INTERPLANT STANDARD - STEEL INDUSTRY		
IPSS	**CODE OF PRACTICE FOR THERMAL INSULATION OF HOT PIPE LINES AND ACCESSORIES** *Based IS 14164:1994*	**IPSS:1-06-015-17** ***(Third Revision)*** Formerly : IPSS:1-06-015-02 *(Second Revision)*

0. **FOREWORD**

0.1 This Inter Plant Standard prepared by the Standards Committee on Pipes, Fittings, Valves and Piping Layout, IPSS 1:6 with the active participation of the representatives of all the steel plants and established manufacturers of thermal insulating materials, was adopted as IPSS Standard in the year of 1984 & subsequently it was first revised in the year of 1993 and second revision done in December 2002.

0.2 In view of updating the Indian Standards this IPSS Standard has been further revised in July 2017.

0.3 Interplant Standards for steel industry primarily aim at achieving rationalization and unification of parts and sub-assemblies used in steel plant equipment and accessories, and provide guidance in indenting stores or equipment for existing or new installations by individual steel plants. For exercising effective control on inventories, it is advisable to select a fewer number of sizes (or types) from among those mentioned in this standard for the purpose of company standards of individual steel plants. It is not desirable to make deviations in technical requirements.

0.4 In preparation of this standard, the assistance has been derived from the following :

Sl No.	**Indian Standard (IS)**	**Description of IS**
1.	277:1992	Specification for galvanized steel sheets (plain and corrugated) (fifth revision) Amendment-3
2.	737:1986	Specification for wrought aluminum and aluminum alloy steel and strip for general engineering purpose (fourth revision)
3.	1322:1993	Bitumen felts for water proofing and damp proofing (third revision)
4.	3069:1994	Glossary of terms, symbols and units relating to thermal insulation materials (first revision)

5.	3144:1992	Methods of test for mineral wool thermal insulation materials (second revision)
6.	3150:1982	Specification for hexagonal wire netting for general purposes (second revision)
7.	3677:1985	Specification for unbonded rock and slag wool for thermal insulation (second revision).
8.	3690:1974	Unbonded glass wool mats for thermal insulation (first revision)
9.	14164:1994	Code of practice for industrial application and finishing of thermal insulating materials at temperatures above 40 deg C and upto 700 deg C (first revision)
10.	8183:1993	Specifications for bonded mineral wool (first revision) Amendment-1
11.	9743:1990	Thermal insulation finishing cements (first revision)
12.	9842:1993	Specifications for pre-formed fibrous pipe insulation (first revision)
13.	13205:1991	Code of practice for the application of polyurethane insulation by the in-situ pouring method.

1. SCOPE

1.1 This Standard covers the method of selection and application of thermal insulation materials to outer surfaces of hot pipe line, flanges and valves for maximum temperature of 550^{o}C.

2. MATERIALS

2.1 The insulation material shall be :

a) Unbonded mineral wool made from slag or rock conforming to IS:3677-1985 or glass wool conforming to IS:3690-1974.

b) Bonded mineral wool conforming to IS:8183 made from slag, rock or glass. Processed from molten state into fibrous form and bonded with a suitable binder.

c) Pre-formed fibrous pipe insulation conforming to IS:9842-1993 (first revision). The material shall be mineral wool processed from rock or glass fibres.

d) In-situ Polyurethane/Polyisocyanurate insulation conforming to IS 13205-1991 (applicable for max operating temperature of 110^{o}C).

2.2 The minimum bulk density (Kg/cum) of insulating materials shall be as given below :

UNBONDED MINERAL WOOL	BONDED MINERAL WOOL			MAX. HOT FACE TEMP. DEG C
	Slabs/Mattresses	Pipe sections		
		Glass Wool	Rock Wool	
120	50	85	120	250
150	80	85	120	400
200	120	85	120	550

3. THICKNESS OF INSULATION

3.1 The thermal conductivity of insulation material shall be as given in respective IS codes. The recommended thickness of insulation, provided in Table 1 to 3 have been calculated based on the following conditions :

a)	Ambient temperature	$40^{O}C$
b)	Maximum surface Temperature	$47^{o}C$ for OT <=$250^{o}C$ $50^{o}C$ for 250 < OT < = $400^{o}C$ $55^{o}C$ for OT> $400^{o}C$
c)	Wind speed	1 m/s
d)	Finishing material	Aluminum sheet/GI sheet

In case actual site conditions which are expected to vary considerably over extended periods, or finishing material is other than aluminum, alternate thicknesses suitable to such conditions can be calculated or obtained from the manufacturer/applicators.

For in-situ polyurethane/polyisocyanurate insulation, the recommended thickness of insulation can be taken as given under column $150^{o}C$ operating temperature (OT) as per Table-1.

4. APPLICATION

4.1 General

4.1.1 All insulating materials shall have intimate contact with the surface.

4.1.2 While applying multilayer insulation, thickness of any layer shall not exceed 75 mm, all joints shall be staggered and each layer shall be separately secured by binding wires. Each layer shall preferably be of equal thickness as far as possible.

4.1.3 Insulation shall be applied to the surface at ambient temperature and with ample provision for thermal movement. This shall be applied in a

manner which will avoid occurrence of breaking and telescoping due to alternate periods of expansion and contraction.

4.1.4 Vertical pipes with diameter of more than 80 mm shall have support rings at intervals not exceeding 2 m to prevent insulation from collapsing. Supporting rings or lugs shall also be installed near the pipe bends (refer Fig 2)(page-15)

4.1.5 Protrusions through the insulation such as pipe lines, supports, piping, instrument take-off etc shall be covered to same thickness as the adjacent insulation and extended up to six times the thickness of insulation (except at hanger rods) and shall be sealed.

4.1.6 All voids, irregularities and joints shall be filled with loose insulation material and properly packed.

4.2 Sequence of Application

a) Removal of existing insulation, if any
b) Surface preparation as per clause 4.3.1
c) Application of insulation as per clause 4.3.2
d) Finishing as per clause 4.3.3

4.3 Method of application

4.3.1 Surface preparation – Before application of the insulation the surface shall be wire brushed to remove all dirt, rust, scale oil, etc and dried. Suitable primer coating shall be provided on the pipe surfaces in case indicated by the customer.

4.3.2 Application of insulation – The insulation shall be provided with any one of type described below :

a) Loose mineral Wool – In case of loose mineral wool mattresses, wire mesh (24 SWG x ¾") conforming to IS 3150 shall be provided on both the sides.

All the joints of wire mesh of adjacent mattresses shall be secured with 20 SWG lacing wire.

NOTE: While insulating pipe of diameter 250 mm and above, lugs of 4 mm dia rods having length 50 mm more than the thickness of insulation shall be welded at a distance of 200 mm on MS flats 20 x 3 mm shaped in the form of rings to suit the circumference of pipe being insulated. These lugs shall be bent inside after the last layer of the insulation and shall remain within the thickness of insulation. The ring segment shall be bolted together with M 8 x 16 bolts. These rings shall be spaced 400 mm apart on pipe (for details refer Fig.2)

b) Bonded Mineral Wool – In case of bonded mineral wool mattresses, the wire mesh shall be provided on one side. All circumferential and longitudinal joints of mattresses to be filled with loose wool so as to ensure heat leak proof joints. All the joints of wire mesh of adjacent mattresses shall be secured with 20 SWG lacing wire.

The material of the wire mesh/stitching wire/lacing wire shall be G.I. for interface temperature upto 400 deg C and stainless steel (IS 6582:1972) for higher interface temperatures.

For general arrangement of insulation pipe system (refer Fig 1)

NOTE: Bonded mineral wool may possibly contain up to approximately 0.01% of chloride. If circumstances can arise in practice such that chloride concentration can take place on the surface of certain alloy steels. For example, austenitic steels, then there is a serious risk of stress corrosion cracking. In such cases, use of aluminum foil/heat resistance anti corrosive paint, as per IPSS:1-07-030-85, over the surface before the application of thermal insulation is suggested.

c) Pre-formed pipe sections – The pre-formed pipe sections shall be snapped on to the pipe surface in a staggered configuration and shall be held in position by means of galvanized wire 20 SWG at 300 mm centre to centre (refer Fig 1).

d) In-situ insulation – The technique of insulating with in-situ polyurethane/polyisocyanurate insulation is a preferred method for many thermal insulation applications such as for process piping and other equipments for the range of operating temperatures upto 110 deg C in case of PUF and upto 140 deg C in the case of PIR. Application of insulation will be carried out as per IS 13205:1991.

In-situ insulation foaming is particularly suited to:

i) Where complicated shapes are involved which would not lend themselves to easy insulation treatment using preformed rigid materials.

ii) Where a joint free insulation is desired or where the number of joints is to be kept to a minimum.

iii) Where very high disbonding stresses (such as leeward wind forces) are to be encountered by the insulation system.

iv) Where speedy installation coupled with high reliability of applied insulation is sought.

4.3.3 Finishing – The insulation shall be finished by any one of the methods described below :

a) Cement plaster – The finishing cement plaster free from asbestos suitable for indoor/outdoor applications as per IS 9743:1990 shall have a total thickness of 12 mm applied in two layers and shall be reinforced with chain link mesh 20 SWG x 20 mm as per IS 3150.

Note : 1) One coat of oil/cement paint may be applied over the plaster in case of indoor applications.

2) Suitable water proofing compound such as bituminous shall be applied over the cement plaster in case of outdoor applications.

b) Sheet metal cladding – Aluminum sheet as per IS 737 or G.I. sheet as per IS 277 shall be rolled, grooved and retained in place with self-tapping screws at 150 mm cc, ensuring minimum 50 mm overlap of cladding sheet at all longitudinal/circumferential joints. The joints shall be rendered water proof by incorporating 25 mm wide bituminous water proofing felt (IS 1322:1993) with the joints being arranged at 8 or 4 O'clock position to shed rain water. Aluminum sheets of 22 SWG and G.I. sheets of 24 SWG are recommended.

Note: Sheet metal will be preferred for outdoor applications.

5. INSULATION OF FITTINGS

5.1 Before insulation of fittings is taken up, insulation of the pipe with its protective finish shall be completed. The insulation of valves, bends/elbows, flanges and clamps shall be done using same thickness as the main equipment/piping (refer Fig 3 to 6).

5.2 At valves and flange fitting location, insulation on pipe lines shall terminate from the face equal to the overall length of the bolts or stud plus two flange thickness so as to permit withdrawal of bolts without damage to adjacent insulation.

Note: Insulation of flanged fittings and valves shall be carried out after hot tightening.

6. INSULATION OF TRACER LINES

6.1 Insulation shall be so applied that no insulating material comes in between the tracer and the process pipe. For steam traced lines, a

protective barrier layer of 0.1mm thick aluminium foil shall be applied enclosing the process and tracer pipes (refer Fig 7), only after which insulation work shall start as per method of application described earlier.

7. PERFORMANCE TESTING

7.1 Performance of the installed insulation system shall be assessed against the specified requirements by carrying out measurements of following parameters after commissioning of insulated systems :

Ambient temperature	Measured 1 m away from insulated surface
Surface temperature	Measured on finished insulation surface
Wind speed	Measured nearest to the surface (within one meter)

Temperature & wind speed shall be measured by suitable instruments surface contact type temperature indicator, with appropriate bow/leaf type probe. Wind speed shall be measured by portable mechanical anemometer. These instruments shall have valid calibration. Measurement spots shall be selected by sampling, to represent entire insulated area. Since the reference conditions during the test may not be same as specified, correlative calculations shall be done to assess and estimate the insulation performance at specified conditions.

Note – Performance testing shall be done after system is stabilized.

8. SPECIAL CONSIDERATIONS FOR COASTAL LOCATIONS

The following are recommended in consideration of conditions that prevail in coastal locations (as described in Appendix-I):

8.1 Surface protection prior to insulation – All pipes and metal surfaces to be insulated shall be cleaned and painted with heat resistant paints suited to maximum operating temperature. Selection shall be made on the basis of paints manufacturers recommendations. Stainless Steel surface shall be protected with aluminum foil 0.1 mm thick applied with minimum 50 mm overlap and secured with 0.4 mm dia stainless steel wires at a spacing of 400 mm.

8.2 Cladding over insulation

8.2.1 Aluminum Cladded system

i) The aluminum sheet shall conform to IS 737:1986 alloy designation 31000 in the following thicknesses :

Up to 600 mm dia over insulation	0.71 mm
601 mm and above	0.91 mm

ii) All cladding joints shall have a synthetic rubber based metal sealant provided in a bead of approximately 6 mm dia.

iii) Securement shall be done with aluminum pop-rivets at a spacing of 150 mm.

iv) Aluminum bands shall be provided over cladding in the following sizes at a spacing of 400 mm (max) :

Upto 300 mm dia meter over insulation	None
301 to 600 mm	25 x 0.91 mm
601 and above	25 x 1.2 mm

8.2.2 Galvanized/Galvalume sheet cladded system

i) Specification for cladding material shall be as per IS 277:1977 with class 2 galvanization or galvalume protected steel and thickness of sheet shall be used as below :

Up to 600 mm dia over insulation	0.6 mm
601 mm and above	0.8 mm

ii) All cladding joints shall have a synthetic rubber based metal sealant provided in a bead of approximately 6 mm dia.

iii) Securement shall be carried out with galvanized pop-rivets and steel screws placed alternatively at a spacing of 150 mm.

iv) Galvanized steel bands shall be provided at a spacing of 400 mm maximum in the following sizes :

Upto 300 mm dia meter over insulation	None
301 to 600 mm	25 x 0.6 mm
601 and above	25 x 0.8 mm

8.3 For brief description of special considerations for Coastal Locations see Appendix- 1

9. GENERAL - Any details not specified in this standard shall be as agreed between suppliers/applicators and client.

TABLE – 1

RECOMMENDED MINIMUM THICKNESS (mm) CHART FOR RESIN BONDED MINERAL WOOL (SLABS / MATTRESSES)

DESIGN CRITERIA

Ambient temperature	40^{O}C
Maximum surface Temperature	47ºC for OT < =250ºC 50ºC for 250 < OT < = 400ºC 55ºC for OT> 400ºC
Wind speed	1 m/s
Insulation material (density)	50 kg/cum for OT < = 250ºC 80 kg/cum for 250<OT< = 400ºC 120 kg/cum for OT > 400ºC
Finishing	Aluminium sheet/G.I. sheet

Pipe NB mm	**Operating temperature (OT), Deg c**				
	Upto 150*	151 to 250	251 to 350	351 to 400	401 to 550
15	50	95	95	100	105
20	50	100	100	105	110
25	55	105	105	110	115
32	55	110	110	115	120
40	55	115	115	120	125
50	60	120	120	125	130
65	60	125	125	135	140
80	65	130	130	140	145
100	65	135	135	145	150
125	70	145	145	150	160
150	70	150	150	160	165
200	75	155	155	165	175
250	75	165	165	175	185
300	80	170	170	180	190
350	80	170	170	185	190
400	80	175	175	185	195
450	80	180	180	190	200
500	85	180	180	195	205
600	85	185	185	200	210
x	95	235	235	255	270
* Thicknesses indicated in this column can be used for in-situ polyurethene/ polyisocyanurate insulation also.					
NOTE: Pipe NB (x) stands for NB more than 600 mm & flat surface. All thicknesses indicated are in mm.					

TABLE – 2

RECOMMENDED MINIMUM THICKNESS (mm) CHART FOR UNBONDED MINERAL WOOL

DESIGN CRITERIA

Ambient temperature	40^{O}C
Maximum surface Temperature	47^{o}C for OT < =250^{o}C 50^{o}C for 250 < OT < = 400^{o}C 55^{o}C for OT> 400^{o}C
Wind speed	1 m/s
Insulation material (density)	120 kg/cum for OT < = 250^{o}C 150 kg/cum for 250<OT< = 400^{o}C 200 kg/cum for OT > 400^{o}C
Finishing	Aluminium sheet/G.I. sheet

Pipe NB mm	**Operating temperature (OT), Deg c**				
	Upto 150	151 to 250	251 to 350	351 to 400	401 to 550
15	55	105	110	130	135
20	60	110	115	140	140
25	65	115	120	145	145
32	65	125	130	155	155
40	70	125	130	155	160
50	70	135	140	165	165
65	75	140	145	175	175
80	75	145	150	180	180
100	80	155	160	190	195
125	85	160	170	200	200
150	85	165	175	210	210
200	90	175	185	220	225
250	95	185	195	230	235
300	95	190	200	240	240
350	95	195	205	245	245
400	100	200	210	250	250
450	100	200	210	255	260
500	100	205	215	260	265
600	105	210	225	270	270
x	120	270	290	360	365

NOTE: Pipe NB (x) stands for NB more than 600 mm & flat surface. All thicknesses indicated are in mm.

TABLE – 3

RECOMMENDED MINIMUM THICKNESS (mm) CHART FOR RESIN BONDED MINERAL WOOL (PIPE SECTION)

DESIGN CRITERIA

Ambient temperature	40^{O}C
Maximum surface Temperature	47ºC for OT < =250ºC 50ºC for 250 < OT < = 400ºC 55ºC for OT> 400ºC
Wind speed	1 m/s
Insulation material (density)	85 kg/cum for glass wool 120 kg/cum for rock wool
Finishing	Aluminium sheet/G.I. sheet

Pipe NB mm	**Operating temperature (OT), Deg c**				
	Upto 150	151 to 250	251 to 350	351 to 400	401 to 550
15	40	75	95	100	105
20	45	80	100	105	110
25	45	85	105	110	115
32	45	90	110	115	125
40	50	90	115	120	125
50	50	90	120	125	135
65	55	100	125	135	140
80	55	105	130	140	145
100	55	110	135	145	155
125	60	115	145	150	160
150	60	120	150	160	170
200	65	125	155	165	175
250	65	130	165	175	185
300	65	135	170	180	190
350	65	135	170	185	195
400	70	140	175	185	200
450	70	140	180	190	205
500	70	145	180	195	205
600	70	145	185	200	215
x	75	175	235	255	275

NOTE: Pipe NB (x) stands for NB more than 600 mm & flat surface. All thicknesses indicated are in mm.

APPENDIX – I

BRIEF DESCRIPTION OF SPECIAL CONSIDERATION FOR COASTAL LOCATIONS

1. Most coastal locations involve high wind velocities and cyclonic storms. Selection of cladding thickness and securement of cladding need special care. In all cases, specifications shall feature positive securement at sheeting joints, by pop rivets/self-tapping screws. Insulation systems for large ducts, and such areas shall incorporate external bands over cladding which are the only means of preventing dislodgment of sheeting by the heavy leeward (suction) pressures that are normally encountered.

2. As is well known, atmosphere in a coastal location, in addition to high humidity, also contains higher levels of electrolytes – thereby increasing the potential for electrochemical corrosion. From this angle, the following become important :

   a) All equipment and piping shall be properly cleaned, surface prepared and coated to desired protection standards prior to releasing them for insulation applications. In heated systems, coatings used shall be selected for suitability for peak temperatures expected in service. Field welded areas on shop fabricated and shop coated equipment need care and attention in this regard.

   b) All stainless steel surfaces need special attention due to their sensitivity to chloride attack. Irrespective of the type and nature of the insulant selected, there is likelihood of high chloride pick-up in storage, handling and application and hence, positive protection against direct concentration of leachable chlorides at the interface between the metal and the insulation is mandatory.

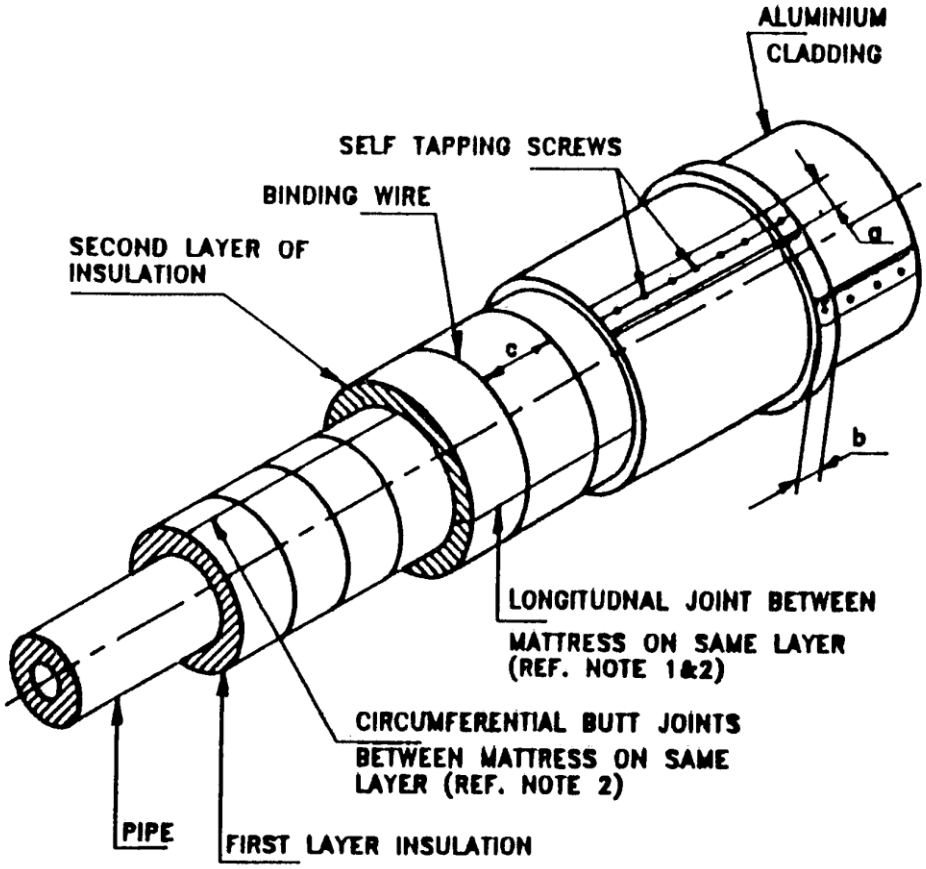
   c) All exposed surfaces, such as cladding shall be selected to be of materials which will not pit, scale or corrode. Aluminum alloy cladding is

preferred in all cases. Where sheet steel is used for any reason, it shall be galvanized with sufficient thickness of coating. Some improved protective techniques such as galvalume treatment or additional coil coating over galvanizing are available which will provide superior service life.

d) Bands and securement devices including screws shall preferably be of the same material as the main cladding. Where they have to be of different metals, they shall be so chosen as to ensure that they are not electrolytically dissimilar at the point of contact.

e) Although sealings at joints in cladding and flashing at the terminations in insulation are important in many systems, coastal areas need special care in these areas since water seepage through imperfect joints can be much more serious, since corrosion under insulated systems due to such occurrence remain undetected till it is too late.

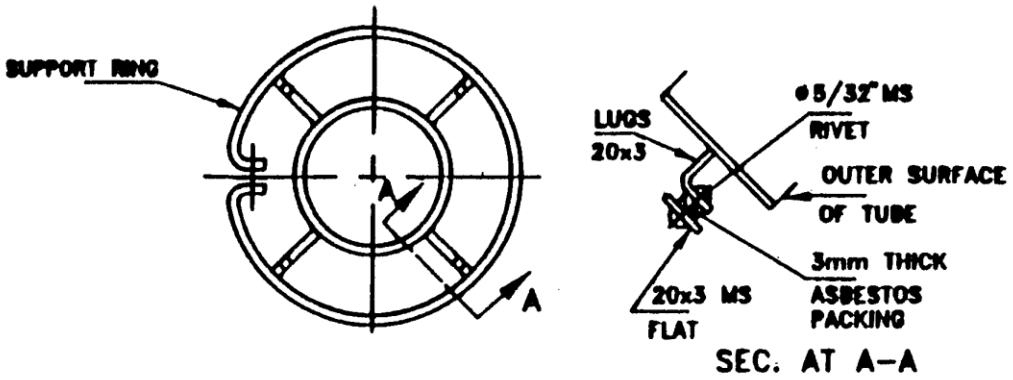
Generally, special care is needed in selecting and inspecting all materials forming part of the insulation system such as the material, sealants, mastics and adhesives, etc. since aging and deterioration rates are higher in aggressive environmental conditions per sec.

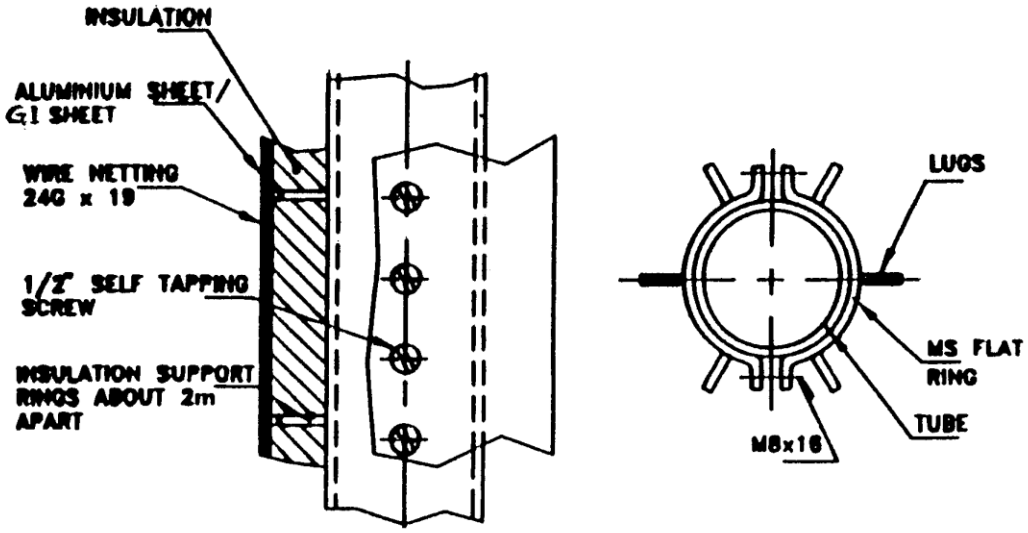


NOTES:

1. LONGITUDINAL INSULATION JOINTS ON SUCCESSIVE LAYERS SHALL BE STAGGERED WITH RESPECT TO LONGITUDINAL JOINTS ON PREVIOUS LAYER PLACED AT 8/4 CLOCK POSITION RESPECTIVELY.
2. ALL JOINTS BETWEEN ADJACENT MATTRESS SHALL BE MADE BY BUTTING AND LACING EXCEPT AT INSULATION EXPANSION JOINTS.
3. SELF TAPPING SCREW SHALL BE 150 mm INTERVALS FOR INSULATION OUTSIDE DIAMETER ABOVE 250 mm.
4. DIMENSIONS : a = (longitudinal Overlap) = 50 mm
   b = (Circumferential Overlap) = 100 mm
   c = 300 mm

FIG. 1 INSULATION OF PIPING SYSTEM

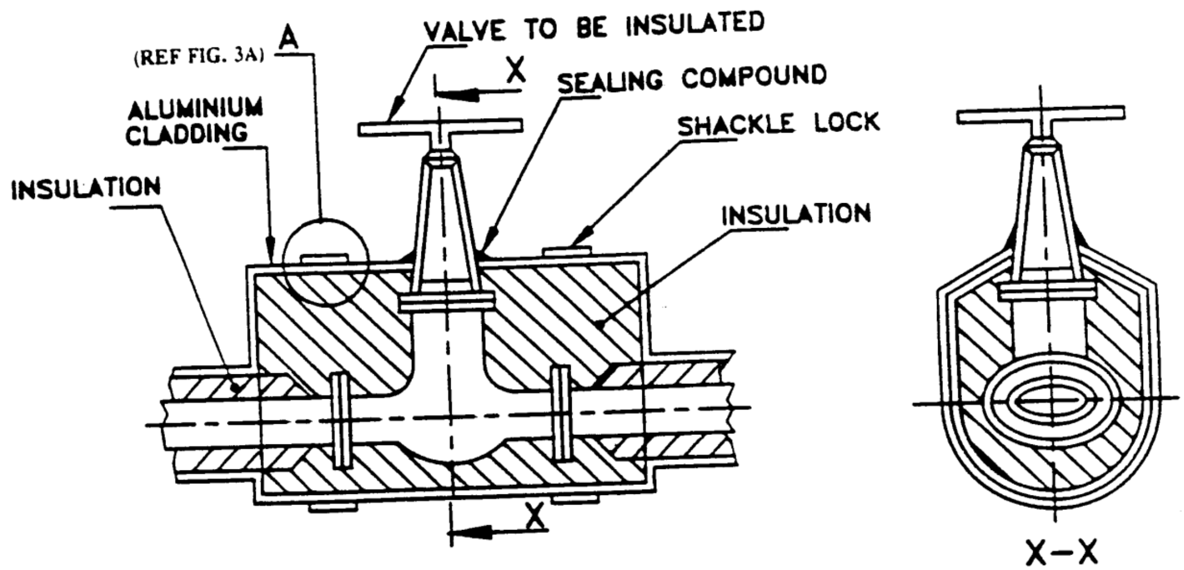




NOTES:

1. IN MULTI-LAYER INSULATION ON VERTICAL PIPES METAL BENDS SHALL BE USED AT 1m TO HOLD INSULATION FIRMLY TOGETHER.
2. SUPPORT RINGS SHALL BE FIXED ON PIPE WITH NUTS AND BOLTS.
3. RADIAL LUGS SHALL BE EQUAL TO 75% OF TOTAL INSULATION THICKNESS.

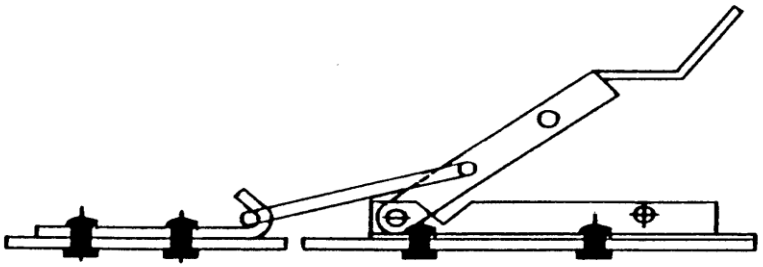
FIG. 2 INSULATION OF VERTICAL PIPING



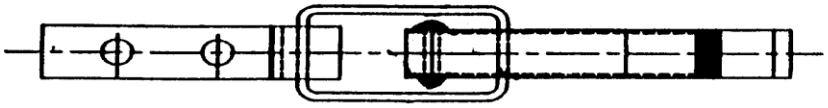
NOTES:

1. ALUMINIUM CLADDING ON VALVES SHALL BE PROVIDED WITH REMOVABLE TYPE BOX.
2. SHACKLE LOCK FOR KEEPING TWO HALVES OF VALVE BOX IN POSITION.
3. INSULATION ON PIPE SHOULD END AT A DISTANCE EQUAL TO SIZE OF BOLT + 2 FLANGE THICKNESS.
4. SUITABLE SEALING COMPOUND SHALL BE USED.

FIG. 3 INSULATION OF VALVES



ELEVATION

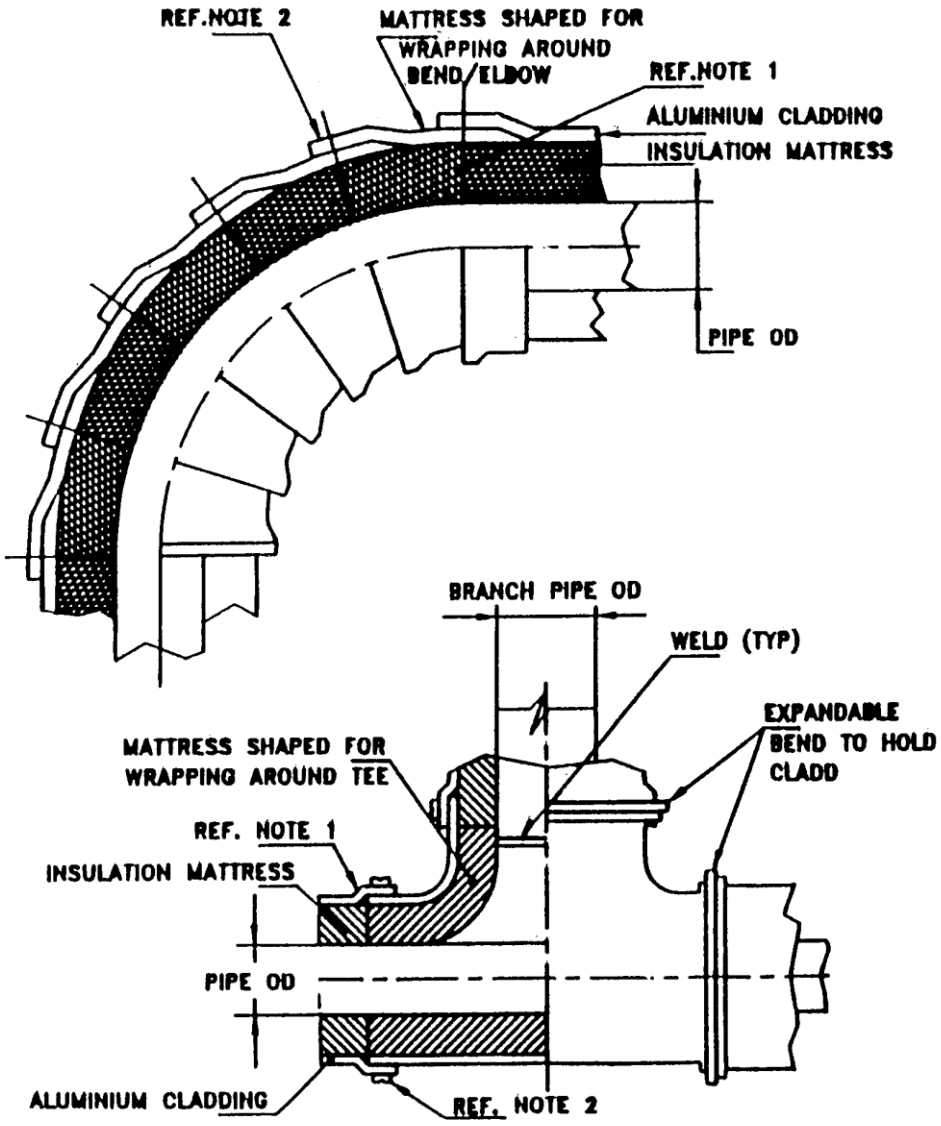


PLAN

(THIS DRAWING SHALL BE READ IN CONJUCTION WITH FIG. 3 INSULATION OF VALVES, AS IN CIRCULE A)

SHACKLE LOCK'S DETAIL AT `A' OF FIG. 3

FIG. 3A SHACKLE LOCK



NOTES :

1. JOINTS BETWEEN ADJACENT MATTRESSES BUTTED TOGETHER AND SEWN.
2. CLADDING JOINT SHALL BE Min. 50mm EXCEPT ON BENDS SHALL BE 20mm.
3. BEND/ELBOW INSULATION SHOWN IS TYPICAL FOR 90 BEND THE NO. OF MATTRESS SECTIONS SHALL BE TAKEN AS SUITABLE FOR SPECIFIED BEND RADIUS AND ANGLE.

FIG. 4 INSULATION OF BENDS / ELBOWS

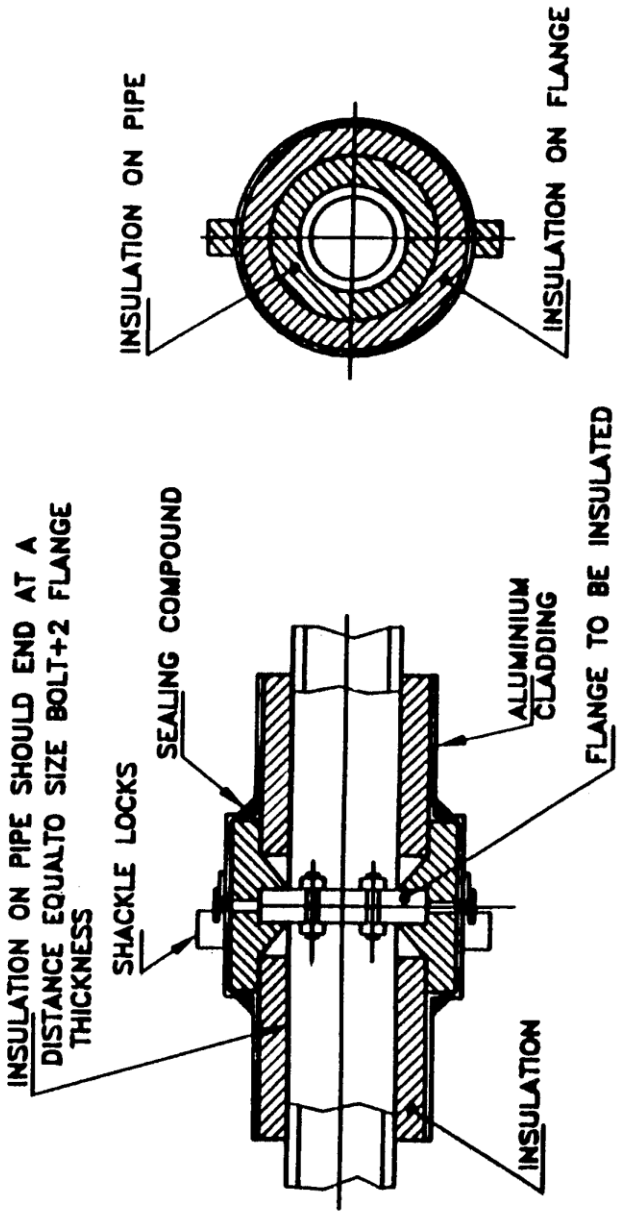
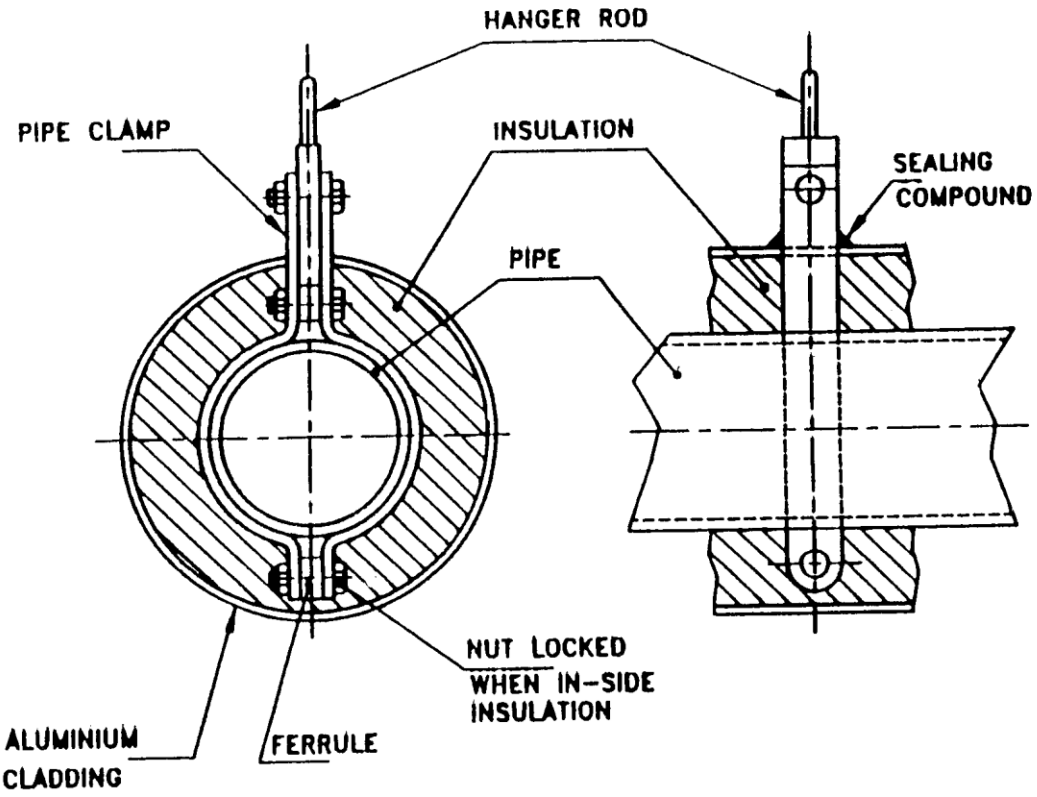


FIG. 5 INSULATION OF FLANGES



NOTES:

1. INSULATION SHALL BE APPLIED TO HANGER ROD AND CONNECTING BOLTS AND NUTS.
2. ANY CIRCUMFERENTIAL JOINT SHALL BE LEAST 150mm AWAY FROM CENTRE LINE OF PIPE.
3. SUITABLE SEALING COMPOUND SHALLBE USED.

FIG. 6 INSULATION AT PIPE CLAMP

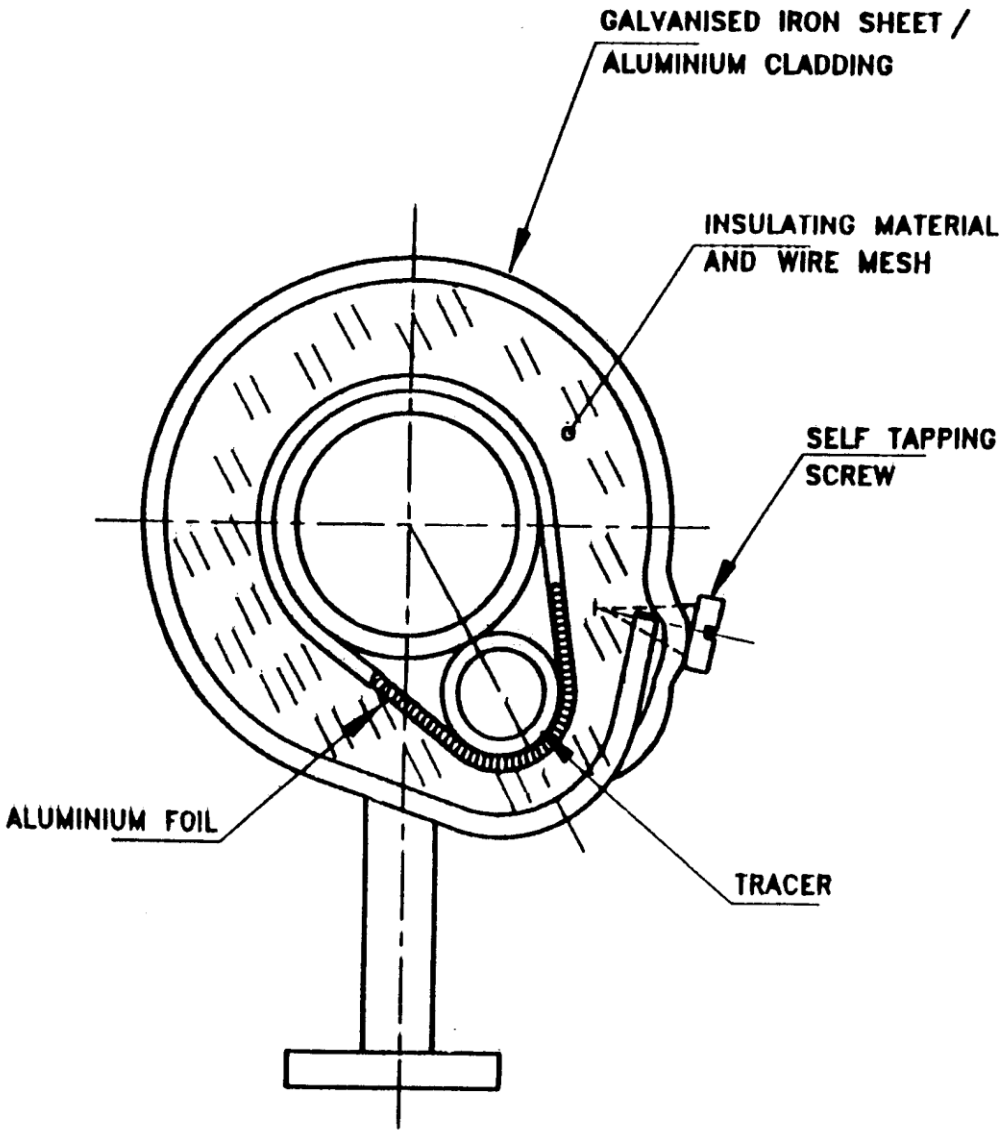


FIG. 7 INSULATION OF TRACER LINES