

वैसल्स, पाइपिंग तथा इक्वीपमेंट्स के
ऊष्ण इन्स्यूलेशन हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR HOT INSULATION OF VESSELS, PIPING AND EQUIPMENTS

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Abbreviations:

Ih	:	Insulation for heat conservation
It	:	Insulation for steam traced surfaces
Ie	:	Insulation for electrically traced surfaces
Is	:	Insulation for personal safety
Ij	:	Insulation for steam jacketed surfaces

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CONTENTS

NO.	TITLE	PAGE
1.	GENERAL.....	5
1.1	Scope.....	5
2.	DESIGN BASIS	5
2.1	Criteria	5
2.2	Extent of Insulation on Piping Systems	6
2.3	Extent of Insulation on Equipments.....	7
3.	MATERIALS	8
3.1	General.....	8
3.2	Insulation Materials	8
3.2.1	Fibrous Material (Rockwool & Glasswool).....	8
3.2.2	Rigid Materials (Calcium Silicate, Expanded Perlite, Polyisocyanurate/ Polyurethane Foam Blocks & Cellular Glass	9
3.2.3	High Temperature Insulation Materials (Above 550°C).....	12
3.2.4	Insulation Material for Impulse lines.....	13
3.2.5	Additional tests/checks for Materials	13
3.2.6	Quality Assurance Plan (QAP).....	14
3.3	Weather Protection Jacket	14
3.4	Ancillary Material.....	15
3.4.1	Securement Bands	15
3.4.2	Rivets.....	16
3.4.3	Screws.....	16
3.4.4	'S' & 'J' Clips.....	16
4.	APPLICATION	16
4.1	General.....	16
4.2	Piping.....	18
4.3	Horizontal Equipments	22
4.4	Vertical Equipments	23
4.5	Flange, Nozzle, Channel Cover, Manway and Handhole Flanged Cover	24
4.6	Irregular Surfaces such as Pump, Compressor, Turbine etc.	24
4.7	Vertical Storage Tanks.....	25
4.8	Horton Spheres	26
4.9	Inspection Windows	27
4.10	Impulse Lines.....	27
5.	INSULATION FINISH	28
5.1	General.....	28
5.2	Piping.....	28
5.3	Equipments	29
5.4	Vertical Storage Tanks.....	30
5.5	Horton Sphere.....	31
6.	GUARANTEE AND TEST CERTIFICATES	32
7.	REFERENCE CODES AND STANDARDS	32

FIGURES

NO.	DESCRIPTION
1.	Pipe Insulation Details (Fibrous & Rigid Insulation)
2.	Pipe Insulations: Method of staggering of sections Rigid & Fibrous Insulation (Preformed Pipe Sections only)
3.	Horizontal Pipe: Fibrous Mattress Insulation; Detail of Spacer Rings for Cladding Support
4.	Detail of Spacer Ring Fibrous Insulation (Mattress)
5.	Bolted Insulation Support for Vertical Pipe
6.	Insulation Details for Bends / Elbows
7.	Insulation Details: Pipe Bends & Elbows
8.	Insulation Details: Pipe Branched & Reducers
9.	Insulated Removable Cover: Valves
10.	Insulation Removable Cover: Flanged Joints
11.	Insulation Details: Pipe Supports
12.	Insulation for Steam Traced Piping
13.	Horizontal Equipment Insulation
14.	Horizontal Equipment Heads
15.	Use of Flexible Insulation in combination with Rigid Insulation to compensate for Vessel Expansion
16.	Insulation details: Vertical Vessel
17.	Insulation Details: Vertical Vessel Heads
18.	Insulation Details: Vertical Vessels
19.	Insulation Details: Vertical Storage Tank
20.	Insulation Details: Sphere

1.0 GENERAL

1.1 SCOPE

- 1.1.1 This specification covers design and material requirements for above ground, external insulation of piping and equipment operating between ambient temperature and 760°C for the purpose of heat conservation, process stabilization, temperature maintenance, personnel protection and fire protection. Wherever necessary this specification indicates the basis for selecting a criterion.
- 1.1.2 This specification is suitable for use in normal process plant atmospheres. Alternative designs and materials would be specified if necessary for corrosive atmosphere or potential leaks and spills of chemicals.
- 1.1.3 All the codes/standards mentioned in this specification shall be of latest issue.
- 1.1.4 This specification does not cover cold service insulation. For cold services, Specification 6-44-0003 is applicable.
- 1.1.5 This specification does not cover insulation for boiler or fired heaters and associated air heaters, economizers, flue ducting and air ducting.
- 1.1.6 Piping, equipment, storage tanks & vessels requiring insulation and the temperatures (operating temperatures) shall normally be specified, as applicable, on the following project documents:
- Piping and Instrument Diagrams (P&IDs) and Line Lists.
 - Piping General Arrangement Drawings & Isometrics.
 - Instrument Piping Details and Schedules.
 - Vessel, Exchanger, Storage Tank and sphere documents and Insulation Schedules.
 - Equipment suppliers General Arrangement Drawings for equipment items in Package plant.

2.0 DESIGN BASIS

2.1 CRITERIA

- 2.1.1 Insulation thickness tables are based on heat loss criteria. For various parameters considered for insulation thickness calculations 'Guideline for selecting insulation material & thickness', Document No. 7544-02-41-GL-56 may be refereed. **Selected 'Insulation thickness tables' for a particular job shall be as per 'Job Process design basis'.**
- 2.1.2 Insulation is required for any of the following purposes, as indicated in P&IDs and line lists:
- Heat conservation
 - Process stabilization to assist process control.
 - Steam tracing
 - Electric tracing
 - Hot water or solvent tracing (liquid)
 - Hot oil tracing
 - Steam jacketing
 - Hot water or liquid jacketing

- Hot Oil Jacketing
- Fire protection
- Personnel protection.

2.1.3 Insulation for 'Personnel protection' is applicable where exposed surface temperatures exceed 65°C in normal or short-term operating conditions. Over internally insulated piping and equipments, provide open mesh metal guards and for surfaces which are not internally insulated, provide insulation on those parts of surfaces with which operating and maintenance personnel may come in contact while performing routine duties. The actual extent of insulation shall be determined by Field Construction Personnel and/or operating personnel using the criteria that the exposed surfaces located within 600mm horizontally or 2100mm vertically of a normal access, walkway or work area are to be insulated.

2.1.4 Internally refractory lined piping and equipment and any other items for which heat loss is essential shall not be insulated. (See para 2.3.6).

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

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

2.2 EXTENT OF INSULATION ON PIPING SYSTEMS

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

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

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

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

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

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

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

- Piping which becomes hot intermittently, such as relief valves, vents, steam-out and snuffing steam systems, flare and blowdown systems.
- Steam condensate lines downstream of steam traps discharging to drainage system, unless otherwise mentioned.
- Supports for piping, excluding pipe hangers to the extent covered by insulation.

- Steam Traps (except as noted in paragraph 2.2.3).
- Valves, including control valves and flanges in process piping systems (except as noted in paragraph 2.2.2). However, personnel protection insulation for these items shall be applied, as required.
- Pipe Union fittings.
- Thermowell bosses, temperature and pressure tapings.
- Expansion joints, hinged joints and hose assemblies
- Sight flow indicators.
- Flange joints in Hydrogen service.

2.3 EXTENT OF INSULATION ON EQUIPMENTS

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

2.3.2 Support skirts of insulated vertical vessels of 1200mm and less shall be insulated externally only, as described in para 2.3.1.

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

2.3.4 Turbines shall be insulated for heat conservation.

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

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

- Pumps with operating temperature below 200°C unless pumped fluid has a pour point above minimum design ambient temperature.
- Fans, compressors and blowers.
- Liquid ends of pumps except as noted in the paragraph 2.3.5 above.
- Internally insulated or refractory lined equipment unless specially designed for metal temperature control.
- Heads of vessels enclosed by support skirts with vessel diameters 1200mm and less.
- Internal surfaces of insulated vessel support skirts with vessel diameter 1200mm or less.
- Turbine casings to be insulated shall exclude shaft seal caps, shaft bearing housings, throttle valves, governors and supports.
- Exchanger channel and covers; shell and channel flanges & Exp. Joints.
- Nozzles flanges, manholes, handholes and flanges of equipment.

- Surfaces of coolers and condensers.
- Nameplates of all equipment items.
- Thermowell bosses, temperature and pressure tapings.

3.0 MATERIALS

3.1 GENERAL

- 3.1.1 Insulation materials shall be as per specifications described in para 3.2. **Selected material(s) for a particular job shall be as per Process Design Basis.**
- 3.1.2 All materials shall be of high quality and good appearance. Insulation materials shall be of low chloride content, chemically inert, non-sulphurous, rot proof, vermin proof, impervious to hot water and steam, non-injurious to health and non-corrosive to steel and aluminium (even if soaked in water at ambient temperatures for extended periods).
- 3.1.3 The use of insulation or finishing materials containing ASBESTOS in any form is not permitted.
- 3.1.4 No inflammable material shall be attached to the insulation.
- 3.1.5 Fibrous insulants, calcium silicate, perlite and ceramic fibres can be used for the full temperature range mentioned against the respective material, for all applications except for electrically heated applications.
- 3.1.6 For electrically heated applications Polyurethane foam (PUR) or Polyisocyanurate (PIR) blocks shall be used in combination, with rockwool as inner layer.
- 3.1.7 For low operating temperature (upto 125°C) services a suitable moisture barrier shall be used.
- 3.1.8 Insulation materials to be used over austenitic stainless steel surfaces shall be zinc free and shall be inhibited with sodium silicate as per ASTM C-795. The amount of leachable chloride in the insulation material (except for calcium silicate) before application shall not exceed 10ppm. In case of calcium silicate it should not exceed 50ppm. For the chemical analysis of insulation materials ASTM C-871 shall be referred.
- 3.1.9 Dimensions and dimensional tolerances for pipe sections, mattresses & slabs shall generally be as per respective codes unless otherwise mentioned. The number of pieces to be used shall be as less as possible. When installed the insulation shall fit snugly and shall have a tight joint.
- 3.1.10 The insulation materials shall be as per ASTM/BS standards/codes for overseas jobs unless otherwise specified.

3.2 INSULATION MATERIALS

3.2.1 Fibrous Materials (Rockwool & Glass Wool)

- 1 Shall be a preformed insulation and shall be of long fibred rock or glass material processed from a molten state into fibrous form bonded with a binder and suitable for the intended operational temperature range from ambient to 550°C and 350°C for rockwool and glasswool respectively. Slagwool is not acceptable.

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

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

- 3 Insulation shall conform to the requirements of respective codes, unless otherwise specified herein and shall be tested and test certificates on representative samples furnished as per IS:8183/IS:9842/ASTM:C547/ ASTM:C592 /ASTM:C612.

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

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

- 1 Calcium Silicate

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

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

2 Expanded Perlite

Insulation shall be block form and pipe sections in accordance with ASTM C 610. It shall be compounded from expanded perlite & sodium silicate binder and shall be suitable for temperatures upto 550°C. Insulation shall conform to requirements of respective codes, unless otherwise specified herein and shall be tested and test certificates on representative samples furnished as per ASTM C 610.

• Bulk Density(min)	192 kg/m ³ . Test as per ASTM C302 (pipe) & ASTM C303(block)	
• Compressive Strength (for blocks only) at 5% deformation	412 kPa(Min). Test as per ASTM C165.	
• Apparent Thermal Conductivity	Shall be as given below: Test method shall be as per ASTM C177/C518 (Block) & ASTM C335 (Pipe)	
	Mean Temp °C	Thermal Conductivity Max. W/mK
	93	0.079
	149	0.086
	204	0.095
	260	0.106
	316	0.111
	371	0.126
• Water Absorption of thermal insulation After heat aging & 48 hr water immersion, moisture gain, % by weight (max)	149	50
	260	50
	371	60

• Linear shrinkage	2%(max) at 649 ^o C for 24hrs
• Chloride content	For stainless steels, less than 10 PPM, for other materials not to exceed 20 ppm

3 Polyisocyanurate (PIR) / Polyurethane (PUR)

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

• Selection of samples for testing	As per ASTM C390 OR BS:2972 (Frequency of sampling clause IV). Unless otherwise stated, the test specimens shall be conditioned without external stress at 23±1°C and 50±2 percent relative humidity for a minimum of 24 hours before testing.		
• Density	40 to 64 kg/m³ To be tested as per ASTM C303 for Block-type and ASTM C302 for pipe covering.		
• Thermal Conductivity	Mean Temp. °C	Thermal Conductivity (Maximum) mW/cm deg	
	10	0.238	
	24	0.245	
	38	0.252	
	Thermal conductivity test shall be as per IS:3346 or ASTM C177. Specimen thickness shall be as per IS:3346 or 25mm per ASTM C177.		
• Comp. Strength (Min.)	After drying at 102°C - 120°C for constant mass as per ASTM C165, at 10% deformation or at yield point, whichever occurs first, shall be 205 KPa. Test shall be as per IS:11239 part X.		
• Water-vapour permeability (max)	8.5 & 5.5 ng/(Pa.s.h) for PIR & PUR respectively Test shall be as per BS5608 or IS12436		
• Fire properties	Insulation shall be self extinguishing type and shall satisfy the requirements for maximum extent of burn (less than 25mm for PIR and 125mm for PUR) when tested as per BS:5608 (Horizontal burning characteristics- max. extent of burn) or IS:12436		
• Flexural Strength	This is applicable to preformed pipe coverings only and shall be 275Kpa(min). Test shall be as per ASTM C446.		
• Humid aging	(Max. allowable value after aging at 60°C – 90 to 100% relative humidity)-Maximum percent change in linear dimension shall be 4. This limit applies to each of the three foam direction. Test shall be as per ASTM D2126.		
• Closed cell content	Minimum percent 85. Test as per BS:4370 Part – II (Test for closed cell content)		
• Dimension stability after heating	Test method as per IS:11239 Part – II The max. dimensional change at different temperatures shall be..		
	100°C ± 2°C (24 hr)	2%	
	125°C ± 2°C (24 hr)	2%	
• Standard size and dimensions	<u>Block</u>		
	Length	upto 2400mm	
	Width	upto 1200mm	
	Tolerance	On length	±6mm
		On width	±3mm
		On thickness	±1.6mm

Pipe Insulation

Length	750 to 1000mm
Inside diameter	To suit standard steel pipe
Shall be supplied as cylindrical shape slit in half lengthwise or as curved segments cut from blocks or moulded segments cut from blocks or moulded to shape. Upto 14" size, only pipe sections slit in half lengthwise shall be used.	
Dimensional Tolerance:	
Length	± 6mm
Thickness	± 1.6mm
• Thickness	20, 25, 30, 40, 50, 60 and 75mm

4 Cellular Glass

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

• Density	110 to 147 kg/m ³ . Test as per ASTM C303 except that no drying will be necessary. Determine the no. of specimens as per ASTM C390.	
• Thermal conductivity (max)	Mean Temp °F	W/m.k
	400	0.094
	300	0.078
	200	0.063
	100	0.052
	75	0.050
	50	0.048
Thermal conductivity shall be tested as per ASTM C240, C177 and C518. Test at least 3 specimens.		
• Compressive Strength (Average min)	517 kPa Test as per method ASTM C240 and recommended Practice ASTM C165. Test at least four specimens.	

3.2.3 High Temperature Insulation Materials (Above 550°C)

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

1 Ceramic Fibre

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

SL No	Chemical & Physical characteristics of Ceramic Fibre Blankets	Test Method
•	Chemical composition(By volume%)	
	Al ₂ O ₃ (Min)	43 IS 1335
	ZrO ₂ (Min)	- IS-10085
	Fe ₂ O ₃ (Max)	0.1 IS-1527

TiO ₂ (Max)	0.3	IS1527
SiO ₂ (Max)	57	-
• Mean Fibre Dia (Microns)		
(Upto 3% Standard deviation)	2.5-3.5	BS-2972
• Dimensional Tolerance		
Thickness	(-) 0% to (+)40%	-
Width	(-)2% (Excess is permitted)	-
Length	(-)0% (Excess is permitted)	-
• Shot Content(% Max)	20	ASTM C-892
• Bulk Density(Kg/m ³ Min)	128	ASTM C-167
• *Bulk Density Tolerance	(+) 30% & (-)0%	-
• Thermal Conductivity (Kcal/M/Hr/°C)**Max (Mean Temp)	0.11(600°C)	ASTM C-177/IS-3346
• Linear Shrinkage(%) (at max temp) for 24hrs	3(1200°C)	ASTM C-356
• Tensile Strength(Kg/cm ² g(min)		
Longitudinal	0.6	BS 1902 part 6
Transverse	0.5	

* The density shall be calculated on the basis of actual dimensions and actual weight only, as offered by the manufacturer.

**In case of thermal conductivity, the test certificate from an international laboratory or any laboratory approved by department of Science & Technology could be considered. However, the same shall indicate values for other characteristics of the material. The test certificate shall not be more than 12 months old from the date of offer of material for inspection.

2 Calcium Silicate

For material specifications refer clause 3.2.2(1)

3 Combination Insulation of Ceramic Fibre (Inner layer) & Rockwool (Outer layer)

For material specifications refer clause 3.2.3(1) & 3.2.1

4 Combination Insulation of Cal. Silicate (Inner layer) & Rockwool (Outer layer)

For material specifications refer clause 3.2.2(1) & 3.2.1

3.2.4 Insulation material for Impulse lines

For impulse lines insulation material shall be Ceramic fibre rope insulation unless otherwise mentioned. Ceramic Fibre rope shall be made up of Ceramic Fibre insulation of min density 250 Kg/m³. It shall comprise of ceramic fibres laid parallel and finally wrapped with stainless steel wire to reinforce the fibres and holding it in position. Other properties of ceramic fibre shall conform to the specifications as described in clause 3.2.3(1)

3.2.5 Additional Tests / Checks for Materials

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

installed thickness could be reduced due to compaction during transportation & storage and thus affecting performance.

- All the codes mentioned shall be the latest issues.
- Client/Client's representative/EIL shall have right to inspect any or all the tests conducted on insulation material by manufacturer at his shop or any laboratory.

3.2.6 Quality Assurance Plan (QAP)

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

3.3 WEATHER PROTECTION JACKET

- 3.3.1 Unless otherwise mentioned, aluminium jacketing shall be used as weather protection over insulation except in fire hazardous areas /above 550°C where it should be stainless steel or aluminized steel. For grade piping in offsites jacket material shall be galvanized steel. Galvanized jacketing shall not be used over insulation on or near austenitic stainless steel and/or austenitic nickel steel Piping & Equipment. Aluminium jacketing shall be as per ASTM B209 Alloy 3003 H16 or IS:737 designation 31000 condition H3 for flat sheets and designation 31500/51300 condition H4 for corrugated sheets. For stainless steel cladding, the materials shall be in accordance with ASTM A167 or A240, type 304 or 316. For aluminized steel cladding, the material shall be in accordance with ASTM A463, type2, coating designation T2-100. Galvanized steel shall be as per IS:277/ASTM A526 with 450 gms/m² of coating. Cladding (other than galvanized steel) shall be coated on the side in contact with the insulation with a polycraft moisture barrier consisting of one layer of one mil high density polyethylene film with a protective layer of 40-pound minimum virgin kraft paper. Polykraft moisture barrier shall be heat laminated and applied in factory. Thickness of the jacketing shall be as follows:

1 Fibrous Material (Rock, Glass Wool & Ceramic Fibre)

• Application	Thickness for Aluminium cladding (other than grade piping in offsites - Refer note below)	Thickness for Stainless steel /Aluminized steel cladding
• For shells of vertical storage Tanks & Vessels	0.71mm (22 SWG) Corrugated; The profile of corrugated sheet shall be 32mmX5mm	0.56mm (24 SWG) Corrugated; The profile of corrugated sheet shall be 32mmX5mm
• For tank Roofs	1.22mm (18 SWG) Flat	0.91mm (20 SWG) Flat
• For Horton Spheres & Horizontal vessel shell and heads; vertical vessel heads	0.71mm (22 SWG) Flat	0.56mm (24 SWG) Flat
• For removable covers	1.22mm (18 SWG) Flat	1.22mm (18 SWG) Flat
• For all piping, other than grade piping in offsites	0.71mm (22 SWG) Flat	0.56mm (24 SWG) Flat
• For grade piping in Offsites	0.56mm (24 SWG) Galvanized steel (Refer note below)	

Note: For grade piping in offsites the cladding material shall be Galvanized steel.

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

Application	Thickness for Aluminum jacket / cladding	Thickness for Stainless steel / Aluminized steel jacket/cladding
• Piping, Horizontal Vessel head & Tanks Roof	0.56mm(24 SWG) flat	0.46mm(26 SWG) flat
• Vertical Vessel Shells & vertical portion of storage Tanks.	0.56mm (24 SWG) corrugated. The circular profile of corrugated sheet shall be 32mmX5mm	0.46mm (26 SWG) corrugated. The circular profile of corrugated sheet shall be 32mmX5mm
• Removable covers	1.22mm (18 SWG) Flat	1.22mm (18 SWG) Flat

3.4 ANCILLIARY MATERIALS

3.4.1 Securement Bands / Wires

- 1 If material is Aluminium, then specification shall be ASTM B209 Alloy 3003 H16 or IS:737 designation 31000 (Old NS3) condition H3; If Stainless Steel, it shall be 18/8.
- 2 For securing fibrous insulation
 - A On Piping
Band, 24 SWG thick x 12mm (min) wide, Stainless Steel.
 - B On Equipments
Band, 24 SWG thick x 20 mm wide, Stainless Steel.
 - C On Vertical Storage Tanks
Band, Stainless Steel, 25mm wide x 24 SWG thick.
 - D Horton Sphere
16 SWG SS Wire & Band, Stainless Steel, 25mm wide x 0.8mm (min.) thk.
- 3 For Securing Rigid Insulation
 - A On Piping upto 16" OD
Wire, stainless steel, 16 SWG.
 - B On Piping 18" OD & Larger, Vertical and Horizontal equipments
Band, stainless steel. 20 wide x 24 SWG thick.
- 4 For Securing Cladding on Insulation (all types)
 - A For Piping
Band, SS 12mm (min) wide x 24 SWG thick.
 - B On Equipment
Band, SS, 20mm wide x 24 SWG thick.
 - C On Vertical Storage Tanks & Spheres
Band, Stainless Steel, 25mm wide x 24 SWG thick.

3.4.2 Rivets

Rivets required for metal jacket securement shall be the expanding Aluminium "POP" blind eye type/ Stainless Steel, 9.5mm long x 5mm diameter.

3.4.3 Screws

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

3.4.4 'S.' and 'J' clips

- Formed from 25mm wide stainless steel banding.

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

4.0 APPLICATION

4.1 GENERAL

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

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

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

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

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

4.1.5 Corrosion Prevention

Carbon steel and low alloy piping, equipment & tanks with normal operating temperatures of 125°C & below and Stainless Steel at all temperatures shall be protected against corrosion by painting under insulation as per specifications described below:

	DESIGN TEMP. IN °C	SURFACE PREPRATION	PAINT SYSTEM		TOTAL DFT IN MICRONS (MIN.)	REMARKS
			PRIMER	FINISH PAINT		
1	INSULATED CARBON STEEL, LOW ALLOY STEEL AND LTCS PIPING					
A	UPTO 125	SSPC-SP-10	REPAIR OF PRE-FABRICATION PRIMER F-9 @65-75μ DFT	2 COATS OF F-14 @125μ DFT/COAT =2X125=250 OR 3 COATS OF F-15 =3X80=240	315	For other temperature ranges no painting is required under insulation.
B	OPER. TEMP. UPTO 125°C BUT DESIGN TEMP. 126 TO 400°C	SSPC-SP-10	- REPAIR OF PRE-FABRICATION PRIMER F-9 @65-75μ DFT	3 COATS OF F-12 @20μ DFT/COAT =3X20=60	105-115	
2	INSULATED STAINLESS STEEL					
A	UPTO 120	SSPC-SP-10	NONE	2 COATS OF F-14 @125μ DFT/COAT =2X125=250 OR 3 COATS OF F-15 =3X80=240	250	If the piping & equipts are already erected then surface shall be prepared by cleaning with emery paper and wash / flush with chloride free DM water followed by wiping with organic solvent
B	121 TO 500	SSPC-SP-10	NONE	3 COATS OF F-12 @20μ DFT/COAT 3X20=60	60	
C	501 TO 1000	SSPC-SP-10	NONE	1 COAT OF AMERCOAT 738 @150μ DFT/COAT	150	Amercoat 738 is available from Ameron
D	CYCLIC SERVICE -196 TO 480 EXPECTING – 45 TO 120	SSPC-SP-10	NONE	1 COAT OF AMERCOAT 738 @150μ DFT/COAT	150	
3	NO PAINTING IS REQUIRED FOR INSULATED MONEL, INCOLOY AND NICKEL PIPING					

ABBREVIATIONS :

F-9	:	Inorganic Zinc Silicate coating
F-12	:	Heat resistant Silicone Aluminium paint
F-14	:	Specially formulated polyamine cured coal for Epoxy coating
F-15	:	Epoxy phenolic coating

- 4.1.6 The insulation contractor shall not carryout any welding or drilling on plant equipment and piping.
- 4.1.7 Insulation shall be finished, bevelled and weatherproofed at all terminal points where it is required to remove bolts etc. without damage to the insulation.
- 4.1.8 Equipment nameplates shall remain visible after insulation has been applied by bevelling back the insulating material and carefully sealing the exposed edges to prevent ingress of moisture.
- 4.1.9 All projections, such as lifting lugs, trunnions and stiffeners on piping and equipment (i.e. vacuum rings) shall be insulated with the same thickness of insulation as specified for the equipment item or pipeline.
- 4.1.10 Thermowell bosses, pressure tappings and weephole nipples shall not be insulated in but left accessible.
- 4.1.11 For Insulation thicknesses upto 75mm only single layer insulation shall be used. Multi-layer insulation shall be required when the insulation thickness is greater than 75mm with the inner layer being larger. Insulation installed in two or more layers shall be staggered joint construction and each layer shall be secured in place and details of securement shall be the same for each layer.

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

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

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

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

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

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

4.2 PIPING

4.2.1 Standard Shapes of insulation

1 Fibrous Material (Rock or Glasswool)

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

2 Calcium Silicate / Expanded Perlite

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

3 Polyisocyanurate / Polyurethane

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

4 Cellular Glass

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

5 Ceramic Fibre

Shall be supplied in blanket strips in sizes as mentioned in the material spec in clause 3.2.3.

4.2.2 Application

1 Horizontal Pipe

A General

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

B Pipe Section / Moulded Blocks / Segments

- End joints of adjacent blocks shall be staggered one half of the length of the block.
- Included angle between segments shall not be less than 30 deg. for both single and double layer insulation.
- Further, minimum arc length of segments should meet following staggering requirements.

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

C Blankets (Fibrous insulation - Rock or Glasswool)

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

D Insulation Securement (All insulation materials)

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

- For calcium silicate & expanded perlite, all joints shall be sealed with insulating cement of same composition as the moulded block.
- For Cellular glass, Polyurethane foam and polyisocyanurate, joints shall be sealed with suitable compatible material.
- Each layer of insulation shall be secured by the same method as above.

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

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

Spacer rings shall be fabricated out of 25x3 M.S. Flats. The outside diameter of these rings shall be equivalent to the outside diameter of the insulation. Spacer rings shall be riveted to 'Z' shaped stays fabricated from the same sized M.S. Flats. These rings shall be suitably painted for corrosion protection. Stays shall be provided at intervals of not more than 300 along the circumference of the insulation, subject to a minimum of 3 stays. Spacer rings shall be provided at every approx. 900. To minimize direct heat conduction through the stays, a packing of 2 sheets of 3 thick asbestos mill board shall be provided at the joints of the stays and pipes. Joints between M.S. Spacer Ring and stays shall be riveted by 6 dia M.S. Rivets with 2 Sheets of 3 thick asbestos mill board interposed.

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

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

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

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

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

3 Expansion Joints (Both vertical and horizontal piping. All insulation Materials) (See Fig.5)

Expansion joint shall be provided at regular intervals as below:

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

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

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

Insulation material shall be mitred and shall be same as that of pipe. Insulation securement bands/wire shall be same as that for equivalent dia pipe. Each mitred section shall be secured with minimum 2 wires/bands. For bends / elbows of nom.

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

5 Tee (All Insulation Materials) (See Fig.8)

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

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

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

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

7 Insulation Flashing (all insulation materials)

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

8 Pipe Supports: (All insulation materials) (Fig.11)

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

9 Steam Traced Piping (All insulation materials) (Fig.12)

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

10 Electrical Traced Piping (Polyisocyanurate / PUR)

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

4.3 HORIZONTAL EQUIPMENTS

4.3.1 Standard Shapes of insulation

1 Fibrous Material (Rock or Glasswool)

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

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

2 Calcium Silicate/ Perlite/ PUR/ Polyisocyanurate/ Cellular Glass

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

3 Ceramic Fibre

Shall be supplied in blanket strips in sizes as mentioned in the material spec in clause 3.2.3.

4.3.2 Application (All Materials)

1 Following provided by the vessel fabricator for insulator / cladding support / securement, as indicated in enclosed sketch No. 7-12-0033, shall be verified for their presence by the insulation contractor, before commencing insulation work:

- For vessels of diameter 2000mm and above are provided insulation support at horizontal centre line as also vertically at tangent lines. Ring support at tangent lines are provided with 6mm diameter holes. These are to be used for insulation securement.
- At vessel heads above 600mm outside diameter are provided flats having 6mm dia holes. The flats are for insulation support and holes provided in them are to be used for insulation securement. Also provided on either head is a central ring made of 10 dia galvanized steel rod. For vessels which do not have central nozzle, these rings shall not be provided by vessel fabricator. For such vessels, insulation contractor shall provide these rings.
- Boot of vessel, if any, is provided with circular support ring with holes, as indicated in sketch.

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

Other block insulation shall be applied with the longer dimension parallel to the axis of the vessel or equipment. When blocks are applied in multiple layers, all joints in successive layers shall be parallel to the long axis, shall be staggered and sealed with insulating cement for calcium silicate or suitable adhesive for others. In all cases, the insulation is to fit the contour of the vessel or equipment, so that the use of a leveling

coat of insulating cement should not be normally necessary to get an acceptable smooth exterior.

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

This provision is required to take care of the effects of equipment circumferential thermal expansion on insulation.

This provision is required only for vessels and Exchangers provided with calcium silicate insulation.

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

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

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

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

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

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

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

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

4.4 VERTICAL EQUIPMENTS

4.4.1 Standard Shapes

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

4.4.2 Application (For all insulation materials) (Fig 16 & 17)

Application details on shell, top and bottom heads shall be similar to that of horizontal equipment. Insulation shall be laid on insulation support rings provided by the fabricator. See Standard 7-12-0025.

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

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

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

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

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

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

4.4.4 Expansion Joints (All insulation materials)

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

4.5 FLANGE, NOZZLE, CHANNEL COVER, MANWAY & HANDHOLE FLANGED COVER (FOR ALL INSULATION MATERIALS)

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

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

4.6 IRREGULAR SURFACES SUCH AS PUMPS, COMPRESSORS, TURBINES ETC.

4.6.1 Application

- 1 Fibrous Material: Material, application and insulation securement

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

- 2 Calcium silicate/Expanded perlite

Insulation material shall be loose fill insulating cement/block insulation cut and fitted.

Insulation shall be applied in maximum 25mm thick layers until the scheduled thickness is obtained.

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

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

4.7 VERTICAL STORAGE TANKS (CARBON STEEL)

4.7.1 Standard Shapes of insulation

- 1 Fibrous Material (Rock or Glasswool)

Shall be in slab form..

- 2 Polyisocyanurate / Polyurethane foam

Shall only be foamed cast in-situ.

4.7.2 Application

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

A Shell

Refer Standard 7-13-0003 Sh.1&2 of 2. This Standard indicates the extent of insulation / cladding supporting / securement details provided by tank fabricator. Insulation contractor shall check for its presence before insulation application work. Following is provided by tank fabricator :

Water Shed

At the junction of shell and roof, a watershed is provided to act as top covering for the shell insulation as shown in Std. 7-13-0003.

Insulation Support

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

Cladding Support

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

B Tank Roof

Shall be provided as per Standard 7-13-0003.

- 2 Insulation laying and securement

A Shell

-Application of fibrous insulation

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

-Application of Polyisocyanurate / Polyurethane foam

Shall be foamed cast in-situ as per vendor's procedure (approved by EIL/Client/Client's representative) and to the satisfaction of Site-in-Charge. The minimum requirement for thermal conductivity, density, compressive strength, fire properties and water vapour permeability shall be as per para 3.2.2(3). Depending upon the application the thickness of cladding and bands shall be as per para 3.3 & 3.4 respectively. Contractor shall ensure that cladding & band thicknesses are capable of withstanding foaming pressures which are developed at the time of injection of foam. Contractor can use foamed cast in-situ insulation only after getting the approval to material specification and application procedure.

B Roof (For all materials)

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

4.8 HORTON SPHERES

4.8.1 Standard shapes & Material

Shall be only Rockwool / Glass wool blanket.

4.8.2 Application

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

Insulation & Cladding supports shall be as per Standard 7-13-0015.

- 2 Insulation laying and securement

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

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

4.9 INSPECTION WINDOWS

4.9.1 Piping

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

Pipe dia 2"	35mm* 120mm diameters
Pipe dia 3"	45mm* 120mm diameters
Pipe dia 4"	75mm* 120mm diameters
Pipe dia 6"	100mm* 120mm diameters
Pipe dia 8"	100mm* 120mm diameters
Pipe dia > 8"	120mm* 120mm diameters

4.9.2 Exchangers

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

4.9.3 Columns & Vessels

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

4.9.4 Tanks

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

4.10 IMPULSE LINES

Wrap the impulse lines with insulation (Ceramic rope) of required thickness(refer note below). Ensure that the rope(s) has been tightly wrapped. A 3mm thick coating of mastic shall be applied to the surface of the insulation. Whilst this coat is still wet, glass cloth shall be laid over the surface and embedded in the mastic. Care shall be taken to ensure that the glass cloth is laid smooth and free from wrinkles and that no pockets of air are trapped beneath the surface. At junctions in the glass cloth, the overlap shall not be less than 75mm. A second 3mm thick coat of mastic shall be applied after approximately 12 hrs. When dry this coating shall be a minimum of 1.50mm thick. Apply a coat of aluminium paint of DFT 25 microns over the mastic after it has dried completely. A suitable sealant shall be provided to stop the water ingress at the termination points of insulation.

Note: Impulse line insulation details shall be as follows:

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

5.0 INSULATION FINISH

5.1 GENERAL

5.1.1 Moisture Barrier

- 1 On all surfaces except horton sphere, provided with fibrous materials, Expanded perlite , Calcium silicate, Polyisocyanurate & Polyurethane foam .

For surfaces upto 125⁰C & on PIR/PUR in case of electric heat tracing apply a breathing type moisture barrier as below. A 3mm thick coating of mastic shall be applied to the surface of the insulation as soon as possible, after erection, to reduce the time the insulation is exposed to the weather, to a minimum. Whilst this coat is still wet, glass cloth shall be laid over the surface and embedded in the mastic. Care shall be taken to ensure that the glass cloth is laid smooth and free from wrinkles and that no pockets of air are trapped beneath the surface. At junctions in the glass cloth, the overlap shall not be less than 75mm. A second 3mm thick coat of mastic shall be applied after approximately 12 hrs. When dry this coating shall be a minimum of 1.50mm thick. Care must be taken, however, to ensure that the individual coats are not greater than 3mm (especially corners) otherwise some cracking of dried coat may result. The mastic shall not be applied over wet insulation or until the adhesive is dry. During the drying time, the insulation shall be protected from the weather by "Alkathene" film type tarpaulin or similar materials approved by Engineer-in-Charge.

5.1.2 Insulation Finish

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

5.2 PIPING (FOR ALL MATERIALS)

- 5.2.1 Straight pipe shall have metal jacketing cut and machine rolled, (approx. 1metre long) wrapped around, with 50mm minimum overlaps on both longitudinal and circumferential overlaps. All laps shall be arranged to shed water.
- 5.2.2 A single bead shall be made on all overlaps to ensure tight metal to metal water tight arrangement. Selftapping screws, at every 150, shall be provided at all longitudinal overlaps for both horizontal & vertical piping.
- 5.2.3 At all operating temperatures the seams at overlap positions shall be rendered watertight per clause 3.4.5 to ensure that insulation remains dry and unwetted, whether the possible water impingement is from rain, hose or fire sprinklers.
- 5.2.4 The metal coverings shall be secured tightly around the insulated pipe and held in place with hands on a maximum of 300mm centres. One band shall be located on each circumferential lap and the distance between laps divided at equal band spacings. The band securing seals shall be kept neatly in line and positioned away from viewing angles as much as is possible.
- 5.2.5 Vertical overlaps on vertical or near vertical piping shall be staggered to provide overlaps at 'North,' and 'South' positions in alternate sections of covering.
- 5.2.6 Each sections of metal covering on vertical piping with insulation OD's larger than 250mm shall be supported from the next lower section with two 'S' clips, fabricated from banding material. The 'S' clip shall be of sufficient length to allow the minimum overlap of 50mm.

- 5.2.7 On vertical piping with OD's of 600mm and larger, the securing bands shall be supported by 'J' clips, fabricated from banding material. The 'J' clip spacing shall be a minimum of two per band. All 'J' clips shall be screwed into position and secured.
- 5.2.8 Insulated bends and elbows in piping 80mm and larger, shall be metallised with 'lobster back' segments using 10mm minimum ball swage to assist shaping. The metal bands shall be screwed with selftapping screws and metal sealants are to be provided to get a completely waterproofed arrangement.
- 5.2.9 Insulated bends and elbows in piping smaller than 80 mm may use complete pressed and humped back flat metal elbows or fabricated 'stove pipe' elbows.
- 5.2.10 The practice of locating all joints in the top portion of elevated horizontal pipes for the sake of good appearance when looking up from grade shall be strongly discouraged. The joints shall be located to shed water.

5.3 EQUIPMENTS (FOR ALL MATERIALS)

- 5.3.1 The metal jacket over vertical vessel shells shall be constructed of sheet metal panels with the weight of the panel taken on the equipment insulation support rings, via angle brackets bolted to the panel. Refer standard 7-12-0025 for details.
- 5.3.2 The panels shall be applied commencing at the bottom of the vessel. Each circumferential ring of panels shall be tensioned by means of tensioning bands until the final joint is screwed tight. 'S' clips shall be used as sheeting support at unscrewed circumferential overlaps.
- 5.3.3 The panels shall be held tight over the vessel insulation by means of circumferential bands and sealed per 3.4.5. The bands shall be positioned on all horizontal overlaps and at 450mm centres. Bands shall be held in their relative positions with 'J' clips and be machine-stretched and sealed to remove slack only. Those bands which are not supported by 'J' clips, shall be held in position on cladding by providing pop rivets every 2 metre centres.
- 5.3.4 The panels shall have a minimum overlap of one corrugation on vertical joints and 80mm on horizontal joints. The overlaps shall be arranged to shed water at all times.
- 5.3.5 The vertical and horizontal overlaps shall be secured with self tapping screws at 150mm pitch except the horizontal overlaps pre-selected to act as expansion joints, these shall be constructed with a 150mm overlap and shall remain unscrewed and left free to permit expansion. All overlaps shall be rendered watertight as per 3.4.5.
- 5.3.6 All equipment projections such as nozzles, shall have the jacketing sealed using a metal flashing, cut to fit the projection and extending above the jacket at least 80mm. The seal between the flashing and jacket shall be made watertight by use of self-tapping screws and sealing mastic.
- 5.3.7 Horizontal cylindrical equipment shall be furnished with flat metal jacket arranged in circumferential bands with the edge of the sheets, with the longer dimension applied around the circumference of the equipment insulation.
- 5.3.8 The panels shall have a minimum of 80mm overlap of both longitudinal and circumferential edges, both overlaps being finished with a simple ball swage and rendered watertight as detailed in clause 3.4.5.

- 5.3.9 Horizontal overlaps shall be secured with No. 8x12mm long self-tapping screws set in the overlap at 150mm intervals, and shall be so arranged that staggered bands of panelling encircle the equipment. Vertical overlaps shall not be screwed for horizontal equipment.
- 5.3.10 The metal finish shall be banded and sealed at 450mm centres.
- 5.3.11 The insulated heads of vertical and horizontal equipment shall be fabricated from flat metal, an "Orange peel" construction with all radial seams overlapping a minimum of 50mm and secured with self-tapping screws at 150mm centres. All overlaps shall be ball swaged and be rendered water tight per 3.4.5.
- 5.3.12 Projections from the heads shall be sealed using metal flashings, neatly cut to fit around the projections and extending above the jacket for a minimum of 80mm. The seal between flashing and jacket shall be weatherproofed with self-tapping screws and mastics.
- 5.3.13 Insulation at bottom heads of fully skirted equipments does not require weatherproofing.
- 5.3.14 Heads of equipments 24" OD and smaller shall be finished and waterproofed with square ended fabricated covers.

5.4 VERTICAL STORAGE TANKS

5.4.1 Cladding Applications and Securement

1 Shell (Fig. 19 and Standard 7-13-0003. Sh.1 and 2 of 2)

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

- Overlaps in the vertical joints will be one corrugation.
- Overlaps in the horizontal joints shall be 50mm (min.).
- Cladding to cladding fastening, at both horizontal and vertical overlaps shall be alternately by "POP" Rivets & selftapping screws at 150mm pitch.
- Cladding shall be secured to support ring by bolting. Bolts are provided by tank fabricator at 300mm centres on angles provided at every 1175 centres vertically. Cladding is secured as indicated in standard 7-13-0003. Felt washer, aluminium washer and nut shall be supplied by insulation contractor for all bolted connections at shell, roof and curb angle.
- Insulation shall be tucked into the skirt portion of the curb angle. Shell cladding and extended roof cladding shall be secured to curb angle by bolting as per standard 7-13-0003, every 1500.
- Horizontal stainless steel bands over-cladding to be provided every 800mm and also to coincide at every horizontal cladding overlaps. Bands shall be tightened, locked and lock fastened featuring stainless steel fastening systems. In order to prevent sliding of the bands downwards, the bands shall be secured to the cladding using POP rivets at horizontal pitch not over 2 metres .

2 Roof

- All cladding joints shall be sealed by elastomeric metal sealants.
- Min. 75mm overlap shall be ensured at all joints.

- At all joints, cladding-to-cladding securement shall be provided by self tapping screws and pop rivets alternately, every 150 centres.
- Cladding shall be secured by bolting at every 300 provided by tank fabricator. For details of cladding arrangement and bolting, see standard 7-13-0003.

5.5 HORTON SPHERE

5.5.1 Cladding Support

Insulation contractor shall provide 25mm x 0.8mm S.S. Bands over insulation and install them longitudinally from top to bottom of the sphere in such numbers so as to afford a maximum spacing of 1175mm at the equator. The S.S. Bands are spanned between four floating rings, the one at the top and bottom of the sphere are provided by the sphere fabricator. Generally the other two rings and SS bands are provided after insulation is applied prior to application of cladding. Floating rings will be constructed of 10mm diameter rods of S.S.. Diameter of ring at the top and bottom, to be provided by sphere fabricator would be around 1.2m. Cladding support bands shall be tightened using mechanical tightners and fastened to MS / AS angles using two S.S.Rivets or four Nos. of Aluminium POP rivets, per angle cleat.

5.5.2 Cladding Application

While applying cladding, following shall be ensured

-Minimum overlap both horizontal and vertical shall be 50mm.

5.5.3 Cladding Securement and Scaling of Joints

All joints to be sealed using elastomeric metal sealant.

Cladding to cladding securement of both vertical and horizontal overlaps shall be alternately by POP rivets and self-tapping screws, at every 150mm spacing.

Cladding shall be secured to the insulation angle support by bolting the cladding on the bolts provided at every 300 pitch at every angle support per standard 7-13-0015. Asbestos mill-board washer, aluminium washer and nut shall be supplied by insulation contractor.

Further cladding shall be secured by 25mm x 0.5mm S.S. bands, applied identical to those for insulation securement. The bands shall be provided between two floating rings, one at the top and one at the bottom and arrangement & details shall be identical to that of insulation securement. Bands shall be secured to cladding every 2M by one SS or two aluminium POP rivets. While providing floating rings, for both insulation and cladding securement, following points shall be taken care of:

-Floating rings shall clear nozzles / manholes etc.

-Exercise extreme care while installing floating rings regarding cut outs in cladding around projections,

-Cladding at interface between leg and the body of the sphere to be provided with care and suitably sealed to prevent water ingress.

6.0 GAURANTEE & TEST CERTIFICATES

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

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

7.0 REFERENCE CODES AND STANDARDS

The following list includes standards and specifications referenced in Spec. 6-44-0002 :

ASTM STANDARDS AND SPECIFICATIONS

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

ASTM C892	Standard specification for High temperature fiber blanket thermal insulation
ASTM D1622	Test method for apparent density of rigid cellular plastics
ASTM D2126	Test method for response of rigid cellular plastics to thermal and humid aging
ASTM E96	Standard test methods for Water vapor transmission of materials

BS STANDARDS AND SPECIFICATIONS

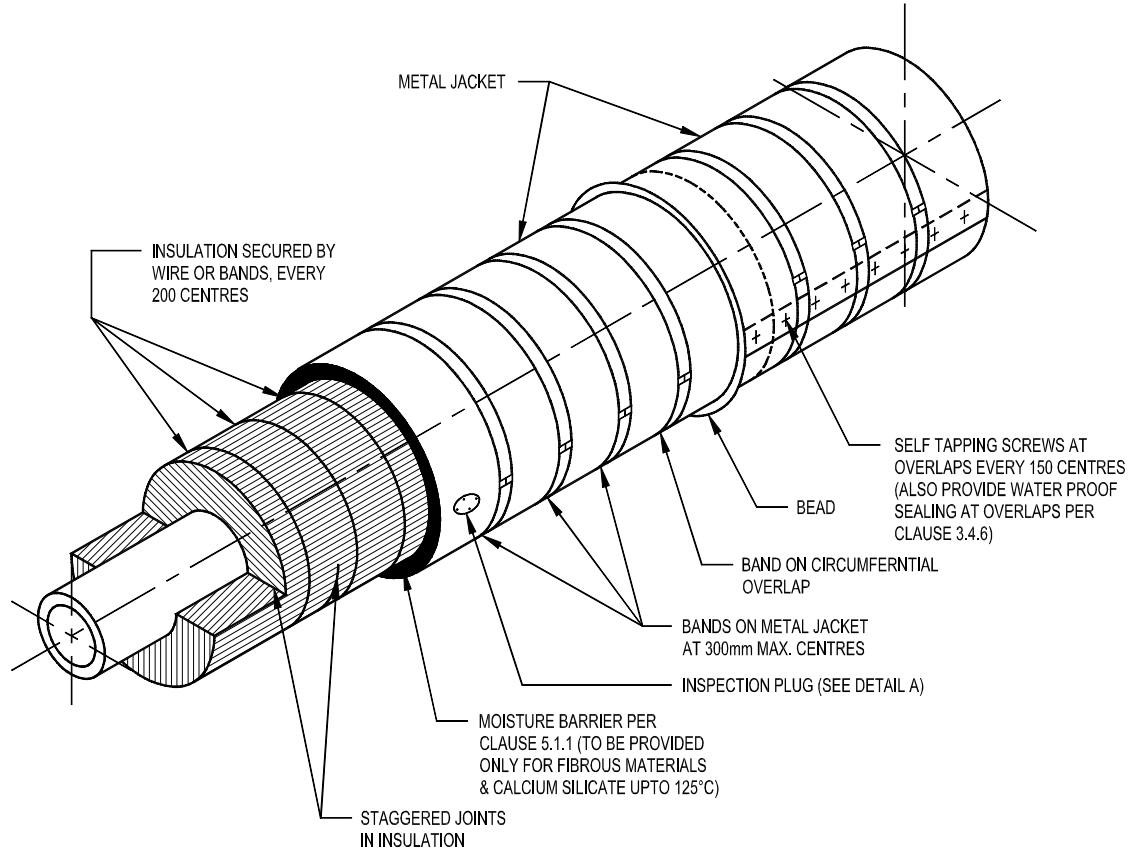
BS 1902 Part 6	Ceramic fibre products
BS 2972	Method of test for Inorganic thermal insulating materials
BS 4370 Part 2	Method of test for rigid cellular materials
BS 5608	Specification for preformed rigid polyurethane (PUR) and polyisocyanurate (PIR) foams for thermal insulation of pipework and equipments

IS STANDARDS AND SPECIFICATIONS

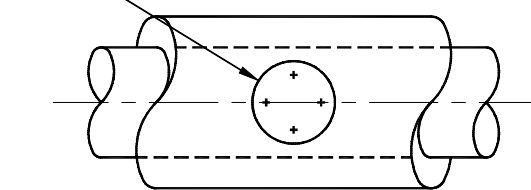
IS 10085	Method for chemical analysis of zircon flour or sand
IS 11239	Method of test for Rigid cellular thermal insulation materials
IS 12436	Specification for Preformed rigid Polyurethane (PUR) and Polyisocyanurate (PIR) foams of thermal insulation
IS 1335	Method of direct determination of alumina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

EIL COMPANY STANDARDS

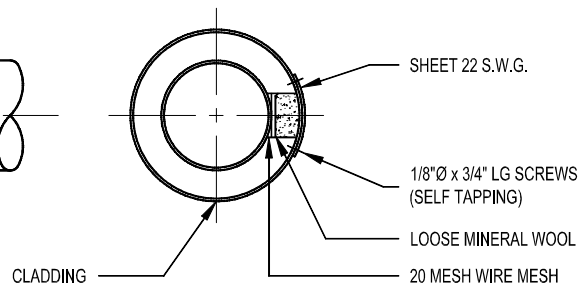
7-13-0003	Hot insulation supports for storage tanks
7-13-0015	Hot insulation supports for spheres
7-12-0025	Fire proofing and insulation supports
7-13-0033	Hot insulation supports for horizontal vessels
7544-02-41-GL-56	Hot insulation supports for storage tanks



INSPECTION PLUG DETAILS FOR
VESSEL & PIPES



NOTE :-
FOR INSPECTION PLUG REFER
APPLICABLE CLAUSE



DETAIL 'A'

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

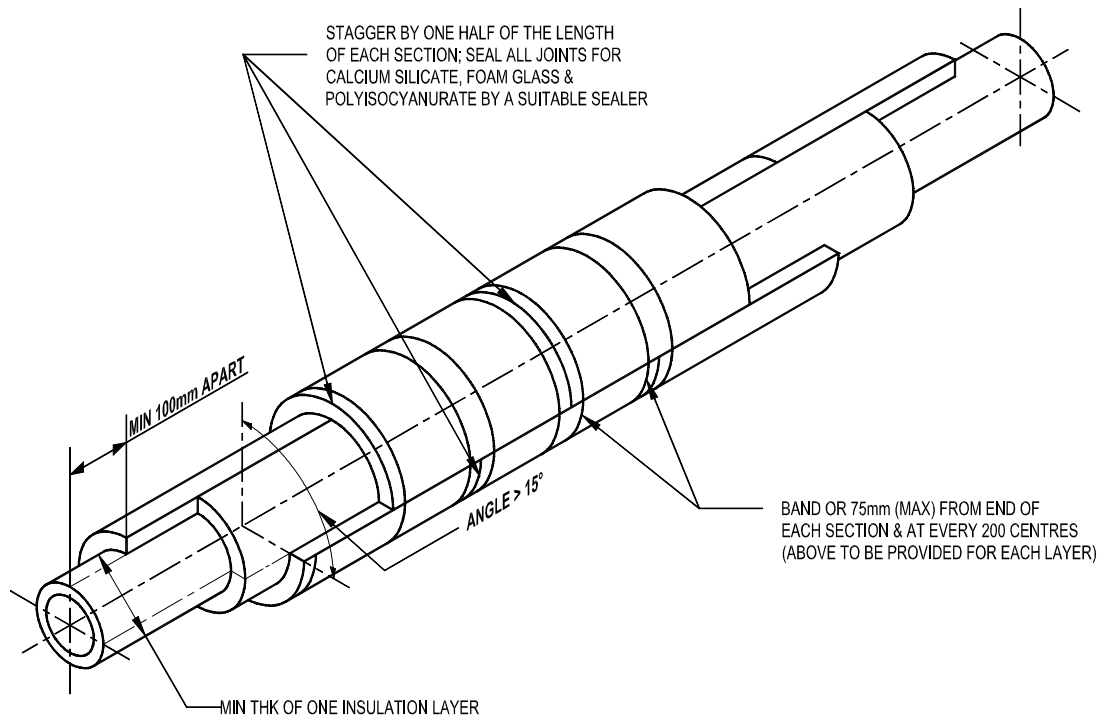


FIGURE – 02
PIPE INSULATION METHOD OF STAGGERING OF SECTIONS
RIGID & FIBROUS INSULATION (PREFORMED PIPE SECTIONS ONLY)

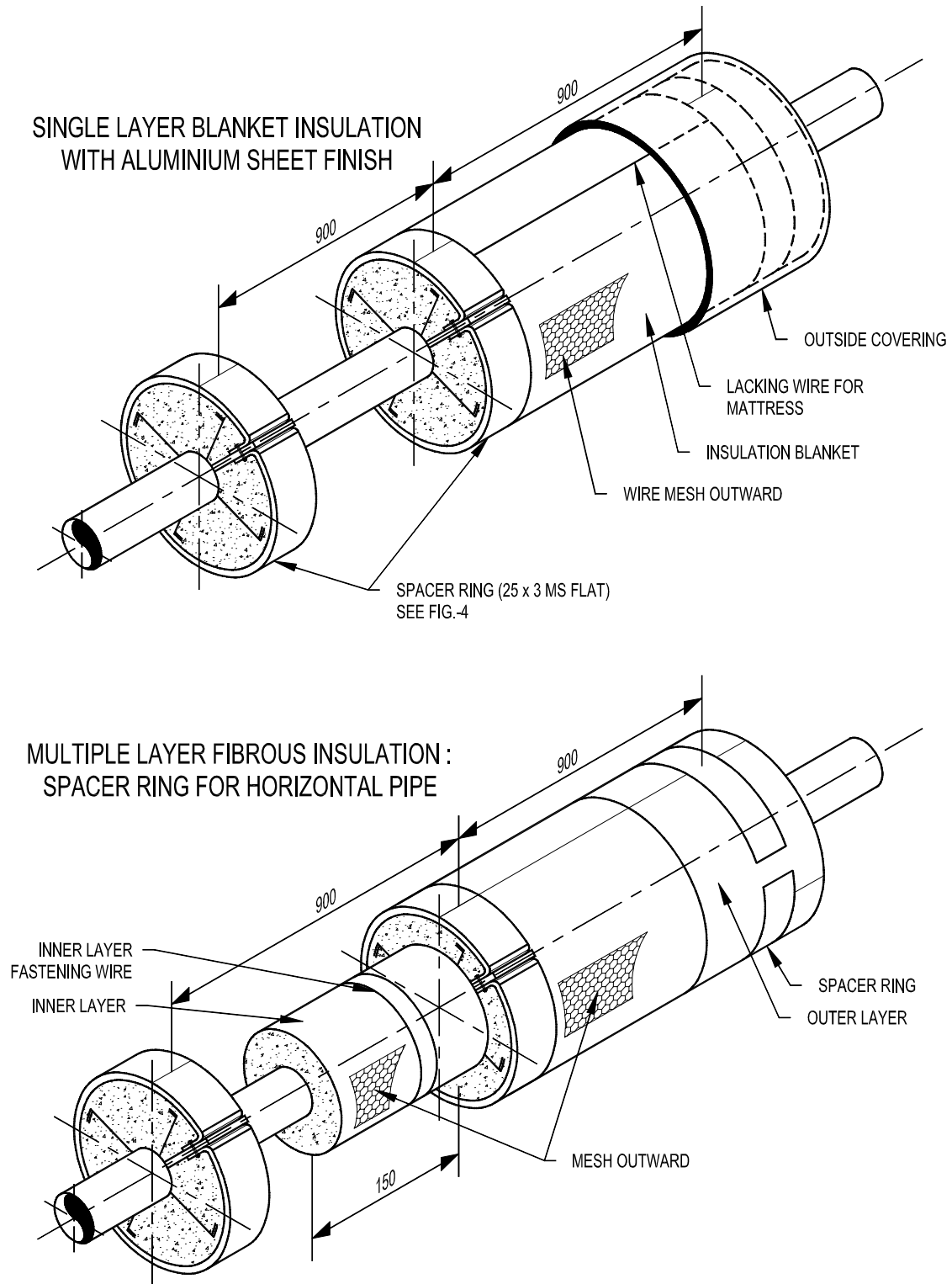
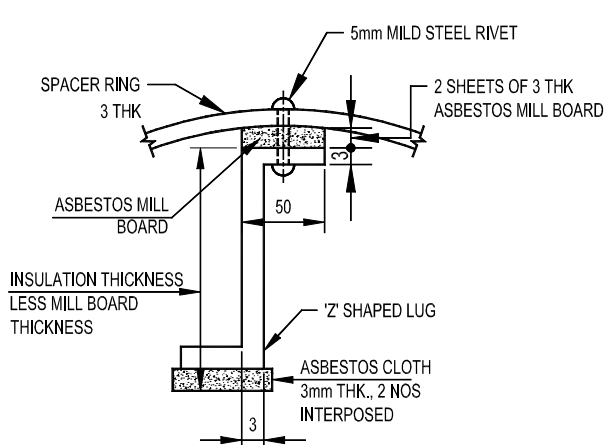
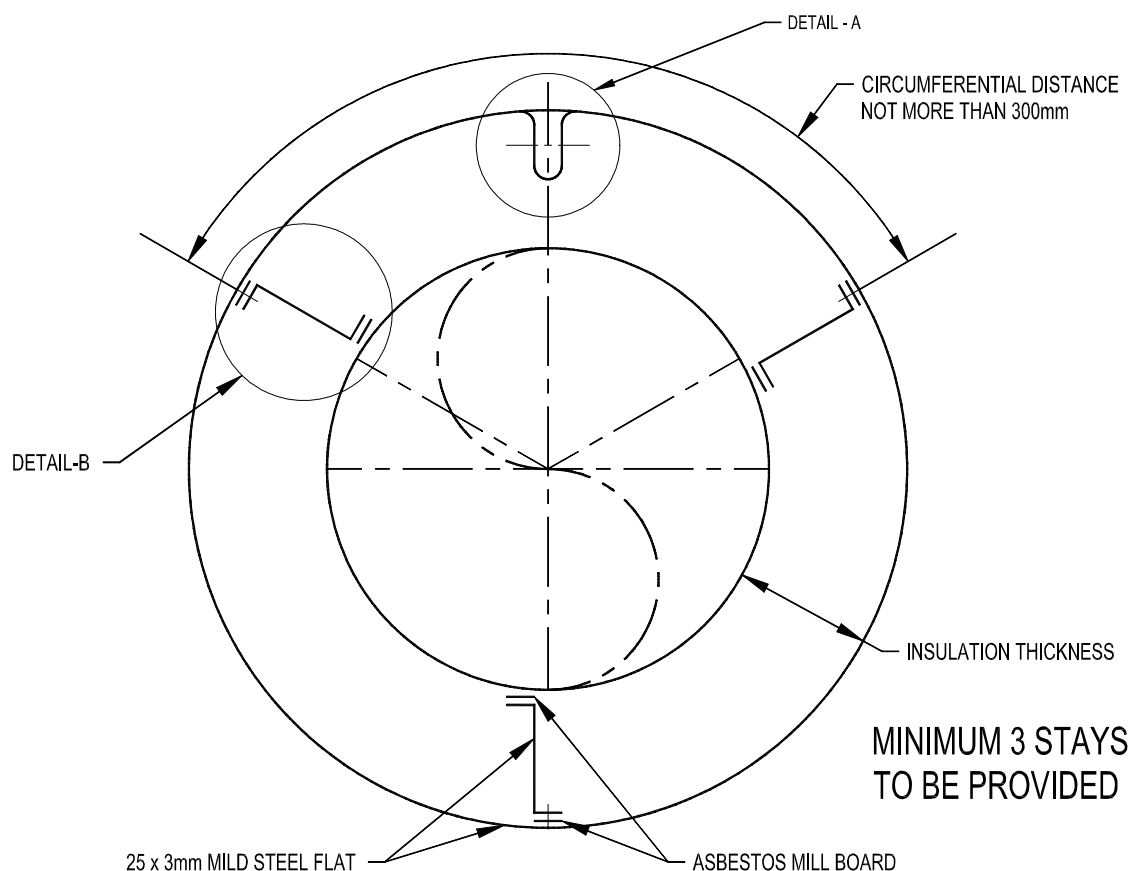
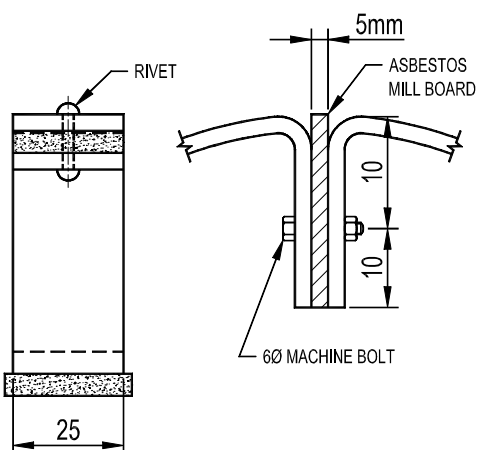


FIGURE – 03
**HORIZONTAL PIPE : FIBROUS INSULATION; DETAIL OF SPACER RINGS FOR
CLADDING SUPPORT**

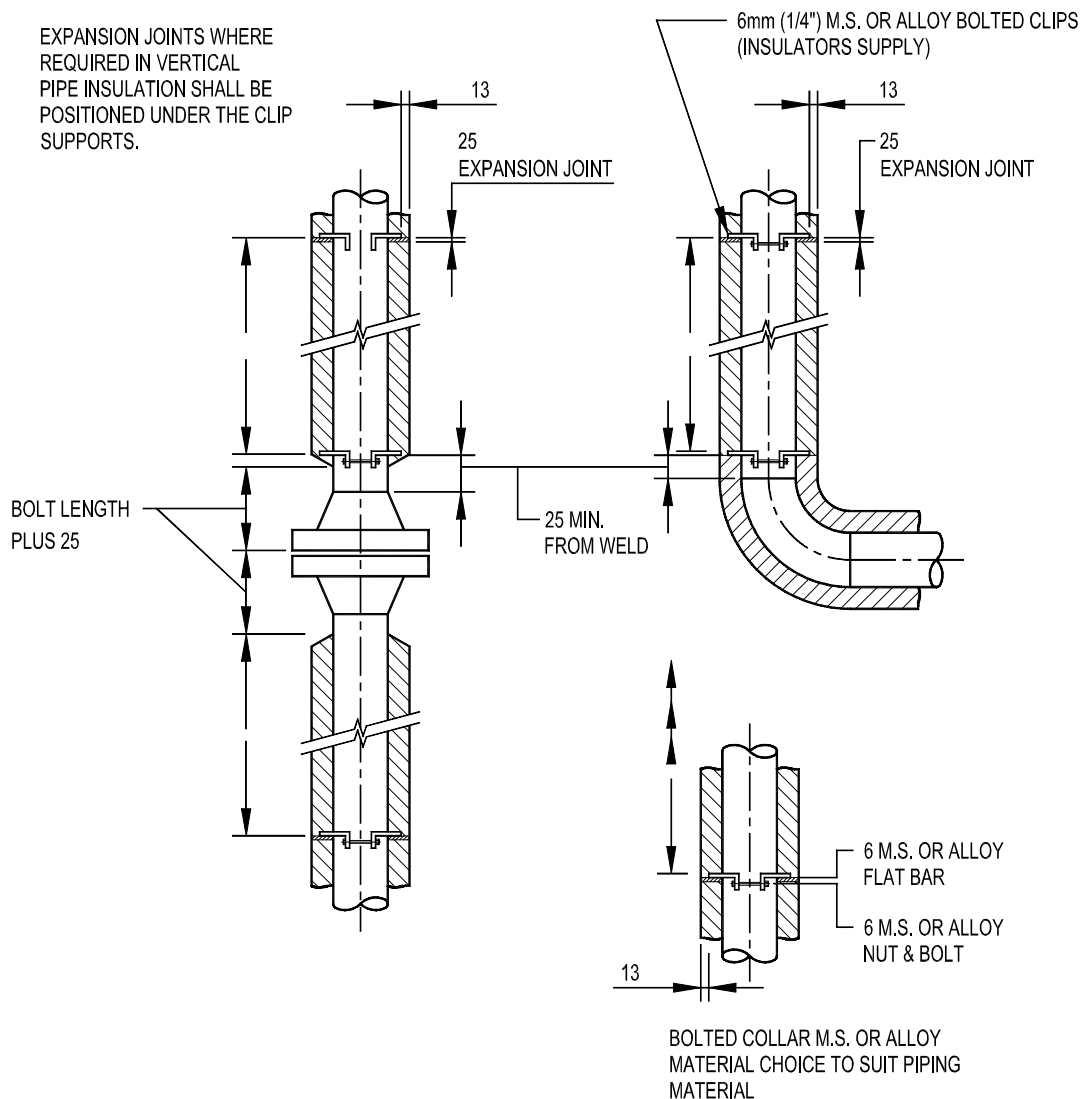


DETAIL - B



DETAIL - A

FIGURE – 04
DETAIL OF SPACER RING FIBROUS INSULATION (MATTRESS)



CLIP SPACING

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

* CIRCUMFERENTIAL EXPANSION SHALL BE CONSIDERED AT THESE OPERATING TEMPERATURES.

FIGURE – 05
BOLTED ON INSULATION SUPPORT FOR VERTICAL PIPE

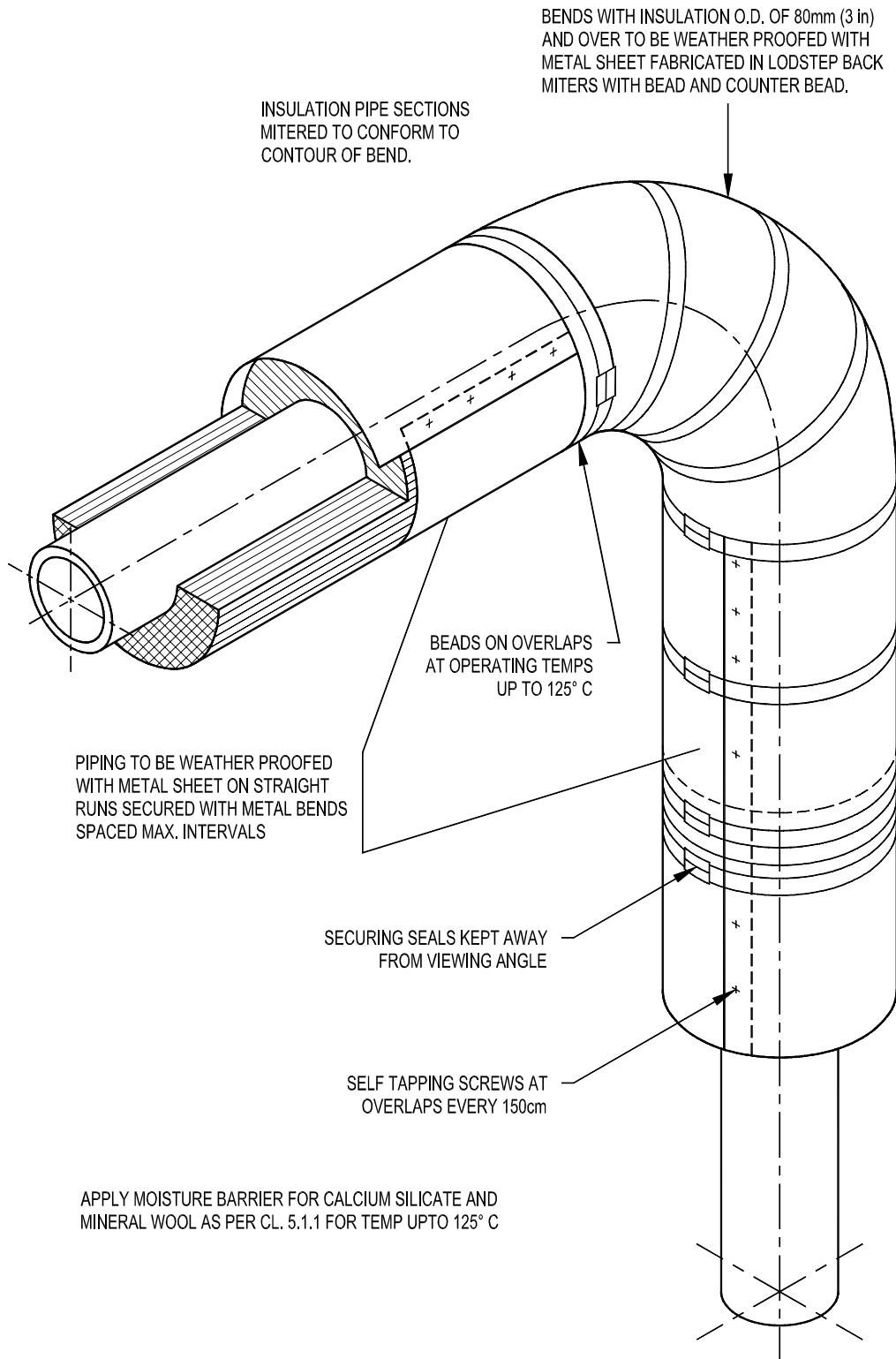


FIGURE – 06
INSULATION DETAILS FOR BENDS / ELBOWS

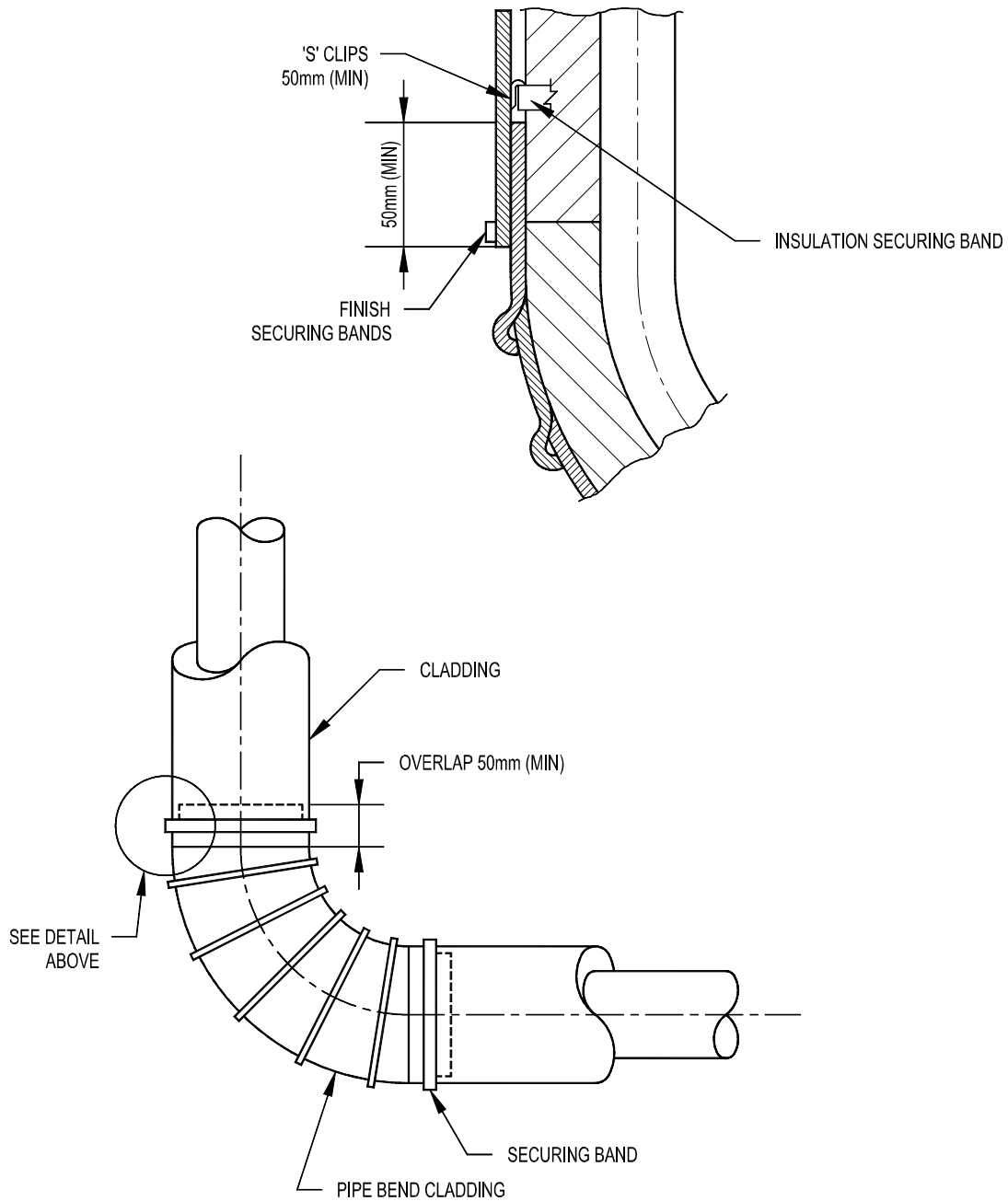


FIGURE – 07
INSULATION DETAILS : PIPE BENDS & ELBOWS

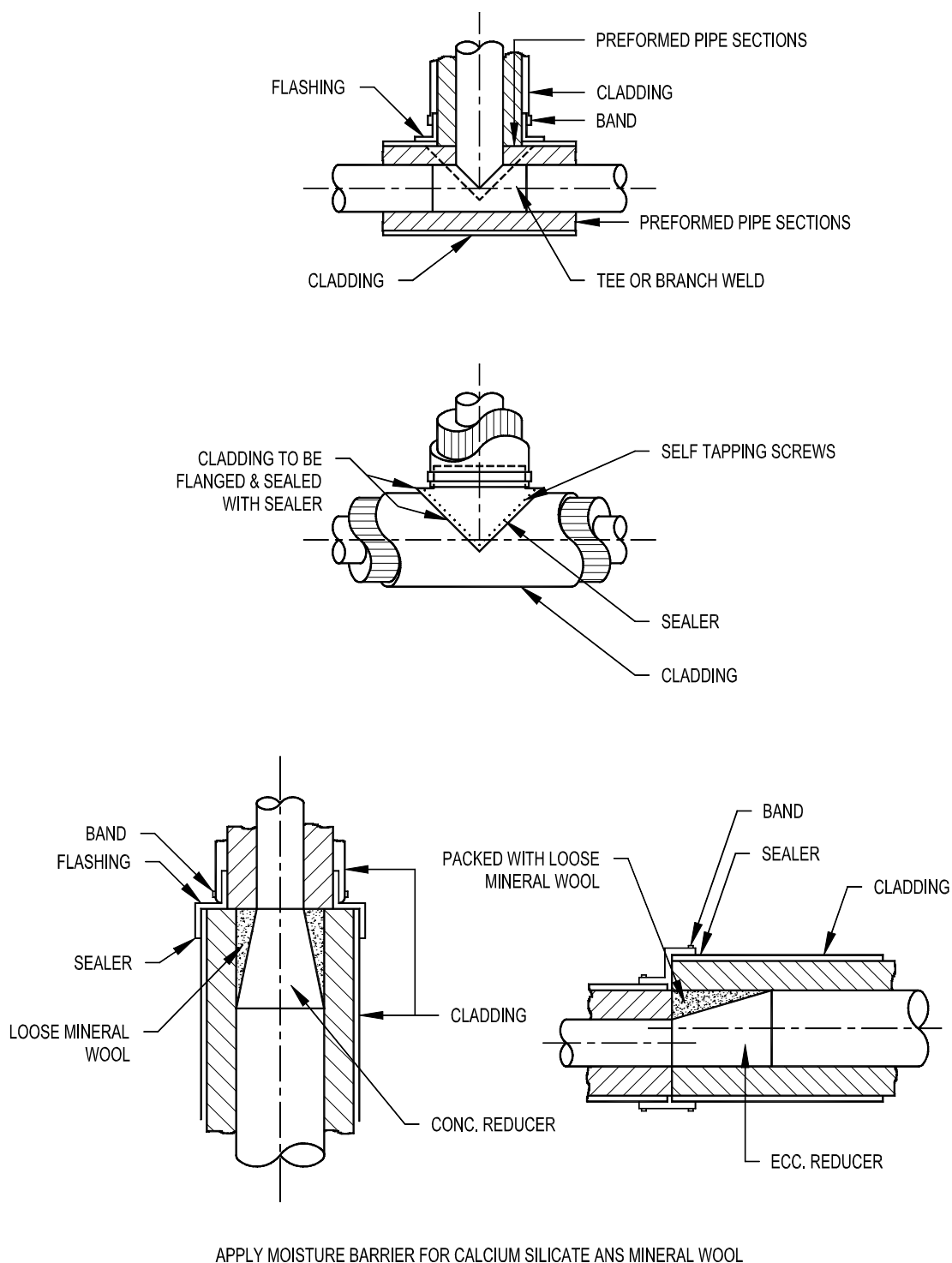


FIGURE – 08
INSULATION DETAILS : PIPE BRANCHED & REDUCER

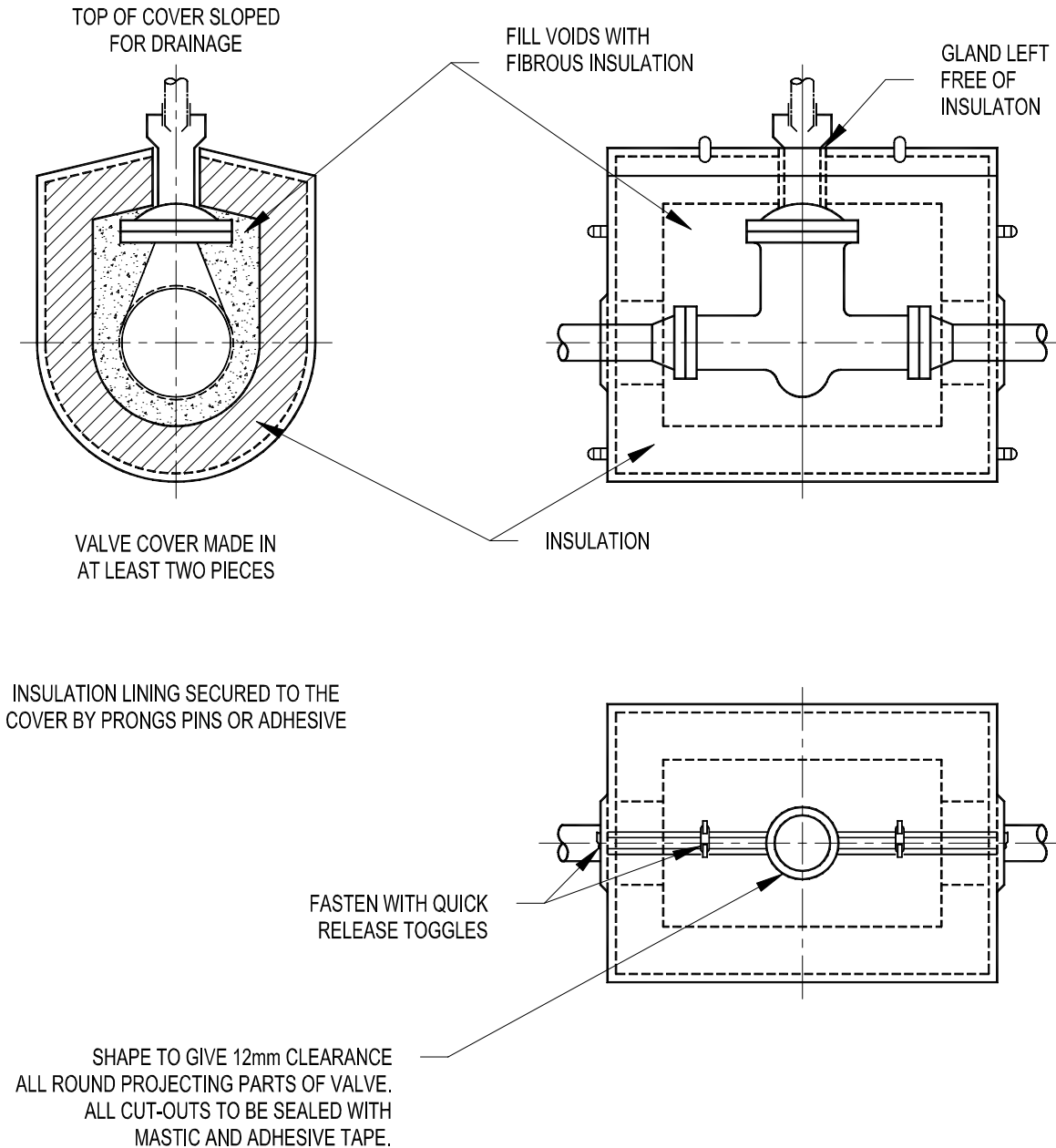


FIGURE – 09
INSULATED REMOVABLE COVER : VALVES

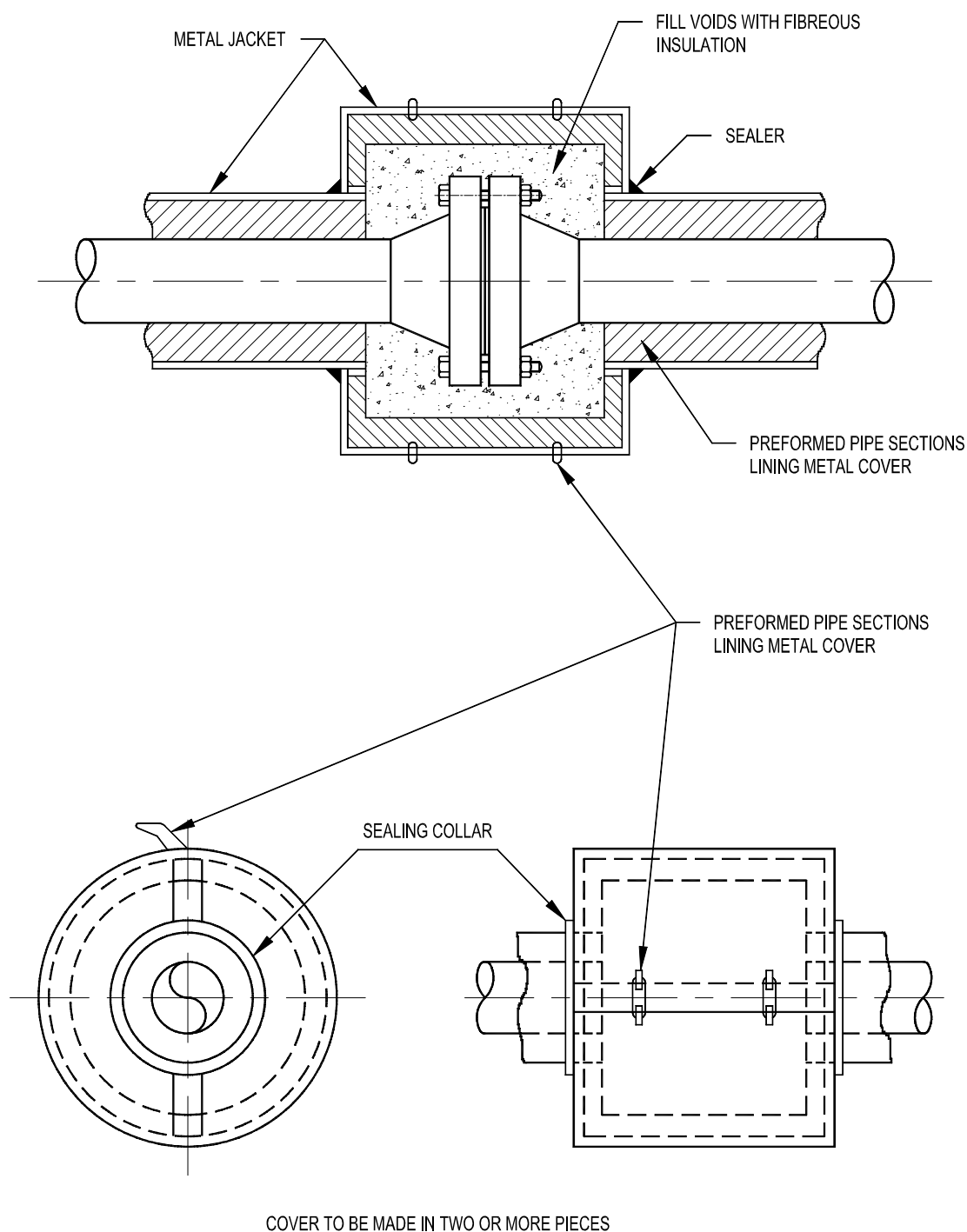
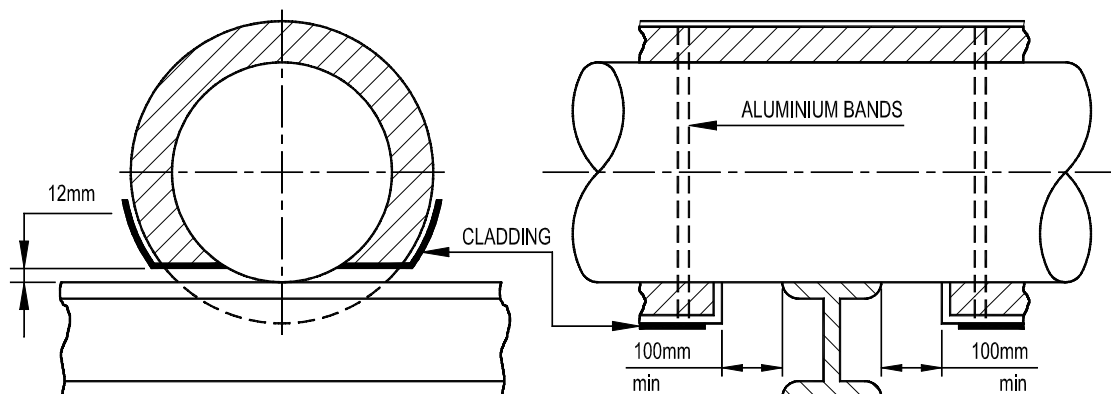


FIGURE – 10
INSULATION REMOVABLE COVER – FLANGED JOINTS



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

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

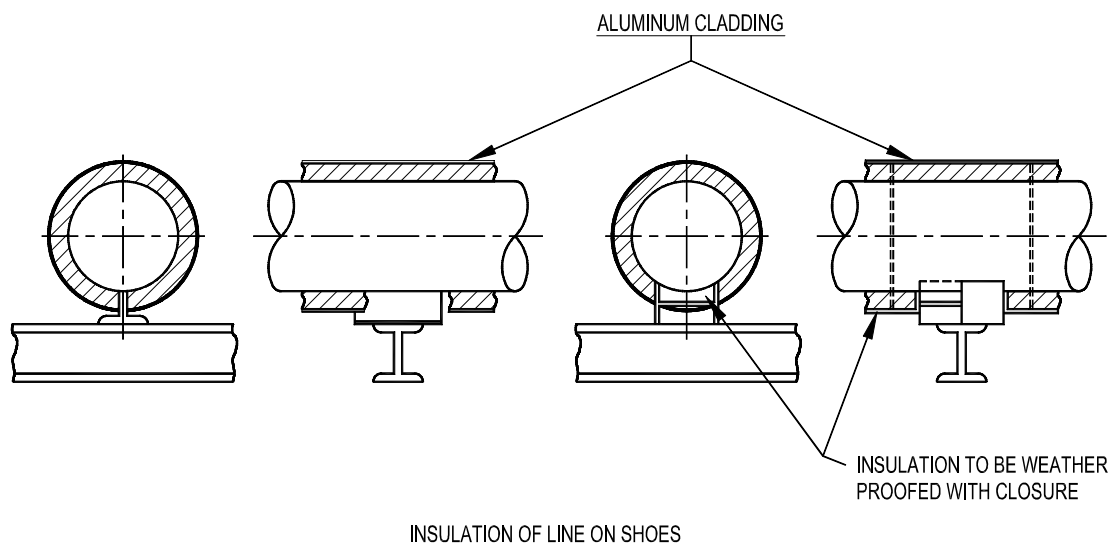


FIGURE – 11
INSULATION DETAILS PIPE SUPPORTS

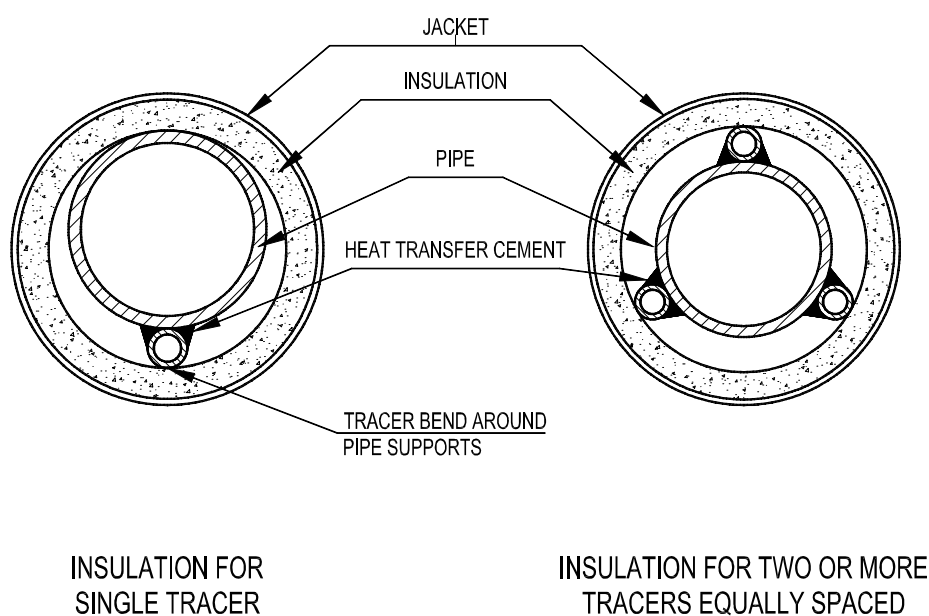
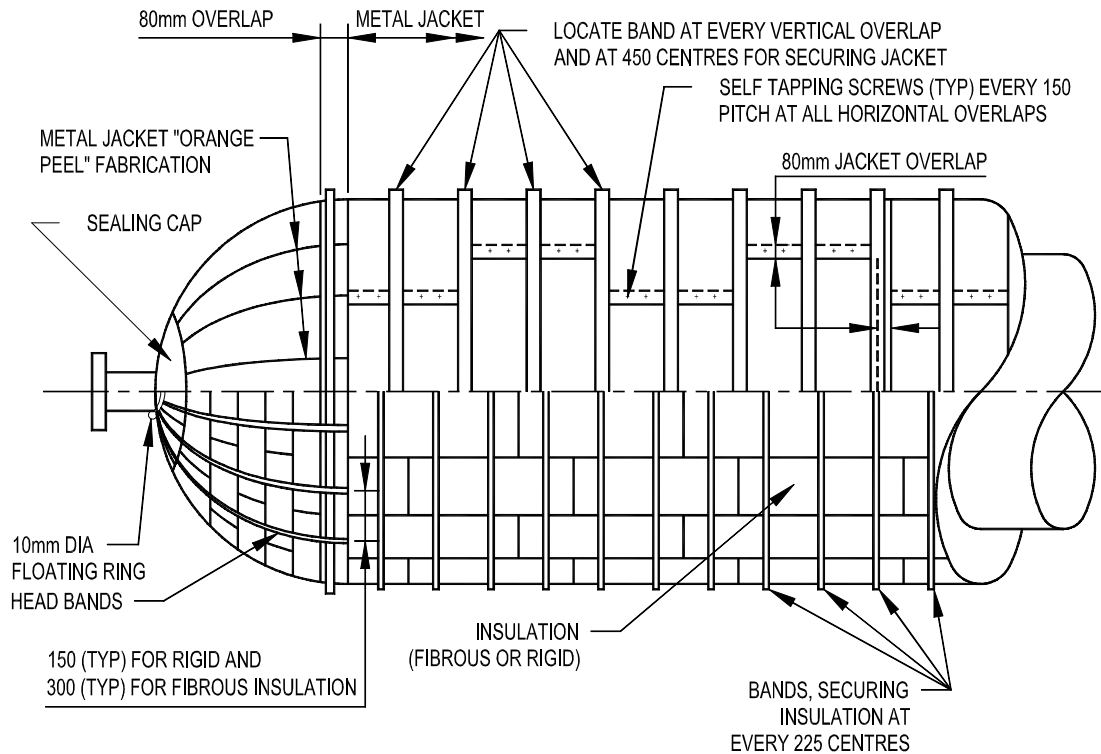


FIGURE – 12
INSULATION OF STEAM TRACED PIPING



NOTES :-

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

FIGURE – 13
HORIZONTAL EQUIPMENT INSULATION

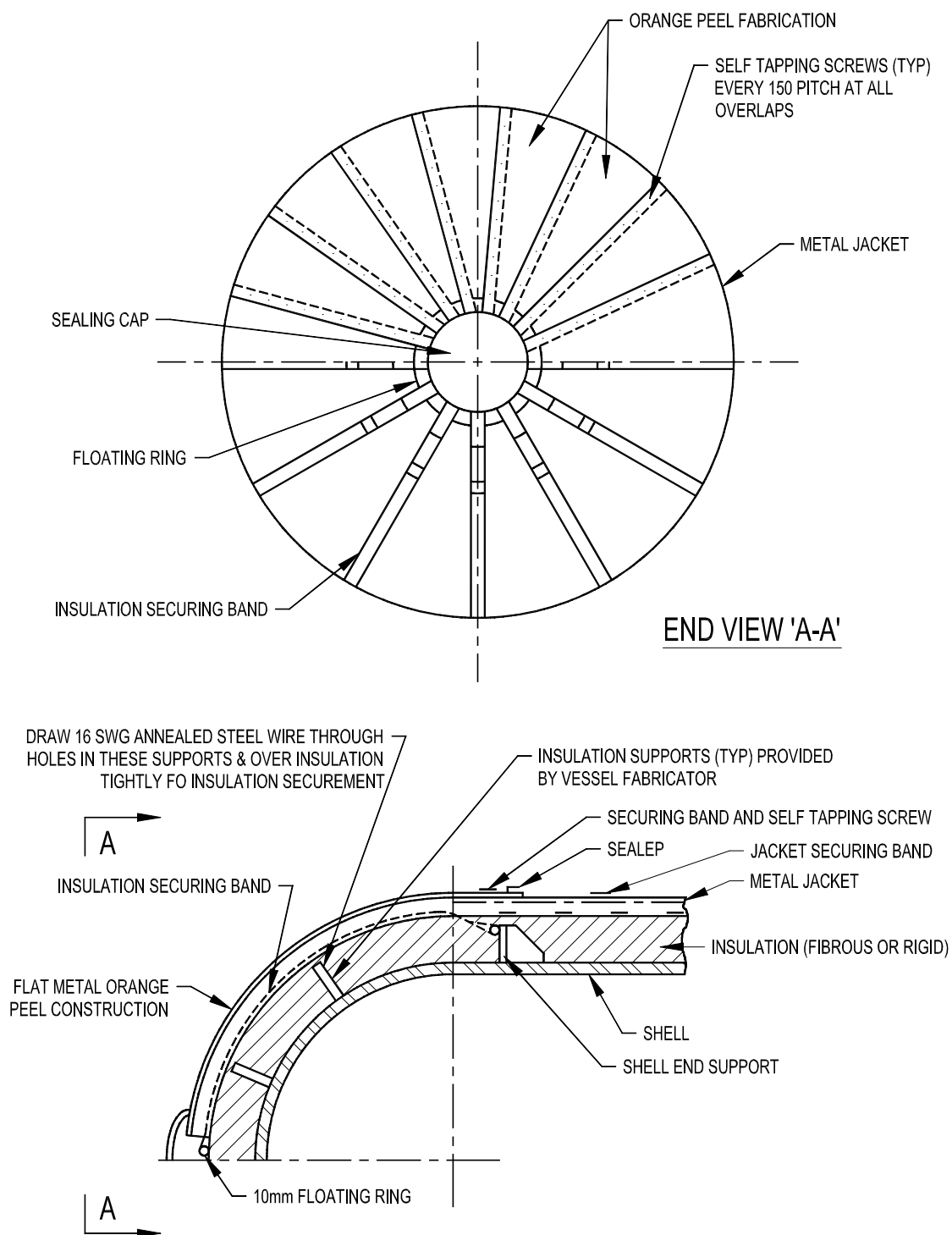


FIGURE – 14
HORIZONTAL EQUIPMENT HEADS

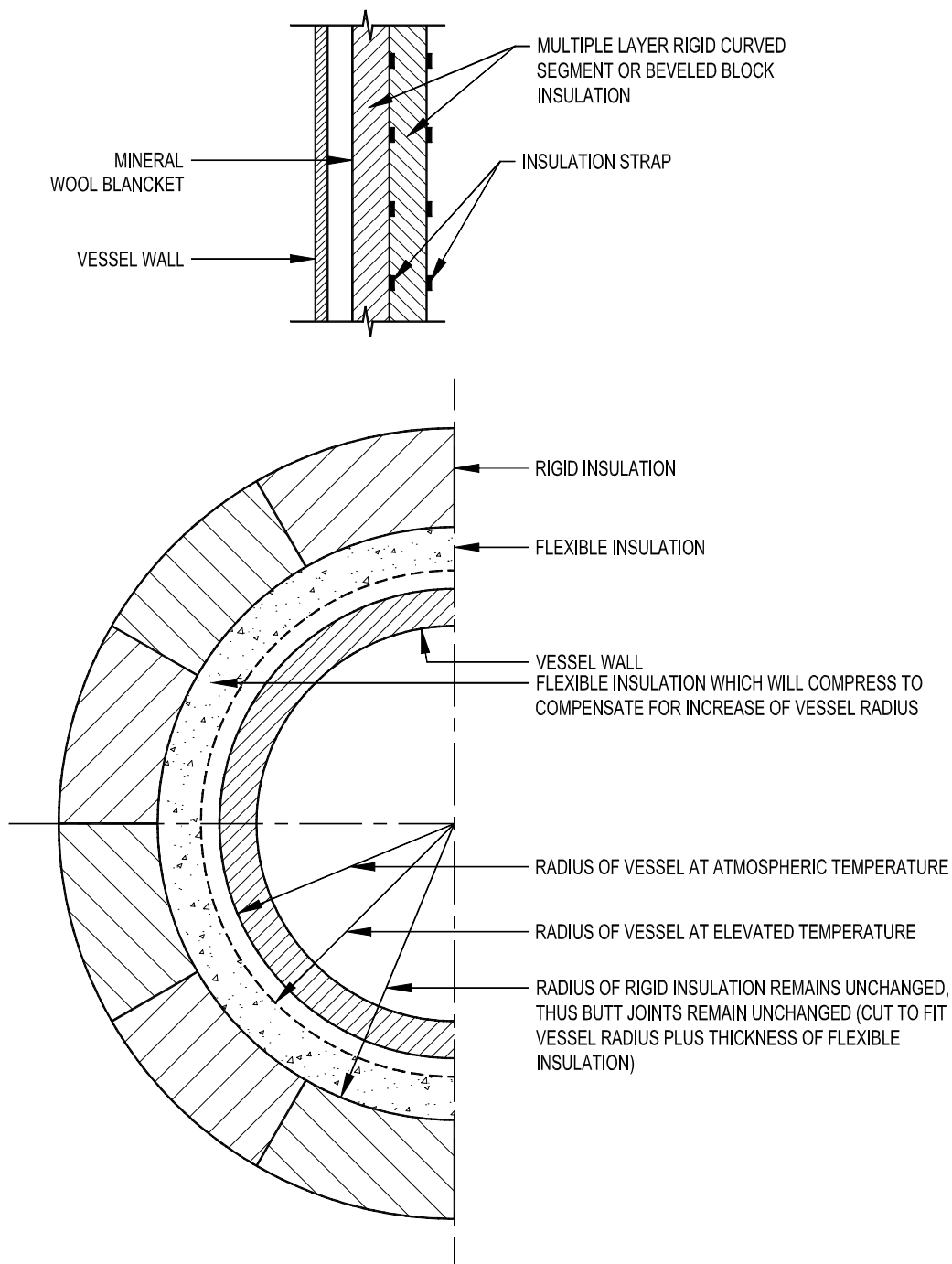
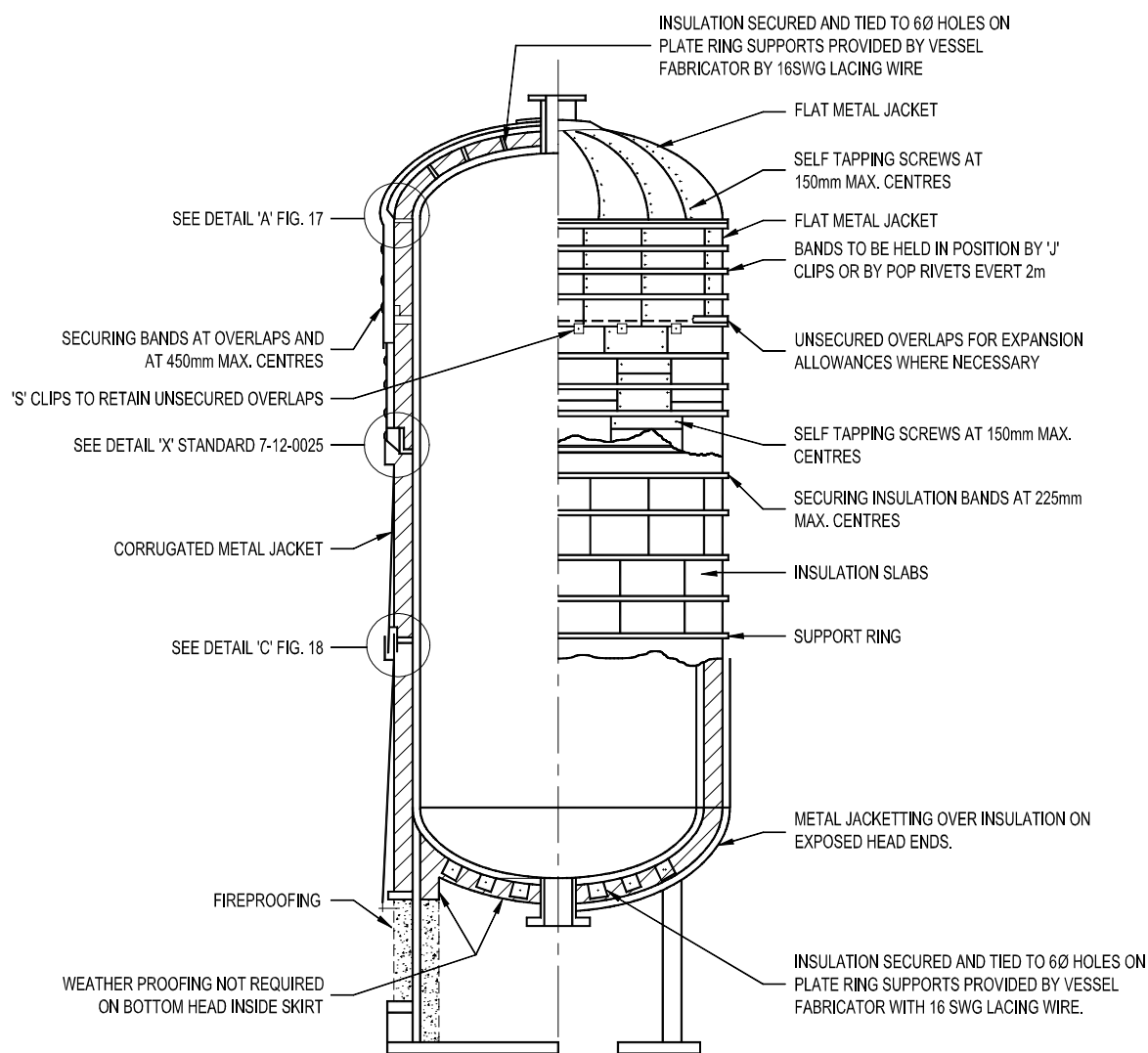


FIGURE – 15
USE OF FLEXIBLE INSULATION IN COMBINATION WITH RIGID INSULATION TO
COMPENSATE FOR VESSEL EXPANSION



NOTE:-

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

FIGURE – 16
INSULATION DETAILS : VERTICAL VESSEL

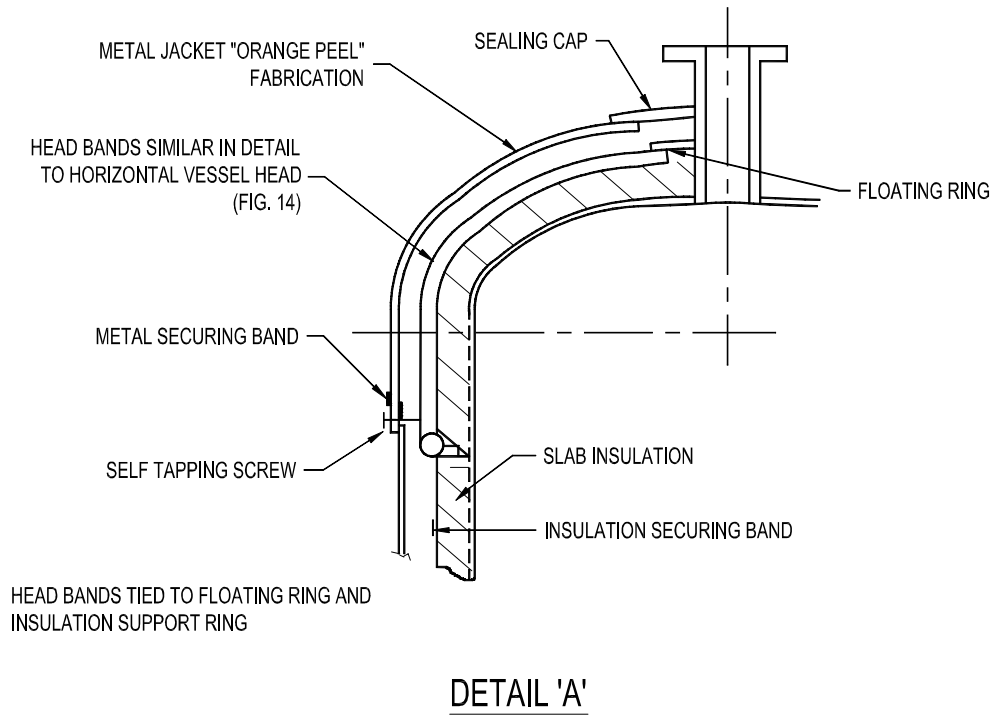
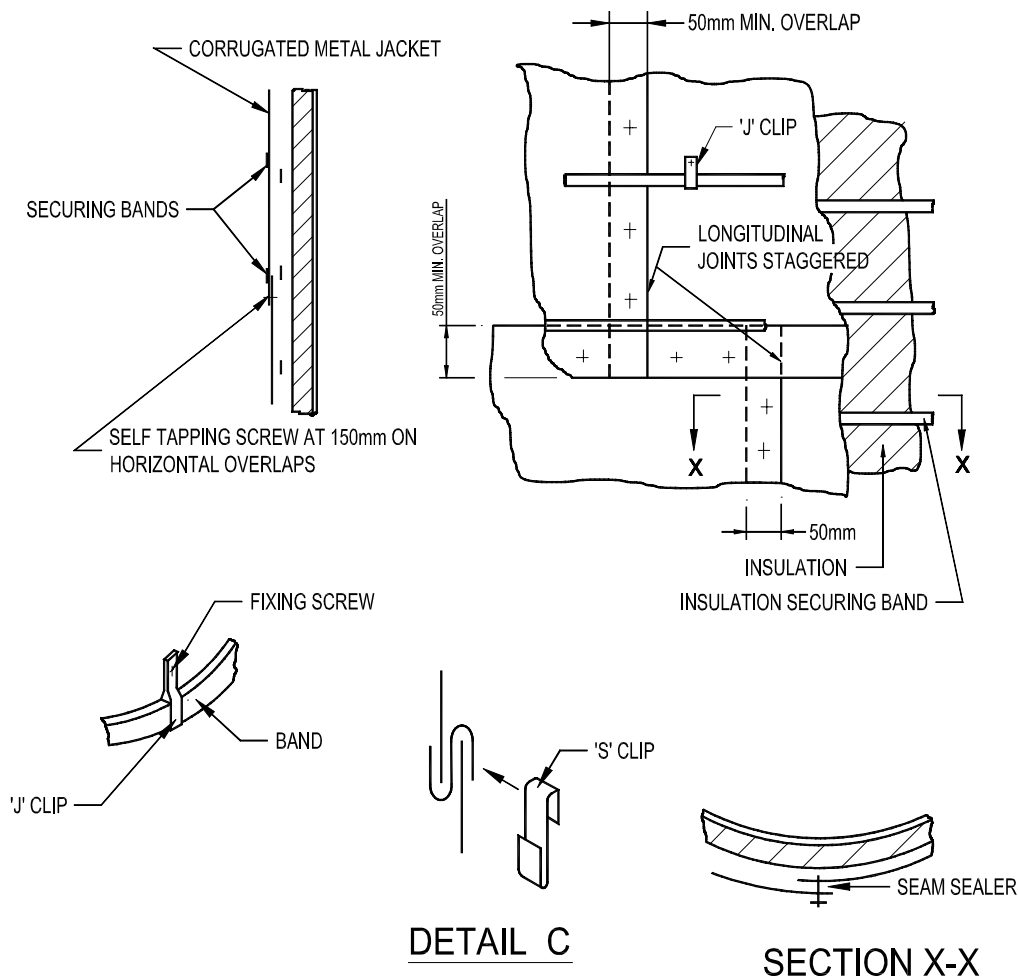


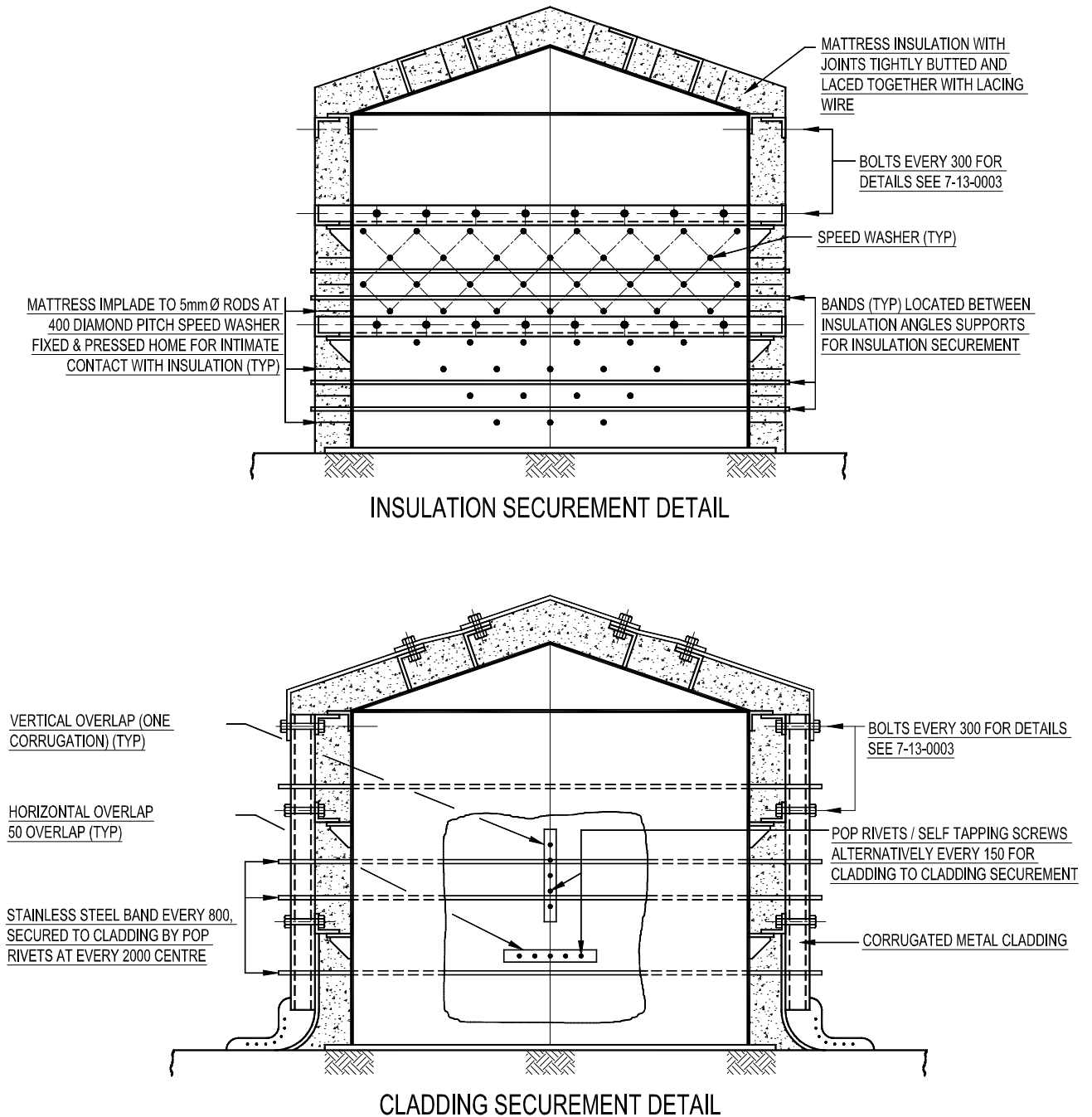
FIGURE – 17
INSULATION DETAILS VERTICAL VESSEL HEADS



NOTE:

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

FIGURE – 18
INSULATION DETAILS : VERTICAL VESSELS



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

FIGURE – 19
INSULATION DETAILS : VERTICAL STORAGE TANK

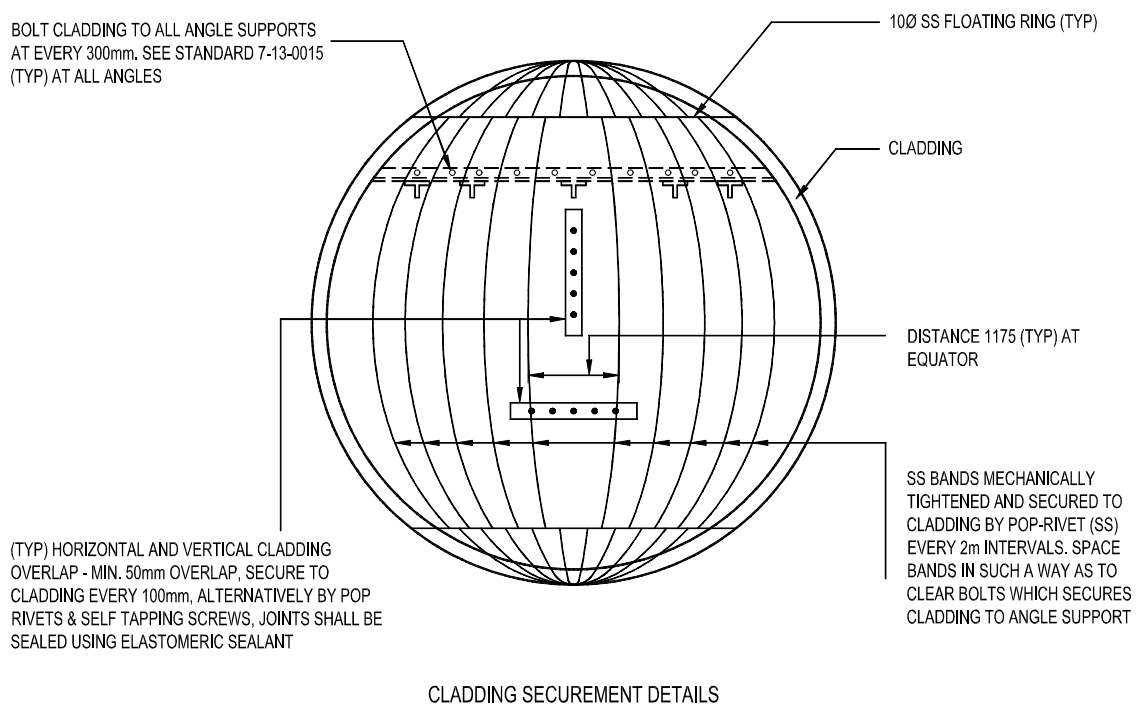
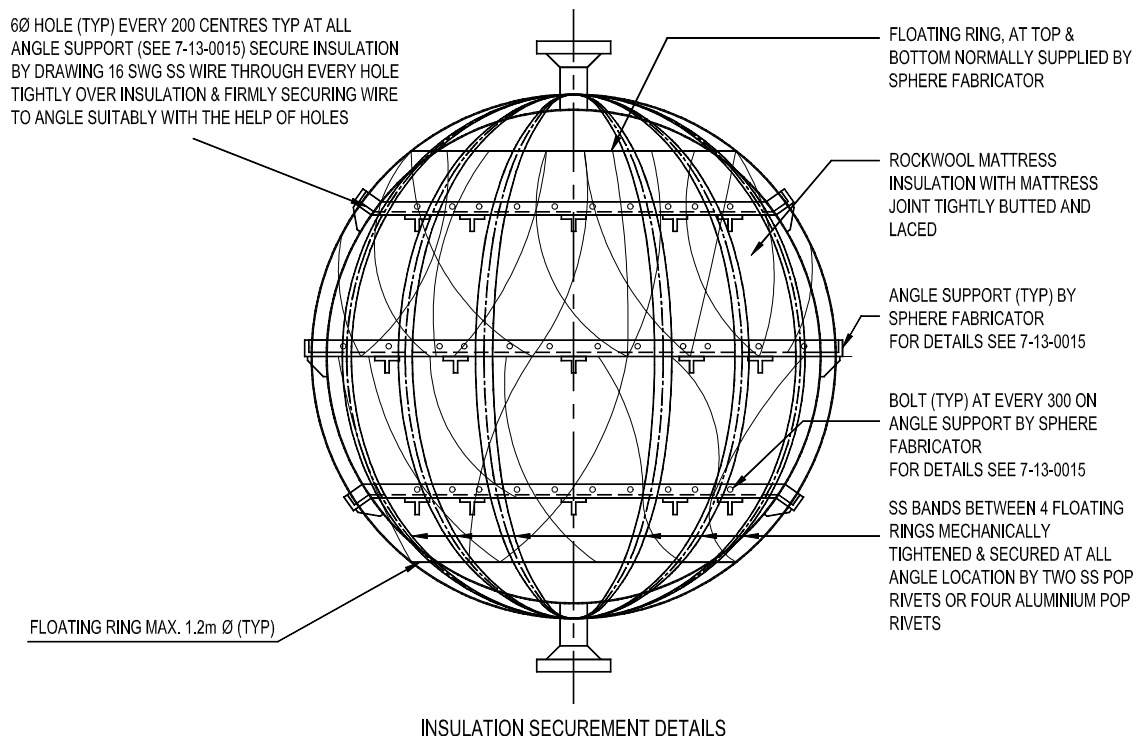


FIGURE – 20
INSULATION DETAILS : SPHERE