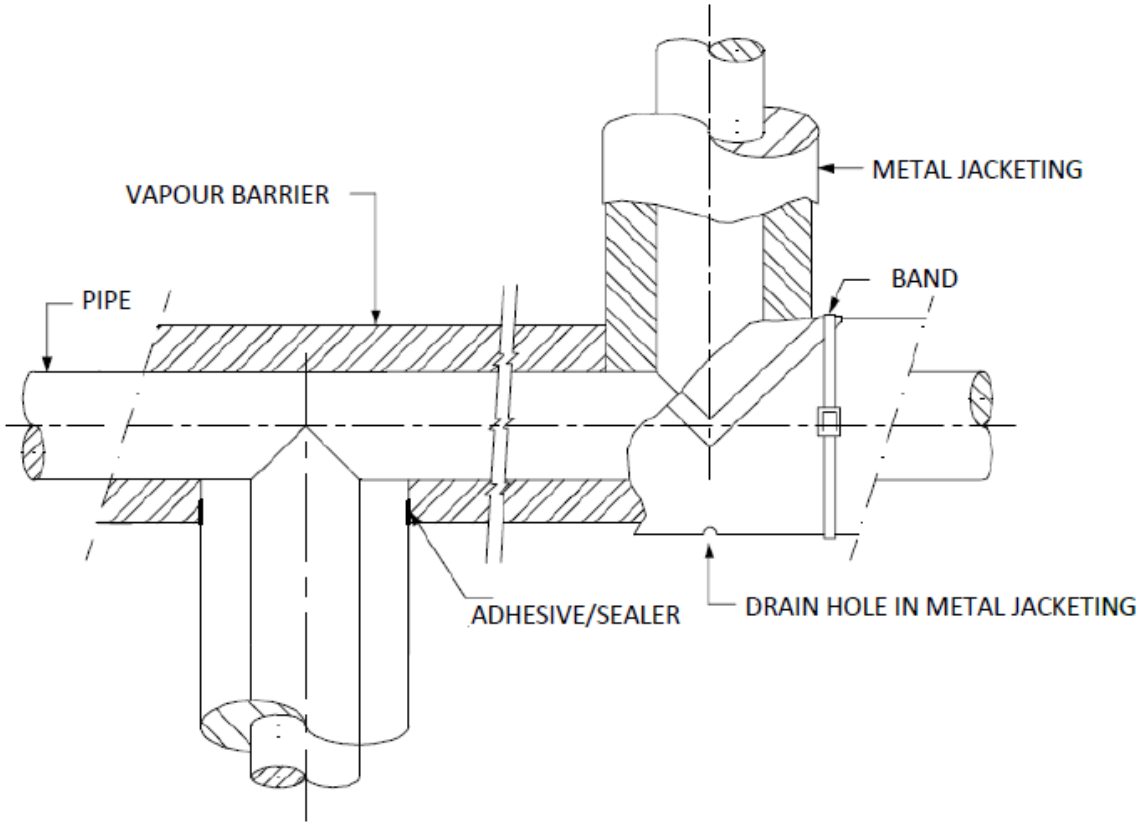

TYPICAL INSULATION DETAILS FOR T-PIECES (SINGLE LAYER)

DRAWING NO.-20.1

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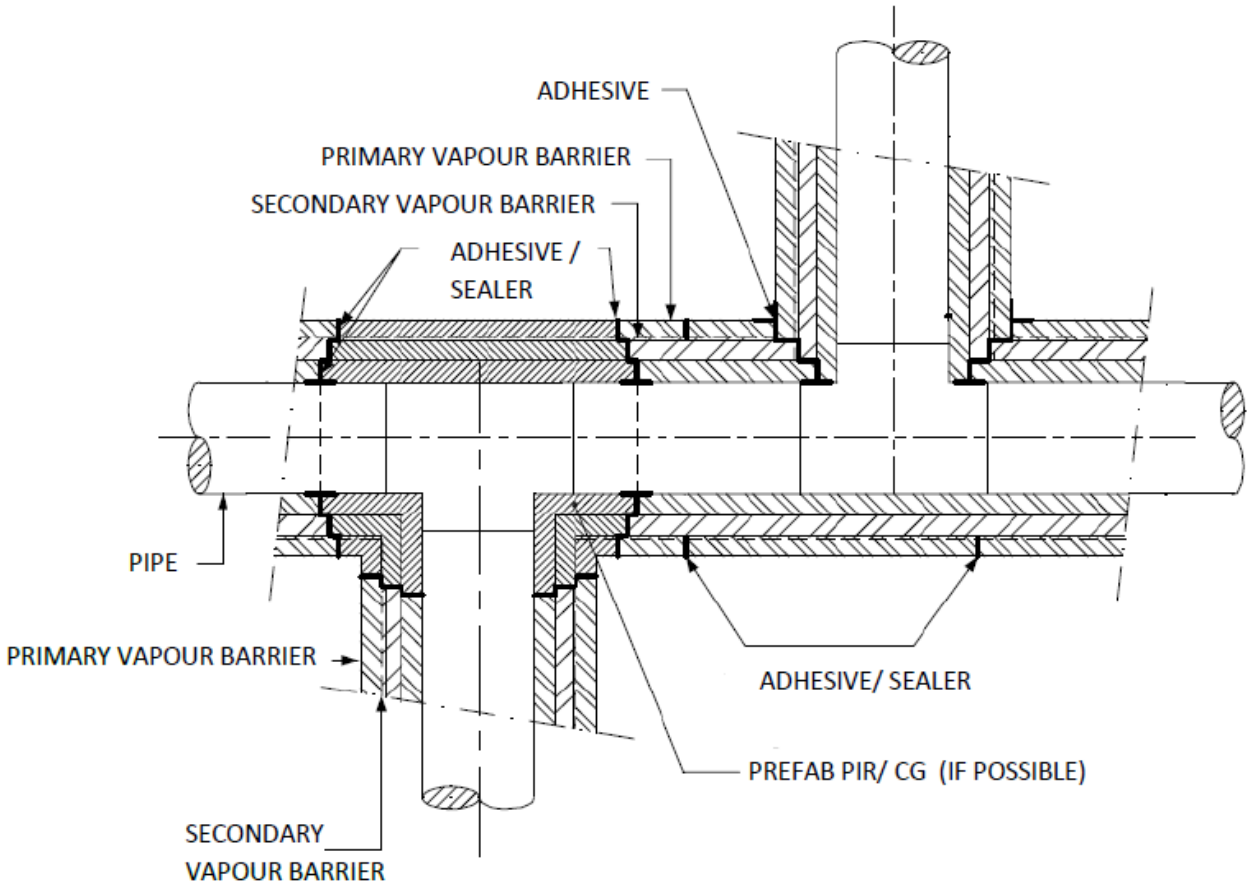

TYPICAL INSULATION DETAILS FOR T-PIECES (MULTIPLE LAYERS)

DRAWING NO.-20.2

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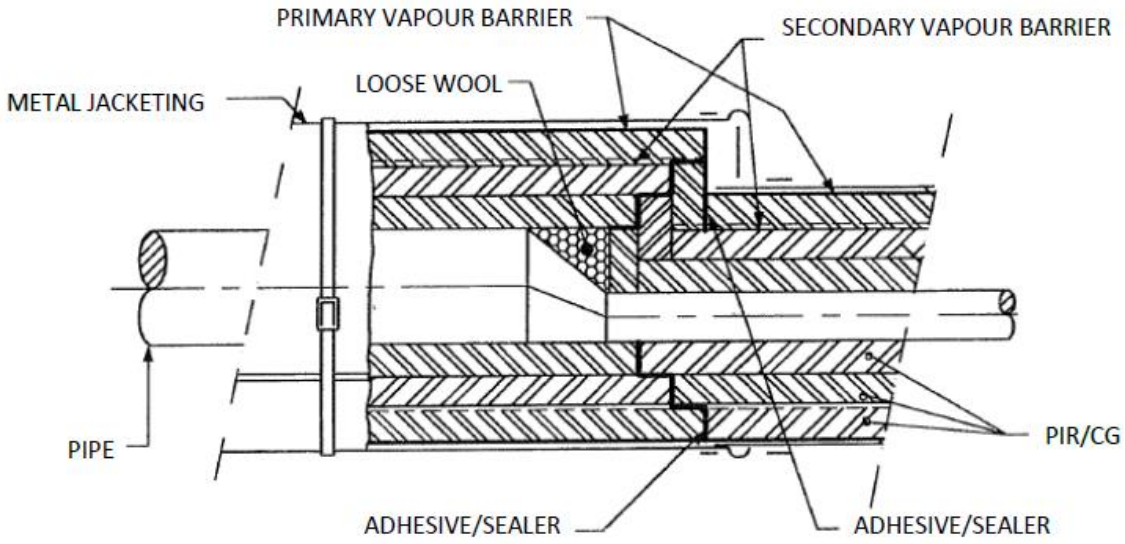
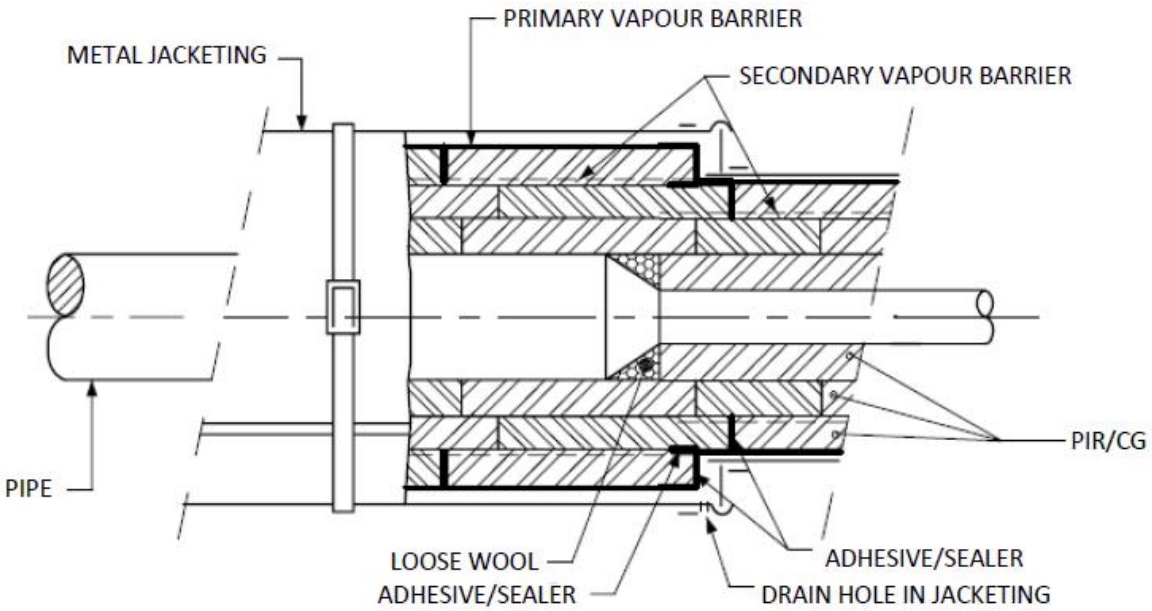


TYPICAL INSULATION DETAILS FOR ECCENTRIC REDUCER

DRAWING NO.-21.1



TYPICAL INSULATION DETAILS FOR CONCENTRIC REDUCER

DRAWING NO.-21.2

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रॉकवूल इन्सुलेशन के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR ROCKWOOL INSULATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	31-01-2024	ISSUED AS STANDARD SPEC.	SK	PP	PS	MN

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Abbreviations:

ASTM	:	American Society for Testing and Materials
IS	:	Indian Standard
min	:	shall indicate a minimum limit value
max	:	shall indicate a maximum limit value
SS	:	Stainless Steel
gsm	:	gram per square meter
ITP	:	Inspection Test Plan
IRN	:	Inspection Release Note
TPIA	:	Third party Inspection Agency

Refractory & Insulation Standards Committee

Convenor : Mr Prasenjit Saha

Members :
Mr Biswarup Sarkar
Mr P. Pal
Mr Udayan Chakravarty (Piping)
Mr Prag Goel (Fired Heaters)
Mr Ayush Mathur (Projects)
Mr Tarun Kumar (Equip Div)
Mr Neeraj Mathur (Inspection)
Dr Arijit Roy (Materials & Corrosion)
Mr Neeraj Rai (Pipeline)
Mr Indrajeet Neog (Construction)

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1.0 SCOPE

This standard specification outlines the technical requirements of Rock wool insulation products for external insulation of piping, vessels and equipment operating temperature from 27°C to 550°C for the purpose of heat conservation, personnel protection, fire safe and acoustic requirements.
Maximum use limit temperature referred above is based on EIL standard design practice followed over a period of time and do not refer the service temperature of material mentioned elsewhere in this specification.

2.0 GENERAL REQUIREMENTS

2.1 The term rock wool shall mean fibrous insulation wool made from natural rock and does not refer to products manufactured from slag or glass. Rock wool is a fibrous insulation made from molten rock, bonded with varying degree of resin or suitable binder. Rock wool is generally noncombustible and should not settle or shrink with age.

2.2 Rock wool shall meet the general classification of respective standards as mentioned below:

Rock wool type	Quality standard
Preformed pipe sections	ASTM C547 TYPE-II / IS 9842
Metal –mesh covered blanket	ASTM C592 CLASS-III/ IS 8183
Block and Board	ASTM C612/ IS 8183

2.3 Chemical and Physical test requirements

Rock wool insulation products shall meet the minimum technical requirements below specified in Table-1.

Table-1: Physical and Chemical Requirements of Rock wool Products

CHARACTERISTICS		MATERIAL TYPE		
		PIPE SECTIONS	BLANKET	BOARD & BLOCK
Service temperature (°C)		650	650	760
Nominal Density (kg/m^3), in acc. with ASTM C302 (pipe)/ ASTM C303 (Slab)/ASTM C167 (blankets)/IS 8183/IS 3144		140	128	192-320
Linear Shrinkage (%) at 550°C/ 24 hours as per ASTM- C-356, max.		2	2	2-4
Non fibrous shot (%) as per ASTM C-1335 / 3144, max		15	15	15
Water vapor sorption (%) as per ASTM C1104, max.		5	5	5
Compressive strength at 10% deformation (kPa) as per ASTM C165, min.		-	-	2.4 (Note-1)
Alkalinity, pH as per ASTM C-871		7-10	7-10	7-10
Leachable Chloride as per ASTM C-871, ppm, max.		10 (Note-2,3)	10 (Note-2,3)	10 (Note-2,3)
Test for incombustibility OR fire resistivity	Incombustibility as per 8183/IS 3144	Pass	Pass	Pass

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	OR Flame spread as per ASTM E84	25	25	25
Thermal Conductivity (W/mK) as per IS 3346 /ASTM C-177/ASTM C-518 at mean temperature, max.	(+) 100°C	0.052	0.052	
	(+) 200°C	0.070	0.068	
	(+) 250°C	0.085	0.080	
	(+) 300°C	0.10	0.090	
Note-1: When intended to use over tank roof the minimum compressive strength shall be 50kPa Note-2: Max. 20 ppm allowed for application over carbon steel and low alloy steel Note-3: Supplier shall provide Type test certificate no older than 2 years Note-4: Asbestos shall not be used as an ingredient or component part				

2.4 Additionally the product shall meet the following requirements:

a) For application over austenitic stainless steel, the material shall be zinc free and shall be inhibited with sodium silicate as per ASTM C-795.

b) For operating temperature up to 175°C and / or carbon steel / low alloy steel substrate metal mesh covered blanket shall have galvanized hexagonal shaped (25mm) wire-woven netting (min. 0.73mm dia.) on one side stitched with tie wires (min. 0.41mm dia.). Galvanization shall be minimum 30 gsm.

c) For operating temperature 176°C or above irrespective of the substrate, blanket metal facing shall be stainless steel as per ASTM A167 type SS304 with 25mm mesh and minimum wire diameter 0.8mm, stitched with 0.41mm dia. tie wire.

d) Irrespective of operating temperature for austenitic stainless steel and all Ni-alloys, Cu-Ni alloys and duplex stainless substrate, blanket metal facing shall be stainless steel as per ASTM A167 type SS304 with 25mm mesh and minimum wire diameter 0.8mm, stitched with 0.41mm dia. tie wire.

3.0 DIMENSIONS AND TOLERANCES

Rock wool insulation shall be supplied in the form of board, blankets, and pipe sections. Standard sizes of the board /block and pipe sections or segments shall be as per the respective standard specifications.
The average permissible variations for length, width and thickness shall be as follows:

Table-2: Dimensional tolerances for various Rock wool insulation products

Form of Insulation	Length (mm)	Width (mm)	Thickness	Inside Diameter
Block and Board	± 12.7	± 6.4	(-)1% or (-)2mm whichever is greater and (+) 3 mm	NA
Blankets	+ excess, -0	± 6	(-)1% or (-)2mm whichever is greater and (+) 3 mm	NA
Pipe sections	± 3mm	-	± 5% or ± 3mm whichever is greater	+ 4mm, -0

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4.0 INSPECTION & QUALITY CONTROL

Prior to dispatch, the insulation material shall be inspected by the Inspection Authority (TPIA or any other agency approved for certifying the quality) as per the approved 'Inspection test plan' (ITP). The ITP shall be prepared by the supplier and approved by competent authority (EIL or authorized agency) prior to inspection.

The ITP shall include reference of purchase order number and date, methods of tests followed, frequency of sampling, lot size and acceptance criteria with the permissible tolerances.

4.1 Sampling

a) Unless otherwise specified, the lot shall consist of all insulation material of same type, class, form, size and thickness produced under the same conditions (8 hours production).

b) The lot size for preformed board/block and pipe section shall be equal to the number of shipping packages. The lot size for blanket shall be based on the square-meter basis of material in a shipping packages. The test sample shall be randomly selected from the lot and tested for the conformity to the requirements of the specification. The lot size and sample size for preformed sections and blankets shall be as prescribed in Table-3 and Table-4 respectively.

Table-3: Sampling plan (Preformed Board / Block and Pipe Sections)

Lot Size (Shipping packages)	Sample Size (Shipping packages)
200	5
201-300	6
301-500	7
501-800	8
801-1300	9
1301 & Above	10

Table-4: Sampling plan (Blankets)

Lot Size (m^2)	Sample Size (Shipping packages)
1500 or less	5
1501 to 2500	6
2501 to 5000	8
5001 to 9000	13
9001 to 15000	15
15001 and Above	20

4.2 Inspection Test Plan

From each shipping package in the sample, test specimens necessary for carrying out the various tests specified in this standard for each form of material shall be taken are given in Table-5. The Inspection Authority (TPIA or any other approved agency) shall witness the minimum testing as per the Inspection Test Plan provided below.

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TABLE-5: INSPECTION AND TEST PLAN (ITP) FOR ROCK WOOL INSULATION

INSPECTION BODY		LEGEND		F- FREQUENCY	
1	Manufacturer	**I**- Inspection Point	**TC**-Test Certificate	**1**	Prior to start of Inspection
2	Contractor	**H**-Hold Point	**R**-Document Review	**2**	During Inspection
3	TPIA/EIL/Client	**W**-Witness Point		**3**	End of Inspection

Sl. No	Inspection Activity	Reference Documents	Acceptance Criteria	Extent of Inspection	Inspection responsibility			F
					1	2	3	
1	Document checking	Purchase order	-	-	**H**	-	-	**1**
2	Density	Approved data sheet	Compliance data sheet	5 specimen / Lot	**I, H**	**W**	**W**	**2**
3	Compressive strength (Note-1)	Approved data sheet	Compliance data sheet	5 specimen / Lot	**I, H**	**W**	**W**	**2**
4	Linear Shrinkage	Approved data sheet	Compliance data sheet	5 specimen / Lot	**I, H**	**W**	**W**	**2**
5	Non fibrous shot	Approved data sheet	Compliance data sheet	3 specimen / Lot	**I, H**	**W**	**W**	**2**
6	Water vapor sorption	Approved data sheet	Compliance data sheet	5 specimen / Lot	**I, H**	**W**	**W**	**2**
7	Thermal Conductivity (Note-2)	Approved data sheet	Compliance data sheet	1 specimen / Lot	**I, H TC**	**R**	**R**	**2**
8	Leachable Chloride	Approved data sheet	Compliance data sheet	3 specimen / Lot	**I, H**	**W**	**W**	**2**
9	Alkalinity, pH	Approved data sheet	Compliance data sheet	3 specimen / Lot	**I, H**	**W**	**W**	**2**
10	Incombustibility	Approved data sheet	Compliance data sheet	1 specimen / Lot	**I, H**	**W**	**W**	**2**
11	Flame spread Index (Note-2)	Approved data sheet	Compliance data sheet	1 specimen / Lot	**I, H TC**	**R**	**R**	**2**
12	Dimensional check	Purchase Order	Conformity report	Note-3	**I, H**	**W**	**W**	**2**
13	Quantity Verification	Purchase Order	Conformity report	-	**I, H**	**W**	**W**	**3**
14	Packing Inspection	-	-	Packing protection	**I, H**	**W**	**W**	**3**
15	Issue of Inspection Release Note (IRN)	-	-	-	**I, H**	**I, H TC**	**I, H TC**	**3**

Note-1: Compressive strength is applicable only for Rock wool Board & Block

Note-2: Independent laboratory test certificate no older than 2 years

Note-3: Apart from Physical / Chemical characteristic check, dimension check shall also be performed. The number of dimensional check shall be at the discretion of TPIA / EIL / Client. However, the minimum number of dimensional check shall be 10.

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4.3 Criteria for conformity

The acceptance/rejection criteria for material is determined by average physical and chemical properties for each sample, which shall fully meet the criteria enumerated in compliance datasheet produced by the manufacturer. In the event a sample fails to conform the specified requirements and test results are within 10% of the acceptable values, manufacturer may propose a re-testing program for the non-conformance batch or production run to Purchaser for approval. The retest shall be conducted using a new sample representing the same pallet(s) of the same batch of insulation as the failed sample. Use the same testing facility, testing procedure, and inspection methods. If the retest is unsuccessful, the material represented by the sample(s) shall not be used.

4.4 Certificate of conformity

The supplier shall furnish a 'certificate of compliance' along with the certified material test record after the inspection. The certified material test record should contain the following information as minimum:

- ✓ Name of the manufacturer
- ✓ Certificate number and date of issue
- ✓ Material specification/designation
- ✓ Production batch /code number (Lot, control number)
- ✓ Quantity
- ✓ Purchaser's reference number
- ✓ Test and Inspection results
- ✓ Name, designation and signature of person authorizing the certificate

5.0 PACKING AND MARKING

The Rock wool insulation materials shall be packaged for shipment such as to ensure that the material will not be damaged by weather humidity and normal handling during shipment. The certified material/conforming material shall be clearly marked either on the product or on the label or on the packing with the following information:

- ✓ Product name and other identifying characteristics (grade, dimensions etc.)
- ✓ Purchase order number
- ✓ Quantity
- ✓ Date of manufacturing
- ✓ Manufacturer name, address and telephone number
- ✓ Destination
- ✓ Country of origin

6.0 STORAGE

The material shall be stored in warehouse or dry covered area to avoid water ingress or moisture. Storage shall be on an elevated, ventilated platform. Moisture shall be directed away from the insulation material.

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7.0 REFERENCE CODES & STANDARDS

ASTM Standards and Specifications

ASTM C165	Measuring Compressive Properties of Thermal Insulations
ASTM A167	Specification for Stainless and Heat-Resisting Chromium Nickel Steel Plate, Sheet and Strip
ASTM C177	Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
ASTM C302	Standard Test Method for Density and Dimensions of Preformed Pipe-Covering-Type Thermal Insulation
ASTM C303	Standard Test Method for Dimensions and Density of Preformed Block and Board–Type Thermal Insulation
ASTM C356	Standard Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat
ASTM C390	Standard Practice for Sampling and Acceptance of Thermal Insulation Lots
ASTM C518	Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
ASTM C547	Standard Specification for Mineral Fiber Pipe Insulation
ASTM C592	Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type)
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 C1104	Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation
ASTM C1335	Standard Test Method for Measuring Non-Fibrous Content of Man-Made Rock and Slag Mineral Fiber Insulation
ASTM E84	Standard Test Method for Surface Burning Characteristics of Building Materials

EIL Standards and Specifications

6-79-0022	Standard Specification for Acoustic Insulation
6-79-0026	Standard Specification for Hot Insulation of Vessels, Piping and Equipment

IS Standards and Specifications

IS 3144	Mineral Wool Thermal Insulation Materials-Method of Test
IS 3346	Method for the Determination of Thermal Conductivity of Thermal Insulation Materials (Two Slab, Guarded Hot Plate Method)
IS 8183	Bonded Mineral Wool-Specification
IS 9842	Preformed Fibrous Pipe Insulation Specification

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विक्रेता कार्यशाला में सकारात्मक सामग्री पहचान के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR POSITIVE MATERIAL IDENTIFICATION (PMI) AT SUPPLIER'S WORKS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	23.12.21	REVISED AND RE-ISSUED	HKM	CS	RK	S Majumdar
3	19.09.16.	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
2	20.10.11	REVISED AND RE-ISSUED	RKS	SCG	AKC	DM
1	15.07.08	REVISED AND RE-ISSUED	NKR	SSL	SKP	VC
0	07.12.00	ISSUED AS STANDARD SPECIFICATION	AKC	AKB	AKB	MI

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Abbreviations:

API	:	American Petroleum Institute
AS	:	Alloy Steel
HIC	:	Hydrogen Induced Cracking
LSTK	:	Lump Sum Turn Key
NACE	:	National Association of Corrosion Engineers
PMI	:	Positive Material Identification
RTJ	:	Ring Type Joint
Sch	:	Schedule
SS	:	Stainless Steel
TPI or TPIA	:	Third Party Inspection Agency

Inspection Standards Committee

Convenor: Mr. Rajeev Kumar

Members: Mr. Rajesh Sinha
Mr. Himangshu Pal
Mr. R. Muthuramalingam (RPO Representative)
Mr. Chandrashekhar
Mr. Avdhesh Agrawal
Mr. P V Satyanarayana (Engg. Representative)
Mr. Mahendra Mittal

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7.0 ACCEPTANCE CRITERIA 6
8.0 REJECTION CRITERIA 7
9.0 RECORDING AND DOCUMENTATION 7
10.0 MARKING 7

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1.0 SCOPE

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

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

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

1.3.1 For alloy Steel materials as below:

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

1.3.2 For Carbon Steel materials as below:

- All Carbon Steel Piping items under NACE or HIC or H2 or Wet Hydrogen Sulfide (H_2S), Hydrofluoric acid (HF), Sulfuric acid (H_2SO_4) services etc.
- Carbon Steel flanges and valves (Rating 900# and above)
- LTCS items

Following items shall be excluded from scope of PMI examination.

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

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

2.0 REFERENCE DOCUMENTS

2.1 API Recommended Practice 578 (Third Edition, Feb 2018) - Material Verification Program for New and Existing Alloy Piping Systems.

3.0 DEFINITIONS

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

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

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3.3 **Alloy Material:** Any metallic material (including welding filler materials) that contains alloying elements such as Chromium, Nickel, Molybdenum or Vanadium, which are intentionally added to enhance mechanical or physical properties and/or corrosion resistance.

4.0 PMI EXAMINATION

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

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

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

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

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

5.0 ACCEPTABLE METHODS FOR PMI

5.1 The method used for PMI examination shall provide a quantitative determination of the alloying elements like Chromium, Nickel, Molybdenum or Vanadium in Alloy Steel items.

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

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

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

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

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

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

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

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5.9 The surfaces to be examined shall be prepared by light grinding or abrasive paper and solvent cleaner. Evidence of Arc burn resulting from examination shall be removed by light grinding or abrasive paper. No permanent marks, which are injurious to the usage of product in service, are acceptable.

5.10 Alloy Steel ring type joint Gaskets shall be inspected by using portable X-Ray fluorescence instrument.

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

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

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

6.0 EXTENT OF PMI EXAMINATION

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

A. Flanges, Fittings Valves, RTJ Gaskets - 100% by Supplier and 10% @ random witness by EIL/TPIA

B. Pipes - 100% (for pipes procured from traders)
2 random samples drawn from each Size/Heat/Lot (for pipes procured directly from mills)

C. Fasteners -

Lot Size	**Sample Size for** EIL/TPIA	Sample size for Supplier
Upto 100	2% (Min 2)	Min 10%
101 to 500	1% (Min 3)	Min 10%
501 and above	0.5% (Min 5)	Min 10%

Note:

a. For Welded Pipes and Fittings and flanges like Fig 8, Spacer and blinds etc. PMI shall be performed on Base Metal as well as weldments.

7.0 ACCEPTANCE CRITERIA

7.1 Base Metal

PMI test results showing presence of characteristic elements upto 10% less than the minimum specified value in the material specification and upto 10% more than the maximum specified value in the material specification shall be acceptable.

7.2 Deposited Weld Metal

For deposited weld metal using welding consumables matching with base metals, the recorded presence of characteristic elements upto 12.5% less than the minimum specified value in the

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welding consumable specification and upto 12.5% more than the maximum specified value in the welding consumable specification shall be acceptable.

8.0 REJECTION CRITERIA

8.1 If PMI test results fall outside the acceptable range as specified in 7.0 above, the supplier shall obtain a quantitative check analysis performed by a laboratory acceptable to Owner / EIL / TPIA for a complete chemical analysis. Alternatively, the item can be tested with a spark analyser for verification. Results of this analysis shall be submitted to Owner / EIL / TPIA for final decision.

Decision of Owner / EIL / TPIA shall be final in this regard.

8.2 If any sample drawn to PMI test on the basis of percentage selection as per 6.0 above, fails to meet specification requirements, 100% of items of lot shall be tested for PMI by supplier. Any failure thereafter during sample check shall mean rejection of whole lot.

9.0 RECORDING AND DOCUMENTATION

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

10.0 MARKING

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

a) Bar Code/Hologram Sticker
b) A low stress stamp marking

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	POSITIVE MATERIAL IDENTIFICATION REPORT BULK MATERIALS							Page of
Project:		Client						Job No.
PMI Report No.		Supplier/Sub-Supplier						
Purchase Order No.		Testing Agency						
Purchase Requisition No:		PMI Location						
Bulk Item Type (as per Requisition)								
Material Specification/Grade Number of items in Lot								
Requisition Item No./ Description		Major content, Weight Percent						Remarks Accept/Reject
Element	Cr	Ni	Mo	V	Ti *	Cb/ Nb **	Mn ***	
Specified Range								
Actual observations 1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
Instrument Type / ID Last Service Date		Inspection Agency						Witnessed By

* To be reported in case of SS321 Material
** To be reported in case of SS347 Material
*** To be reported in case of LTCS Material

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निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
WELDED PIPES

Rev. No.	Date	Purpose	Prepared By	Checked By	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.12.2021	REVISED AND RE-ISSUED	HKM	CS	RK	S Mazumdar
5	19.09.2016	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
4	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
3	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
2	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND

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Abbreviations:

CEIL	:	Certification Engineers International Limited	MRT	:	Mechanical Run Test
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NPSH	:	Net Positive Suction Head
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DPT	:	Dye Penetrant Testing	PESO	:	Petroleum Explosive Safety Organization
DHT	:	De-hydrogen Heat Treatment	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification
MTC	:	Material Test Certificate			

Inspection Standards Committee

Convenor : Mr. Rajeev Kumar

Members:

Mr. Rajesh Sinha
Mr. Chandrashekhar
Mr. Mahendra Mittal
Mr. Himangshu Pal
Mr. Avdhesh Agrawal
Mr. R. Muthuramalingam (RPO Representative)
Mr. P V Satyanarayana (Engg. Representative)

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements for Welded Pipes.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedure**						
1.1	Hydrostatic Test, Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ (Approved under EIL/Reputed TPIA)	Welding Parameters & Qualification Record	100%	WPS,PQR &WPQ	-	H	W- New R- Existing (Qualified under reputed TPIA)
2.0	**Material Inspection**						
2.1	Raw Material Inspection	Review of MTC for Chemical & Mechanical Properties	100%	Test Certificates	-	H	R

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	**In Process Inspection**						
3.1	Welding	Welding Parameters as per WPS / PQR	100%	Inspection Reports	-	H	-
3.2	Heat Treatment	Stress Relieving, Normalizing, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart	-	H	R
3.3	Ferrite Check of SS Pipes (as Applicable) Before HT	% Ferrite Check	Random On Weld	Inspection Report	-	H	R
3.4	UT / RT As applicable	Surface & Internal Imperfections	PR / Purchase Specification	RT Films, Reports & UT Reports	-	H	R (Film review for RT)
3.5	TPM (Identification of Test Samples)	Product analysis, Tensile, Hardness, Impact, IGC and Other test as applicable	Lot as per specification.	Test Reports	-	H	H
3.6	Product Analysis	Chemical Composition	PR / Purchase Specification	Test Reports	-	H	R
3.7	Destructive Testing	Tensile (0.2 Offset/0.5% extension under load), Hardness, Impact, IGC and Other test as applicable	Lot as per specification.	Test Reports	-	H	H

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.8	Galvanizing (If Applicable)	Integrity Of Galvanized Coating	100%	Inspection Report	-	H	R
4.0	**Final Inspection**						
4.1	Hydrostatic Testing	Leak Check	100%	Test Report	-	H	RW (Min.5%)
4.2	Visual and Dimensional Inspection (VDI)	Surface Condition, Straightness, End Finish, Bevel Angle, Root Face, Outer Dia., Profile Thickness, Length, End Finish, Marking etc	100%	Inspection Report	-	H	RW (Min.5%)
4.3	Weight Checking as applicable	Weight	100%	Inspection Report	-	H	-
4.4	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.5	Final Stamping	Stamping of Accepted Pipes	Stamping of Pipes which are witnessed by EIL/TPIA.	Inspection Report	-	H	H

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.0	**Painting**						
5.1	Rust Preventive Coating & Color Coding (As applicable)	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Manufacturer TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable (Unless otherwise agreed upon).
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred therein /Job Specification /Approved Documents.
3. For orders placed on stockist, items shall be accepted based on manufacturer's TC with EN10204 type 3.2 certification from EIL approved suppliers.

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निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
BOLTING MATERIAL

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
5	23.12.2021	REVISED AND RE-ISSUED	HKM	CS	RK	S Mazumdar
4	19.09.2016	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
3	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
1	28.09.2007	REVISED AND RE-ISSUED	PD	RB	MVKK	VC

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Abbreviations:

CEIL	:	Certification Engineers International Limited	MRT	:	Mechanical Run Test
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NPSH	:	Net Positive Suction Head
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DPT	:	Dye Penetrant Testing	PESO	:	Petroleum Explosive Safety Organization
DHT	:	De-hydrogen Heat Treatment	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification
MTC	:	Material Test Certificate			

Inspection Standards Committee

Convenor Mr. Rajeev Kumar

Members:

Mr. Rajesh Sinha	Mr. Himangshu Pal	Mr. R. Muthuramalingam (RPO Representative)
Mr. Chandrashekhar	Mr. Avdhesh Agrawal	Mr. P V Satyanarayana (Engg. Representative)
Mr. Mahendra Mittal		

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Bolting Material.

2.0 REFERENCE DOCUMENTS

PO/PR/ Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedure**						
1.1	Heat Treatment & NDT Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
2.0	**Material Inspection**						
2.1	Raw Material Inspection	Chemical, Mechanical properties, Steel making process, Macro Etch, etc.	100% one no. per heat per size	Mill Test Certificates/ Lab Reports	H	H	R
3.0	**In Process Inspection**						

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.1	Thread Rolling, Hot forging of Nuts/Bolt Heads, Machining	Process Parameters	100%	Inspection Report	-	H	-
3.2	Heat Treatment	Normalising & Tempering, Quenching & Tempering Solution Annealing, Stabilization Heat Treatment, Strain Hardening, Nitriding etc. as applicable	100%	Heat treatment process records /charts	-	H	R
3.3	NDT (as applicable)	Defects detection	100%	Test Reports	-	H	R
3.4	TPM Identification of Test Samples	Product Analysis, Proof Load Test , Stress Rupture, Tensile, Hardness, Impact, and Other test as applicable	Lot as per specification.	Test Reports	-	H	H
3.5	Chemical Testing	Chemical analysis	Lot as per specification.	Test Reports		H	H

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.6	Mechanical Testing	Mechanical (0.2 Offset/0.5% extension under load), Hardness, Proof Load Test for Nuts (as applicable) , Stress Rupture (As Applicable), Impact and Other test as applicable	Lot as per specification.	Test Reports	-	H	H
3.7	Galvanizing (If Applicable)	Integrity of Galvanised Coating	100%	Inspection Report	-	H	R
4.0	**Final Inspection**						
4.1	Visual & Dimension	Visual Marking & Dimensions	100% by supplier & Random by EIL/ TPIA	Inspection Report	-	H	RW (Note-3)
4.2	Final Stamping	Stamping of Accepted Bolting Material	Stamping of bolting material which are witnessed by EIL/TPIA. Others to have supplier's identification.	Inspection Report	-	H	RW (Note 3)

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.3	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW (Note 3)
5.0	**Painting**						
5.1	Rust Preventive & Color Coding (as applicable)	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness {As specified or NOTE 3), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

Notes (as applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable (unless otherwise agreed upon).
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred therein /Job Specification /Approved Documents.
3. Final visual and dimension And PMI Check shall be checked as per below sampling plan:

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Lot Size (Nos.)	Sample Size (Minimum) for EIL/TPIA	Sample size (Min) for Supplier
Upto 100	2% (Min. 2 Nos.)	10%
101 to 500	1% (Min. 3 Nos.)	10%
501 and above	0.5% (Min. 5Nos.)	10%

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निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
CHAIN PULLEY BLOCK / WINCH

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
4	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
3	09.09.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	10.04.12	REVISED AND RE-ISSUED	SK	SCG	AKC	DM
1	31.01.08	REVISED AND RE-ISSUED	CS	RB	MVKK	VC
0	23.07.02	ISSUED FOR IMPLEMENTATION	SKT	NKN	AKB	GRR

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Abbreviations:

BIS	:	Bureau of Indian Standards	MTC	:	Material Test Certificate
CEIL	:	Certification Engineers International Limited	MRT	:	Mechanical Run Test
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NPSH	:	Net Positive Suction Head
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DPT	:	Dye Penetrant Testing	PESO	:	Petroleum Explosive Safety Organization
DHT	:	De-hydrogen Heat Treatment	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification

Inspection Standards Committee

Convenor: Mr. R.K. Singh

Members:

Mr. Rajesh Sinha
Mr. Chandrashekhar
Mr. Mahendra Mittal
Mr. Himangshu Pal
Mr. Avdhesh Agrawal
Mr. R. Muthuramalingam (RPO Representative)
Mr. Shishupal Choudhary (Engg. Representative)

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1.0 SCOPE:

This Inspection Test Plan covers the minimum testing requirements of Chain Pulley Block / Winch

2.0 REFERENCE DOCUMENTS:

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Material Procurement**						
1.1	Trolley & Chain Pulley Block Plates	Chemical & Physical	One Sample Per Lot/Heat	Test Certificates	H	R	R
1.2	Wire rope	Strand configuration, size & tensile strength	Per drum / length	Manufacturer's Test Certificate	H	R	R
1.3	Hook	Load & Proof load test, Chemical, Physical, HT & NDT	100%	Manufacturer's Test Certificate	H	R	R
1.4	Gears/Ratchet Pawl/ Wheel	Chemical Composition	One Sample Per Lot/Heat	Manufacturer's Test Certificates	H	R	R
2.0	**In-process Inspection**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.1	Hooks	Proof load	100%	Manufacturer's Test Certificates	-	H	-
2.2	Load Chain / Wire Rope	Proof load	100%	Manufacturer's Test Certificates	-	H	-
2.3	Ratchet Pawl	Hardness	100%	Inspection Report	-	H	-
3.0	**Final Inspection**						
3.1	Complete Assembly	Load & Proof Load test	100%	Inspection Report	-	H	RW
		Operational Effort	100%	Inspection Report	-	H	RW
		Lift	100%	Inspection Report	-	H	RW
		Statutory certification / BIS License, if any	100%	Test Certificate/ License	-	R	R
4.0	**Painting**						
4.1	Panting (As applicable)	Visual & Dry Film Thickness	100%	Inspection Report	-	W	-
5.0	**Documentation and IC**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.1	Final stamping, review of inspection documents and issue of IC	Verifying stamping details and review of inspection documents	100%	IC / Inspection reports	-	H	H
5.2	Final documents as per PR	Verification & compilation of inspection & test records for submission to customer	100%	Final dossier	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (as applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.

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निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
CHAIN PULLEY BLOCK / WINCH

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
5	09.04.2026	REVISED AND RE-ISSUED	SG	TKK	HP	NK
4	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
3	09.09.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	10.04.12	REVISED AND RE-ISSUED	SK	SCG	AKC	DM
1	31.01.08	REVISED AND RE-ISSUED	CS	RB	MVKK	VC
0	23.07.02	ISSUED FOR IMPLEMENTATION	SKT	NKN	AKB	GRR

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Abbreviations:

BIS	:	Bureau of Indian Standards	MTC	:	Material Test Certificate
CEIL	:	Certification Engineers International Limited	MRT	:	Mechanical Run Test
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non-Destructive Testing
CE	:	Carbon Equivalent	NPSH	:	Net Positive Suction Head
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DPT	:	Dye Penetrant Testing	PESO	:	Petroleum Explosive Safety Organization
DHT	:	De-hydrogen Heat Treatment	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification

Inspection Standards Committee

Convener: Mr. Himagnshu Pal

Members:

Mr. G Suresh
Mr. T Kamalakannan
(RPO- Representative)

Mr. R. Muthuramalingam
Mr. Shishupal Choudhary
(Engg. Representative)

Mrs. Rajeshwari Venkatasubramanian
Mr. Themballi Vasu

Mr. Aravaazhi V

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1.0 SCOPE:

This Inspection Test Plan covers the minimum testing requirements of Chain Pulley Block / Winch

2.0 REFERENCE DOCUMENTS:

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Material Procurement**						
1.1	Trolley & Chain Pulley Block Plates	Chemical & Physical	One Sample Per Lot/Heat	Test Certificates	H	R	R
1.2	Wire rope	Strand configuration, size & tensile strength	Per drum / length	Manufacturer's Test Certificate	H	R	R
1.3	Hook	Load & Proof load test, Chemical, Physical, HT & NDT	100%	Manufacturer's Test Certificate	H	R	R
1.4	Gears/Ratchet Pawl/ Wheel	Chemical Composition	One Sample Per Lot/Heat	Manufacturer's Test Certificates	H	R	R
2.0	**In-process Inspection**						

Signature Not Verified
Digitally signed by ARITRA DE
Date: 2026.05.18 16:53:02 IST
Location: eProcure-EPROC

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