under site conditions as specified in the data sheet. If not specifically mentioned therein, a design ambient temperature of 40° C and an altitude not exceeding 1000m above mean sea level shall be considered.

5.0 POWER SUPPLY

5.1 Lighting and power panels shall be suitable for 415V, 50Hz, TPN incoming power supply and outgoing circuits for 240V, SPN power supply.

5.2 For projects falling under the jurisdiction of DGMS, the following additional requirements shall apply:

5.2.1 The phase-to-phase voltage shall not exceed 125V (where electric lighting is used in underground mine)/ 250V (where electric lighting is used in open cast mine or surface of a mine), with the neutral or the mid-point of the lighting system connected with earth.

5.2.2 The panels shall have three phase, 3-wire system, without neutral.

5.2.3 Outgoing circuits shall be controlled by 2-pole MCBs. Earth leakage protection shall be provided for all outgoing circuits, which shall isolate both poles.

6.0 CERTIFICATION

All Hazardous area equipment shall have hazardous area test certificates and approvals as per following:

For Indigenous manufactured hazardous area equipment:
For all electrical items manufactured in India, the testing shall be carried out & test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished.

Alternatively, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

For Imported hazardous area equipment:
For all electrical items manufactured outside India, test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished.

As an alternative option-1 to this, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

As an alternative option-2 to this, EU Type Examination Certificate, which is applicable for manufacturers having manufacturing locations in countries covered under the European Union, valid copy of Production Quality Assessment / Assurance Notification shall be furnished.

All equipment i.e. Indigenous & imported, shall also have valid statutory approvals, as applicable for the specified location and marking as per IS/IEC 60079 and as required by statutory authorities.
For installations in India, PESO approval letter shall be provided.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The enclosures of the lighting and power panels shall be made of cast light metal alloy, unless otherwise specified. The enclosures of the lighting and power panels intended for use in units

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handling sulphuric acid/ other corrosive materials shall be made of stainless steel grade SS-316L, if specified in MR/ Tender.

7.1.2 The panels shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection. They shall preferably be provided with integral canopy. However, where the enclosure has been certified without integral canopy, a separate canopy can be accepted. The separate canopy shall be made of at least 1.6 mm (16 gauge) galvanized sheet steel/ stainless steel minimum SS-304 (as specified in MR/ Tender). The canopy shall be suitable for providing protection against rain from top, back and two sides.

7.1.3 The lighting and power panels shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the panels shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

- Flame proof Exd (Gas group IIA/IIB): Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flame proof Exd (Gas group IIC): Light yellow shade 355 of IS-5/ RAL 1012.

All unpainted steel parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving elements, then these shall be greased with non-solidifying grease. However, in case of stainless steel lighting and power panels, finish shall be Electropolish/ Buffed/ equivalent finish.

7.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

7.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

7.1.7 All the non-current carrying metallic parts of the panel shall be inherently bonded together. Each lighting and power panel shall be provided with two earthing studs (bolt, nut with spring and plain washer) with lugs on the exterior of the panel enclosure suitable for termination of 10 mm dia GI wire rope. No screw type fixing arrangement shall be allowed.

7.1.8 Each outgoing feeder shall be provided with distinct terminals for phase, neutral and earth. The terminal block enclosures shall be adequately sized to properly terminate the cables by taking into account the required bending radii of cable cores and shall have the following minimum gland to terminal distances:

Conductor Size	Up to 2.5 mm^2	Above 2.5 mm^2 & Up to 10 mm^2	Above 10 mm^2 & Up to 35 mm^2	Above 35 mm^2 & Up to 95 mm^2	Above 95 mm^2 & Up to 185 mm^2	Above 185 mm^2 & Up to 300 mm^2
Gland to terminal distance	40 mm	60 mm	100 mm	150 mm	200 mm	300 mm

7.1.9 The panels shall be provided with suitably sized cable entries at the bottom/ sides, for incoming and outgoing cables. Panels shall be complete with double compression type nickel plated brass flameproof cable glands. Flameproof nickel plated brass sealing plugs shall be supplied, for plugging the unused cable entries. The quantity of sealing plugs shall be equal to 20% of the total number of outgoing cable entries.

7.1.10 The panels shall have external fixing lugs for mounting on wall or column. The holes provided on these lugs shall be of oblong type.

7.1.11 A tag plate indicating Tag Number shall be provided on each lighting and power panel. Nameplates shall also be provided for each incoming and outgoing feeder. A separate

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nameplate shall be provided to indicate the name of manufacturer, testing agency, test certificate number, serial number, BIS license number, applicable gas group as per IS/IEC 60079, statutory agency (PESO) approval number and any additional marking required by statutory authority. The nameplates shall be engraved on 3 ply black white black lamicold sheets using square cutters. Black engraved perspex sheet nameplate shall also be acceptable. Nameplates shall be fixed by screws and shall not be pasted. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the main nameplate.

7.2 Component Specification

7.2.1 Bus bars in the lighting and power panels shall be made of high conductivity copper, and shall be supported by non-hygroscopic insulators. Bus bars shall be colour coded for identification of phases and neutral.

7.2.2 The incomer shall have one no. 4 pole MCB isolator (without overload and short-circuit release) and one no. 4 pole RCCB (if specified in the MR/ Tender). RCCBs shall have a maximum sensitivity of 30mA.

7.2.3 The outgoing feeders shall be provided with double pole MCBs having overload and short-circuit releases. Further, separate 2 pole ELCBs with maximum sensitivity of 30mA shall be provided for outgoing feeders if specified in MR/ Tender.

7.2.4 All MCBs (except isolators) and RCCBs shall be with 10kA interrupting capacity.

7.2.5 The RCCB shall be self-reset type.

7.2.6 The operating knobs (ON/ OFF/ RESET) shall be provided with a suitable rack and pinion arrangement or cam type operating mechanism for operating them smoothly from outside.

7.3 Terminals & Wiring

7.3.1 The panels shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. Tinned Copper lugs shall be provided for cable termination. Incoming and outgoing terminals shall be suitably segregated.

7.3.2 All internal wiring in lighting and power panels shall employ adequately sized, 660V/ 1100V grade, FRLS type, XLPE/ PVC insulated, Copper conductor wires, colour coded for phase, neutral and earth, with minimum conductor sizes as below:

Incomer	:	16 mm^2
Outgoing	:	2.5 mm^2

All terminations shall be with suitable lugs.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL accredited/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The test certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be submitted to the inspection agency, as per inspection and Test Plan no. 6-81-1008.

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8.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test plan no. 6-81-1008.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight', 'Owner's particulars', 'PO no.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

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संकटमय क्षेत्रों में लाइटिंग फिक्सचरों एवं जंक्शन बक्सों के लिए विनिर्देश

SPECIFICATION FOR HAZARDOUS AREA LIGHT FIXTURES AND JUNCTION BOXES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	09.04.26	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/SAC	ANPS	HK	NK
6	23.12.20	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/RKS	ANPS	PG	SM
5	24.02.16	REVISED AND ISSUED AS STANDARD SPECIFICATION	NNB/AK	ANPS	BRB	SC
4	11.04.11	REVISED AND ISSUED AS STANDARD SPECIFICATION	PS	ANPS	UAP	DM
3	27.08.07	REVISED AND ISSUED AS STANDARD SPECIFICATION	ANPS	UAP	JMS	VC
2	30.01.02	REVISED AND ISSUED AS STANDARD SPECIFICATION	UAP	AAN	VPS	GRR

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Abbreviations:

AC	Alternating Current
BIS	Bureau of Indian Standards
CEA	Central Electricity Authority
CRI	Colour Rendering Index
DC	Direct Current
DGCA	Director General Civil Aviation
EIL	Engineers India Limited
FRLS	Flame Retardant Low Smoke
IEC	International Electrotechnical Commission
IES	Illuminating Engineering Society
IP	Ingress Protection
IS	Indian Standard
LED	Light Emitting Diode
MR	Material Requisition
NABL	National Accreditation Board for Testing and Calibration Laboratories
PESO	Petroleum and Explosives Safety Organisation
PO	Purchase Order
PVC	Poly Vinyl Chloride
SPD	Surge Protection Device
SPN	Single Phase Neutral
SS	Stainless Steel
XLPE	Cross Linked Poly Ethylene

Electrical Standards Committee

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1.0 SCOPE

This specification covers the requirements of design, manufacture, testing, packing and supply of LED lighting fixtures, complete with LED lamp and driver, junction boxes and accessories suitable for installation in locations handling flammable liquids and gases/ vapours.

2.0 CODES AND STANDARDS

2.1 The equipment shall comply with the requirements of latest revision of the following standards issued by BIS:

IS-5	:	Colours for ready mixed paints and enamels
IS-10322	:	Luminaires
IS-13383	:	Photometry of luminaires - Method of measurement
IS 15885 (Part 2/ Sec 13)	:	Safety of lamp control gear-Part-2 Particular requirements-Section 13 d.c. or a.c. supplied electronic control gear for LED modules
IS-16101	:	General lighting – LEDs and LED modules – Terms and Definitions
IS-16102	:	Self-ballasted LED lamps for general lighting services
IS-16107	:	Luminaires performance
IS / IEC 60079-0	:	Electrical apparatus for explosive gas atmospheres (General requirements)
IS / IEC 60079-1	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Flameproof Enclosures "d")
IS / IEC 60079-7	:	Electrical apparatus for explosive gas atmospheres (Equipment Protection by Increased Safety "e")
IS / IEC 60079-15	:	Electrical apparatus for explosive gas atmospheres Construction, test & marking of type of protection "n"
IS / IEC 60529	:	Degrees of protection provided by enclosures (IP Code).

2.2 In case of imported equipment, only IECEx (or equivalent, if more stringent than the applicable IEC) certified equipment shall be used.

2.3 The equipment shall also confirm to the provisions of CEA Regulations with latest amendments and statutory regulations currently in force in the country.

2.4 In case Indian standards are not available for any equipment, standards issued by IEC or equivalent agency (if more stringent than IEC) shall be applicable.

2.5 In case of any conflict between requirements specified in various applicable documents for the project, the most stringent requirement shall govern. However, Owner's/ EIL's decision in this regard will be final and binding.

3.0 GENERAL REQUIREMENTS

3.1 The offered equipment shall be brand new with state of art technology and having proven field track record. No prototype equipment shall be offered.

3.2 Vendor shall ensure availability of spare parts and maintenance support services for the offered equipment for at least 10 years from the date of supply.

4.0 SITE CONDITIONS

The equipment shall be suitable for installation and satisfactory operation in classified hazardous locations in tropical, humid and corrosive atmosphere as prevalent in refineries,

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petrochemical and fertilizer plants. Unless otherwise specified, a design ambient temperature of 40° C and an altitude not exceeding 1000 m above mean sea level shall be considered.

5.0 POWER SUPPLY

All AC lighting fixtures/ junction boxes shall be suitable for 240V ± 10%, SPN, 50Hz ± 3% power supply and all DC lighting fixtures/ junction boxes shall be suitable for 110/ 220V ± 10% power supply.

6.0 CERTIFICATION

All Hazardous area equipment shall have hazardous area test certificates and approvals as per following:

For Indigenous manufactured hazardous area equipment:
For all electrical items manufactured in India, the testing shall be carried out & test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished.

Alternatively, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

For Imported hazardous area equipment:
For all electrical items manufactured outside India, test report issued by Indian test laboratory recognized by the Chief Controller of Explosives shall be furnished. For Ex protection Electric Apparatus having flameproof type protection, a copy of valid BIS license shall be furnished.

As an alternative option-1 to this, IECEx Certificate of Conformity, valid copy of IECEx Quality Assessment Report (summary) and IECEx Test Report shall be furnished.

As an alternative option-2 to this, EU Type Examination Certificate, which is applicable for manufacturers having manufacturing locations in countries covered under the European Union, valid copy of Production Quality Assessment / Assurance Notification shall be furnished.

All equipment i.e. Indigenous & imported, shall also have valid statutory approvals, as applicable for the specified location and marking as per IS/IEC 60079 and as required by statutory authorities.
For installations in India, PESO approval letter shall be provided.

7.0 TECHNICAL REQUIREMENTS

7.1 Construction

7.1.1 The enclosures of the lighting fixtures and junction boxes shall be of cast light metal alloy.

7.1.2 All equipment shall be suitable for use in outdoor open locations and shall have minimum IP-55 degree of protection.

7.1.3 The enclosures shall be provided with gaskets made of non-inflammable and self-extinguishing material.

7.1.4 All metal surfaces shall undergo manufacturer's standard cleaning/ painting/ powder coating cycle. After surface preparation, the equipment shall be painted with two coats of epoxy based final paint or epoxy powder coated with minimum coating thickness of 80 microns, with colour shade as below:

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- Flameproof Exd (Gas group IIA/IIB) and AC supply: Dark admiralty grey shade 632 of IS-5/ RAL 7031
- Flameproof Exd (Gas group IIC) and AC Supply : Light yellow shade 355 of IS-5/ RAL 1012
- Non-sparking ExnR/ Increased safety Exec and AC Supply : Dark admiralty grey shade 632 of IS-5/ RAL 7031
- DC lighting fixtures : Bright red shade 538 of IS-5/ RAL 3003

All unpainted parts shall be suitably treated to prevent rust formation/ corrosion. If these parts are moving elements then these shall be greased with non-solidifying grease.

7.1.5 A warning inscription "DO NOT OPEN WHEN ENERGIZED" shall be provided on each enclosure. The warning inscription shall be embossed on the enclosure or a separate warning plate with above inscription shall be fixed to the enclosure with screws. The warning plate shall be of nickel plated brass or stainless steel.

7.1.6 All accessories like nuts, bolts, washers etc. shall be made of stainless steel SS-304.

7.1.7 All equipments on single phase supply shall be provided with an independent earth terminal with lug inside the enclosure for terminating the third (earth) core of the cable and shall have facility for looping.

7.1.8 A nameplate shall be provided to indicate the details of testing agency, name of manufacturer, test certificate number, statutory approval agency (PESO), serial number, BIS license number, applicable gas group etc. and any additional marking required by statutory authority like approval no. etc. The nameplates shall be engraved on 3 ply black white black lamicold sheets using square cutters. Black engraved perspex sheet nameplate shall also be acceptable. Nameplates shall be fixed by screws and shall not be pasted. In case the standard details given above are embossed on the enclosures, the same need not be repeated on the main nameplate.

7.2 Lighting Fixtures

7.2.1 Glass used for all types of lighting fixtures shall be clear and suitable for use under conditions involving exceptional risk of mechanical damage. Glass shall be toughened type.

7.2.2 All well/ bowl glass fixtures shall be provided with Stainless Steel SS-304 protective wire cage using minimum 5mm welded steel construction and having mesh dimension not exceeding 50mm x 50 mm. The mounting bolts of SS-304 required for physically connecting the hazardous area well/ bowl glass lighting fixtures (bracket/ ceiling mounted type) to the respective mounting bracket shall be supplied by Vendor along with the fixtures.

7.2.3 The fixing parts of the enclosure, which are to be opened for replacement of lamp, shall be so fastened that they can be unfastened only with special tools.

7.2.4 The lighting fixtures in Zone-2 area shall be Ex nR type, unless otherwise specified in the MR/ Tender.

7.2.5 For LED fixture, integral junction box shall be provided with 3 nos. cable entries for loop-in, loop-out and associated wiring to fixture. Alternatively, lighting fixtures shall be provided with 2 nos. threaded entries and 2 nos. hazardous area double compression nickel plated brass cable glands, and internal wiring shall be provided for driver and lamp. The glands shall be suitable for the specified cable size. 20% of the fixtures shall be supplied with 1 no. nickel plated brass plug for sealing the unused entry.

7.2.6 The top of all well/ bowl glass lighting fixtures shall be identically drilled/ threaded to facilitate installation on pole/ column or ceiling.

7.2.7 The flood lighting fixtures shall be supplied with adjustable mounting arrangement both in horizontal and vertical plane.

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7.2.8 The aviation warning lighting fixtures shall have cluster LED lamps of Type C, medium intensity (as per DGCA civil aviation statutory regulations) and of red colour, fixed (not flashing), 2000cd, unless otherwise specified.

7.2.9 All lighting fixtures shall be provided with suitable mirror-polished aluminum internal reflector of suitable thickness to ensure adequate mechanical strength.

7.2.10 Lighting fixtures shall be tested for resistance to impact in line with IS/ IEC 60079-0. Impact test certificates shall be furnished by vendor.

7.2.11 All LED fixtures shall be supplied complete with lamp and driver. LED driver shall be suitable for surge protection of minimum 4 kV surge. However, for flood lights, aviation warning lights, and lighting fixtures with wattage higher than 90W, LED driver shall be suitable for surge protection of minimum 10 kV surge. An additional fail safe SPD may be provided, as required, to achieve 10 kV surge protection. LED driver shall comply with the requirement of IS 15885-2-13. Fixture lifetime (L70) shall be greater than 50000 hours at ambient temperature of 40°C.

7.2.12 LED type lighting fixtures shall fulfill the following requirements:

a. Minimum power factor shall be 0.95.

b. LED lighting fixture luminous efficacy shall be minimum 100 lumen per watt.

c. LED lighting fixture beam angle shall be 120°/ 90° depending upon fixture location and mounting height.

d. The CRI for LED lighting fixtures shall be greater than 80 for indoor fixture and greater than 70 for outdoor fixture.

e. The colour temperature of white colour LED shall be from 5700K to 6500K, unless otherwise specified.

f. Polar curves/ photometric drawings shall be submitted by vendor for the offered lighting fixtures.

g. LED lamps and drivers shall be provided with minimum 5 years warranty period, unless specified otherwise in the MR/ Tender. Driver shall have valid BIS certification and the same shall be furnished during drawing review stage.

h. The LED light fixtures, should be tested for luminous lux level as per IES-LM-79. Wherever wire guard is provided, testing shall be done with wire guard. Type test certificates for LM-79 for all fixtures shall be from an NABL-accredited/ IECEx-certified/ equivalent lab.

i. The LEDs used in the lighting fixtures should be tested for the service life as per IES-LM-80. Type test certificates shall be furnished in compliance to same.

7.3 Junction Boxes

The junction boxes shall be of flameproof or non-sparking type construction as mentioned in the MR/ Datasheet. All junction boxes for looping of single phase lighting circuits using cables up to 6mm^2 shall be minimum 125mm diameter in size. Each junction box shall be complete with requisite number of cable entries and double compression flameproof nickel plated brass cable glands to suit the specified cable size.

7.4 Terminals & Wiring

7.4.1 The fixtures and junction boxes shall be provided with sufficient number of terminals. More than 2 wires per terminal shall not be permitted. If required, additional terminal with shorting link may be used. The terminals for external cable termination shall be suitable for 2.5mm^2 solid Copper conductor. Tinned copper lugs shall be provided for cable termination wherever applicable.

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7.4.2 All internal wiring shall employ 1.5mm², 660/ 1100 V grade, FRLS type, XLPE/ PVC insulated Copper conductor wires, colour coded for phase, neutral and earth. All termination shall be with suitable lugs.

8.0 INSPECTION, TESTING AND ACCEPTANCE

8.1 During fabrication, the equipment shall be subjected to inspection by EIL/ Owner or by an agency authorised by the Owner, as per agreed Inspection Test Plan. Manufacturer shall furnish all necessary information concerning the supply to EIL/ Owner's inspector. All routine/ acceptance tests shall be carried out at manufacturer's works under his care and expense.

8.2 Type test certificates from NABL accredited/ Central Government Labs in India/ IECEx-certified/ equivalent Labs, Manufacturer's works test reports, applicable PESO approval and BIS license and original drawings referred in type test certificates shall be shown to the inspection agency on demand during inspection. The test certificates, BIS license and PESO approval must be valid at the time of despatch.

8.3 Test certificates of bought out components shall be submitted to the inspection agency, as per Inspection and Test Plan no. 6-81-1061.

8.4 All equipments shall be subjected to various routine/ acceptance tests as per Inspection and Test Plan no. 6-81-1061.

9.0 PACKING AND DESPATCH

All the equipment shall be divided into several sections for protection and ease of handling during transportation. The equipment shall be properly packed for the selected mode of transportation, i.e. by ship/ rail or trailer, and shall be wrapped in polythene sheets before being placed in crates/ cases to prevent damage to finish. The crates/ cases shall have skid bottom for handling. Special notations such as 'Fragile', 'This side up', 'Center of gravity', 'Weight',' Owner's particulars', 'PO nos.' etc., shall be clearly marked on the packages together with other details as per purchase order.

The equipment may be stored outdoors for long periods before installation. The packing should be suitable for outdoor storage in areas with heavy rains and high ambient temperature unless otherwise agreed. A set of instruction manuals for installation, testing and commissioning, a set of operation & maintenance manuals and a set of final drawing shall be enclosed in a waterproof cover along with the shipment.

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मानक विनिर्देशन
सिविल एवं संरचनात्मक कार्य

STANDARD SPECIFICATION
CIVIL AND STRUCTURAL WORKS

प्रीकास्ट कंक्रीट
PRECAST CONCRETE

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	17.05.2024	REVISED & REISSUED AS STANDARD SPECIFICATION	DB	RM	AS	MN
1	10.03.2019	REAFFIRMED & ISSUED AS STANDARD SPECIFICATION	AVM	AJS	RS	RKT
0	26.07.2013	ISSUED AS STANDARD SPECIFICATION	AK	VG/RS	PKM	DM

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Abbreviations:

IS: Indian Standard

Structural Standards Committee

Convenor: Mr. Anurag Sinha

Members:
Mr. Virender Goel
Mr. Deepak Agrawal
Mr. VK Panwar
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Charanjit Singh (Proj.)
Mr. Ravindra Kumar (Const.)

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1.0 GENERAL

This Specification defines the requirements for the manufacture of precast concrete units. Precast concrete units shall be designed and fabricated by an experienced and acceptable precast concrete manufacturer. The manufacturer shall have been regularly and continuously engaged in the manufacture of precast concrete units either RCC or PCC similar to that indicated in the project specifications or drawings for at least 7 years. The units to be precast shall take care of any special requirements specified in the "**Contract Specific Requirements**" or on the Drawings.

The precast units shall be manufactured in accordance with Specification No. 6-68-0004.

1.1 Reference Codes and Specifications

Apart from this specification, the construction of Precast concrete works shall be in accordance with the Indian Standard Code of Practice for "Building Design & Erection using Prefabricated Concrete" IS 15916 along with all amendments till date and other relevant codes mentioned therein.

2.0 QUALITY REQUIREMENTS

At a minimum, the Contractor's Quality Plan shall include the following documents, procedures and/or instructions:

(a) Lifting methods (where not shown on the Drawings).

(b) Erection methods including the erection sequence (where not shown on the Drawings).

(c) Minimum concrete strength requirements prior to lifting (where not shown on the Drawings).

(d) Where it is proposed to stack units, evidence to demonstrate the strength and stability of the stack.

(e) Procedure/format of records keeping for precast works. (Refer Annexure -I).

This documentation shall be submitted at least 28 days prior to the commencement of site work, if not submitted beforehand.

3.0 MANUFACTURE

Formwork shall be of rigid construction and concrete vibration shall be such that intense concrete compaction will be achieved. This may require the use of form vibrators or vibrating tables on some large and/or complex-shaped units.

Formwork and embedded items shall not restrain movements nor damage precast units within the formwork due to the effects of shrinkage or steam curing.

The casting of the precast units shall be carried out on specially prepared casting beds which will prevent any distortion or misalignment of the forms during and after concreting. Each precast unit shall be cast in one continuous operation with no construction joints.

If the batch volume is less than 2 cubic metres, the sampling rate shall be reduced as follows:

(a) Less than 2 cubic metres per batch : 50% rounded up

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(b) Less than 0.5 cubic metres per batch : 30% rounded up.

In any case a minimum of 1 test representing each member shall be undertaken. Test specimens, for the purpose of determination of adequate unit strength for lifting and handling, shall be subjected to the same curing regime as the unit they represent. The Contractor shall ensure that sufficient cubes are provided to enable the required testing to be undertaken.

4.0 CURING

Concrete shall be:

(a) moist cured in accordance with Specification No. 6-68-0004 or

(b) membrane cured in accordance with Specification No. 6-68-0004

5.0 MARKING

For the purposes of unit curing, testing, location and orientation within the final structure, each batch of units, or if continuous production methods are used, each day's production, shall be clearly identified and indelibly marked to show:

(a) Unit identification

(b) Date of manufacture.

(c) Marking of top and bottom surface to ensure correctness of the reinforcement.

Each unit shall be marked on a surface which is not visible in the final structure.

6.0 LIFTING, HANDLING, STORAGE AND ERECTION

Precast units shall not be lifted or handled before the concrete has attained a compressive strength of 10 MPa or strength required during lifting as per design requirement or as specified on the Drawings, whichever is greater.

The Contractor shall detail in the Quality Plan the measures to be taken to minimise handling stresses, in particular those due to de-moulding.

The Contractor shall carefully handle precast units by methods that will not damage them or their connections. Units shall be handled from the approved lifting points shown on the Drawings. Beams and slabs shall be lifted and supported with the top surfaces uppermost at all times, unless shown otherwise on the Drawings.

Units shall be stored clear of the ground and supported on non-staining timber bearers only at approved bearing points. The thickness and width of the bearers shall be compatible with the strength group of the timber used, the type of precast unit and the site. The bearers shall support the units over their full width at the specified lifting points. The ground or space between the bearers supporting the units shall be carefully cleared and leveled to prevent the unit from being supported at positions other than on the bearers. The bearers shall rest on a firm foundation and adequate precautions shall be taken to prevent subsidence.

If units are stacked in tiers, the bearers shall be placed directly over each other. The lowest unit shall not be overstressed.

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Temporary props, if required, shall be used to hold the precast elements joints till it attain the required strength. After attaining the required strength, props shall be removed.

7.0 TRANSPORTATION

Unless stated otherwise on the Drawings, units shall not be transported until the concrete has reached its 28 day characteristic compressive strength and is at least 7 days old.

No unit shall be removed from the casting yard until a lot conformance package has been completed.

Submission of the lot conformance package prior to removal from the yard shall be required.

Units shall be securely fixed to the transporter by ties fitted with suitable tensioners. Provision shall be made to protect the units from damage caused by these ties.

Precast concrete units shall be delivered to the site in accordance with the delivery schedule to avoid excessive build-up of units in storage at the site. Upon delivery to the jobsite all precast concrete units shall be inspected by the Engineer-in-charge for quality and final acceptance.

8.0 PAYMENT

8.1 Payment for precast concrete members shall be made on cubic meter basis of the volume of the finished member. The rate quoted shall include cost of formwork, preparation of casting yard, finishing as specified, curing, marking, lifting, handling, storage, transportation to site of work, fixing in position etc. Reinforcement and pipe sleeves shall be paid separately under relevant items. Lifting hooks shall be paid on the same basis as reinforcement. Metal inserts shall be paid as per relevant clauses of Specification No. 6-68-0008 (Miscellaneous Steel Works).

8.2 The quoted rate shall be inclusive of providing pockets, openings, recesses of all sizes, chamfers, fillets grooves, holes, curing (hot, cold or by using curing compounds). The rate shall be deemed to include complete cost of taking and testing concrete cubes and carrying out other tests including tests of various ingredients as per specification and as directed by the Engineer-in-Charge.

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ANNEXURE-I

Procedure/format of record keeping for precast works shall at least include the following:

I. PRE-POURING INSPECTION REPORT:

This shall include mould cleaning & oiling, inspection of shutter joins, reinforcement & cover check, prestressed strands check, inspection of lifting hooks, inserts, embedments, etc.

II. CONCRETE TESTING REPORT:

This shall include the strength attained by concrete at various stages i.e. de-shuttering, lifting transportation, erection, loading, with other structural components, grouting, etc.

III. POST POURING INSPECTION REPORT (PREDELIVERY / DISPATCH)

This shall include inspection of the size of precast element, honeycomb, cracks, exposed reinforcement, finishing works, etc.

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वैसल्स, पाइपिंग तथा इक्वीपमैंट्स के ऊष्ण इन्स्यूलेशन हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR HOT INSULATION OF VESSELS, PIPING AND EQUIPMENT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
			Raghava			Nalin
1	12-03-2026	REAFFIRMED	VT / RB	PP	PS	NK
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					Approved by	

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Abbreviations:

ASTM	:	American Society for Testing and Materials
CG	:	Cellular Glass
CUI	:	Corrosion Under Insulation
DFT	:	Dry Film Thickness
ESCC	:	External Stress Corrosion Cracking
GI	:	Galvanized Iron
IE	:	Insulation for Electrically traced surfaces
IH	:	Insulation for heat conservation
IJ	:	Insulation for Steam jacketed surfaces
IS	:	Indian Standard
IS	:	Insulation for Personnel safety
IT	:	Insulation for Steam traced surfaces
ITP	:	Inspection Test Plan
PIR	:	Poly Isocyanurate Foam
PUF	:	Poly Urethane Foam
SS	:	Stainless Steel
SWG	:	Standard Wire Gauge
min	:	shall indicate a minimum limit value
max	:	shall indicate a maximum limit value

Definitions:

Ambient temperature:	Unless otherwise mentioned, ambient temperature referred in this specification shall mean 30^0C
Hot service:	Operating temperature from ambient to 760 deg C is considered as Hot service
Dual service:	Operating temperature ranging from minus (-) 200 to + 350 deg C is considered as dual service

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1.0 SCOPE

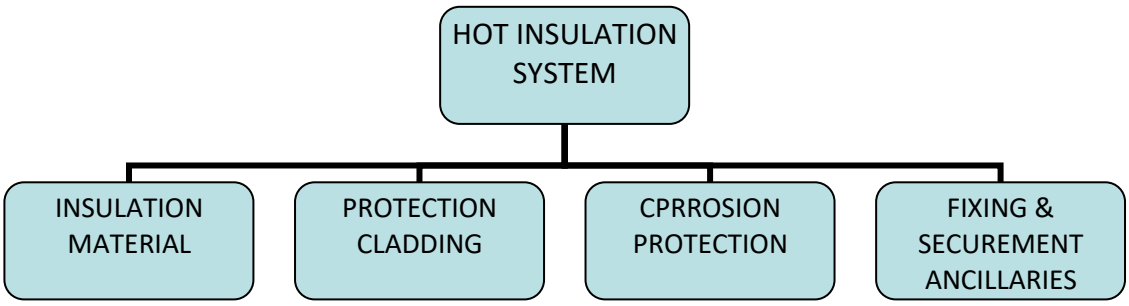
This specification covers the design and material aspects of external insulation of above ground piping, vessels and equipment having operating (process fluid) temperature from ambient to 760^{O}C for the purpose of heat conservation, process stabilization, temperature maintenance, personnel protection and fire protection.

Insulation material and thickness for a project shall be as per Process design basis, BEDB Part-B agreed with client. Insulation system, material properties and specific design requirements are provided in this specification.

Exclusion:
Unless otherwise specified, this specification shall not be binding for insulation of incinerators, boilers, economizers, air pre-heater / ducting of fired heaters etc. for which requirements may be covered in respective package specification. This specification shall not apply to licensed units, where licensor's standard/ specification is applicable.

2.0 GENERAL

Main constituents of a hot insulation system are insulation material and weather protection cladding. Insulation can lead to corrosion to the substrate (commonly known as CUI), especially at low operating temperatures (below 175^{0}C), hence some CUI prevention measures are adopted. Several other materials are used for fixing and securement ancillaries.



Near potential fire hazards a fire resisting insulation system shall be considered. The insulation shall consist of Cellular glass insulation or cellular glass insulation as outer layer insulation.

2.1 Insulation materials generally used in the industry for hot insulation are given below. Service temperature of each material is different and some may overlap. Material for an application temperature range is selected based on specific advantage of the materials in that range with respect to CUI and other relevant aspects. Insulation material for a project shall be specified in the Process design basis BEDB Part-B.

Insulation Material	General Classification	Temperature limit
Rock wool	ASTM C-547/592/612 / IS 8183	550^{0}C
Calcium silicate	ASTM C-533 / IS 9428	760ºC
Moulded Perlite	ASTM C-610	649^{0}C
Ceramic fiber	ASTM C-892	760^{0}C

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Cellular glass	ASTM C-552	427^{0}C
PUF/ PIR	ASTM C-591	100/125^{0}C
Glass wool	ASTM C-553	350ºC
Aerogel	ASTM C-1728	649ºC
Insulating cement	ASTM C-195	760ºC

2.2 Insulation shall be covered with a weather protection jacket, commonly known as cladding. Unless otherwise specified, aluminium is to be used as default cladding material. Stainless steel / aluminized steel cladding shall be used at higher temperature (>550°C) or where fire protection is an intended service requirement and / or fire safe is a criterion. Non-metallic cladding like UV cured GRP and HDPE can also be used for specific purposes.

2.3 Water ingress into insulation is a major concern, especially at low operating temperature, which may remain into the system and can cause corrosion to the substrate. The risk of corrosion is maximum at operating temperature $\leq$175°C (hereinafter referred as CUI risk zone).

2.4 Painting is used for general corrosion protection for all temperature range and for all types of insulation. Additional corrosion protection measure is necessary at CUI risk zone particularly when insulation material is fibrous in nature (like rock wool, glass wool, calcium silicate) and metal cladding is used for weather protection.

2.5 In order to prevent / minimize moisture ingress into insulation, a layer of moisture barrier / breather mastic shall be used in CUI risk zone where insulation is designed with fibrous material and metal cladding. All insulation system designed with fibrous material and metal cladding, falling in CUI risk zone, irrespective of the purpose i.e. whether it is for heat conservation, acoustic, fire protection or any other service, shall use this barrier layer. This layer is however not necessary when insulation is designed with a closed cellular material like PUF, PIR, Cellular glass or a water repellent material like aerogel or moulded perlite and / or non-metallic cladding like UV cured GRP or HDPE is used for weather protection.

2.6 Inspection window shall be provided at specific intervals to facilitate periodic inspection for CUI.

3.0 DESIGN BASIS

Insulation type and thickness for a project is finalized in Process design basis, BEDB Part-B. Wherever insulation is provided for heat conservation, thickness is decided on the basis of thermal conductivity of the insulation material, allowable heat loss, max allowable surface temperature/ maintenance temperature, emissivity of cladding material and wind velocity.

3.1 Insulation is required to meet any (or combination of) of the following objectives, generally indicated in P&IDs and line lists:

- Heat conservation
- Process stabilization to assist process control.
- Heat tracing (Steam or Electric)
- Hot water or solvent tracing (liquid)

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- Hot Oil tracing
- Steam jacketing
- Hot water or liquid or Oil jacketing
- Fire protection
- Personnel protection

3.2 Insulation type and thickness shall normally be specified in project specification/ SOR and any of the following 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.

3.3 Typical details of any vessel part not covered in this specification, but needs insulation as per good engineering practice shall be submitted by the contractor for approval of owner/ engineer in charge. The details shall include the following as minimum:

- Removable insulation housings
- Flashing details
- Additional Insulation supports
- Vessel head insulation supports
- Expansion joints
- Vessel insulation details
- Exchanger removable housings
- Machinery removable housings etc.

3.4 Codes & Standards

This specification shall be used along with relevant standards / code of practice wherever specified. However, specific technical requirement mentioned in this specification shall prevail over standards/ code and in the event of any difference or conflicting requirement between the code and this specification, stringent of the two shall apply.

Latest issue of the codes/standards prevailing on last submission date of the tender shall be applicable.

3.5 Extent of insulation

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

Insulation is not desired for piping and equipment for which heat loss is desired - excepting for personnel protection or to avoid thermal stress problems. Instruments and associated piping (other than impulse piping/tubing) subject to operating flow and/or temperature conditions prevailing in the connected piping or equipment shall be insulated to the same requirements as that of piping or equipment.

3.5.1 Extent of insulation on piping system

a) Items requiring insulation

- Insulated piping systems shall have straight pipe, bends, tees and pipe-fittings completely insulated.
- Unless otherwise specified, all valves and flanged joints shall be completely insulated only in steam, condensate service, hot oil lines and in lines which are trace heated or jacketed to maintain temperatures.
- For bucket and float type traps the inlet piping and trap shall be insulated.
- Insulation on inlet piping to thermostatic and thermodynamic steam traps shall terminate at approximately 500mm before the trap.
- Steam trap outlet piping other than closed condensate recovery system shall not be insulated except for personnel protection reasons.
- Heat traced instrumentation shall be insulated. The fluid 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.

b) Items NOT requiring insulation

- Piping which becomes hot intermittently, such as relief valves, vents, steam-out and snuffing steam systems, flare and blow down 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 above).
- Valves, including control valves and flanges in process piping systems (except as noted above). However, personnel protection insulation for these items shall be applied, as required.
- Pipe Union fittings.
- Thermowell bosses, temperature and pressure tappings.

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- Expansion joints, hinged joints and hose assemblies
- Sight flow indicators.
- Flange joints in Hydrogen service

3.5.2 Extent of insulation on equipments

a) Items requiring insulation

- Support skirts of insulated vertical vessel greater than 1200mm diameter shall be insulated both internally and externally for a minimum distance of 600mm below the bottom tangent line. The insulation shall terminate not less than 300mm above the anchor chair.
- Support skirts of insulated vertical vessels of 1200mm and less shall be insulated externally.
- Bottom heads of insulated vertical vessels enclosed by a support skirt shall be insulated without finishing material and shall be insulated only when the vessel outside diameter is greater than 1200mm.
- Turbines shall be insulated for heat conservation.
- Liquid ends of pumps shall be insulated when heat traced and jacketed.

b) Items NOT requiring insulation

- Pumps with operating temperature below 200°C unless pumped fluid has a pour point above minimum design ambient temperature.
- Fans, compressors and blowers and Liquid ends of pumps as noted 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, Thermowell bosses, temperature and pressure tappings.
- Name plates of all equipment items.

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3.6 Safety Insulation (Personnel Protection)

Exposed surfaces of piping, equipment/ vessels above 60°C in normal or even for a short-term operation, where insulation is not a requirement from heat conservation or process point of view, but in approachable range of operating and maintenance personnel, shall be protected from accidental touch for human safety by appropriate personnel protection. Extent of personnel protection may be decided by the field construction personnel using the criteria that exposed surfaces within 600mm horizontally and / or 2100mm vertically of a normal access of walkways or adjacent to handrails, platforms travelled by personnel shall be protected as minimum.

3.6.1 Insulation at low temperature carries a risk of CUI. Hence, insulation to the extent possible should be avoided in CUI risk zone and appropriate personnel protection shall be selected based on the criteria given below.

a) Metal cage / guards may be used for personnel protection for 61 to 175°C

b) Insulation shall be used for personnel protection for 176°C and above

c) Equipment / piping having internal refractory / other lining, shall not be insulated unless specifically required in the design. Personnel protection wherever applicable shall be provided by means of metal cage / guards only.

3.6.2 Requirement and type of personnel protection to be adopted in a project shall be specified in Process design basis BEDB Part-B.

3.6.3 The metal cage / guards, wherever used for personnel protection shall typically be placed at a gap from the surface as given below:

Pipe / Equipment dimension	Gap to be maintained from hot surface (mm)
Pipe diameter up to 6 inches	50
Pipe diameter greater than 6 inch but less than 10 inch	75
Pipe diameter greater than 10 inch	100
Equipment / vessels	100

3.7 Hot insulation in Acoustic service

In specific cases, where a line is to be provided both hot insulation as well as acoustic insulation, following shall be adopted:

3.7.1 Wherever, the material for hot and acoustic insulation are same (e.g. materials like rock wool, glass wool or ceramic fibre), higher of the insulation thickness shall be adopted, cladding shall be as per acoustic requirement.

3.7.2 If the material for hot insulation is different (for example, calcium silicate, PIR, perlite, Cellular glass etc.), hot insulation except the metal cladding shall be first installed over the pipe and then the complete acoustic system installed over it with cladding as per acoustic requirement.

3.7.3 EIL standard specification 6-79-0022 shall be referred for Acoustic insulation.

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3.8 Hot & Fire safe insulation

Insulation system in certain service may require serving the purpose of heat conservation and meeting the fire safe criteria. In such cases, insulation thickness needs to be designed for heat conservation during normal operation as well as to limit heat gain in a fire situation, when surrounding is at a higher temperature due to high heat flux released in a hydrocarbon fire.

Wherever insulation material selected for heat conservation is suitable for the fire safe range (for example rock wool, calcium silicate, ceramic fibre etc.), higher of the thickness required for heat conservation and fire safe requirement shall be adopted. Cladding shall be of stainless steel / aluminized steel.

Wherever material for hot insulation is not fully fire resistant (for example, PIR, PUF etc.), insulation for heat conservation except the metal cladding shall be first installed over the pipe/equipment and then a layer of fire-resistant insulation like rock wool / ceramic fibre etc. of appropriate thickness as applicable for fire safe criteria shall be installed over it with stainless steel / aluminized steel cladding.

3.9 EHT (Electrical heat trace) insulation

Unless otherwise specified, insulation system for the electrically heat traced piping shall consist of pre formed pipe sections of rock wool (LRB is acceptable for higher pipe diameter, refer 4.1.2) with an outer layer of preformed PUF/ PIR, wrapped with a multiplex foil, followed by metal cladding as weather barrier.

Wherever EHT system uses a heat tube, the rock wool pipe section shall be one-inch higher size of the pipe diameter. The PUF pipe section shall be of appropriate diameter so that same is snugly fit over the rock wool layer.

Unless otherwise specified, a heat containment shall be created by wrapping a layer of 0.1-0.15mm aluminium foil over the tracing (along with heat tube wherever used) prior to installation of insulation.

3.10 Steam traced insulation

Unless otherwise specified, insulation system for steam traced piping / equipments and instruments shall consist of pre formed pipe sections of rock wool (LRB is acceptable for higher pipe diameter, refer 4.1.3) with a multiplex foil underneath metal cladding as weather barrier. In general, rock wool pipe section shall be one inch higher size of the pipe diameter to accommodate tracer pipes.

A heat containment shall be created by wrapping the tracer pipe (heat tube) along with the parent pipe with a layer of 0.1-0.15mm aluminium foil (or stainless steel foil for >400 deg C) prior to installation of insulation.

Steam tracing expansion loops or couplings extending outside of insulated pipe surfaces shall be insulated for heat conservation.

3.11 Impulse lines

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Unless otherwise specified, for impulse lines of austenitic stainless steel, insulation material shall be sodium silicate inhibited ceramic fiber rope (min density 250 Kg/m³). Ceramic fiber ropes shall comprise of ceramic fibres laid parallel and reinforced with stainless steel wire.

3.12 Removable Insulation

Part of equipment and piping requiring periodic inspection may be provided with a removable and reusable type insulation. Pumps or turbines requiring insulation should have removable insulation cover.

3.12.1 Removable insulation may consist of a fibrous insulation stitched into a quilt of glass cloth fabric envelope and tied with wire around the valve or flange connections. Insulation thickness / number of wraps shall provide equivalent insulation as that of adjacent piping/ equipment.

3.12.2 Wherever box insulation is used, removable insulation shall be of the same type and thickness as adjacent pipe or equipment insulation.

3.12.3 Removable insulation cover box shall be fabricated from flat sheet with locked formed joints either from Aluminium or stainless steel (Type 304 or 316) with insulation installed inside the box. The thickness of the flat sheet for aluminium shall be min. 1mm and for stainless steel min. 0.8mm. If the weight of the box exceed 25 kg, it shall be in two or more parts and weight of each part be less than 25 kg.

3.12.4 Insulation covers box shall fit tightly over fittings and protrusions and shall be held in place with straps and stainless-steel toggles. Box shall have an integral metal flashing extending at least 50 mm on adjacent pipe insulation and must be designed to prevent air movement behind insulating covers.

4.0 INSULATION MATERIALS

Insulation material shall be selected primarily based on range of service temperature and other parameters like desired thermal performance, fire protection requirement etc. 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, non-injurious to health and non-corrosive to steel and aluminium (even if soaked in water at ambient temperatures for extended periods), shall not disintegrate, settle, change its form of composition, in a detrimental way during service conditions. Typical details/ minimum technical specification of the major insulation materials and accessories are given in this specification as a guideline.

- Insulation materials in general shall conform to respective ASTM standard/ grade. Equivalent IS grade are acceptable.
- ASBESTOS in any form is NOT permitted. Insulation or finishing materials shall contain no asbestos.
- No inflammable material shall be attached to the insulation.
- Special attention shall be paid for use over austenitic stainless-steel surfaces for max permissible chloride level and additional testing for respective material.

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- Unless otherwise mentioned, dimensions and tolerances for pipe sections, mattresses & slabs shall generally be as per respective codes. Lesser the number of segments is better. The installed insulation shall fit snugly and shall have a tight joint.

4.1 Rock wool

Rock wool is a fibrous insulation made from molten rock, bonded with resin or suitable binder. The term rock wool shall mean fibrous insulation wool made from natural rock and does not refer to products manufactured from slag or glass. For application over austenitic stainless steel, the material shall be zinc free and shall be inhibited with sodium silicate as per ASTM C-795.

4.1.1 The material may be used up to 550^0C, but shall meet the general classification of respective standards and service temperature requirements as mentioned below:

Form of Fibrous Material	Quality standard	Max service temperature
Preformed pipe sections	ASTM C547 TYPE-II / IS 9842	760^0C
Insulation blanket with wire net facing (details as per 4.1.4, 4.1.5 & 4.1.6)	ASTM C592 CLASS-III/ IS 8183	649^0C
Resin bonded mattress (max 2% resin)	ASTM C612/ IS 8183	760^0C

4.1.2 Rock wool shall meet following minimum properties:

Properties			Values	Remarks
Density (kg/m^3) as per IS 8183 / IS 3144 / ASTM C-167	Pipe sections		140	Note-1
	Resin bonded mattress / Insulation blanket (density is measured without metal facing)		128	
Linear Shrinkage (%) at 550°C/ 24 hours as per ASTM-C-356, max			2	
Non fibrous shot (%) as per ASTM C-1335 / 3144, max			15	
Compressive strength at 10% deformation (kg/m^2), min			120	
Alkalinity, pH as per ASTM C- 871 / IS 8183			7-10	
Leachable Chloride as per ASTM C-871, ppm, max			10	Note-1, 2
Thermal conductivity (W/mK) as per IS 3346 / ASTM C-177 / ASTM C-518 at mean temperature, max		(+) 100°C	0.052	Note-3
		(+) 200°C	0.068	
		(+) 250°C	0.080	
		(+) 300°C	0.090	
Test of incombustibility OR fire resistivity	Incombustibility as per IS 8183 / IS 3144		Pass	
	OR flame spread index		25	

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Properties		Values	Remarks
	as per ASTM E84, max		
Note-1: Supplier shall provide test certificate for each production Batch *Note-2: Max 20ppm allowed for application over carbon steel and low alloy steel* *Note-3: Supplier shall provide Type test certificate no older than 2 years*			

4.1.3 Forms of rock wool insulation

Nominal pipe diameter	Form of Fibrous Material
Up to 6 inch	Preformed pipe section is mandatory
> 6 inch to 14 inch	Preformed pipe section is desirable
>14 inch & equipments	Insulation blanket with wire net facing OR resin bonded mattress

4.1.4 For operating temperature up to 175°C for application over carbon steel and low alloy steel pipe, insulation blanket wherever used shall have GI metal facing on one side with hexagonal shaped (25mm) wire-woven netting (0.88 to 0.73mm dia.) stitched with tie wires (0.41mm dia.). Galvanization shall be minimum 30gsm.

4.1.5 For operating temperature 176°C and above, for application over carbon steel and low alloy steel pipe, insulation blanket wherever used shall have metal facing as per ASTM A167 type SS 304 with 25mm mesh and 0.8mm wire diameter, stitched with 0.41mm dia. tie wires.

4.1.6 For austenitic stainless steel and alloy 20 piping, irrespective of operating temperature, insulation blanket wherever used shall have metal facing as per ASTM A167 type SS 304 with 25mm mesh and 0.8mm wire diameter, stitched with 0.41mm dia. tie wires.

4.2 Moulded Expanded Perlite

Perlite block and pipe sections shall be made of expanded perlite and sodium silicate or appropriate binder, shall be suitable for continuous service up to 649°C.

4.2.1 Material shall conform to the general classification of ASTM C-610 and meet the following minimum properties:

Properties		Values	Remarks
Density (kg/m^3) as per ASTM C-302/303, max		240	Note-1
Compressive strength at 5% deformation (kPa), min as per ASTM C 165 (for block)		483	
Linear Shrinkage (%) max at 649°C for 24hrs,	Length and width	2	
	thickness	8	

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Properties		Values	Remarks
Water absorption after heat aging at 315°C & 48 hr water immersion, weight gain %		50	
Alkalinity, pH as per ASTM C- 871		6-10.5	
Flexural Strength as per ASTM C203, Proc-D (kPa), min		310	
Leachable Chloride as per ASTM C871, ppm, max		10	Note-1 & 2
Thermal conductivity (W/mK) ASTM C-177 / ASTM C-518 / ASTM C-335, at mean temperature	(+) 93 deg C, max	0.079	Note-3
	(+) 149 deg C, max	0.086	
	(+) 204 deg C, max	0.095	
	(+) 260 deg C, max	0.106	
	(+) 371 deg C, max	0.126	
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Max 20ppm allowed for application over carbon steel and low alloy steel* *Note-3: Type test - Supplier shall provide Type test certificate no older than 2 years*			

4.2.2 For application over austenitic stainless steel, perlite block and pipe sections shall also meet the requirements of ASTM C-692.

4.2.3 Forms of moulded perlite

Nominal pipe diameter	Form of Fibrous Material
Up to 14 inch	Preformed pipe section
>14 inch & equipments	Pipe sections / Wedge cut from block

4.3 Calcium silicate

Calcium silicate block or pipe sections shall conform to general classification of IS 9428 (950 grade) or ASTM equivalent C533 TYPE II, shall be suitable for continuous service up to 927°C.

4.3.1 Material shall conform to the general classifications of respective ASTM / IS code and meet the following minimum properties:

Properties		Values	Remarks
Density (kg/m^3) as per IS 5688 / ASTM C302/303, min		240	Note-1
Linear shrinkage as per IS 5688 / ASTM C-356 at 927^{0}C for 24hrs, (%) max.		2	
Moisture content , by weight, max, %		20	
Compressive strength (of dry	IS 5688 OR	415	

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Properties		Values	Remarks
sample) at 5% deformation, kPa	ASTM C165	688	
Heat resistance after exposure to 927^{0}C for 24hrs, as per IS 5688	(%) loss in weight, max	15	
	Compressive strength at 10% deformation, kPa, min.	345	
Leachable Chloride as per ASTM C871, ppm, max		50	
Thermal conductivity (W/mK) max. at mean temperature as per IS 9490 / ASTM C-177	(+) 204 ^{0}C	0.088	Note-2
	(+) 316 ^{0}C	0.097	
	(+) 427 ^{0}C	0.105	
	(+) 538 ^{0}C	0.111	
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Type test - Supplier shall provide Type test certificate no older than 2 years*			

4.3.2 Forms of calcium silicate insulation

Nominal pipe diameter	Form of Fibrous Material
Up to 14 inch	Preformed pipe section
>14 inch & equipments	Pipe sections / Wedge cut from block

4.4 Ceramic Fiber

Ceramic fiber is a fibrous insulation made from molten alumino-silicate compositions, fibers are mechanically interlocked through a needling process into blanket form without use of chemical binder, shall conform to general classification of ASTM C892 Type III, Grade 8 (1260°C Grade) and meet the following minimum properties:

Properties		Values	Remarks
Density (kg/m^3) as per ASTM C-167, min		128	
Linear Shrinkage (%) at 1200°C for 24hrs as per ASTM C-356, max		3	Note-1
Chemical composition	Al_2O_3, min	43	
	SiO_2, max	57	
	Fe_2O_3, max	0.1	
	TiO_2, max	0.3	
Mean fibre diameter (microns), 3% standard deviation		2.5-3.5	
Non fibrous shot (%) as per ASTM C-1335, max		20	
Tensile strength as per BS 1902 Part-6, kg/cm^2, max	Longitudinal	0.6	
	Transverse	0.5	

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Properties	Values	Remarks
Leachable Chloride as per ASTM C871, ppm, max	50	
Thermal conductivity (W/mK) ASTM C-177 / IS 3346 at 600°C mean temperature, max	0.13	Note-2
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Type test - Supplier shall provide Type test certificate no older than 2 years*		

4.5 Cellular Glass

Cellular glass is a closed cellular structured rigid insulation made from glass, a preferred material for cyclic service in the temperature range of (-) 200 to (+) 427 ^{0}C. The material conform to general classification of ASTM C552 Type-II, Grade-6, cut into pipe sections or profile of the substrate as per ASTM C1639 and meet the following minimum properties:

Characteristics		Values	Remarks
Density(kg/m^3), min. (ASTM C303)		98	Note-1
Closed cell content		100	
Compressive Strength (kPa) (ASTM C165), min.		414	
Flexural strength (kPa), ASTM C203, min.		283	
Water absorption (Volume %), max., (ASTM C240)		0.5	
Water Vapour Permeability, ng/Pa.s.m (ASTM E96)		0.007	
Thermal conductivity , w/mK (ASTM C518/ASTM C177)	(+)10°C, max	0.046	
	(-) 18°C, max	0.042	
	(-) 73°C, max	0.033	
	(-)101°C, max	0.030	
Surface burning characteristics as per ASTM E84	Flame spread index, max	5	Note-2
	Smoked developed index, max.	0	
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Type test - Supplier shall provide Type test certificate no older than 2 years*			

4.6 PIR / PUF rigid foam insulation

Rigid PIR (polyisocyanurate) / PUF (polyurethane) is closed cellular structured plastic foam insulation. PUF is generally suitable for use up to 100^{0}C, whereas PIR can be used to little higher, up to 125^{0}C. Wherever in the specification PUF / PIR or PUF is specified, any of the two can be used, but wherever PIR is only specified, PUF shall not be used.

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4.6.1 PIR shall be performed into free rise rigid buns using HCFC free chemicals and cut into pipe sections or required profile using a CNC machine. The material shall be chemically inert, moisture free, rot and vermin proof, shall not disintegrate, settle, change its form or composition in a detrimental way while in service, shall conform to general classification of ASTM C591 Grade-2 Type-II, suitable for application up to 125^{0}C and meet the following minimum properties:

Characteristics		Value	Remarks
Bulk density (kg/m3) ASTM-C302/ ASTM -D1622/ IS-11239, min		40	Note-1
Closed Cell content (%) ASTM D-6226 Procedure-2/ IS-11239 Part-5, min		95	
Chloride content (ppm) ASTM C 871, Procedure 2, max		60	
pH (ASTM C 871)		6-7	
Water vapour transmission (ng/Pa-s-m) ASTM E-96 method-A at 23°C & 50% RH, max		5.1	
Compressive strength at 10% deformation (kPa), ASTM D 1621, min		240.	
Flame spread Index as per ASTM E84 OR Horizontal burning as per equivalent BIS method, max		25	Note-1
Thermal conductivity of 180 days aged sample at mean temp (W/mK) ASTM C-177	(+)10 °C, max	0.024	
	(+)24 °C, max	0.024	
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Type test - Supplier shall provide Type test certificate no older than 2 years*			

4.6.2 PUF shall generally be supplied in performed pipe sections or required profile using HCFC free chemicals from vendor shop. The material will have equivalent physical properties as of PIR except temperature limit shall be 100^{0}C and may exhibit higher horizontal burning characteristics compared to PIR.

4.6.3 In-situ foaming of polyuretnane (PUR)

Certain applications like tank may specify use in-situ polyurethane foam (PUR), where the insulation foam can be formed by in-situ injection of the chemicals into an enclosed volume that after curing will be converted into PUF. The quality of in-situ foaming can vary and depends on substrate temperature, ambient temperature, humidity etc. Every time the in-situ foaming going to be adopted, it requires demonstration through mock up for achievement of optimum quality. This shall only be used where in-situ PUR is specified and NOT to be used as replacement for preformed rigid PIR / PUF.

4.7 Flexible aerogel insulation

Flexible aerogel insulation is a composite of an amorphous silica-based aerogel, a fibrous carrying media, or reinforcements, or a combination thereof, that allow the construct to be flexible. The material shall be in accordance with ASTM C1728 Type-III, Gr.1A. The material shall have following general properties:

Characteristics	Value	Remarks

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Temperature range (°C)		24 to 649	
Density (kg/m^3) ASTM C303, min		160	
Compressive Strength (kPa), min, at 10% deformation (ASTM C165)		20.7	
Linear shrinkage at maximum exposure temperature for 24h , max, % (ASTM C356) in length & width		2	
Water absorption, max, % by weight		8	
Water vapour sorption, by weight, max %, (ASTM C1104/C1104M)		5	
Flame spread index (ASTM E84) , max Smoke developed index (ASTM E84) , max		5 10	
Thermal conductivity (W/mK) at mean temperature (°C) (ASTM C177)	(+) 24 °C, max	0.021	
	(+) 149 °C, max	0.025	
	(+) 204 °C, max	0.029	
	(+) 260 °C, max	0.032	
	(+) 371 °C, max	0.043	
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Type test - Supplier shall provide Type test certificate no older than 2 years*			

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4.8 Glass wool

Glass wool is a fibrous insulation made from molten glass into fibrous form bonded with organic or inorganic binder and suitable for application up to 350°C. Glass wool blanket shall meet the requirements specified in ASTM C553 Type-I and meet the following minimum properties:

Characteristics		Values	Remarks
Density (kg/m^3) as per ASTM C-167, max		64	Note-1
Water vapor sorption % by weight, max, (ASTM C1104/C1104M)		5	
Chlorides, ppm, (ASTM C 871, procedure 2)		10	
pH values, (ASTM C 871)		6-10	
Thermal conductivity, W/mK (ASTM C518)	(+) 24 ^{0}C, max	0.030	Note-2
	(+) 50 ^{0}C, max	0.033	
	(+) 100 ^{0}C, max	0.040	
Note-1: Batch test - Supplier shall provide test certificate for each production Batch *Note-2: Type test - Supplier shall provide Type test certificate no older than 2 years*			

4.9 Insulating cement

Insulating cement is primarily composed of chopped rock wool and heat resistant cement and may contain inorganic fillers / suitable heat resistant binder. The material shall conform to general classification of ASTM C195 and shall be suitable up to 1038^{0}C.

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Properties		Values	Remarks
Linear Shrinkage (%) (at 871°C) for 24hrs, max, ASTM C356		5	Supplier shall provide test certificate for each production Batch
Volume change (shrinkage) upon drying, max, ASTM C166		35	
Thermal conductivity, at mean temperature, ASTMC177	(+) 93 deg C, max	0.101	
	(+) 260 deg C, max	0.123	
	(+) 482 deg C, max	0.173	

4.10 Materials / components for Specific insulation system

Primary insulation type / combination and thickness shall be specified in Process design basis BEDB Part-B. Based on the insulation type and temperature range, additional components like moisture barrier mastic, foil etc. needs to be as per below guideline:

4.10.1 There is always a risk of water ingress into the insulation through joints of metal cladding. Hence, except specific applications were non-metallic cladding like UV cured GRP or HDPE are used, the risk of CUI needs to be addressed by appropriate material selection and moisture barrier system.

4.10.2 The risk of CUI is highest in the operating zone 50-175°C. Materials like Perlite, Cellular glass, PIR (up to 125°C) and PUF (up to 100°C) are preferable in this zone.

4.10.3 When a fibrous material like rock wool / glass wool is used in CUI risk zone (<175°C), a moisture barrier layer of breather mastic must be used underneath metal cladding.

4.10.4 A combination system with inner aerogel (5-10mm) + outer rock wool can provide good CUI prevention in low operating temperature (<175°C) and shall not require this breather mastic moisture barrier.

4.10.5 The breather mastic need not be used in CUI risk zone (<175°C) wherever moulded perlite or a closed cellular material like PIR/ PUF/ Cellular glass is used as insulation material and / or where a layer of aerogel is used in the innermost layer. The joints of the block insulations shall be sealed with appropriate joint sealant and a multiplex foil (commonly known as mylar foil) shall be used over the outermost insulation layer underneath cladding.

4.10.6 In general, the breather mastic and / or multiplex foil is not necessary above 175°C. However, for HP steam lines longer than 2km which uses rock wool as insulation, a layer of multiplex foil shall be used underneath the metal cladding. The multiplex foil need not be used where insulation is designed with perlite or rock wool in combination with a closed cellular material like PIR or aerogel on the outermost layer.

4.10.7 Cellular glass be shall be chosen where any one of the following is a requirement:

a) Service is dual temperature, the lower range extents below ambient and upper limit of the exposure exceeds (+) 125 ^{0}C
b) The insulation requires fireproofing over it (epoxy intumescent or vermiculite)

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4.11 Insulation thickness

Insulation thickness and thickness for inner and outer insulation for combination lining shall be specified in schedule of rate / equipment datasheet.

Unless otherwise specified, layering of insulation as given below shall be followed:

Insulation thickness (mm)	Number of layers
≤ 75	Single layer
76-150	Two layers
>150	Three layers

4.12 Form of insulation

All the preformed insulation (Cellular glass, PIR, Calcium silicate, Perlite, Pipe section made from Rock wool etc.) should match the contour of pipe /surface profile of the equipment. Half sections or radial sections shall have longitudinal and circumferential faces flat and smooth so as to match with the other half/ section. Ends of the preformed half sections shall be flat and perpendicular to the center line.

Cellular glass shall be fabricated as per ASTM C1639.

Preformed rigid insulation blocks of PIR shall be cut from buns using CNC machine.

Application	Sections
Pipes up to 12 inch NB	Two half sections
>12 inch up to 20 inch NB	Max 3 radial sections
>20 inch NB	Max 4 radial sections
Equipments, Vessel shells	Machine cut radial sections in required contour of the substrate/ underneath layer
Vessel heads	Manually cut slabs contoured to the profile of vessel heads is acceptable

5.0 ANCILLARY MATERIALS

Hot insulation system shall have the following ancillary components:

Primary components	Secondary components	Other ancillaries
• Multiplex foil • Weather protection Jacket • Protection guard	• Heat transfer cement • Painting • Expansion joint • Sealing tapes • Adhesive	• Band • Sealant for cladding • Screw • Clips • Rivets • Compression spring

5.1 Weather Protection Jacket (Cladding)

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5.1.1. Insulation shall be protected with cladding. Type of cladding shall be as below:

a) Unless otherwise mentioned, aluminium jacketing shall be used as weather protection cladding up to temperature 550 deg C. Aluminium cladding shall be as per ASTM C1729, Class-A having polysurlyn lamination on inside surface and shall meet the requirements of ASTM B209 alloy 3003 H14. Equivalent IS code shall be acceptable for the metal sheet.

b) For temperature above 550 deg C and/ or for fire safe insulation (for all temperature range) cladding shall be stainless steel or aluminized steel as per ASTM A167 / A240 type 304 or aluminized steel as per ASTM A463, type 2, coating designation T2-100, with polysurlyn lamination on inside surface. Equivalent IS code shall be acceptable for the metal sheet.

c) 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. Galvanized steel shall be as per ASTM A526 with 275 gsm of coating of Zinc Layer on both the surfaces. Equivalent IS code shall be acceptable for the metal sheet.

5.1.2. Thickness of metal cladding shall be as follows:

Application	Thickness for Aluminium cladding	Thickness for Stainless steel /Aluminized steel cladding
For shells of vertical storage Tanks & Vessels	0.7lmm (22 SWG) Corrugated; The profile of corrugated sheet shall be 32mm x 5mm	0.56mm (24 SWG) Corrugated; The profile of corrugated sheet shall be 32mm x 5mm
For tank Roofs	1.22mm (18 SWG) Flat	0.91mm (20 SWG) Flat
For Horton Spheres & Horizontal vessel shell and heads; vertical vessel heads	0.7lmm (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	0.7lmm (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.

5.2 Securement Bands / Wires

1 If material is Aluminium, then specification shall be ASTM B209 Alloy 3003 H16 , 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.

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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 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.

5.3 Compression Spring

Compression spring (commonly known as MITY spring) shall be used on jacketing over tank, pressure vessels and equipment. The compression springs shall be of 100mm length made of SS 302 / SS 304 stainless steel, shall not be stretched more than 13mm during installation.

Requirement for springs on banding to secure metal jacketing shall be as follows:

Equip. OD	Equip. Circ.	Number of Jacket Expansion Springs					
		Steel Temperature					
(m)	(m)	93°C	204°C	315°C	427°C	538°C	649°C
1	2.9	0	0	0	1	1	1
2	5.7	0	1	1	1	2	2
3	9.6	0	1	2	2	2	2
4.6	14.3	1	1	2	3	3	4
6	19.1	1	2	3	3	4	4
≥7.6	≥ 23.9	1	2	3	4	5	6

5.4 Rivets

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

5.5 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.

5.6 'S.' and 'J' clips

Formed from 25mm wide stainless-steel banding.

5.7 Heat Transfer Cement

Maximum Exposure Temperature: 677°C
Heat Transfer Coefficient to Equipment wall: 114-227 W/m^2°C
Bond Shear: 1.034 kPa
Electrical resistivity: 1.299 ohm/cm

5.8 Sealant for cladding

Sealing materials which may either be in the form of a elastomeric sealing compound or fibre based bituminous felt strips.

The technical requirement and typical elastomeric material for joint sealant of metal cladding (aluminium and stainless steel) is specified below.

General Characteristics	Combustibility/ fire resistance	Water vapour permeance (max)
Average 52% volume solid as per ASTM C461	FSI (flame spread index) ≤ 20 as per ASTM E-84, tested on a 6.3mm inorganic reinforced cement board with DFT ~2mm	0.0092 metric perms (as per ASTM F-1249 with DFT 2.8mm)

5.9 Moisture barrier (breather mastic)

When a fibrous material like rock wool / glass wool is used in CUI risk zone (<175°C), a moisture barrier layer of breather mastic must be used underneath metal cladding. The moisture barrier shall be a polymeric water based, breather type mastic (vapor under pressure will pass through it), fire resistive, flexible and be compatible with the type of insulation. Material shall be suitable for the range of temperature to which it is exposed.

Material shall be evaluated for fire resistance as per as per ASTM E-84 (flame spread index ~10) and water vapour permeance in accordance with ASTM E96, procedure-B >1perms for 1/16'' thickness. Average nonvolatile content: 60 to 64% by volume (64% by weight).

5.10 Multiplex foil

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Multiplex foil may be used as an alternative to mastic moisture barrier in specific applications (details shall be as per respective SOR). Multiplex foil shall consist of sandwiched sheets of aluminium and polyester be applied over the insulation prior to weather protection jacketing. It shall confirm to the following requirements:

Foil composition:	12 µm polyester film 25 µm aluminum foil 12 µm polyester film
Tensile strength Yield strength Tear resistance	100 MPa 70 N / cm 400 g / mm
Temperature range	+120°C to -60°C
Volumetric mass	1.93 kg / dm³
Water vapour permeance in acc. with ASTM E 96, procedure E (37.8°C, 90% RH)	max. 10 µg / (m².h.mmHg)

5.11 Sealing tapes for multiplex foil

The sealing tape for joints in the multiplex foil shall meet the following requirements:

Foil composition	12 µm polyester film 25 µm aluminium foil 12 µm polyester film adhesive layer: polyacrylate
Total thickness exclusive of adhesive layer	50 µm
Temperature range	+120°C to -45°C
Volumetric mass	1.93 kg / dm³
Water vapour permeance in acc. with ASTM E 96, procedure E (37.8°C, 90% R.H.)	Max. 10 µg / (m².h.mmHg)

5.12 Joint sealant for insulation blocks

The joint sealant for joints between insulation blocks shall be compatible with the base insulation material and suitable for the temperature range to which it is exposed. Typical material and technical requirement for PUR/PIR insulation system is specified below. For cellular glass insulation, compatibility or specific products shall be recommended/ confirmed by the cellular glass supplier

General Characteristics	Combustibility/ fire resistance	Water vapour permeance (max)
Average 82% volume solid as per ASTM D2369	Flame spread ASTM E-84 and fuel contribution negligible when used as 3.2 mm wide sealant between joints of incombustible insulation blocks	Negligible when measured across 3.2 mm wide sealant between joints of impermeable insulation blocks

5.13 Protection guard

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Guards and their supports shall be manufactured from carbon steel, which may be galvanized or painted or with Stainless Steel (SS-304). (The mesh may be painted with yellow stripes, 50 mm wide, and shall include a hazard sign indicating 'Hot surface'.). The guard mesh shall be of 2mm thick and 12 mm square. Guard shall be designed with end cap of 0.7 to 1mm thk from galvanized Al-Zn coated or Al coated carbon steel with recommended spacing of 450mm to 600mm. Care to be taken that end caps are fitted in an orientation that will allow water drainage. If the metal surface requires greater protection, a fibre glass insulation tape can be fitted to area where end caps make contact to protect pipe work and reduce heat transfer. Mesh shall be rolled to shape as per normal cladding and shall be provided with 50 mm of overlap, sharp edges of cut mesh to be filed. In case of removable guard, the same can be made from toggle clips.

In case of protection guard for small bore piping, perforated metal sheet may be used. Sheet thickness shall be 1mm.Perforation hole shall be minimum 5mm, with minimum 40% free passage. Steel sheet shall be stainless steel in accordance with ASTM A167, type 304.

6.0 APPLICATION

6.1 General requirements

6.1.1 The application methods, given in this specification 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.

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

6.1.3 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.

6.1.4 Co-ordination with Other Agencies

Contractor shall work in close co-ordination with the erection Contractor. Wherever temporary supports are provided the contractor shall remove these and provide necessary support as per standard or as specified in the bid package/tender.

6.1.5 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.

6.1.6 Under Insulation Painting

Equipments and piping shall be protected from corrosion by providing appropriate painting under insulation, as per applicable painting specification for the project.

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Austenitic stainless steel especially 300 and 400 series are susceptible for external stress corrosion cracking (ESCC). For to avoid ESCC in stainless steel, 0.1mm thick aluminium foil up to 550°C, above which stainless steel foil can be wrapped with an overlap of 50mm. Overlap joint shall be sealed with barium chromate sealer or self-adhesive (chloride free) aluminum tape at the edge of foil. Foil shall be secured in position either by pressure sensitive tape or aluminium band.

6.1.7 The insulation contractor shall not carry out any welding or drilling on plant equipment and piping.

6.1.8 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.

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

6.1.10 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.

6.1.11 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.

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

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

6.1.14 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.

6.1.15 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.

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

6.1.17 Packing and transport to site

Insulating materials should be packed in cartons, crates, bags or shrink film wrapping to minimize mechanical damage and to provide adequate weather-protection and to avoid contamination. Preferably, insulating materials should not be unpacked on site until required for immediate use.

All forms of packaging of insulating materials should be carefully marked. The marking should indicate the type of material and the size, thickness, quality, and quantity contained in each package.

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6.1.18 Protection of Materials During Storage

Insulation materials must be protected against any damage, from delivery to finish cladding. Decking and covering with tarpaulins alone are not considered sufficient protection from weather for any length of time and shall not be permitted. Insulation material slabs, blankets and sections shall be stored on a flat surface in a horizontal position. Insulation material shall never be stacked directly on the ground. The contractor shall make own arrangement for covered storage for insulation materials as directed by the Engineer-in-Charge.

6.1.19 Protection of Partially Completed Jobs

Precautions must be taken to ensure that each day's work is adequately protected before being left over-night to prevent seepage of water. Unfinished / partially finished / ongoing insulation jobs shall be protected from water ingress by appropriate water shed / wrapping and other protective means.

6.2 Piping applications

6.2.1 Horizontal Pipe

a) General

Insulation material shall be applied to fit snugly against the contours and shaped only where necessary to achieve this requirement

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) Shall be applied over the surface with joints tightly butted and laced together with stainless steel 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.

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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 and moulded expanded perlite, all joints shall be sealed with insulating cement of same composition as the Moulded block.

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

e) Frame work for supporting cladding fibrous insulation

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 CF paper shall be provided at the joints of the stays and pipes. Joints between M.S. Spacer Ring and stays shall be riveted by 6 dia M.S. Rivets with 2 Sheets of 3 thick mill board interposed.

6.2.2 Vertical Pipe

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:

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

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

Expansion joint shall be provided at regular intervals as below:

Temp.(°C)	Spacing (meter)

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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 loose rock wool. 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.

6.2.4 Elbows and Bends (All insulation materials)

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 joint for calcium silicate shall be suitably sealed by insulating cement. Fittings below 50mm nom. dia, if insulated of calcium silicate 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.

6.2.5 Tee (All Insulation Materials)

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.

6.2.6 Flanged Joints or Valves (all insulation materials)

Flanged Joints or Valves, if to be insulated, shall be insulated with removable type insulation.

6.2.7 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.

6.2.8 Pipe Supports: (All insulation materials)

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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.

6.2.9 Steam Traced Piping (All insulation materials)

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.

6.2.10 Electrical Traced Piping

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

6.3 Horizontal Equipments

6.3.1 Application in horizontal vessel

a) The vessel fabricator shall provide insulation cladding support /securement as per fabrication drawing / standard. Insulation contractor shall verify the same before commencing.

- 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 stainless steel rod.

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

b) Blanket shall be applied over the surface with joints tightly butted and laced together with 1mm dia stainless steel 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 suitable sealant.

6.3.2 Insulation Securement

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Each layer of insulation on shells of equipment shall be secured by bands at every 300 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.

6.4 Vertical Equipments

6.4.1 Application in vertical vessel

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.

6.4.2 Insulation Securement (For all insulation materials)

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 300 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.

6.4.3 Expansion Joints (For rigid insulation)

Expansion joints shall be provided every 4000mm (max.). The expansion 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.

6.5 Flange, Nozzle, Channel Cover, Manway & Handhole Flanged Cover (For All Insulation Materials)

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

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

6.6 Application over Irregular Surfaces Such as Pumps, Compressors, Turbines etc.

a) Rockwool: This shall be prefabricated removable covers, lined with pipe sections / lags / slabs / mattresses.

b) Calcium silicate/ Moulded expanded perlite: Insulation material shall be loose fill insulating cement/block insulation cut and fitted.

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

Each layer shall be covered with a layer of 25mm hex. 20 SWG 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.

6.7 Vertical Storage Tanks (Carbon Steel)

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

- Shell

The extent of insulation/ cladding support/ securement details shall be as per the relevant tank fabrication standard/ drawings. Insulation contractor shall check for its presence before insulation application work.

Water Shed

At the junction of shell and roof, a watershed is provided to act as top covering for the shell insulation. The details of water shedding shall be as per the relevant tank fabrication standard/ drawings. Insulation contractor shall check for its presence prior to insulation application work.

Insulation Support

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

Cladding Support

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

- Tank Roof

Shall be provided as per relevant tank fabrication standard.

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b) Insulation laying and securement

- Shell (Application of fibrous insulation)

Insulation shall be applied between rings in horizontal mode. Mattresses insulation shall be applied with joints tightly butted and laced together with 1mm dia. Stainless steel 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.

- Shell (Application of Polyisocyanurate / Polyurethane foam)

Shall be foamed cast in-situ as per vendor's procedure (approved by 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 specified herein this specification. Contractor shall ensure that cladding & band thicknesses are capable of withstanding foaming pressures which are developed at the time of injection of foam. Contractor can use foamed cast in-situ insulation only after getting the approval to material specification and application procedure.

- Roof (For all materials)

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

6.8 Horton Spheres

a) Structural members provided by spheres fabricator for insulation/cladding securement. Insulation & Cladding supports shall be as per relevant sphere fabrication standard

b) 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.

6.9 Inspection Windows

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Removable plug type inspection window shall be provided on the outside thermal insulation metal jacketing to facilitate the maintenance inspection of substrate. The removable plug shall be made of silicon rubber and secured with small chain or lanyard made of stainless steel. Sealing flange shall be made of stainless (SS-304). An O-ring made of rubber shall be placed for any metal seal flange for proper retrofit.

Plug flange shall be fixed by screws and washers to outside metal jacketing and same shall be silicon sealed for a perfect watertight assembly sealing.

When inspection window installed on corrugated metal jacketing, a neoprene transition gasket shall be installed between cladding and flange

The insulation insert shall be filled with insulation packed within high temperature silicon cloth snug fit tightly before closing silicone rubber plug.

6.9.1 Piping

Plug type inspection windows of ellipsoidal shape shall be provided on all the insulated pipelines having diameter 2" and above. The locations of inspection plugs shall be as follows:

- Straight section:

  Two inspection window at 0-6 o'clock position shall be provided at a distance of every 12 meters.

- Bends/Elbows:

  There must be three inspection window shall be installed near the bends. In case of no supports are welded at the centre of the elbows, one inspection window at the centre of the outer arc and another two at 100 mm away from the above and downstream of the plug. In case of supports are welded at the centre of the elbows, one on side of the elbows and another two at 100 mm away from the support upstream and downstream.

- Tee joints:

  Two no. inspection window shall be installed, one at the Tee bottom and another at the side of Tee.

6.9.2 Exchangers

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

6.9.3 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.

6.9.4 Tanks

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

6.9.5 Dimension of Inspection window

Application	Size
Pipe dia 2''	35mm minor diameter x 120mm major diameter
Pipe dia 3"	45mm minor diameter x 120mm major diameter
Pipe dia 4"	75mm minor diameter x 120mm major diameter
Pipe dia 6"	100mm minor diameter x 120mm major diameter
Pipe dia 8"	100mm minor diameter x 120mm major diameter
Pipe dia > 8"	120mm minor diameter x 120mm major diameter
Exchangers, Columns& Vessels and Tanks	120mm minor diameter x 120mm major diameter

6.10 Impulse Lines for heat traced lines

Wrap the impulse lines with insulation (Sodium Silicate inhibited Ceramic rope) of required thickness after cleaning the impulse lines from dust, rust, grease etc. Ensure that the rope(s) have been tightly wrapped without leaving any gaps. Apply two layers of self adhesive Aluminium foil tape of minimum 0.1 mm thick spirally bound over the fibre rope surface with the joints in two layers staggered. Ceramic rope shall have minimum density of 250 Kg/m^3, other property like maximum use temperature, tensile strength, linerar shrinkage, non-fibrous content etc. shall meet the requirement specified as per ASTM C892, Type III. 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:

Size of Impulse line (inch)	Temperature (°C)	No. of layers	Thickness of each layer (inch)
1/2	150	2	1/2
3/4	150	2	1/2
1/2	250	2	3/4
3/4	250	2	3/4

6.11 Impulse Lines for hot insulated lines

Wrap impulse lines with sodium silicate inhibited ceramic fiber rope (SS-wire braided) with thickness of layer as 3/4" irrespective of temperature, after cleaning the impulse lines from dust, rust, grease etc. The wrapping of the rope around impulse line shall cover it completely without leaving any gap. Apply two layers of self adhesive Aluminum foil tape of minimum 0.1 mm thick spirally bound over the fiber rope surface with the joints. Ceramic rope shall have minimum density of 250 Kg/m^3, other property like maximum use temperature, tensile strength, linerar shrinkage, non-fibrous content etc. shall meet the requirement specified as per ASTM C892, Type III. A suitable sealant shall be provided to stop the water ingress at the termination points of insulation

6.12 INSULATION FINISH

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6.12.1 Multiplex vapor barrier

In case of closed cell material (Cellular glass, perlite etc.) in CUI risk zone and on PIR in case of electrical tracing, multiplex vapour barrier shall be applied over the outer surface of Insulation. The joints of the vapor barrier foil shall be overlapped by 50mm. The joints shall be sealed with a tape confirming to the specification as mentioned herein in this specification.

6.12.2 Moisture Barrier

(Applicable for application on outer surface of the fibrous insulation in CUI risk zone)

The mastic shall be applied in two coats with glass cloth reinforcement such that total dry thickness is ~ 3mm.

Immediately after the insulation, a 3mm thick coating of the mastic shall be applied to the surface and a 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. The glass cloth shall have min 75mm overlap at joint. A second coat of 3mm shall be applied after approximately 12 hrs. 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.

6.12.3 **Insulation Finish with metal jacketing**

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.

a) Piping

- 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.

- A single bead shall be made on all overlaps to ensure tight metal to metal water tight arrangement. Self-tapping screws, at every 150, shall be provided at all longitudinal overlaps for both horizontal & vertical piping.
- At all operating temperatures the seams at overlap positions shall be rendered watertight to ensure that insulation remains dry and unwetted, whether the possible water impingement is from rain, hose or fire sprinklers.

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

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

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

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

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

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

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

b) Equipments

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

- The panels shall be applied commencing at the bottom of the vessel. Each circumferential ring of panels shall be tensioned by means of tensioning bands until the final joint is screwed tight. 'S' clips shall be used as sheeting support at unscrewed circumferential overlaps.

- The panels shall be held tight over the vessel insulation by means of circumferential bands and sealed. The bands shall be positioned on all horizontal overlaps and at 300mm centres. Bands shall be held in their relative positions with ‘J’ clips fastened to the jackets with screw. Each band shall have J-clips on 1.8m maximum centre but not less than four J-clips per band. Each band shall have compression spring as specified in this specification.

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

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

- 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

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80mm. The seal between the flashing and jacket shall be made watertight by use of self-tapping screws and sealing mastic.

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

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

- 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.

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

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

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

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

- Heads of equipments 24” OD and smaller shall be finished and waterproofed with square ended fabricated covers.

c) Vertical Storage Tanks

Cladding Applications and Securement

➢ Shell

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

- Overlaps in the vertical joints will be one corrugation.

- Overlaps in the horizontal joints shall be 50mm (min.).

- Cladding to cladding fastening, at both horizontal and vertical overlaps shall be alternately by "POP" Rivets & self tapping screws at 150mm pitch.

- Cladding shall be secured to support ring by bolting. Bolts are provided by tank fabricator at 300mm centres on angles provided at every 1175 centres vertically. Felt washer, aluminium washer and nut shall be

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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 relevant fabrication standard.

- 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 .

➢ 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.

d) Horton Sphere

➢ 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 tighteners and fastened to MS / AS angles using two S.S.Rivets or four Nos. of Aluminium POP rivets, per angle cleat.

➢ Cladding Application

While applying cladding, following shall be ensured

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

➢ Cladding Securement and Scaling of Joints

All joints to be sealed using elastomeric metal sealant.

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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.

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.

7.0 QUALITY CONTROL

7.1 Incoming material control

7.1.1 Insulation materials and accessories shall be inspected by appropriate authority according to inspection categorization of the materials as per project execution philosophy.

7.1.2 Irrespective of the inspection performed by TPI / PMC / Owner's representative, contractor shall submit QAP (quality assurance plan) of the materials and internal test reports for every production batch and type test wherever specified in this specification.

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.

7.1.3 Besides the inspection performed at supplier premises and / certificate of conformance provided by supplier, at the discretion of engineer-in charge, random inspection may be performed on the supplied materials. Parameters and extent of testing shall be advised by engineer-in charge.

On the advice of engineer-in charge, the contractor shall organize the testing on representative sample selected at random from an independent NABL approved laboratory. In the event of non-conformance in testing, repeat test may be performed. Failure in repeat test may call of rejection of the batch.

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7.2 Installation quality control

7.2.1 Insulation shall be installed after hydrostatic testing and inspection. Insulation shall be protected from weather before and during installation.

7.2.2 Insulation system should be applied as per approved drawings/sketches, installation procedure and quality plan.

7.2.3 Contractor shall prepare an inspection test plan (ITP) for installation of insulation identifying inspection / witness points, frequency etc. and submit for approval of owner / engineer in charge at construction site.

7.2.4 The engineer in-charge may finalize the same with consultation of HO specialist. If so desired by engineer-in charge, HO specialist may assist inspection of insulation work at critical stages.

7.3 Qualification of application crews

Prior to start for installation work, contractor's credential shall be approved by engineer in-charge of insulation work. The application crew must be fully trained work force. At the beginning of every installation, the application shall be demonstrated and quality checks shall be carried out at site and shall be certified by Owner/Engineer in charge.

7.4 Documentation

Insulation contractor shall submit Insulation Application Procedure for review and approval. Such procedure shall contain minimum following information:

- Product data sheet, material safety data sheet and compliance certificate of all the insulation and ancillaries material.
- Insulation detail drawings showing insulation system, expansion/contraction joints, insulation supports, terminations etc.
- Method statement for insulation system application and repair.
- Quality Control Plan for Insulation application (QCP)

7.5 Safety

The insulation contractor shall provide adequate protective appliances like hand gloves, masks, glasses etc. to the workmen carrying out the insulation work, to protect them from inhaling and touching insulation dust and fibers.

7.6 Specification Deviation / Concession Control

The insulation contractor shall notify Owner/Engineer in charge of any apparent conflict between this specification, product data sheets, the codes and standards, and any other specification or document noted herein. Resolution and/or interpretation precedence shall be obtained from the Owner/Engineer in charge in writing before proceeding with application of any insulation material.

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Any technical deviation to the purchase order/contract and its attachment including, but not limited to, the data sheets and specification shall be sought by the insulation contractor only through the concession request format. Concession requests require the Owner's/Engineer in charge's review and approval, prior to the proposed technical changes being implemented. Technical changes implemented prior to Owner's approval are subject to rejection.

7.7 Guarantee for supply and installation quality

Contractor shall ensure supplied materials conform to the technical requirements of this specification and relevant standards / codes applicable for the job. The insulation and ancillary materials shall be procured fresh for the project. Use of excess material from other site which does not have proper traceability shall not be allowed. It is the responsibility of insulation contractor to ensure adequate precautions are taken against damage and deterioration during sourcing, transportation and storage of insulation materials. For major insulation materials like rock wool, Perlite, Ceramic fiber PIR, cellular glass, aerogel etc. batch and type test certificates as applicable shall be submitted. For ancillary materials like multiplex foil, band, sealant etc. and metal cladding may be accepted based on supplier's compliance certificate.

Any deviations shall be clearly stated, and work shall proceed only after the deviations are approved by competent authority. The workmanship in execution of the insulation works shall be in accordance with sound engineering practice.

7.0 REFERENCE CODES & STANDARDS

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

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ASTM C390 Standard criteria for Sampling and acceptance of preformed thermal insulation lots

ASTM C446 Standard test method for Breaking load and calculated modulus of rupture of preformed insulation of pipes

ASTM C518 Standard test method for Steady-state thermal transmission properties by means of the heat flow meter apparatus

ASTM C533 Standard specification for Calcium silicate block and pipe thermal insulation

ASTM C547 Standard specification for Mineral fiber pipe insulation

ASTM C552 Standard specification for Cellular glass thermal insulation

ASTM C591 Standard specification for Unfaced preformed rigid cellular polyisocyanurate thermal insulation

ASTM C592 Standard specification for Mineral fiber blanket insulation and blanket-type pipe insulation (metal-mesh covered) (industrial type)

ASTM C610 Standard specification for block and pipe thermal insulation

ASTM C612 Standard specification for Mineral fiber block and board thermal insulation

ASTM C795 Standard specification for thermal insulation for use in contact with austenitic stainless steel

ASTM C871 Standard test methods for Chemical analysis of thermal insulation materials for leachable chloride, fluoride, silicate and sodium ions

ASTM C892 Standard specification for High temperature fiber blanket thermal insulation

ASTM D1622 Test method for apparent density of rigid cellular plastics

ASTM E96 Standard test methods for Water vapor transmission of materials

EIL Standards and Specifications

7-13-0003 Hot insulation supports for storage tanks

7-13-0015 Hot insulation supports for spheres

7-12-0025 Fireproofing and insulation supports

7-13-0033 Hot insulation supports for horizontal vessels

6-79-0022 Standard specification for acoustic insulation

6-79-0027 Standard specification for cold insulation of vessels, piping and equipment

6-79-0040 Standard Specification for Rockwool Insulation

6-79-0041 Standard Specification for Calcium Silicate Insulation

IS Standards and Specifications

IS 8183 Bonded mineral wool-Specification

IS 9428 Calcium silicate insulation blocks and pipe-coverings

IS 11239 Method of test for Rigid cellular thermal insulation materials

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8.0 INSULATION DIAGRAMS

The drawings/ sketches are general in nature. Specific insulation system/ requirement if any from insulation manufacturer, shall be submitted by contractor for approval by owner/ Engineer in charge.

The attached sketches describe general arrangement of insulation material, ancillaries and cladding. Difference if any on material type & quality between sketch and the description elsewhere in this specification/ SOR, later shall apply.

S.No.	Description	Drawing
1	Pipe insulation details (fibrous &rigid insulation)	DRAWING. No. 01
2	Pipe insulation method of staggering of sections rigid & fibrous insulation (preformed pipe sections only)	DRAWING. No. 02
3	Horizontal pipe : fibrous insulation; detail of spacer rings for cladding support	DRAWING. No. 03
4.	Detail of spacer ring fibrous insulation (mattress)	DRAWING. No. 04
5.	Bolted on insulation support for vertical pipe	DRAWING. No. 05
6.	Insulation details for bends / elbows	DRAWING. No. 06
7.	Insulation details : pipe bends & elbows	DRAWING. No. 07
8.	Insulation details: pipe branched & reducer	DRAWING. No. 08
9.	Example of removable flange box, horizontal	DRAWING. No. 09
10.	Removable flange box, vertical	DRAWING. No. 10
11.	Insulation details pipe supports	DRAWING. No. 11
12.	Insulation of traced piping	DRAWING. No. 12
13.	Horizontal equipment insulation	DRAWING. No. 13
14.	Horizontal equipment heads	DRAWING. No. 14
15.	Use of flexible insulation in combination with rigid insulation to compensate for vessel expansion	DRAWING. No. 15
16.	Insulation details : vertical vessel	DRAWING. No. 16
17.	Insulation details vertical vessel heads	DRAWING. No. 17
18.	Insulation details : vertical vessels	DRAWING. No. 18
19.	Insulation details : vertical storage tank	DRAWING. No. 19
20.	Insulation details : sphere	DRAWING. No. 20
21.	Non- insulated flanges, horizontal and vertical	DRAWING. No. 21
22.	Removable valve box, "T" connection, horizontal	DRAWING. No. 22
23.	Removable valve box, "T" connection, vertical	DRAWING. No. 23
24.	Hanger support	DRAWING. No. 24
25.	Personal protection	DRAWING. No. 25
26.	Details of lifting lugs	DRAWING. No. 26
27.	Removable box for pump	DRAWING. No. 27

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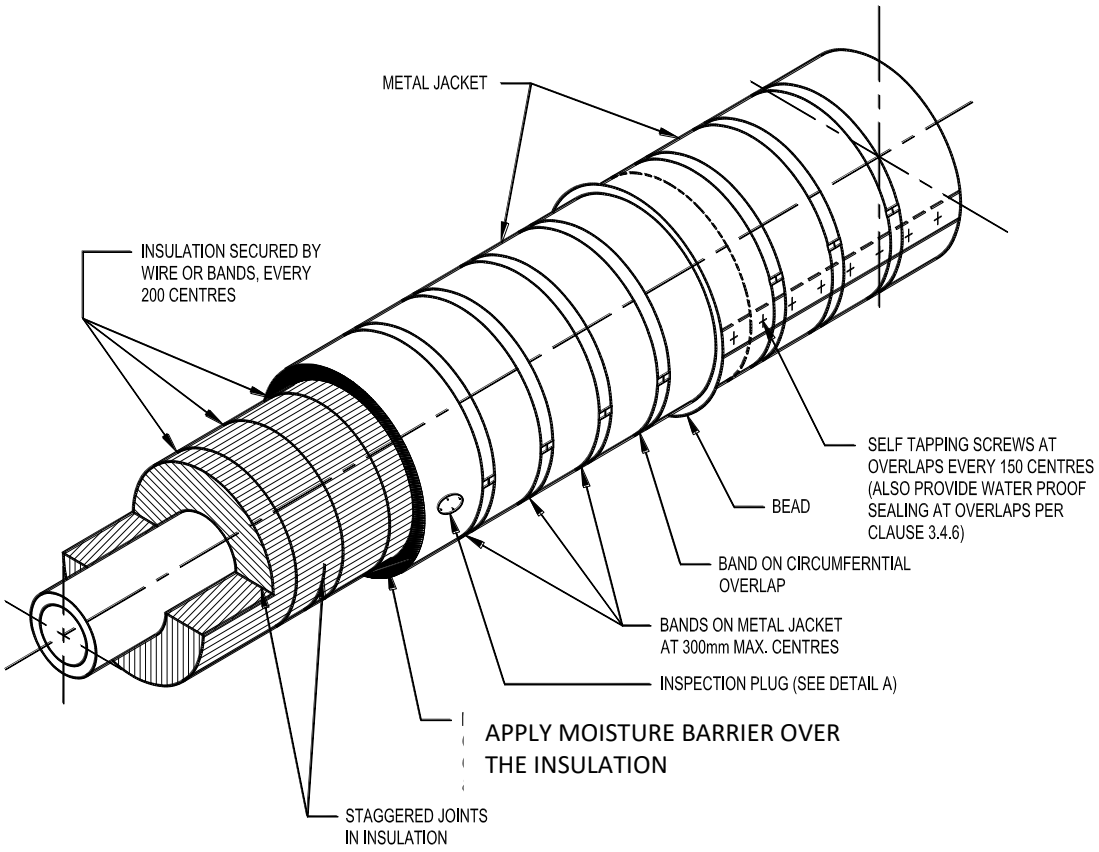

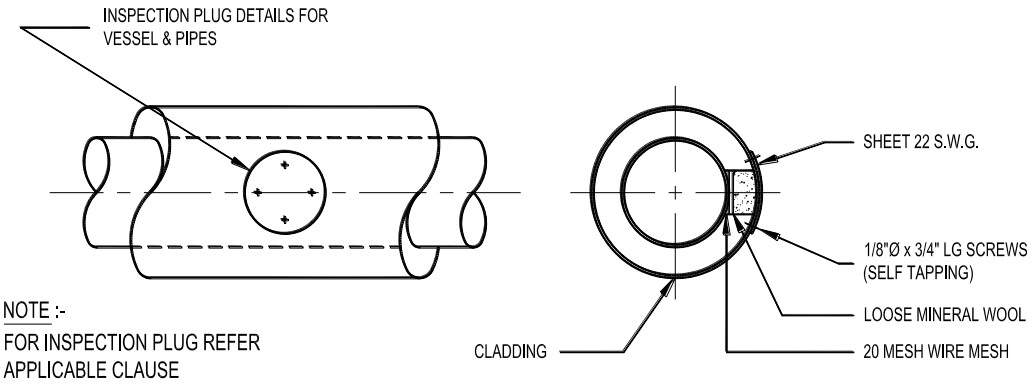

DETAIL 'A'

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

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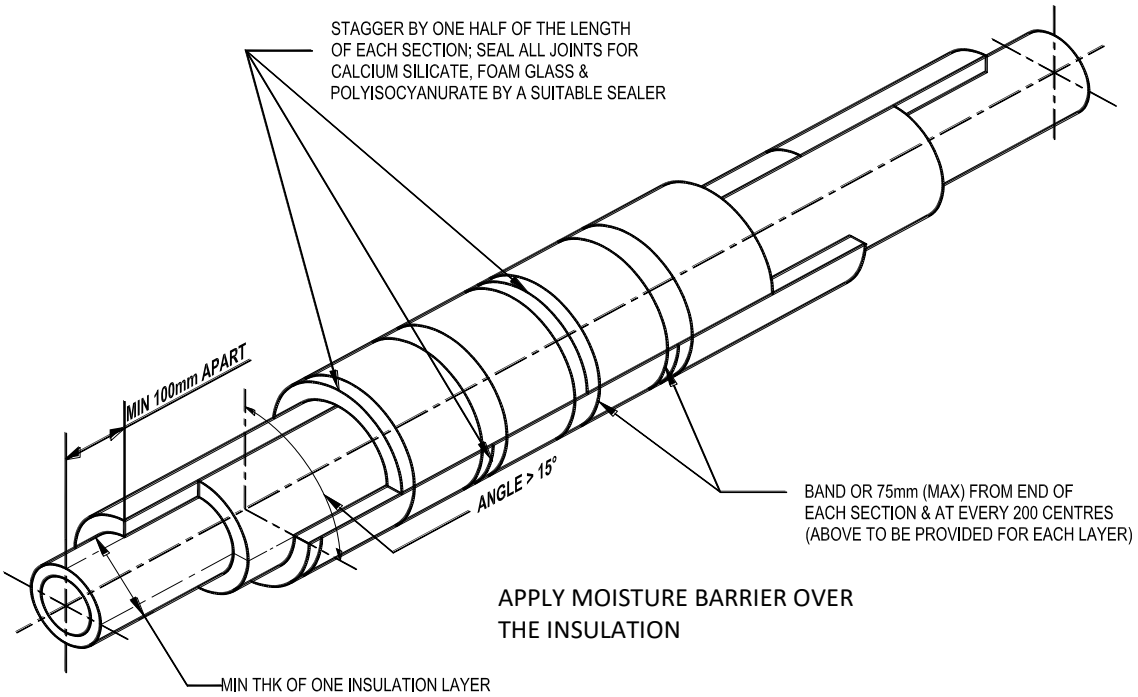

FIGURE – 02
PIPE INSULATION METHOD OF STAGGERING OF SECTIONS
RIGID & FIBROUS INSULATION (PREFORMED PIPE SECTIONS ONLY)

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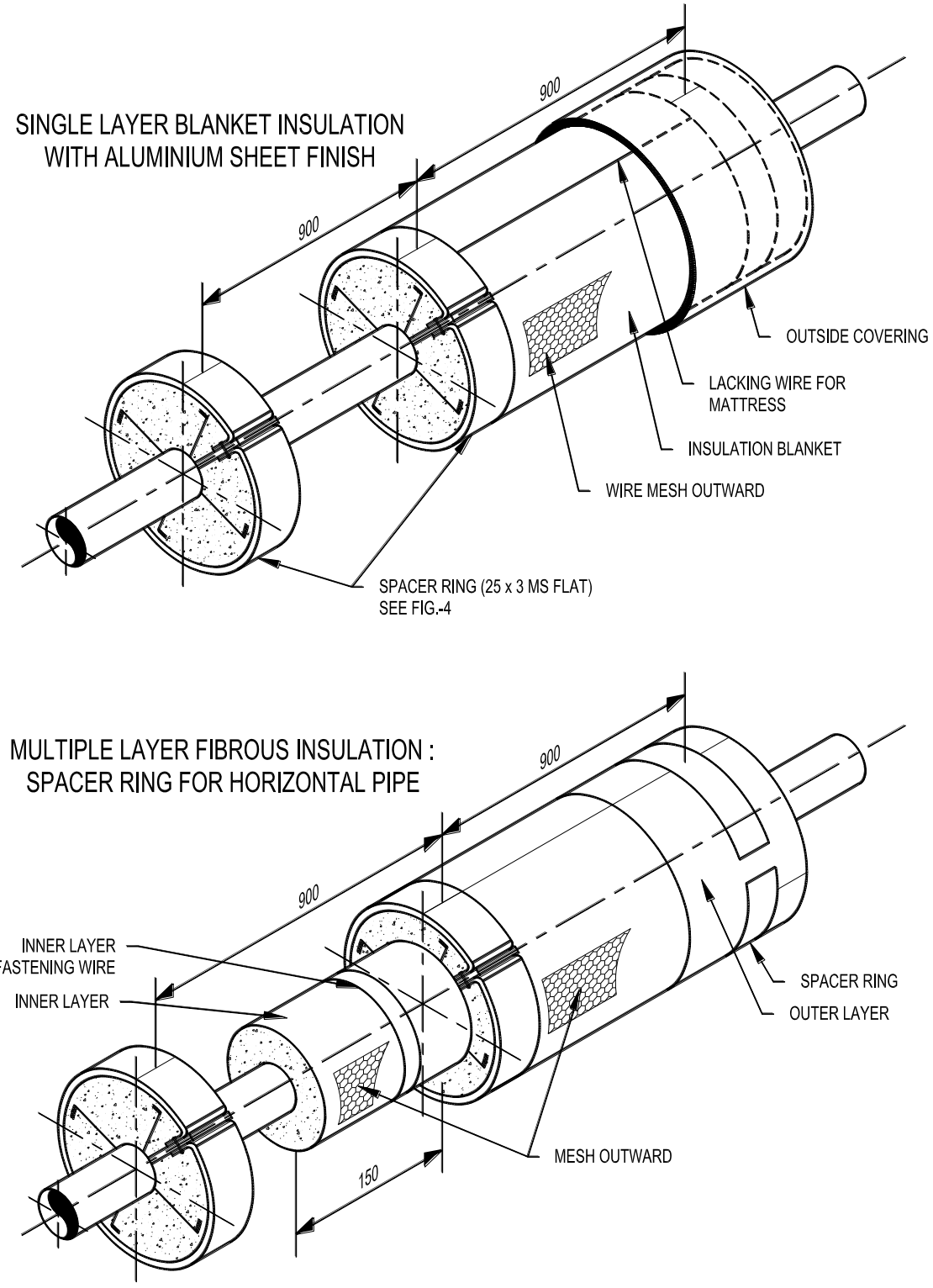

FIGURE – 03
HORIZONTAL PIPE : FIBROUS INSULATION; DETAIL OF SPACER RINGS FOR CLADDING SUPPORT

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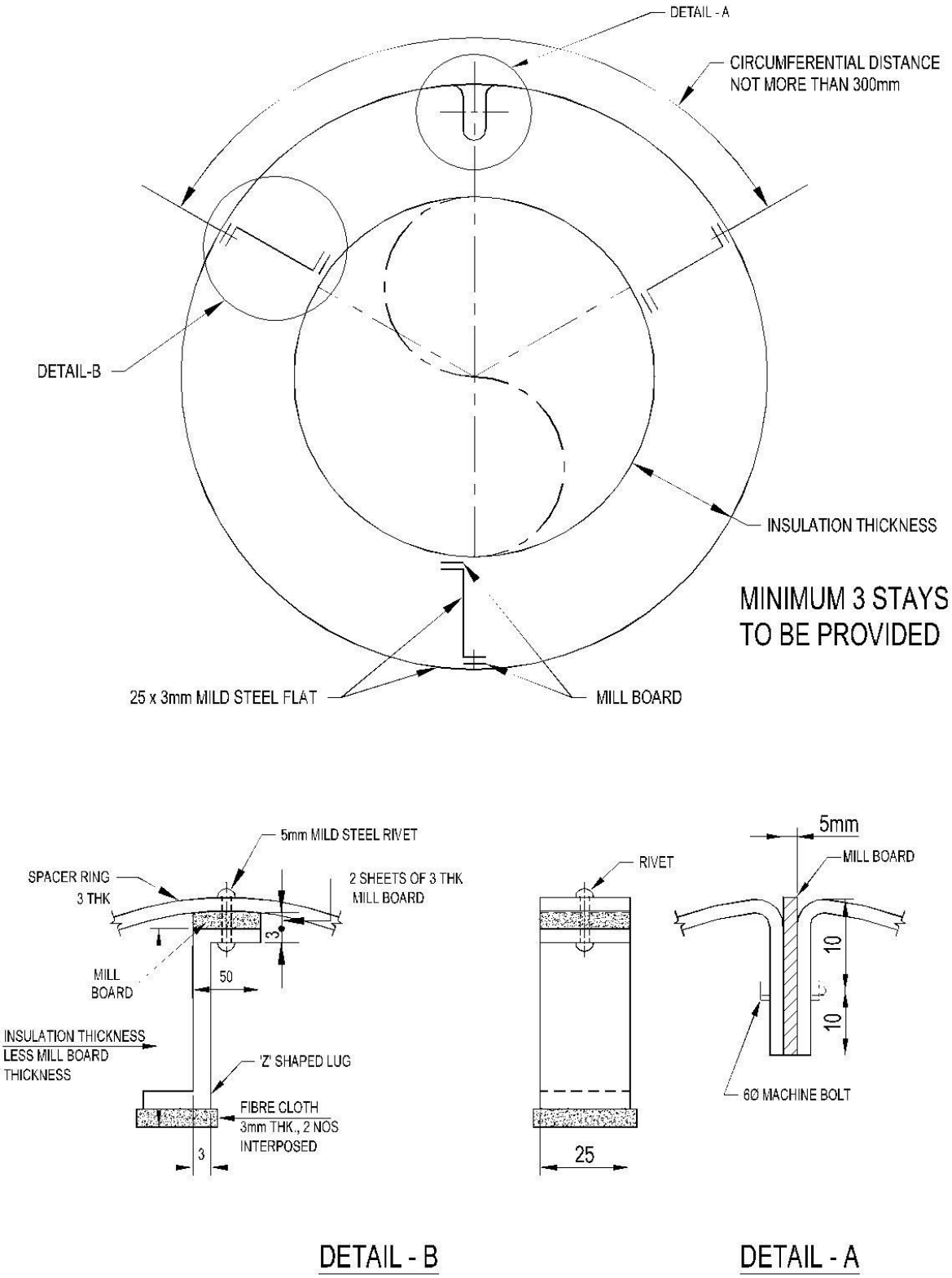

FIGURE – 04
DETAIL OF SPACER RING FIBROUS INSLUATION (MATTRESS)

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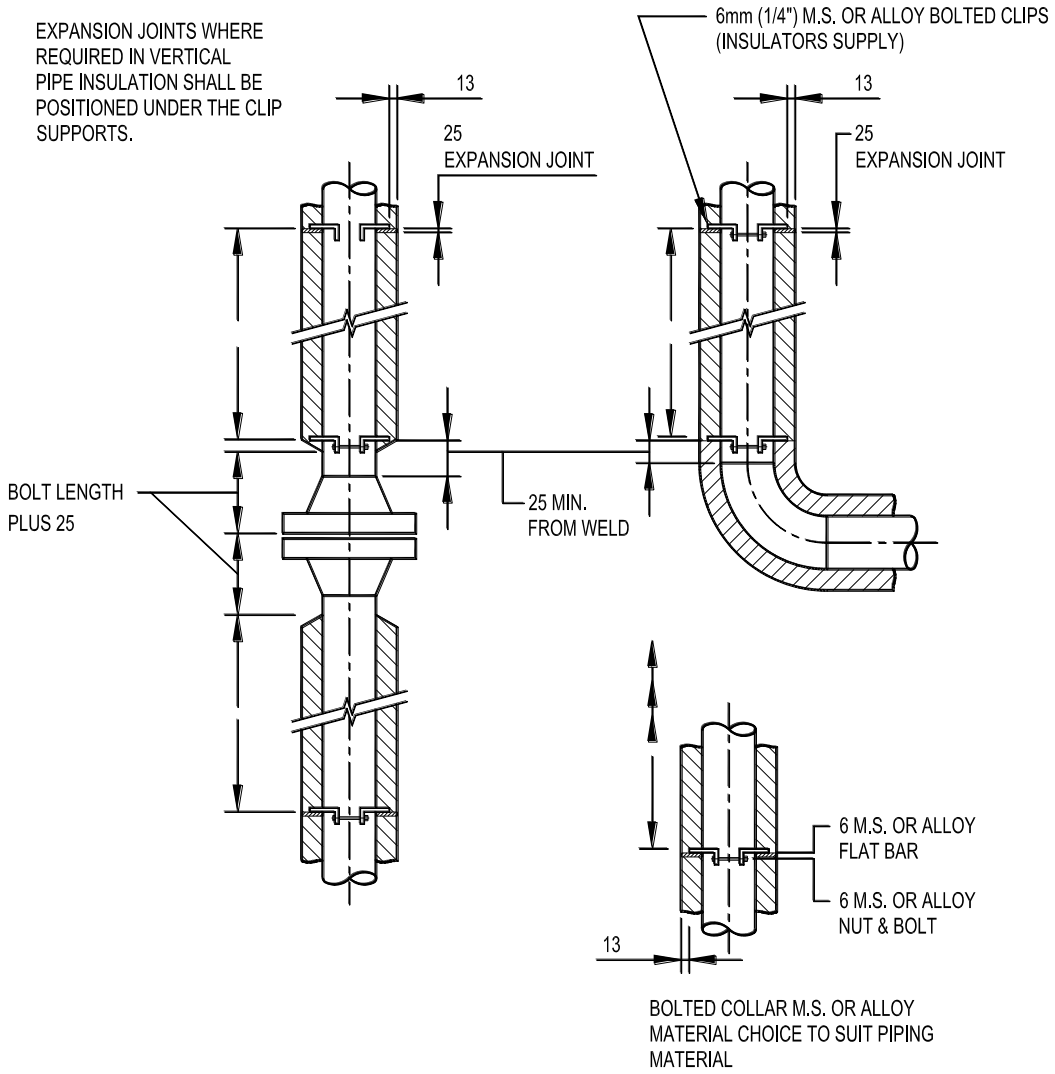

CLIP SPACING

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

* CIRCUMFERENTIAL EXPANSION SHALL BE CONSIDERED AT THESE OPERATING TEMPERATURES.

FIGURE – 05
BOLTED ON INSULATION SUPPORT FOR VERTICAL PIPE

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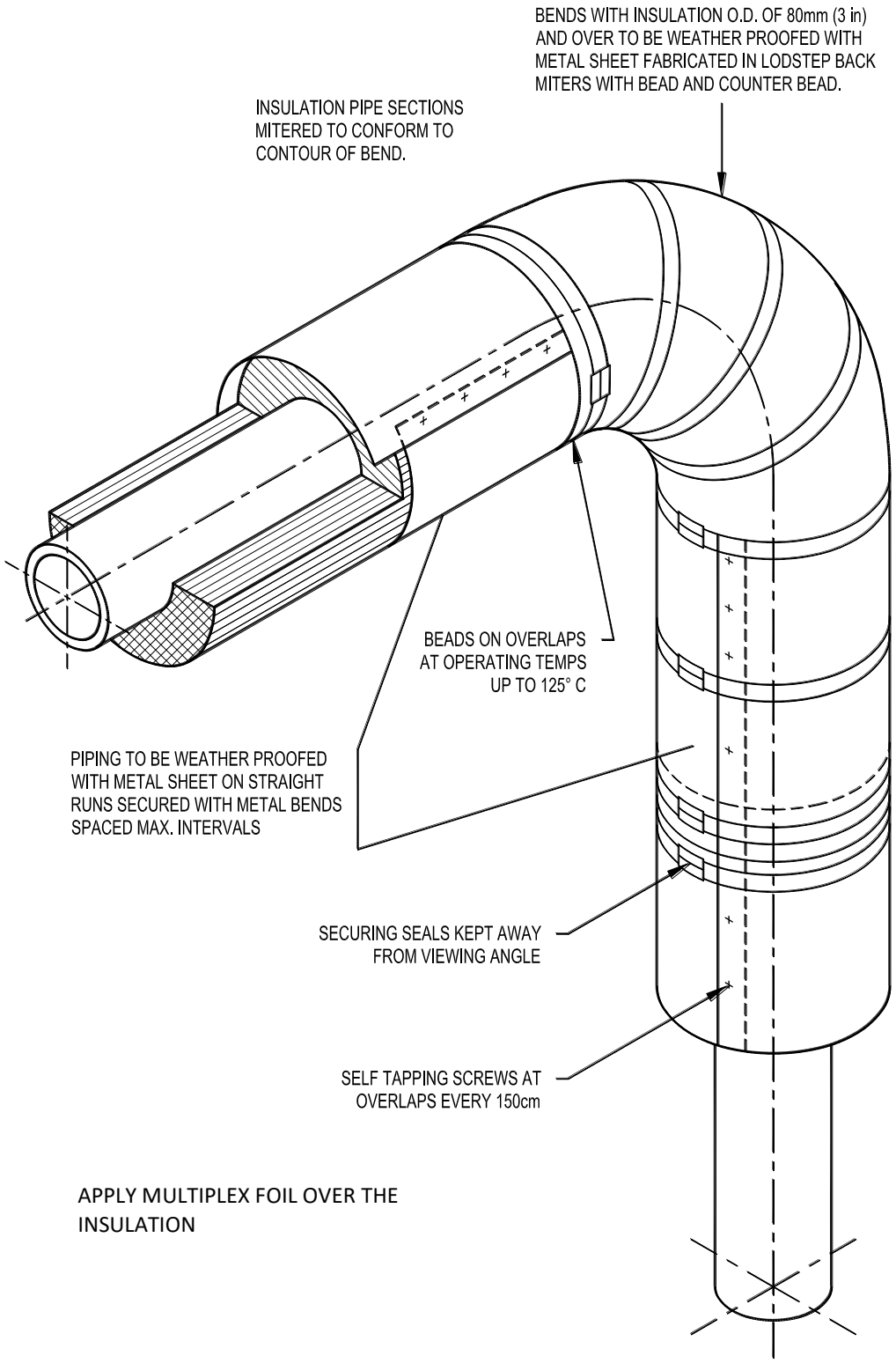

FIGURE – 06
INSULATION DETAILS FOR BENDS / ELBOWS

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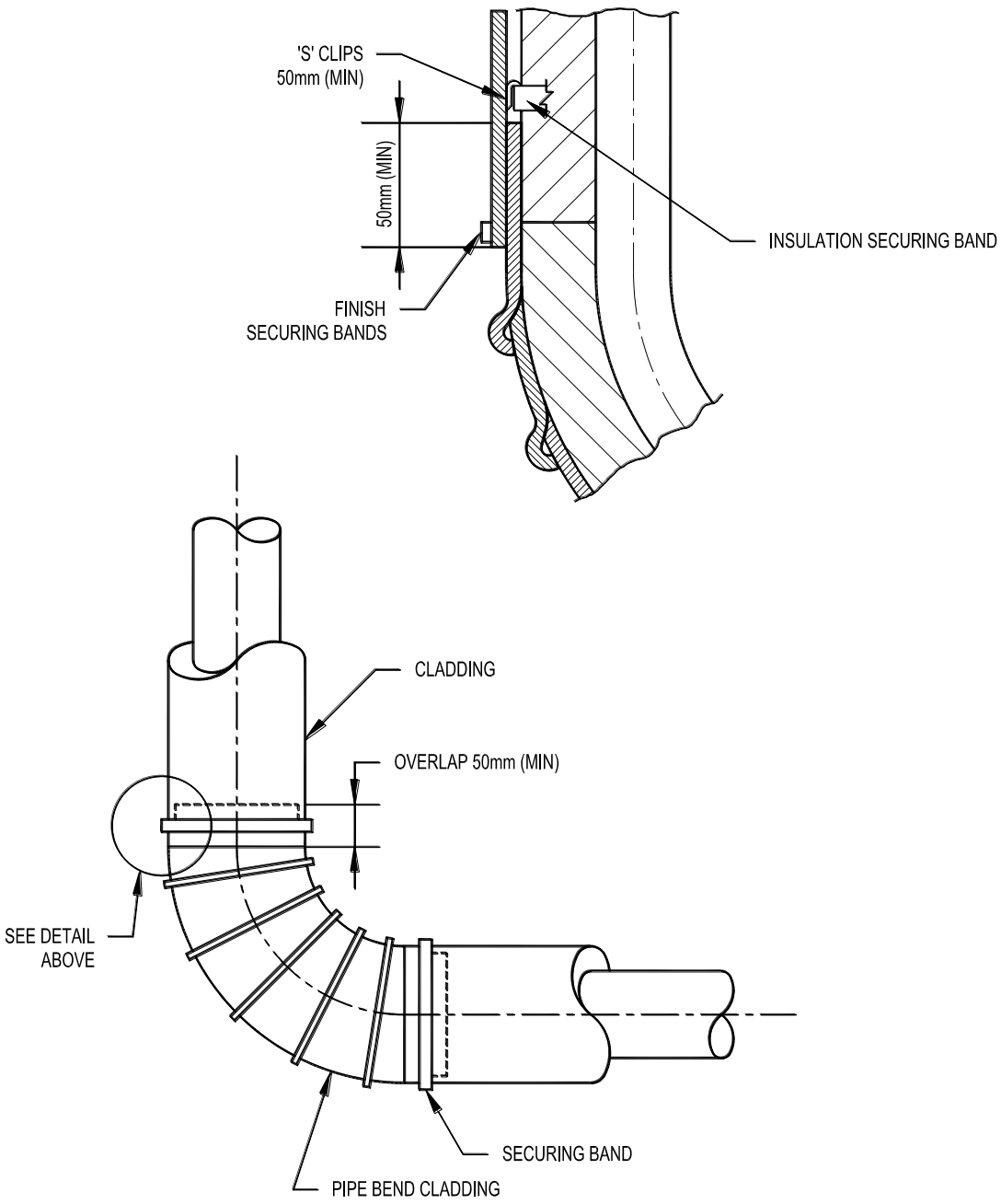

FIGURE – 07
INSULATION DETAILS : PIPE BENDS & ELBOWS

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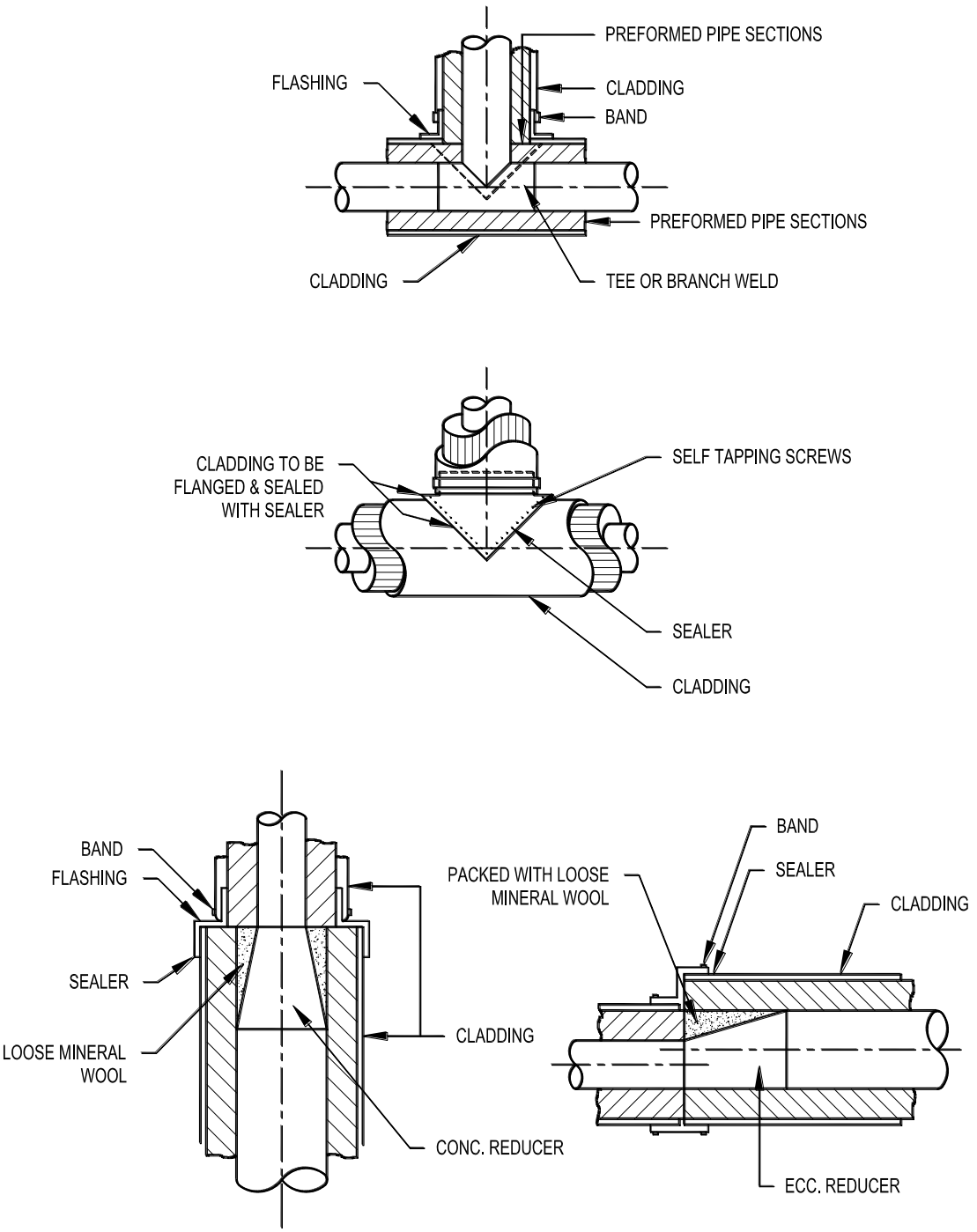

FIGURE – 08
INSULATION DETAILS: PIPE BRANCHED & REDUCER

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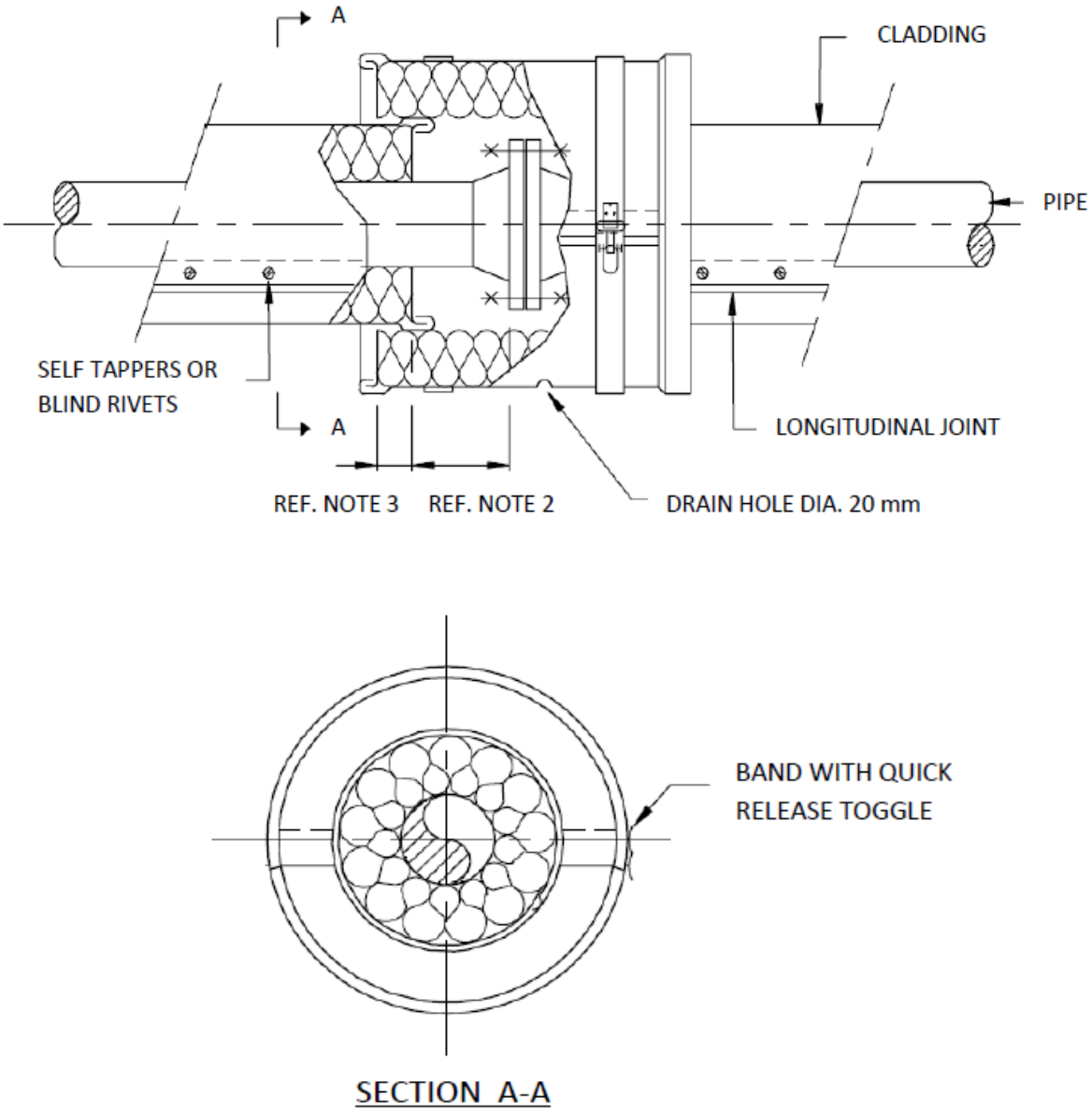

SECTION A-A

NOTE

1. MATERIAL AND FINSHING IN ACCORDANCE WITH INSTALLATION INSTRUCTIONS AND SPECIFICATION
2. DISTANCE BETWEEN INSULATION AND FLANGE TO BE BOLT LENGTH + 30 mm
3. INSULATION THICKNESS

FIGURE – 09
EXAMPLE OF REMOVABLE FLANGE BOX, HORIZONTAL

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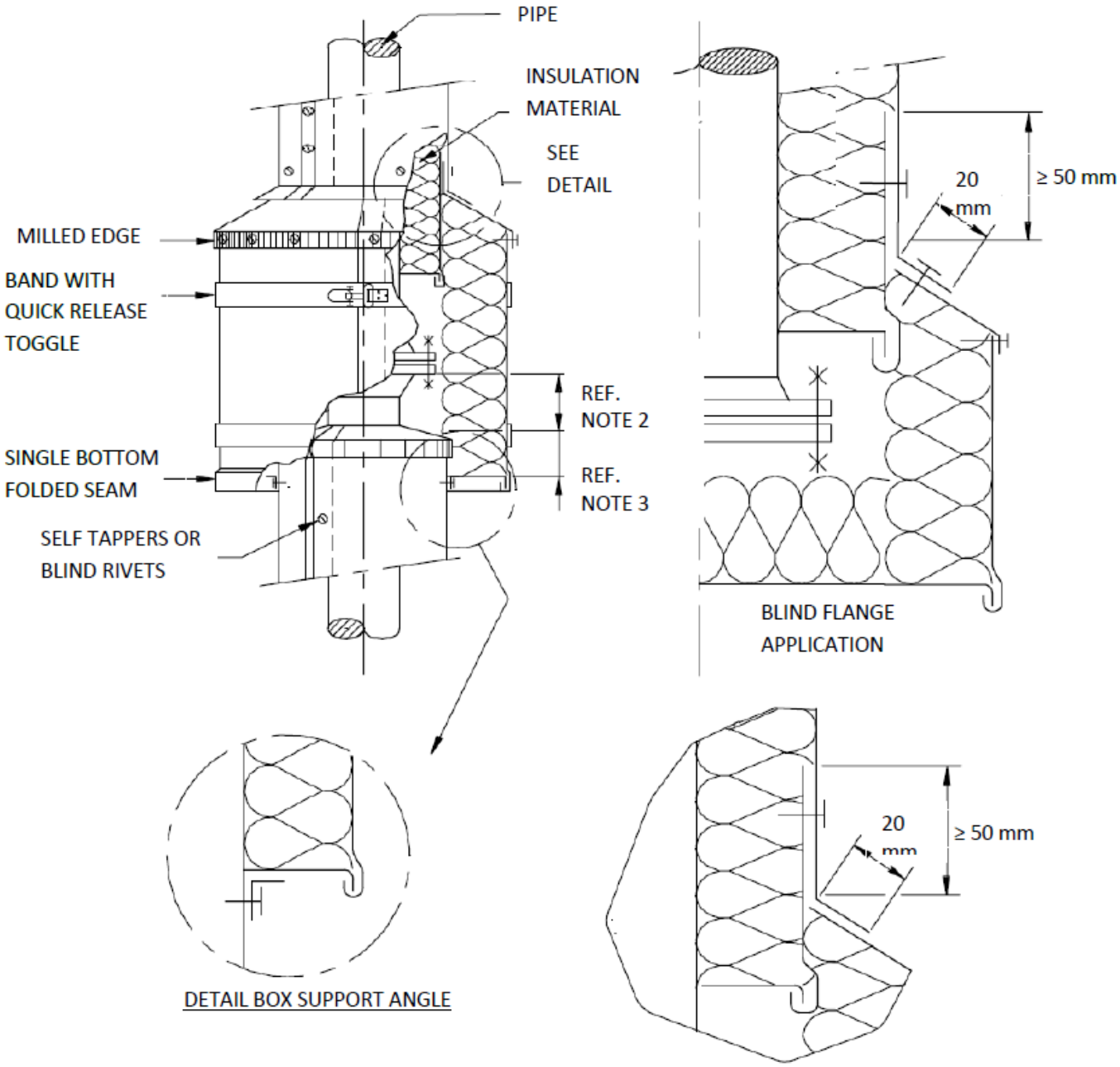

NOTE

1. MATERIAL AND FINSHING IN ACCORDANCE WITH INSTALLATION INSTRUCTIONS AND SPECIFICATION
2. DISTANCE BETWEEN INSULATION AND FLANGE TO BE BOLT LENGTH + 30 mm
3. INSULATION THICKNESS

FIGURE – 10
REMOVABLE FLANGE BOX, VERTICAL

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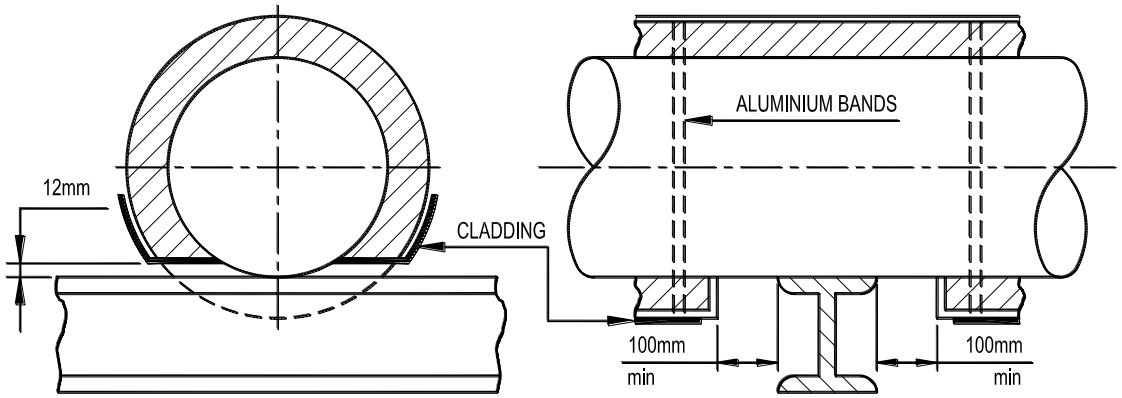
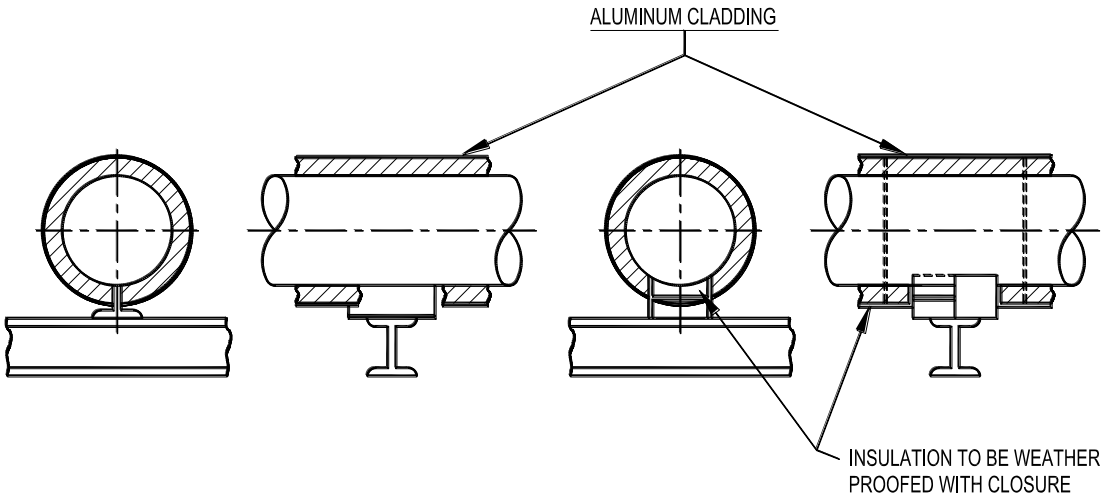


WHERE CLADDING IS TO BE CUT AWAY IT SHALL FIT CLOSELY TO THE PIPE AND TO BE COMPLETELY WEATHERPROOF

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



INSULATION OF LINE ON SHOES

FIGURE – 11
INSULATION DETAILS PIPE SUPPORTS

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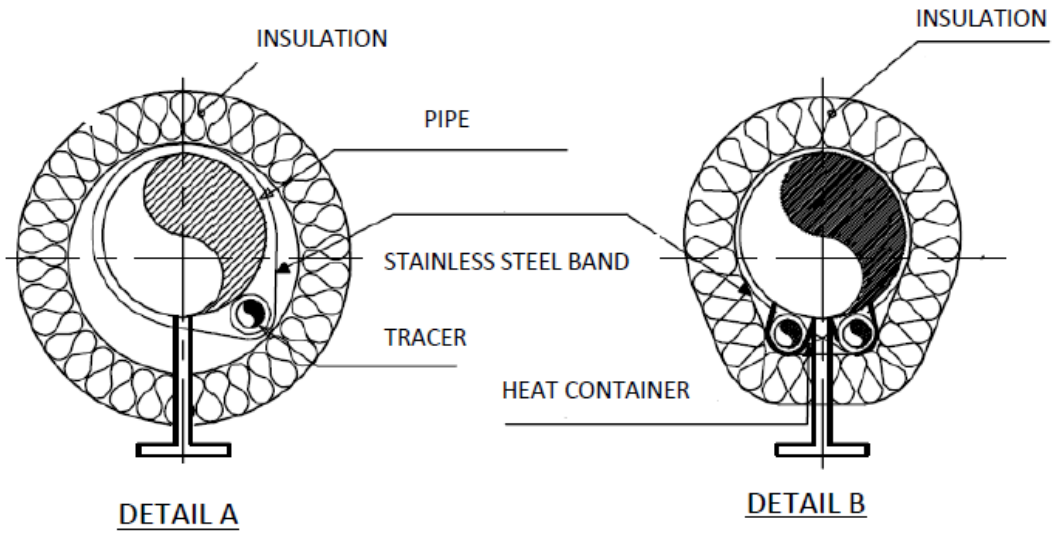
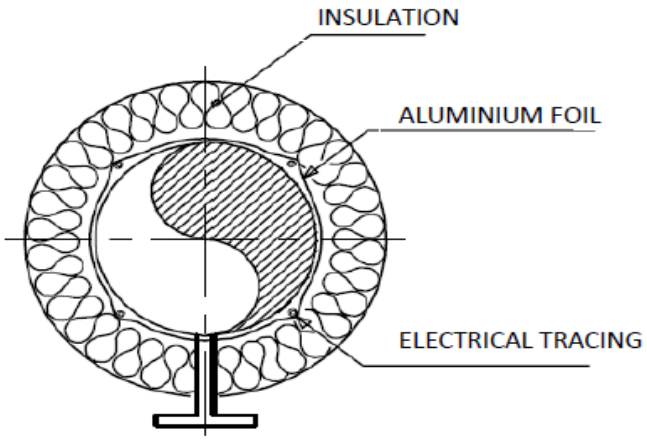
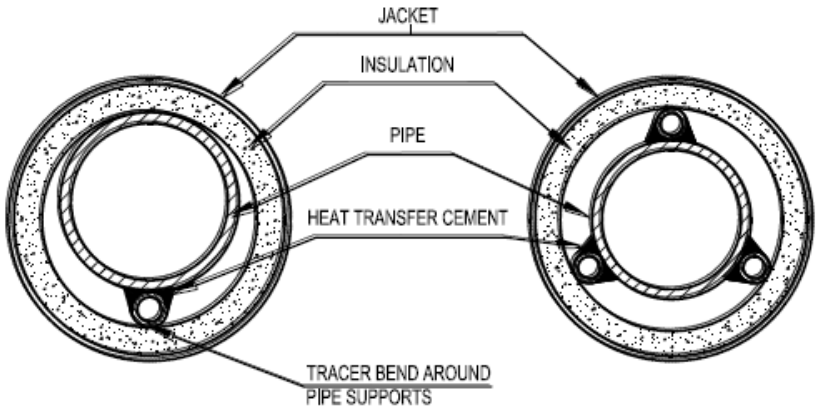


DETAIL A

DETAIL B



DETAIL C



DETAIL D

FIGURE – 12
INSULATION OF TRACED PIPING

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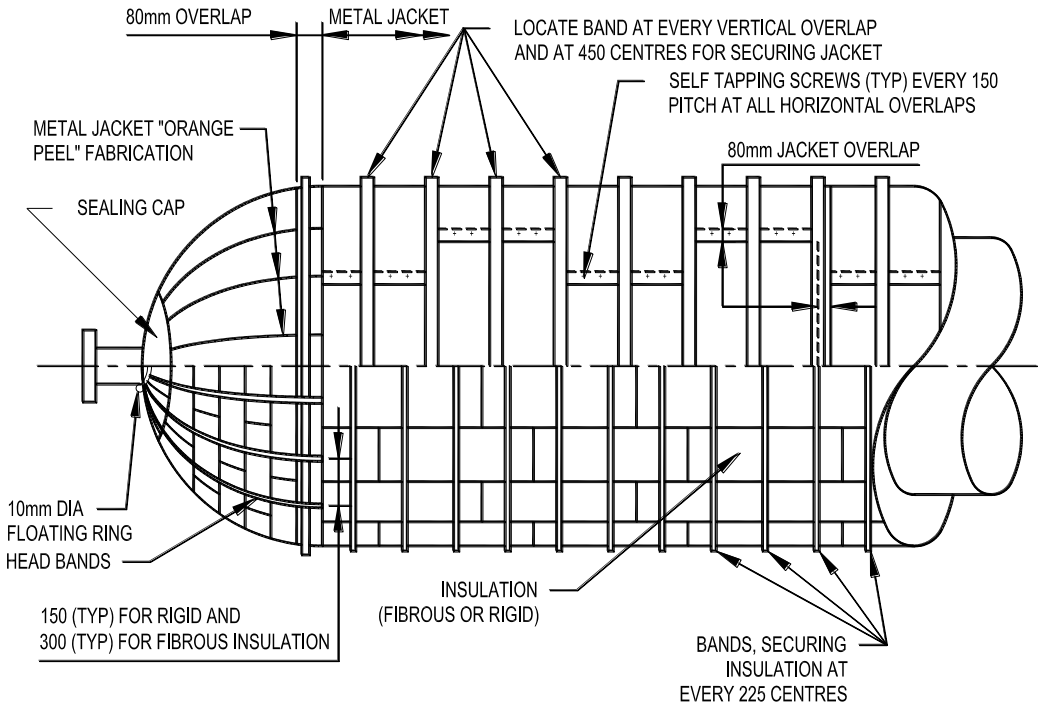

NOTES :-

1. SADDLE SUPPORTS FOR HORIZONTAL EQUIPMENT TOGETHER WITH SHOE AND ANCHOR SUPPORTS FOR HORIZONTAL PIPNG 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.

FIGURE – 13
HORIZONTAL EQUIPMENT INSULATION

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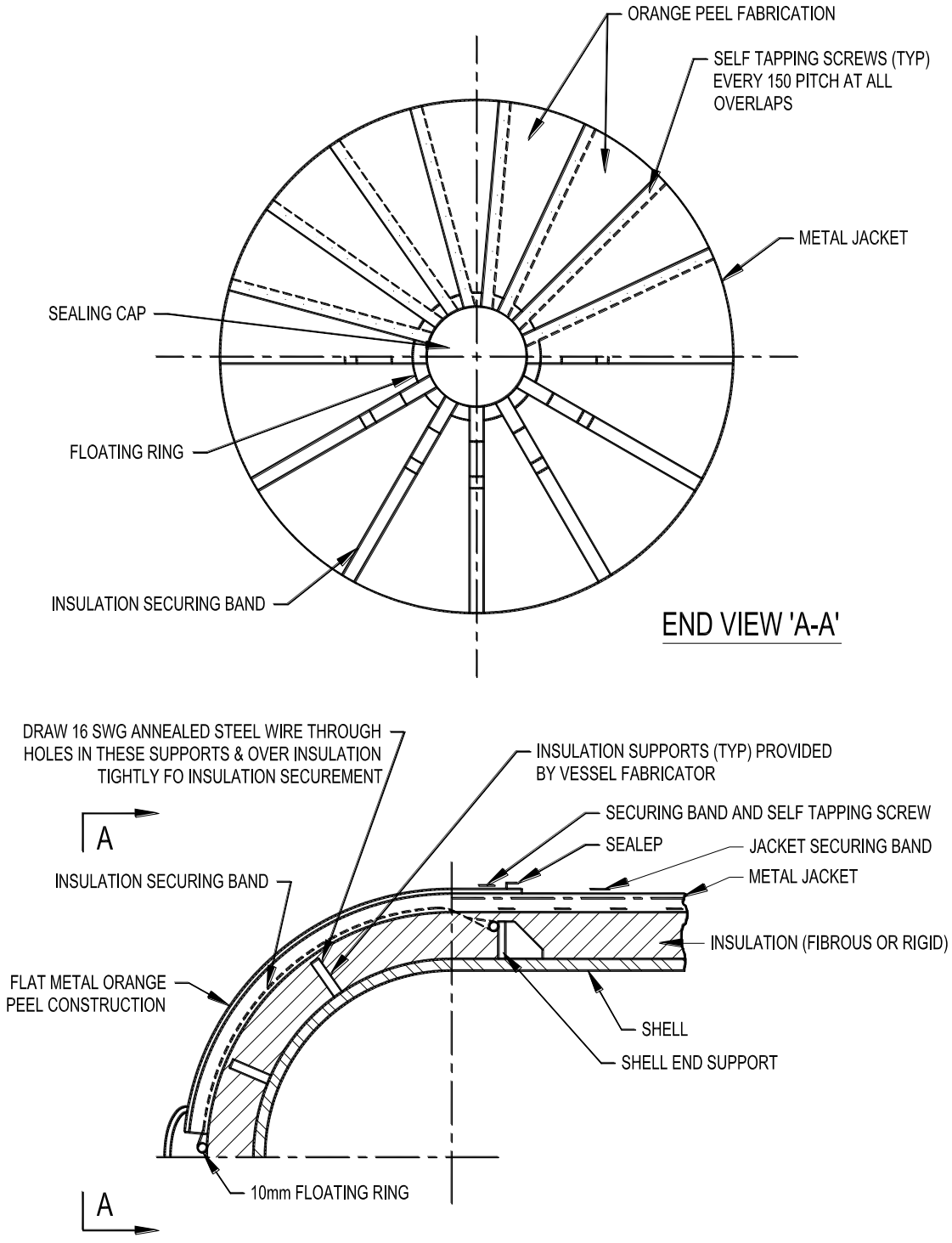

FIGURE – 14
HORIZONTAL EQUIPMENT HEADS

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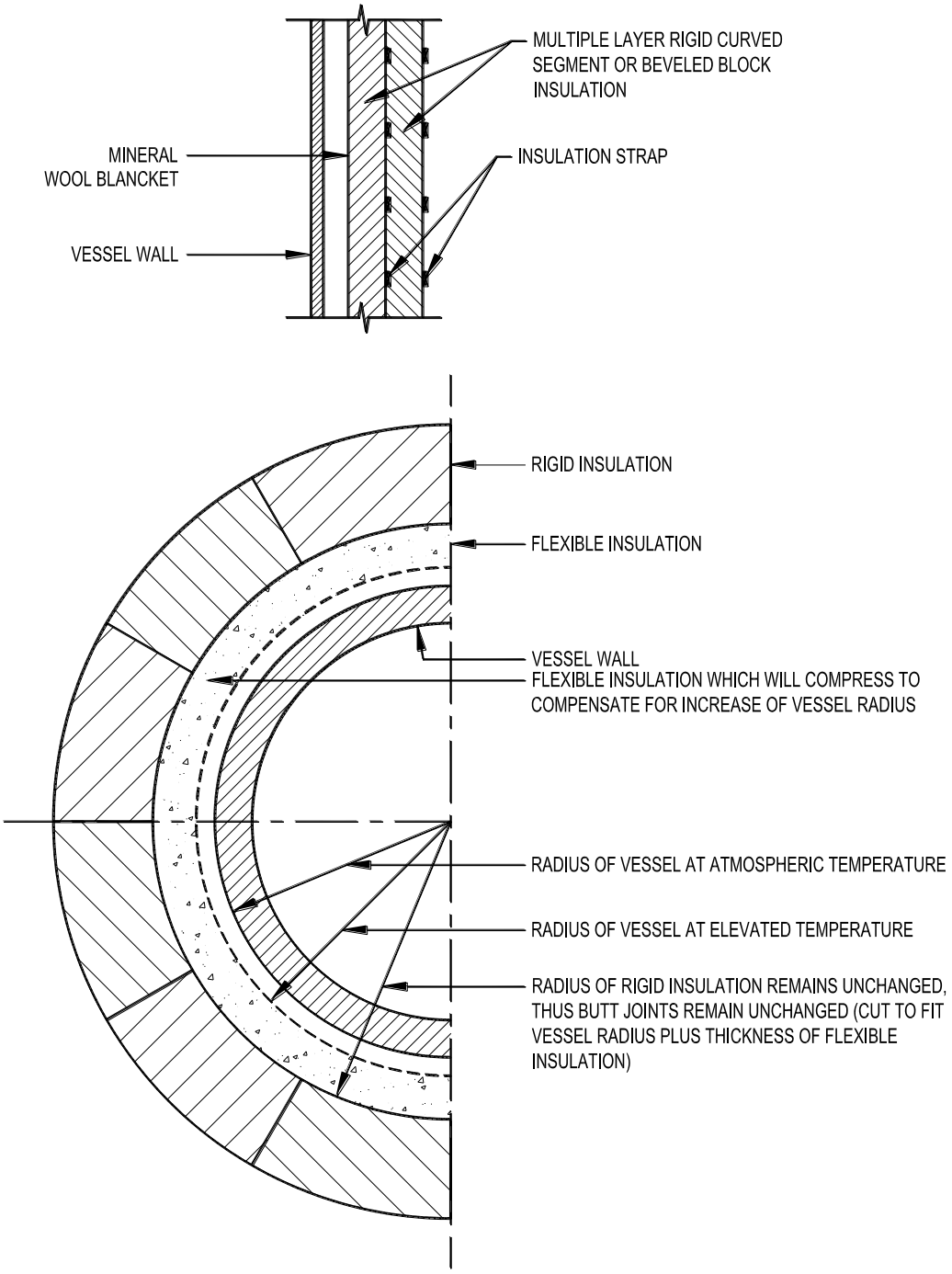

FIGURE – 15
USE OF FLEXIBLE INSULATION IN COMBINATION WITH RIGID INSULATION TO COMPENSATE FOR VESSEL EXPANSION

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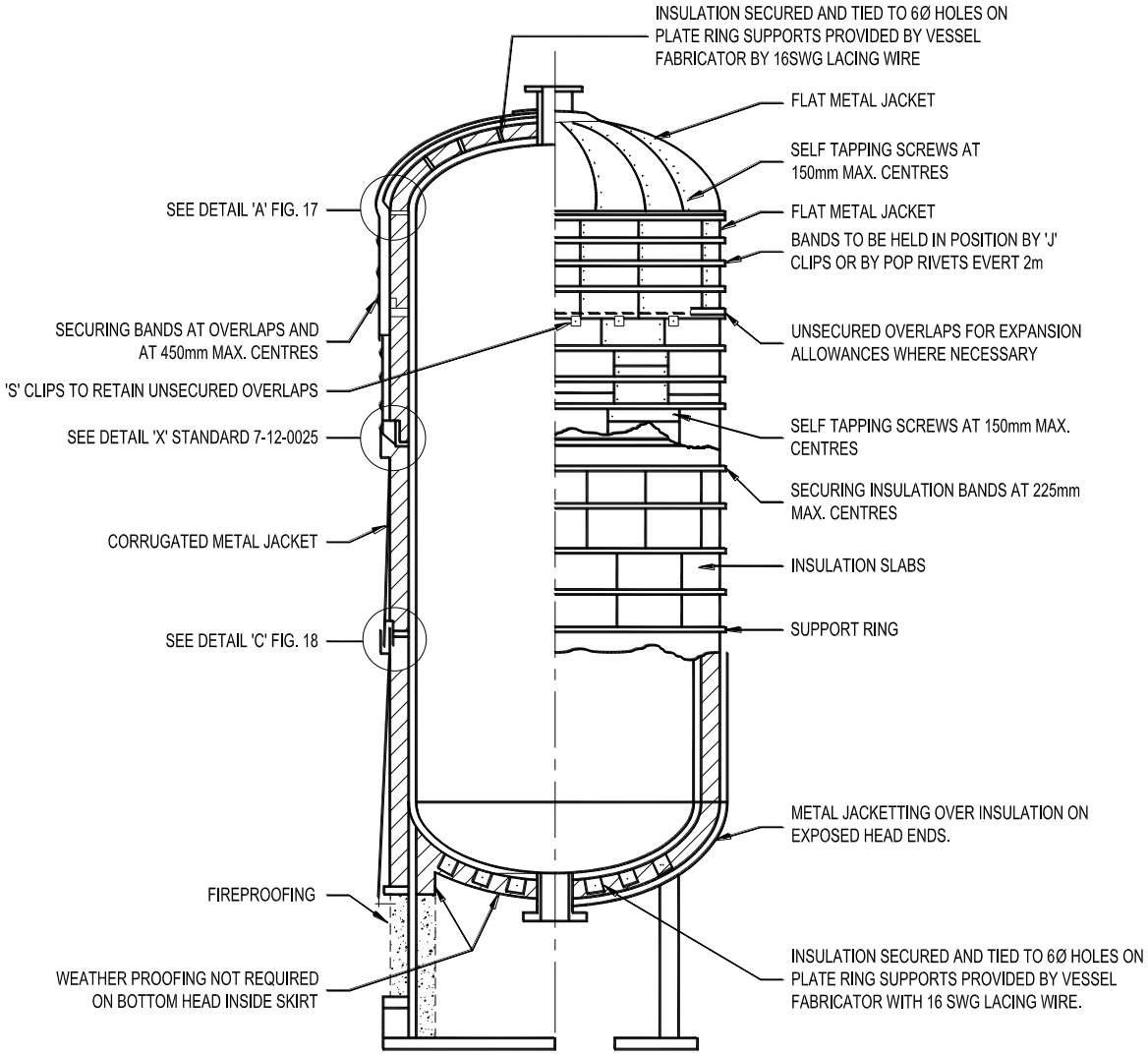

FIGURE – 16
INSULATION DETAILS : VERTICAL VESSEL

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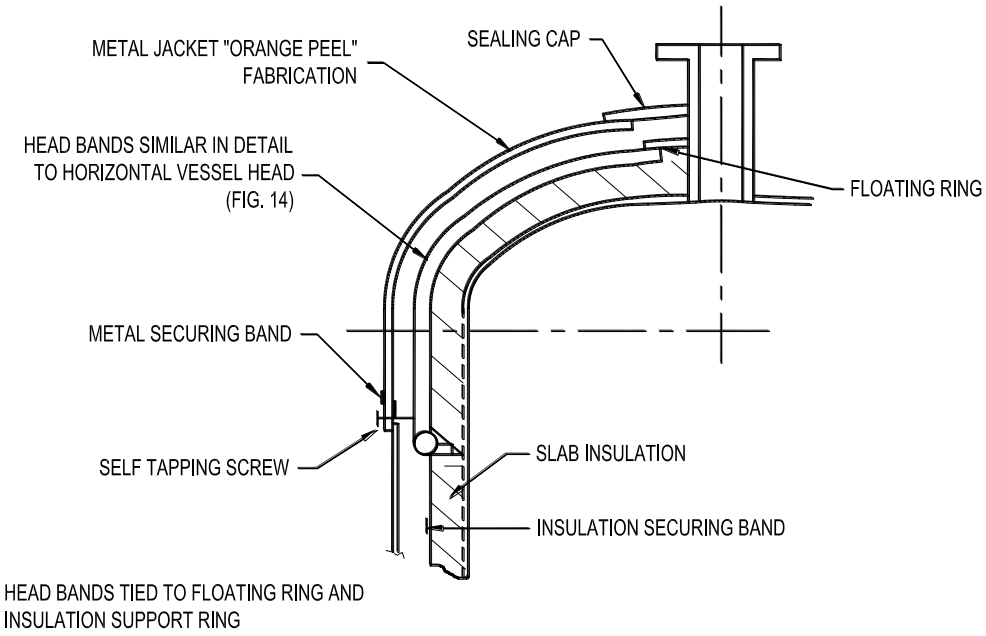

DETAIL 'A'

FIGURE – 17
INSULATION DETAILS VERTICAL VESSEL HEADS

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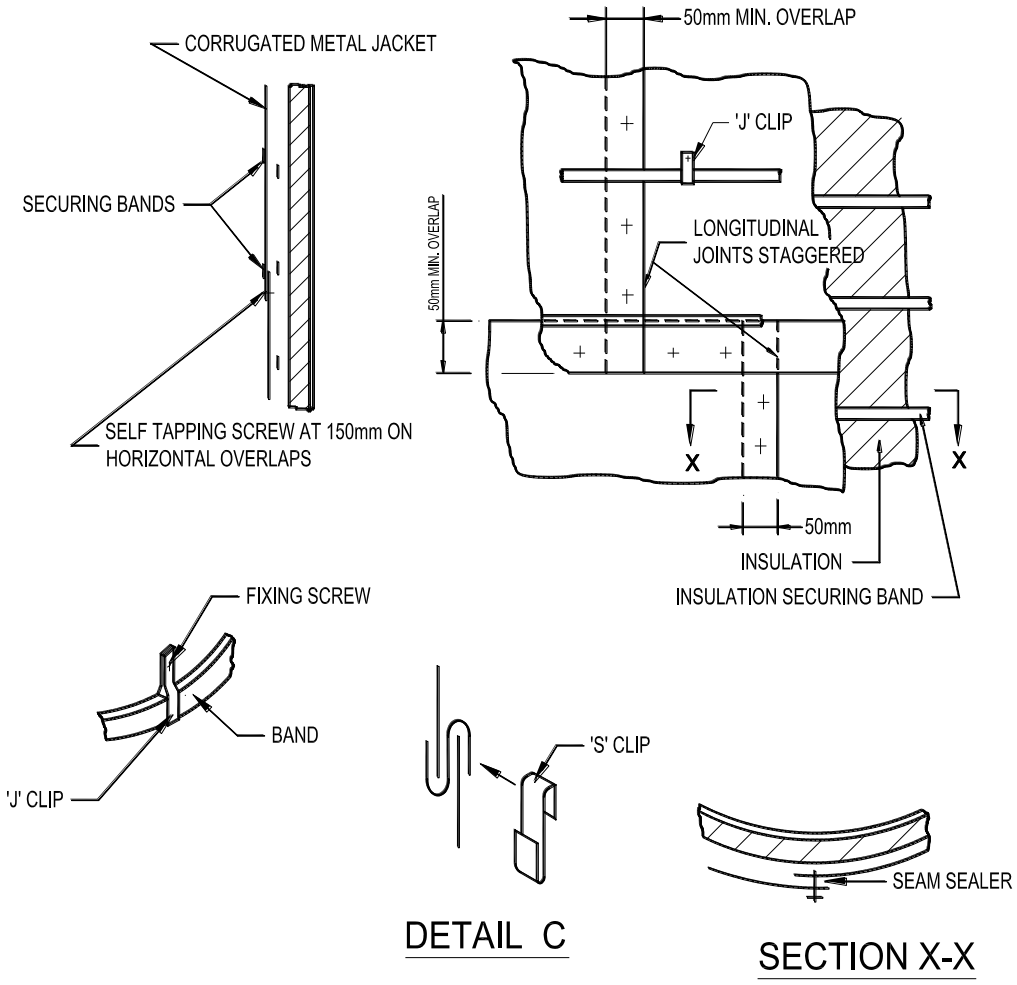

NOTE:

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

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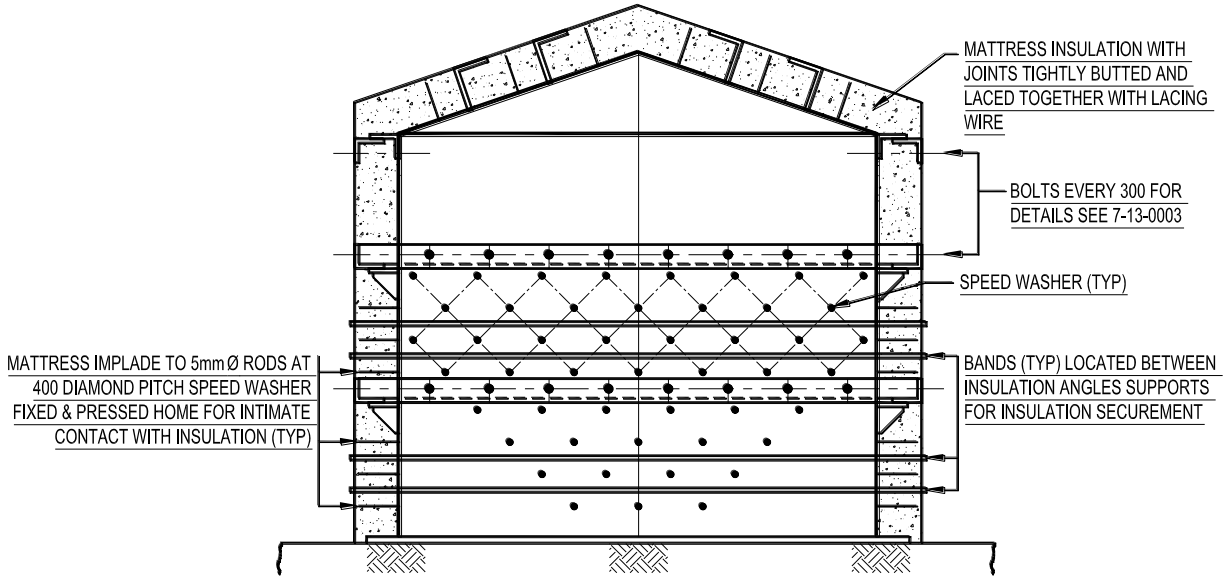
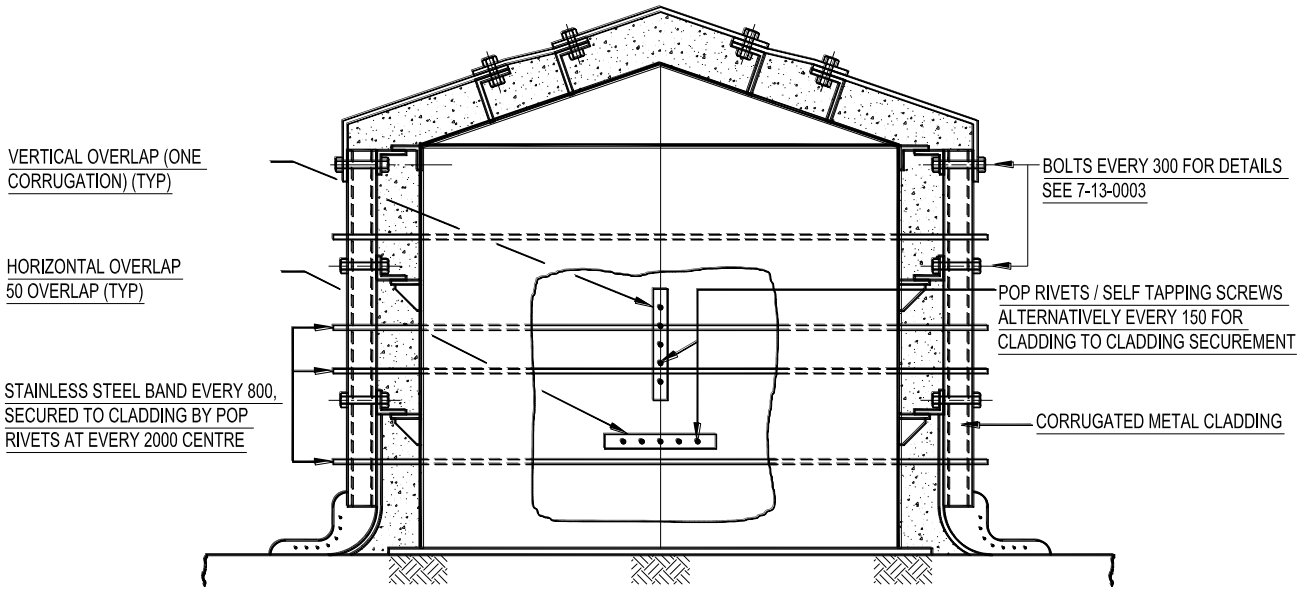


INSULATION SECUREMENT DETAIL



CLADDING SECUREMENT DETAIL

FIGURE – 19
INSULATION DETAILS : VERTICAL STORAGE TANK

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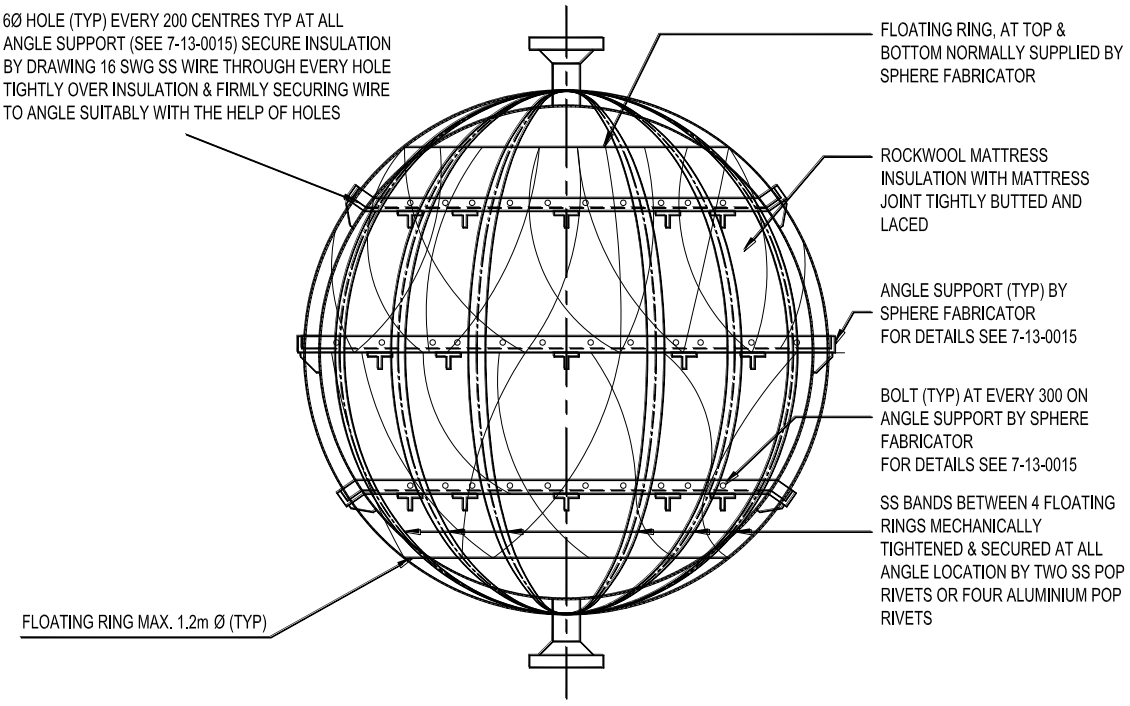
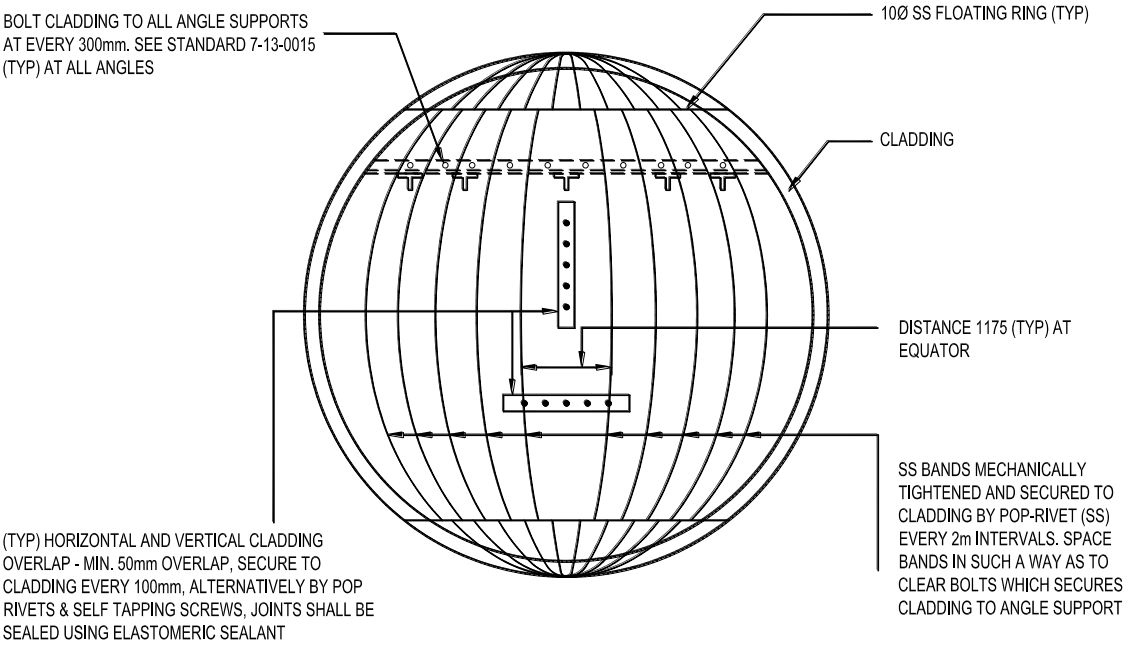


INSULATION SECUREMENT DETAILS



CLADDING SECUREMENT DETAILS

FIGURE – 20
INSULATION DETAILS : SPHERE

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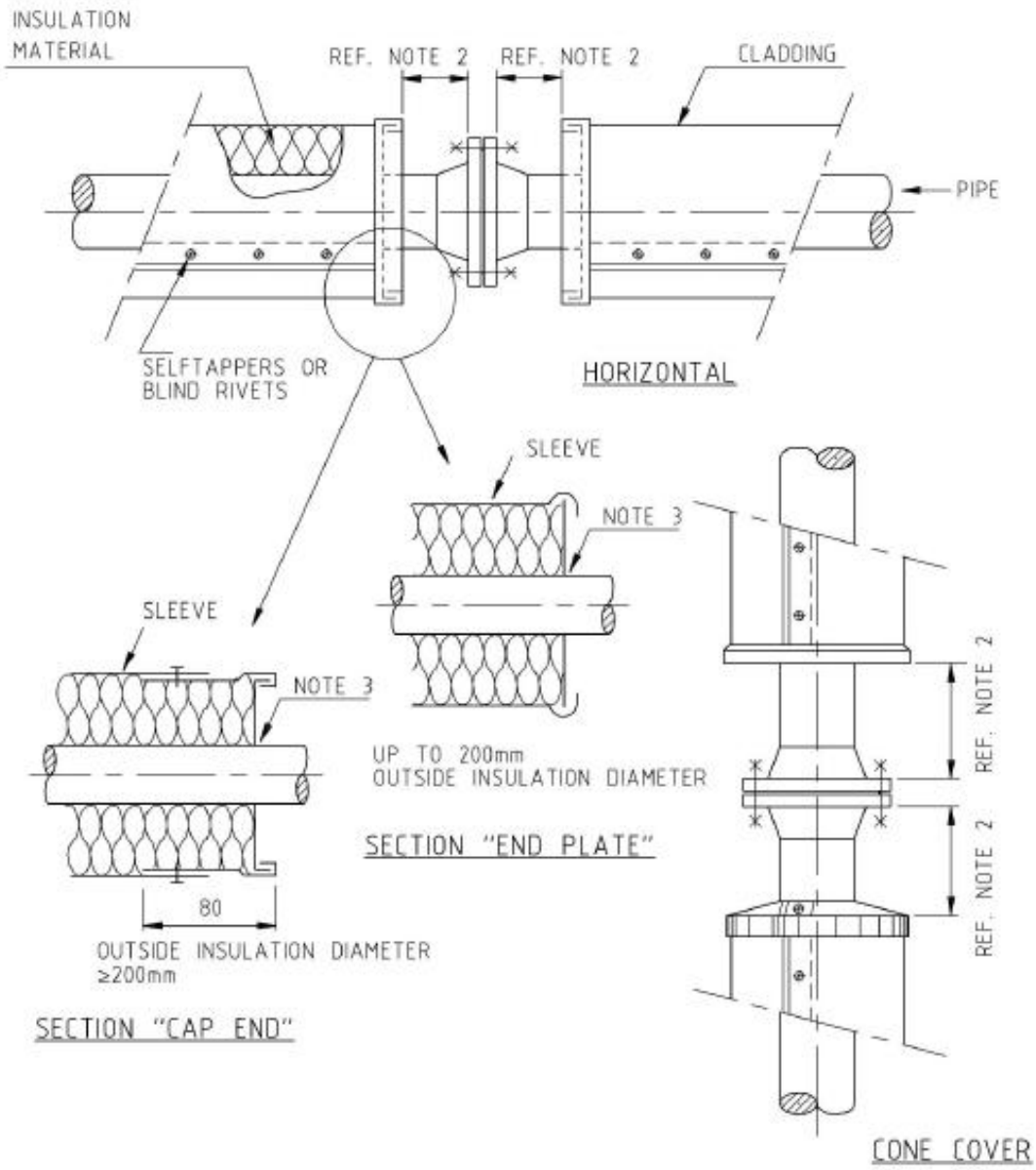
Page 3725 of 4391 : B957-TENDER DOC-B957-300-16-43-MR-T-3001 : Rev. A



Note

1. Materials and finishing in accordance with installation instructions and specification.
2. Distance between insulation and flange to be bolt length+30mm
3. In case a end plate/cap end may damage the pipe, a heat resistant tape or gasket material to be installed between pipe and plate.

FIGURE – 21
NON- INSULATED FLANGES, HORIZONTAL AND VERTICAL

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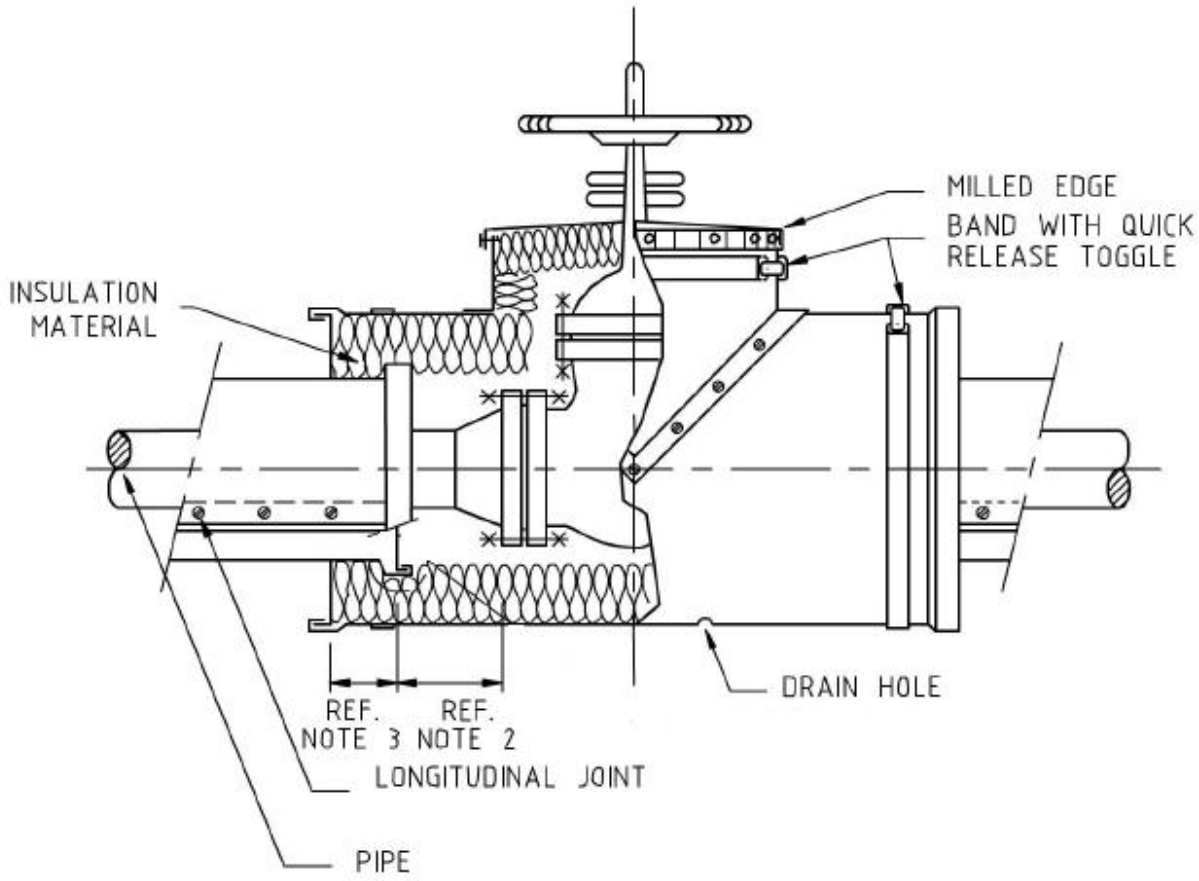

Note

1. Materials and Finishing in accordance with installation instructions and specification
2. Distance between insulation and flange to be bolt length + 30mm
3. Insulation Thickness

FIGURE – 22
REMOVABLE VALVE BOX, "T" CONNECTION, HORIZONTAL
Applicable only valves which needs to be insulated as per applicable specification

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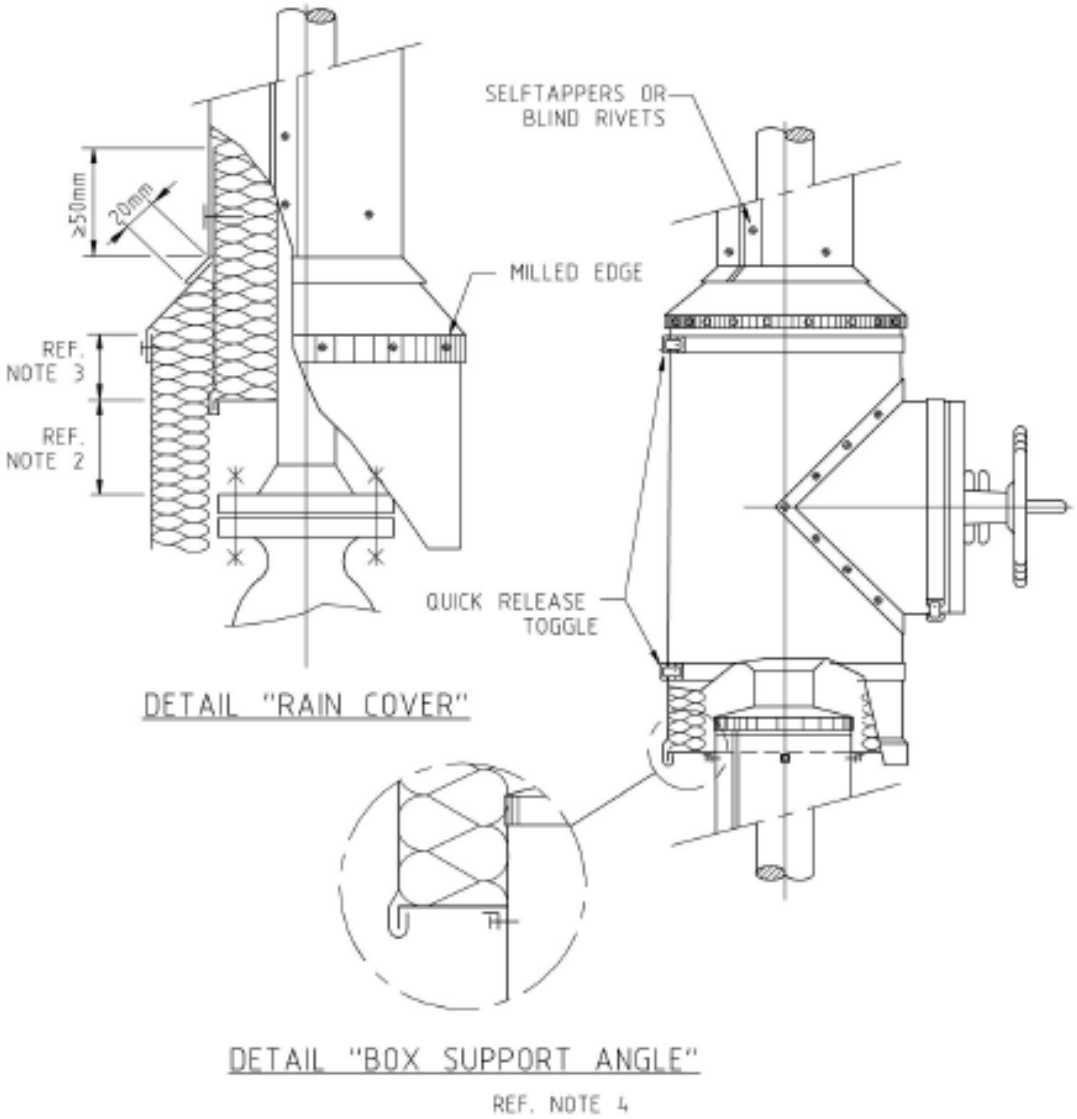

Note

1. Materials and Finishing in accordance with installation instructions and specification
2. Distance between insulation and flange to be bolt length + 30mm
3. Insulation Thickness
4. Per box minimal 4 support angles ≥ 30mm wide ≥ 0.8mm thick

FIGURE – 23
REMOVABLE VALVE BOX, "T" CONNECTION, VERTICAL

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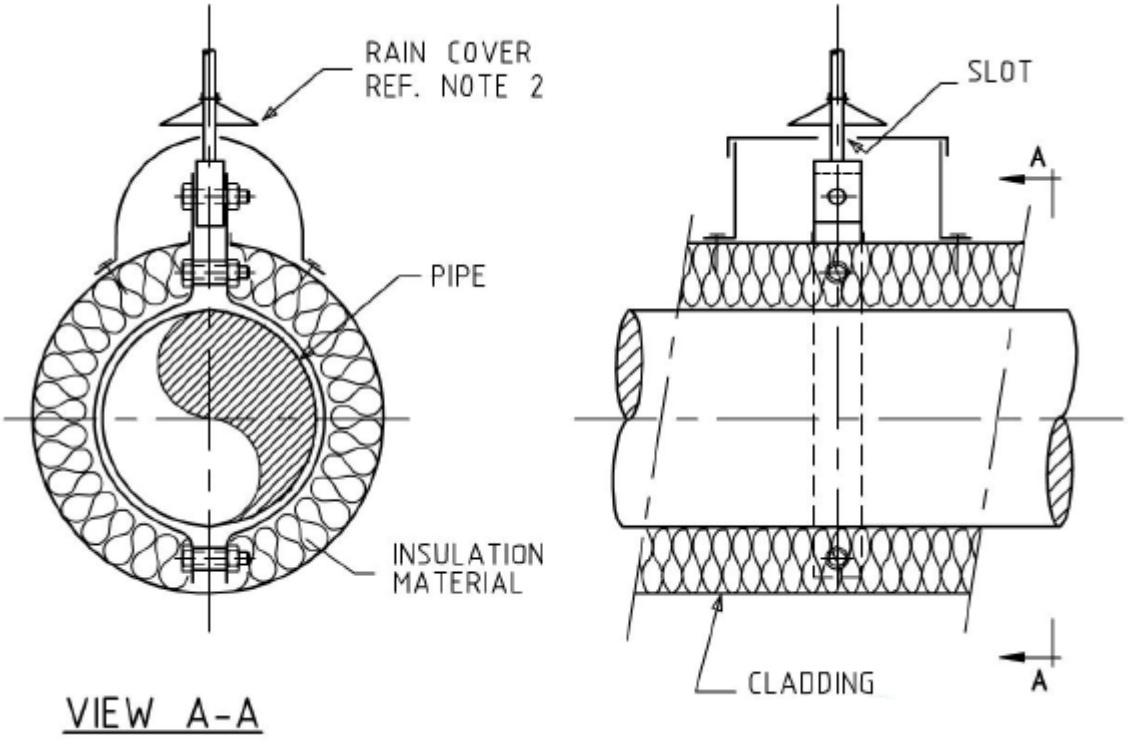
Applicable only valves which needs to be insulated as per applicable specification



Note
1. Materials and finishing in accordance with installation instructions and specifications
2. Rain cover is a part of the bracket

FIGURE – 24
HANGER SUPPORT

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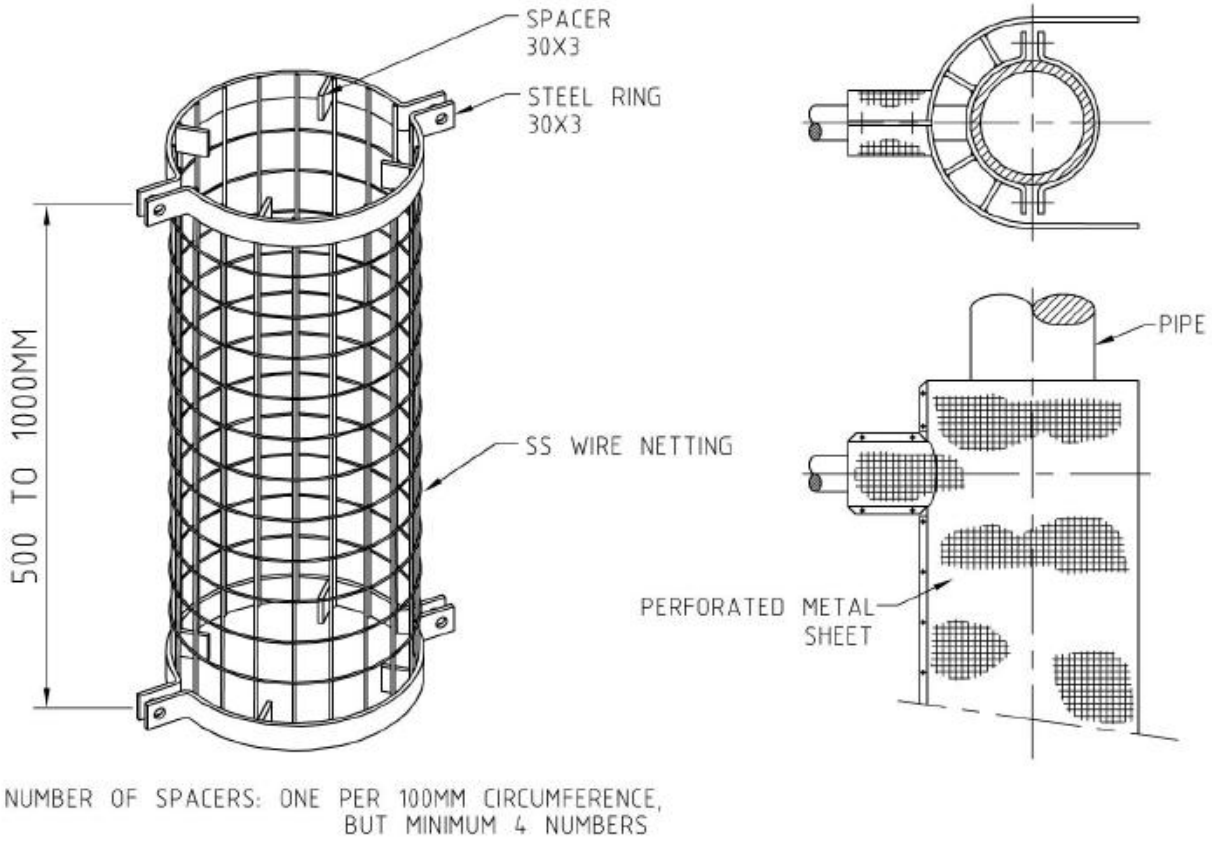

WIRE NETTING

PERFORATED METAL SHEET

Note

1. Materials and finishing in accordance with installation instructions and specifications

FIGURE – 25
PERSONAL PROTECTION

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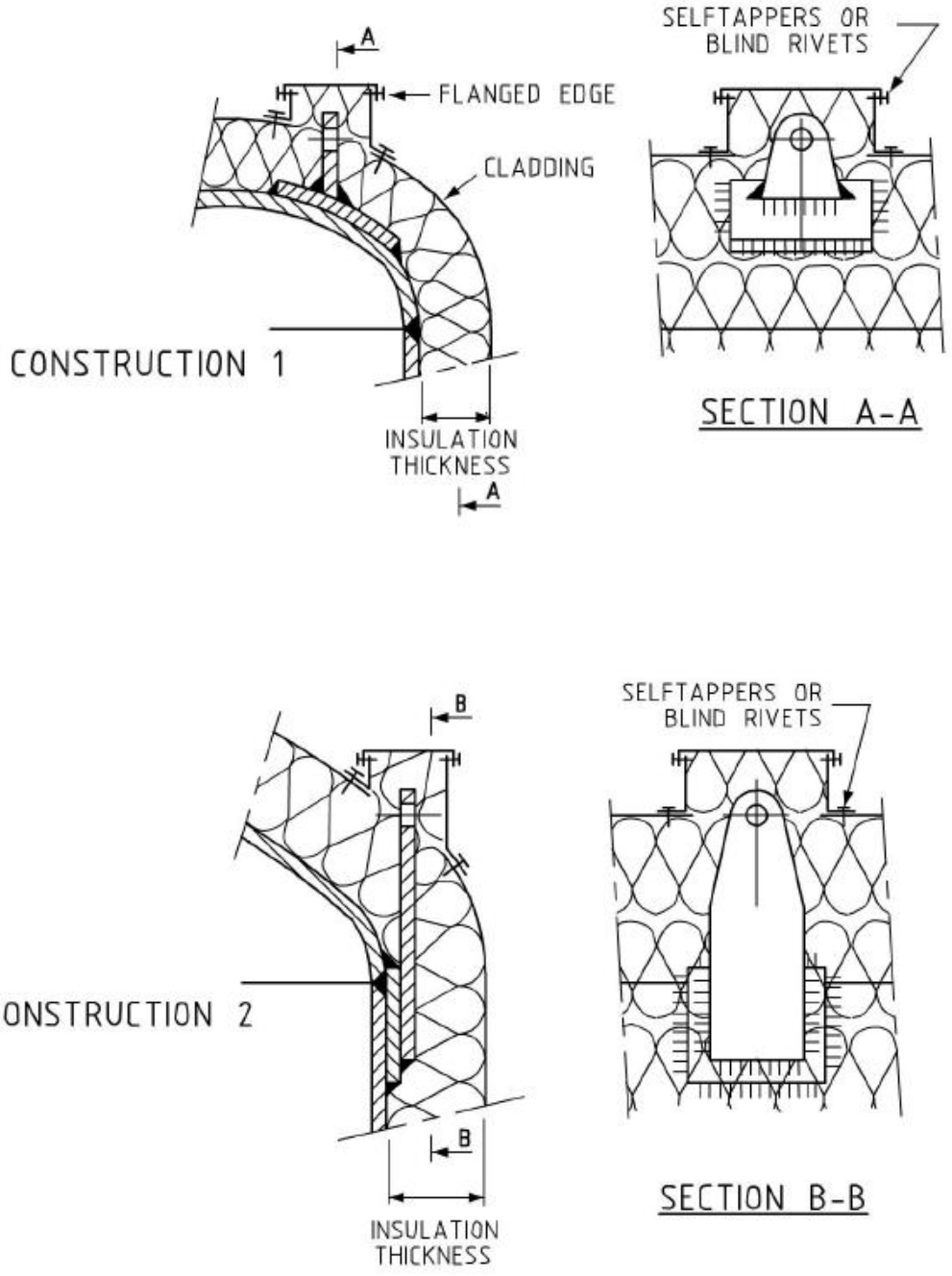

FIGURE – 26
DETAILS OF LIFTING LUGS

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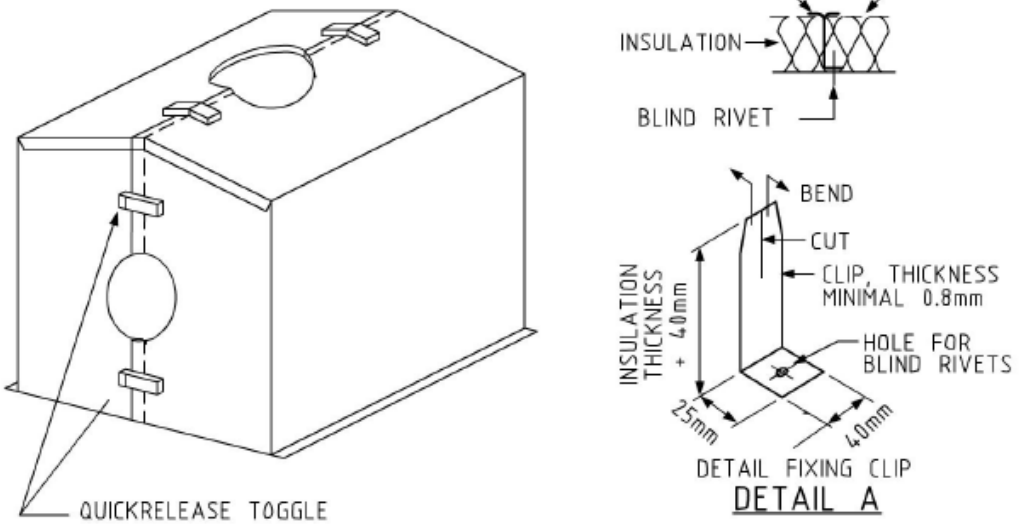

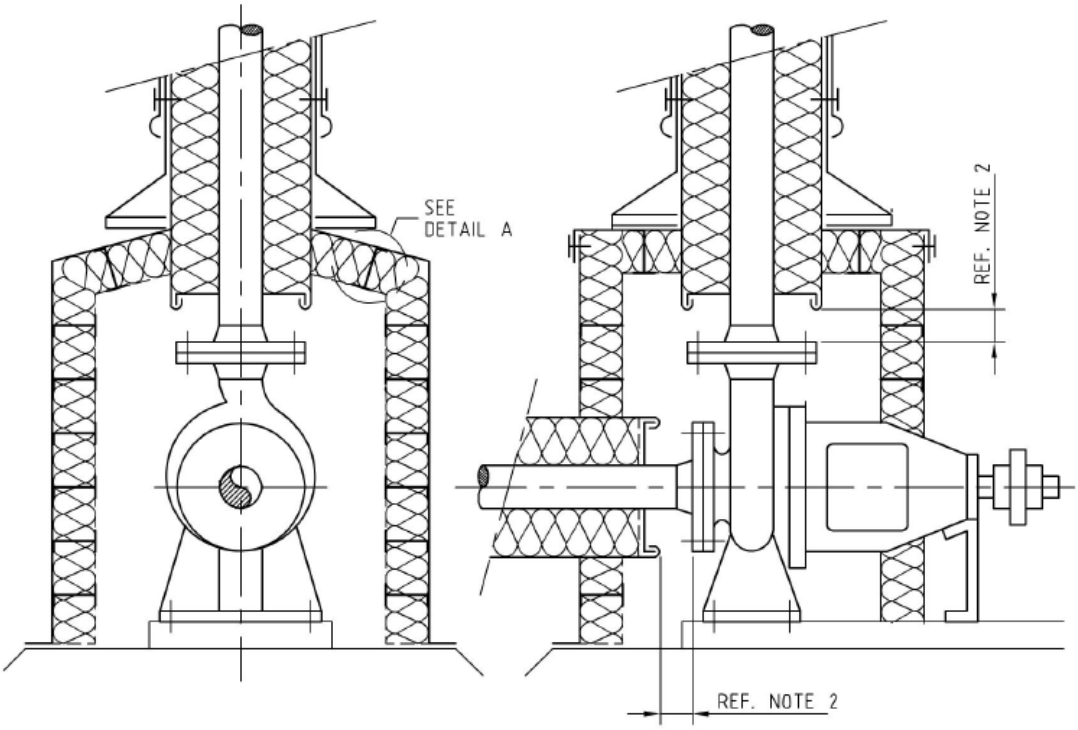

Note
1. Materials and Finishing in accordance with installation instructions and specification
2. Distance between insulation and flange to be bolt length + 30mm

FIGURE – 27
REMOVABLE BOX FOR PUMP

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कार्बन स्टील प्रैशर वेसल / कॉलम के लिए
निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
PRESSURE VESSELS/ COLUMNS CARBON STEEL

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
5	09.04.2026	REVISED AND RE-ISSUED	SG	TKK	HP	NK
4	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
3	09.09.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	15.07.2011	REVISED AND RE-ISSUED	HP	SCG	AKC	DM
1	28.09.2007	REVISED AND RE-ISSUED	PD	RB	MVKK	VC
0	10.12.2002	ISSUED FOR IMLEMENTATION	NKN	SPS	AKB	GRR

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Abbreviations:

AS / CS / SS		Alloy Steel / Carbon Steel / Stainless Steel
CEIL	:	Certification Engineers International Limited
CIMFR	:	Central Institute of Mining & Fuel Research
CE	:	Carbon Equivalent
DFT	:	Dry Film Thickness
DPT	:	Dye Penetrant Testing
DHT	:	De-hydrogen Heat Treatment
ERTL	:	Electronics Regional Test Laboratory
FCRI	:	Fluid Control Research Institute
HT	:	Heat Treatment
HIC	:	Hydrogen Induced Cracking
ITP	:	Inspection and Test Plan
IP	:	Ingress Protection
IHT	:	Intermediate Heat Treatment
IC	:	Inspection Certificate
IGC	:	Inter Granular Corrosion
MPT/MT	:	Magnetic Particle Testing
MTC	:	Material Test Certificate
MRT	:	Mechanical Run Test
NDT	:	Non-Destructive Testing
NPSH	:	Net Positive Suction Head
PO	:	Purchase Order
PESO	:	Petroleum Explosive Safety Organization
PQR	:	Procedure Qualification Record
PR	:	Purchase Requisition
PMI	:	Positive Material Identification
PWHT	:	Post Weld Heat Treatment
RT	:	Radiography Testing
SSCC	:	Sulphide Stress Corrosion Cracking
TC	:	Test Certificate
TPI or TPIA	:	Third Party Inspection Agency
UT	:	Ultrasonic Testing
VDR	:	Vendor Data Requirement
WPS	:	Welding Procedure Specification
WPQ	:	Welders Performance Qualification

:

Inspection Standards Committee

Convener: Mr. Himagnshu Pal

Members:

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Mr. T Kamalakannan
(RPO- Representative)

Mr. R. Muthuramalingam
Mr. P V Satyanarayana
(Engg. Representative)

Mrs. Rajeshwari Venkatasubramanian
Mr. Themballi Vasu

Mr. Aravaazhi V

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1.0 SCOPE

This Inspection and test plan covers the minimum testing requirements of Pressure vessels/ Columns carbon steel

2.0 REFERENCE DOCUMENTS

PO/PR/ Standards referred there in/ Job specifications /approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**						
1.1	Hydro test, heat treatment, NDT, hot forming, Helium Leak test, Pneumatic Test, Thickness Measurement Procedure. Painting, Drying /Cleaning, Hardness test, PMI, Weld repair, and other Procedures **(as applicable)**	Documented procedures.	100%	Procedure documents	-	H	R
1.2	Weld Plan & NDT Plan	As per PR/ Purchase Specification/ Applicable codes	100%	Procedure documents	-	H	A
1.3	WPS/ PQR /WPQ	Documented procedures.	100%	Procedure documents	-	H	R-Existing W-New
2.0	**Materials Procurement**						

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.1	Plates, pipes, Forgings, Expansion Bellows, Fittings, Fasteners, Gaskets, etc (As applicable)	As per PR/Purchase Specification	100%	Mill TC	H	H	W / R (Note-3)
2.2	Internals like Trays, Distributors, Packings, Demisters, Johnson screens, support grids, Diffusers etc. (as applicable)	As per PR/Purchase Specification	100%	Mill TC and IRN & reports	H	H	W/R (Note – 4)
3.0	**In process inspection**						
3.1	Materials identification for plates, pipes (pressure parts)	Review of test certificates, markings visual & dimensional inspection, identity correlation & transfer of identity	100%	Material clearance record	-	H	H
3.2	Material identification for forgings, fittings, fasteners, gaskets (pressure parts)	Review of test certificates, markings Identity correlation.	100%	Material clearance record	-	H	R
3.3	Non-pressure parts (including internals, supports, etc.)	Review of test certificates	100%	Material test certificate	W	R	R
3.4	Inspection of formed components (cold or hot formed)	NDT of the weld seam as applicable	100%	NDT Reports / Films	H	H	R

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
		NDT (dished ends and tori-cone) on inside & outside surfaces in knuckle zone and edges.	100%	Inspection report	H	H	R
		HT chart review as applicable	100%	HT Chart	W	W	R
		Test coupon as applicable	100%	Inspection report	H	H	W
		Visual & dimensional (min. thickness, profile, ovality, etc.) inspection.	100%	Inspection report	H	H	H
3.5	Welding consumable	Chemical & mechanical properties	100%	Batch test certificates	W	R	R
3.6	Weld edge preparation & set up of pressure parts	Visual & dimensional inspection, weld edge, root gap, offset, alignment, cleanliness, etc.	100%	Inspection check list	-	W	-
		NDT of weld edges, as applicable	100%	NDT Reports	-	W	R
3.7	Intermediate inspection of welds	Visual, Welding Parameters, NDT (as applicable)	100%	Inspection report	-	RW	-
		Heat treatment during welding (as applicable)	100%	HT chart	-	H	R
4.0	**Final inspection**						

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.1	Visual and dimensional inspection (before PWHT) (internals & externals), including welds (as applicable)	Visual, dimensions, completeness of assembly, and weld visual for reinforcement, undercuts, Surface defects, etc.	100%	Inspection report	-	H	H
4.2	PMI (as applicable)	Chemical check	All components and weld	Inspection report		W	RW
4.3	Pneumatic test of RF pads	Leak check	100%	Test report	-	W	R
4.4	Trial assembly of internals and column/vessel sections as applicable	Dimensions, completeness of assembly and alignment	100%	Inspection report	-	H	W
4.5	Inspection of completed welds	PWHT (as applicable)	100%	HT chart		W	R
		NDT After PWHT (as applicable)	100%	NDT Reports / RT Films	-	W	RW
4.6	Hardness check of all Base, welds, HAZ (as applicable)	Hardness	100%	Inspection report	-	W	RW
4.7	Production test coupon as applicable	Production test coupon testing	As per spec/drg.	Inspection report	-	H	H
4.8	Manway Blind hang test 8 Hrs	Soundness of Sling weld Joint	100%	Inspection report	-	H	R (Note- 7)

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.9	Water Quality Check	Chloride Content < 25ppm (SS Internals)	100%	Inspection report	-	H	R
4.10	Hydrostatic test	Material soundness & Leak check	100%	Hydro test report	-	H	H
4.11	Cleaning, Hot air Passing, and Nitrogen Purging (as applicable)	Cleanliness, Relative humidity, N2 pressure	100%	Inspection report	-	W	R
5.0	**Template Inspection**						
5.1	Foundation Template & Gauge plate inspection	Visual & Dimensions, Orientation markings	100%	Inspection report	-	H	H
6.0	**Surface preparation & Painting**						
6.1	Surface preparation & Final painting	Visual inspection (after surface preparation and final painting for workmanship, uniformity) DFT check	100%	Inspection report	-	H	R
7.0	**Spare Verification**						
7.1	Verification of Spare / Special Tools & Tackles	Spare verification	100%	Inspection report	-	H	W/R
8.0	**Documentation and IC**						

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
8.1	Final stamping, review of inspection documents and issue of IC	Verifying stamping details and review of inspection documents	100%	IC /Name plate rub-off and inspection reports	-	H	H
8.2	Final documents as per PR	Verification & compilation of inspection & test records for submission to customer	100%	Final Dossier / Completeness Certificate	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after the scheduled date).

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents, shall also be applicable. (Unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. Third Party Certifications shall be as per EN 10204 Type 3.2 for CS Plates (LTCS/NACE/H2/HIC), Pipes, Forgings, Fittings, Expansion Bellows and RTJ gaskets. TPIA shall be arranged by the supplier. Certifications shall be as per EN 10204 Type 3.1 for non-pressure parts like Pipes, CS Plates (non-NACE/H2/HIC), Gaskets and Fasteners.
4. Inspection of Internals shall be as per relevant EIL Std ITP's attached with PR; if not attached with PR, separate ITP's shall be submitted for EIL approval.
5. For EPC jobs, all inspections shall be carried out by TPIA, unless notified otherwise.
6. Recording of Hydrotest chart as per Job specification (as applicable).
7. DPT / MPI to be carried out to check weld integrity.
8. Trial assembly of Internals Demisters/ Loose internal of Equipment to be done at shop & witness by TPIA/ EIL and same to be reassembled after hydrotest.
9. Pipe Davit & Manway Davit trail assembly to be verified by TPIA /EIL during Final Inspection.

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ट्रे एवं टावर इंटर्नलों के लिए निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN FOR TRAYS AND TOWER INTERNALS

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
4.	05-03-2026	REVISED AND RE-ISSUED	PW	RM	HP	NK
3	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
2	18.06.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
1	02.01.08	REVISED AND RE-ISSUED	AM	RB	MVKK	VC
0	19.07.02	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	SB

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Abbreviations:

AS/CS/SS	:	Alloy Steel / Carbon Steel / Stainless Steel	MTC	:	Material Test Certificate
CEIL	:	Certification Engineers International Limited	MRT	:	Mechanical Run Test
CIMFR	:	Central Institute of Mining & Fuel Research	NDT	:	Non Destructive Testing
CE	:	Carbon Equivalent	NPSH	:	Net Positive Suction Head
DFT	:	Dry Film Thickness	PO	:	Purchase Order
DPT	:	Dye Penetrant Testing	PESO	:	Petroleum Explosive Safety Organization
DHT	:	De-hydrogen Heat Treatment	PQR	:	Procedure Qualification Record
ERTL	:	Electronics Regional Test Laboratory	PR	:	Purchase Requisition
FCRI	:	Fluid Control Research Institute	PMI	:	Positive Material Identification
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification

Inspection Standards Committee

Convenor: Mr. Himangshu Pal

Members:

Mr. Suresh G
Mrs. Rajeshwari Venkatasubramanian
Mr. R. Muthuramalingam
Mr. Themballi Vasu
Mr. Aravaazhi V
Mr. T Kamalakannan
Mr. Pesala Venkata Subba Satyanarayana (Engg. Representative)

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1.0 SCOPE:

This Inspection and Test Plan covers the minimum testing requirements of Trays and Tower Internals.

2.0 REFERENCE DOCUMENTS:

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**						
1.1	Leak Test, NDT, WPS/ PQR and other Procedures (as applicable)	Documented Procedures	100%	Inspection Report	-	H	R (existing) W (for new WPS/PQR)
2.0	**Materials Procurement**						
2.1	Plates/Sheets/Coils, Pipes, Fittings Fasteners With Lock Nuts, Gaskets, Welding Consumable etc.	Chemical Analysis Mechanical Properties, Condition, Finish, Bend Test, Hardness Check, Heat Treatment, IGC Visual & Dimensional Inspection	100%	Mill Test Certificates	W	H	R
3.0	**IN PROCESS**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.1	Slitting, Shearing Punching, Bending (Deck Plates, Down Comers, Weir Plates, etc.)	Visual { Finish -Smooth, True, Clean, Free From Burs) & Dimensional Accuracy	100%	Inspection Report	-	H	-
3.2	Bubble Caps, Valves, 'U' Clamps	Visual(Finish-Smooth, True, Clean, Free From Burs) & Dimensional Accuracy	100%	Inspection Report	-	H	-
3.3	Heat Treatment Of Bubble Caps (As applicable)	As per specification	100%	HT Chart	-	W	R
3.4	Inspection Of One Type Of Component Of Each Type	Dimensions, Completeness Of Assembly. Visual Inspection Of Welds.	100%	Inspection Report	-	H	RW
3.5	Inspection of Completed Welds	Visual Inspection For Reinforcement, Undercuts, Surface Defects Etc.	100%	Inspection Check List	-	W	RW
		DPT Of Welds ,	100%	Inspection Check List	-	W	R
4.0	**Final Inspection**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.1	Mock Assembly of Each Type of Trays, Down Comers, Chimney Trays, Seal Pans, Trial Assembly of Support Beams etc.	Dimensions, Completeness Of Assembly. Visual Inspection Of Welds, etc.	One Assembly/Eac h Type Of Tray	Inspection Report	-	H	H
4.2	PMI (As applicable)	Chemical Check	As Per EIL Spec.	Inspection Report	-	W	RW
4.3	Leak Test for Seal Pan, Chimney And Bubble Cap Trays, Distributors, etc.	Check For Leakage Rate	100%	Inspection Report	-	H	RW/H Note-4
4.4	Pickling & Passivation (As applicable)	Visual Inspection & Surface Finish.	100%	Inspection Report	-	W	R
4.5	Final Marking	Marking / Etching On Each Individual Tray/Component	100%	Report	-	W	R
4.6	Packing	Visual Inspection	100%	Inspection Report	-	W	-
4.7	Verification of spares	Identification, Visual & Quantity as per Tender requirement (approved packing list/ drawing)	100%	Inspection Report	-	W	H
5.0	**Documentation & IC**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Manufacturer TC & IC	-	H	H
5.2	Final Document submission	Compilation of Inspection reports, drawings, etc as per VDR / PR	100%	Final data folder /Completeness certificate	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.
4. Leak test of seal Pan and distributers shall be witnessed by EIL/TPIA. Leak test of chimney and bubble cap trays shall be random witnessed by EIL/TPIA.

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टावर पैकिंग्स के लिए
निरीक्षण व परीक्षण योजना
INSPECTION AND TEST PLAN
FOR
TOWER PACKINGS

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
4	05.03.2026	REVISED AND RE-ISSUED	PW	RM 6/3/26	HP	NK
3	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
2	18.06.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
1	15.07.08	REVISED AND RE-ISSUED	NKR	SSL	SKP	VC
0	19.07.02	ISSUED FOR IMPLEMEMTATION	NKN	SPS	AKB	GRR

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Abbreviations:

AS/CS/SS	:	Alloy Steel / Carbon Steel / Stainless Steel	MRT	:	Mechanical Run Test
CEIL	:	Certification Engineers International Limited	NDT	:	Non Destructive Testing
CIMFR	:	Central Institute of Mining & Fuel Research	NPSH	:	Net Positive Suction Head
CE	:	Carbon Equivalent	PO	:	Purchase Order
DFT	:	Dry Film Thickness	PESO	:	Petroleum Explosive Safety Organization
DPT	:	Dye Penetrant Testing	PQR	:	Procedure Qualification Record
DHT	:	De-hydrogen Heat Treatment	PR	:	Purchase Requisition
ERTL	:	Electronics Regional Test Laboratory	PMI	:	Positive Material Identification
FCRI	:	Fluid Control Research Institute	PWHT	:	Post Weld Heat Treatment
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification
MTC	:	Material Test Certificate			

Inspection Standards Committee

Convenor : Mr. Himangshu Pal

Members:

Mr. Suresh G	Mrs. Rajeshwari Venkatasubramanian	Mr. R. Muthuramalingam	Mr. Themballi Vasu
Mr. Aravaazhi V	Mr. T Kamalakannan	Mr. Pesala Venkata Subba Satyanarayana (Engg. Representative)	

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Tower Packings

2.0 REFERENCE DOCUMENTS

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**						
1.1	NDT and other Procedures (as applicable)	Documented Procedures	100%	Inspection Report	-	H	R
2.0	**Materials Procurement**						
2.1	Sheets/Coils/ Strips	Chemical Analysis Mechanical Properties, Condition, Finish, Bend Test, Hardness Check, HT, IGC test, Visual & Dimensional Inspection	100%	Mill Test Certificates	W	W	R
3.0	**In Process**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.1	Slitting, Shearing, Punching, Bending	Visual (Finish - Smooth, Clean, Free from Burs, Tears, Cracks) & Dimensional Accuracy	100%	Inspection Report	-	W	-
4.0	**Final Inspection**						
4.1	Load (Crushing) Test of Random Packings (As applicable)	As per specification	As Per EIL Spec.	Inspection Report	-	W	W
4.2	Pall Ring, Hypak Ring, Nutter Rings and other types of packing	Dimensional Accuracy and Visual Inspection for Workmanship and Free of Burs	100% (Sample Pieces)	Inspection Report	-	W	RW
4.3	Nesting Check for Intalox Metal Tower Packing (IMTP)	No Ring to enter another at any orientation	Random	Inspection Report	-	H	RW
4.4	Piece Density	Density (No of Pieces in a given volume)	Lot	Inspection Report	-	H	RW
4.5	PMI (AS / SS Components)	Chemical Check	As per EIL Specifications	Inspection Report	-	W	RW

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.6	Packing	Visual Inspection	100%	Inspection Report	-	W	R
4.7	Verification of spares	Identification, Visual & Quantity as per Tender requirement (approved packing list/ drawing)	100%	Inspection Report	-	W	R
5.0	**Documentation & IC**						
5.1	Documentation Review & Issuance of Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports	100%	Manufacturer TC & IC	-	H	H
5.2	Final Document submission (If applicable)	Compilation of Inspection reports, drawings etc as per VDR / PR	100%	Final data folder /Completeness certificate	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.

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INSPECTION AND TEST PLAN FOR UN-ENGINEERED TRAYS AND TOWER INTERNALS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	05.03.2026	REVISED AND RE-ISSUED	PW	RM	HP	NK
3	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
2	18.06.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
1	02.01.08	REVISED AND RE-ISSUED	AM	RB	MVKK	VC
0	10.12.02	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	GRR

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Abbreviations:

AS/CS/SS	:	Alloy Steel / Carbon Steel / Stainless Steel	MRT	:	Mechanical Run Test
CEIL	:	Certification Engineers International Limited	NDT	:	Non Destructive Testing
CIMFR	:	Central Institute of Mining & Fuel Research	NPSH	:	Net Positive Suction Head
CE	:	Carbon Equivalent	PO	:	Purchase Order
DFT	:	Dry Film Thickness	PESO	:	Petroleum Explosive Safety Organization
DPT	:	Dye Penetrant Testing	PQR	:	Procedure Qualification Record
DHT	:	De-hydrogen Heat Treatment	PR	:	Purchase Requisition
ERTL	:	Electronics Regional Test Laboratory	PMI	:	Positive Material Identification
FCRI	:	Fluid Control Research Institute	PWHT	:	Post Weld Heat Treatment
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification
MTC	:	Material Test Certificate			

Inspection Standards Committee

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Members:

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Mrs. Rajeshwari Venkatasubramanian
Mr. R. Muthuramalingam
Mr. Themballi Vasu
Mr. Aravaazhi V
Mr. T Kamalakannan
Mr. Pesala Venkata Subba Satyanarayana (Engg. Representative)

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1.0 SCOPE:

This Inspection and Test Plan covers the minimum testing requirements of Un-Engineered Trays and Tower Internals.

2.0 REFERENCE DOCUMENTS:

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**						
1.1	Leak Test, NDT, WPS/ PQR and other Procedures(as applicable)	Documented Procedures	100%	Inspection Report	-	H	R (existing) W (for new WPS/PQR)
2.0	**Materials Procurement**						
2.1	Plates/Sheets/Coils, Pipes, Fittings Fasteners With Lock Nuts, Gaskets, Welding Consumable etc.	Chemical Analysis Mechanical Properties, Condition, Finish, Bend Test, Hardness Check, Heat Treatment, IGC Visual & Dimensional Inspection	100%	Mill Test Certificates	W	H	R
3.0	**IN PROCESS**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.1	Slitting, Shearing Punching, Bending (Deck Plates, Down Comers, Weir Plates etc.)	Visual (Finish -Smooth, True, Clean, Free From Burs) & Dimensional Accuracy	100%	Inspection Report	-	H	-
3.2	Bubble Caps, Valves, 'U' Clamps	Visual (Finish-Smooth, True, Clean, Free From Burs) & Dimensional Accuracy	100%	Inspection Report	-	H	-
3.3	Heat Treatment of Bubble Caps (As applicable)	As per specification	100%	HT Chart	-	W	R
3.4	Inspection of one type of Component of each type	Dimensions, Completeness of Assembly. Visual Inspection of Welds	100%	Inspection Report	-	H	RW
3.5	Inspection of Completed Welds	Visual Inspection For Reinforcement, Undercuts, Surface Defects Etc.	100%	Inspection Check List	-	W	RW
		DPT Of Welds	100%	Inspection Check List	-	W	R
4.0	**Final Inspection**						

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.1	Mock Assembly of Each Type of Trays, Down Comers, Chimney Trays, Seal Pans, Trial Assembly of Support Beams etc.	Dimensions, Completeness of Assembly. Visual Inspection of Welds etc.	One Assembly/Each Type of Tray	Inspection Report	-	H	H
4.2	PMI (as applicable)	Chemical Check	As Per EIL Spec.	Inspection Report	-	W	RW
4.3	Leak Test for Seal Pan, Chimney And Bubble Cap Trays, Distributors, etc.	Check for Leakage rate	100%	Inspection Report	-	H	H Note-4
4.4	Pickling & Passivation (as applicable)	Visual Inspection & Surface Finish.	100%	Inspection Report	-	W	R
4.5	Final Marking	Marking / Etching on Each Individual Tray/Component	100%	Report	-	W	R
4.6	Packing	Visual Inspection	100%	Inspection Report	-	W	-
4.7	Verification of spares	Identification, Visual & Quantity as per Tender requirement (approved packing list/ drawing)	100%	Inspection Report	-	W	H

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.0	**Documentation & IC**						
5.1	Documentation Review & Issuance of Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports	100%	Manufacturer TC & IC	-	H	H
5.2	Final Document submission	Compilation of Inspection reports, drawings, etc as per VDR / PR	100%	Final data folder /Completeness certificate	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.
4. Leak test of seal Pan and distributers shall be witnessed by EIL/TPIA. Leak test of chimney and bubble cap trays shall be random witnessed by EIL/TPIA.

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इजेक्टर के लिए
निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
EJECTORS

Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
					Approved by	
5	07.03.2026	REVISED AND RE-ISSUED	AA	RM 16/3/26.	HP	NK
4	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
3	09.09.13	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	10.04.12	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
1	31.01.08	REVISED AND RE-ISSUED	CS	SS	MVKK	VC
0	12.12.02	ISSUED FOR IMPLEMENTATION	KSR	NKN	AKB	GRR

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Abbreviations:

CS/AS/SS	:	Alloy Steel / Carbon Steel / Stainless Steel	MRT	:	Mechanical Run Test
CEIL	:	Certification Engineers International Limited	NDT	:	Non-Destructive Testing
CIMFR	:	Central Institute of Mining & Fuel Research	NPSH	:	Net Positive Suction Head
CE	:	Carbon Equivalent	PO	:	Purchase Order
DFT	:	Dry Film Thickness	PESO	:	Petroleum Explosive Safety Organization
DPT	:	Dye Penetrant Testing	PQR	:	Procedure Qualification Record
DHT	:	De-hydrogen Heat Treatment	PR	:	Purchase Requisition
ERTL	:	Electronics Regional Test Laboratory	PMI	:	Positive Material Identification
FCRI	:	Fluid Control Research Institute	PWHT	:	Post Weld Heat Treatment
HT	:	Heat Treatment	RT	:	Radiography Testing
HIC	:	Hydrogen Induced Cracking	SSCC	:	Sulphide Stress Corrosion Cracking
ITP	:	Inspection and Test Plan	TC	:	Test Certificate
IP	:	Ingress Protection	TPI or TPIA	:	Third Party Inspection Agency
IHT	:	Intermediate Heat Treatment	UT	:	Ultrasonic Testing
IC	:	Inspection Certificate	VDR	:	Vendor Data Requirement
IGC	:	Inter Granular Corrosion	WPS	:	Welding Procedure Specification
MPT/MT	:	Magnetic Particle Testing	WPQ	:	Welders Performance Qualification
MTC	:	Material Test Certificate			

Inspection Standards Committee:

Convenor: Mr. Himangshu Pal

Members: Mr. Suresh G **Mrs. Rajeshwari Venkatasubramanian** **Mr. R Muthu Ramalingam**
Mr. Themballi Vasu **Mr. T Kamalakannan** **Mr. Aravaazhi V**
Mr. Pesala Venkata Subba Satyanarayana (Engg. Rep.)

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1.0 SCOPE:

This Inspection and Test Plan cover the minimum testing requirements of Ejectors.

2.0 REFERENCE DOCUMENTS:

PO/PR/ Standards referred there in/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS:

S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**PROCEDURES**						
1.1	Hydro-test, Heat Treatment, NDT, PTC and other procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS/ PQR /WPQ	Documented procedures.	100%	Procedure documents	-	H	R-Existing W-New
2.0	**MATERIAL PROCUREMENT**						
2.1	Plates, Pipes, Forgings, Fittings, Fasteners, Gaskets, etc. (Note – 3)	As per PR/ Purchase Specification	100%	Mill Test Certificates	H	H	R
2.2	Welding Consumables	Chemical and Mechanical Properties / IGC (as applicable)	100%	MTC/Batch Certificates	H	R	R

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	**MATERIAL INSPECTION**						
3.1	Material identification for Pressure Parts (Plates, Pipes)	Review of Test Certificates, TPIA IRN, Markings, Visual and Dimensional inspection, identity co-relation & Transfer of identification marks	100%	Inspection report	-	H	H
3.2	Material identification for Pressure Parts (Forgings, Fittings, Fasteners, Gaskets, etc.)	Review of Test Certificates, TPIA IRN, Markings, identity co-relation	100%	Inspection report	-	H	R
3.3	Non-Pressure Parts (Supports, Internals, etc.)	Review of Test Certificates	100%	Material Test Certificates	-	W	R
4.0	**IN PROCESS INSPECTION**						
4.1	Inspection of Formed Components	NDT of weld seam, as applicable	100%	NDT Report /RT Film	-	H	R
		NDT on knuckle portion after forming - inside & outside	100%	NDT Report	-	H	R
		HT as applicable	100%	HT Graph & record	-	H	R
		Test coupon, if applicable	100%	Test Report	-	H	W
		Visual & Dimensional Inspection (Min. Thickness, profile, ovality etc.)	100%	Test Report	-	H	W
4.2	Weld Edge & Set up of pressure parts	Visual & dimensional, Weld edge, root gap, offset, alignment, cleanliness etc.	100%	Inspection Report	-	W	R

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.3	NDT-as applicable	NDT	100%	NDT Report	-	W	R
4.4	Intermediate Inspection of Welds	Visual, Inter-pass temperature, NDT (as applicable)	100%	NDT / Inspection Report	-	W	R
		Heat Treatment as applicable	100%	HT Graph & record	-	W	R
5.0	**FINAL INSPECTION**						
5.1	Inspection of finished Welds	Visual inspection for reinforcement, undercuts, surface defects, etc.	100%	Inspection Report	-	W	R
		Non-Destructive Testing (as applicable)	100%	NDT Report / RT Films	-	W	R
5.2	Visual and dimension check before PWHT (as applicable)	Dimensions, Surface defects, Completeness of equipment.	100%	Inspection report	-	H	H
5.3	PWHT (as applicable)	Temperature & time	100%	HT Graph & record	-	H	R
5.4	Pneumatic Test of RF Pads	Leak Test	100%	Inspection Report	-	H	R
5.5	PMI (as applicable)	PMI	Each component & weld	Inspection Report	H	W	RW
5.6	Visual & Dimensional Inspection after PWHT	Dimensions, Surface defects, Completeness of equipment, Hardness etc.	100%	Inspection Report	-	H	R

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S. NO	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	FORMAT OF REPORT	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.7	Hydrostatic Test	Leak Check	100%	Inspection Report	-	H	H
6.0	**PAINTING**						
6.1	Final painting (As applicable)	Visual inspection (after surface preparation and final painting for workmanship, uniformity) DFT check	100%	Inspection report	-	H	R
7.0	**DOCUMENTATION AND IC**						
7.1	Final stamping, review of inspection documents and issue of IC	Verifying stamping details and review of inspection documents	100%	IC / Inspection reports	-	H	H
7.2	Final documents as per PR	Verification & compilation of inspection & test records for submission to customer	100%	Final dossier	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (as applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. Third Party Certifications shall be as per EN 10204 Type 3.2 for Forgings, Fittings and all AS materials. Certifications shall be as per EN 10204 Type 3.1 for Pipes, CS Plates, Gaskets and Fasteners. TPIA shall be arranged by supplier.
4. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.

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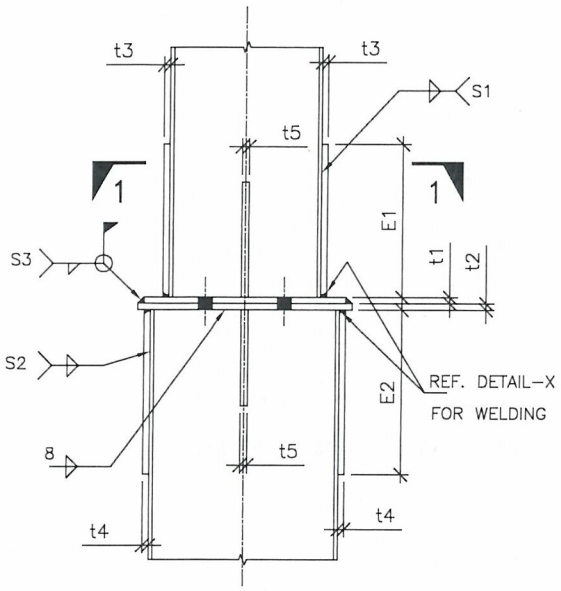
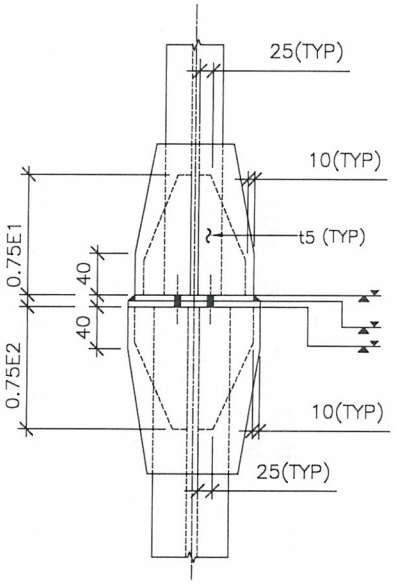
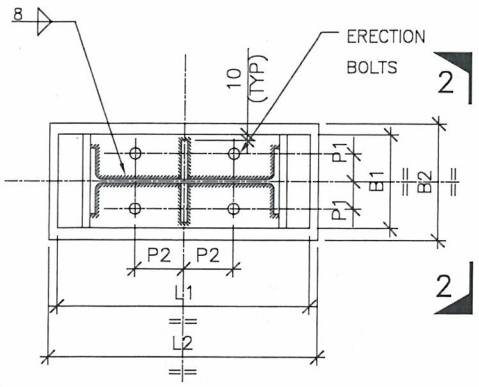
DETAIL OF WELDED COLUMN SPLICE
(UNEQUAL PARALLEL FLANGE SECTION)



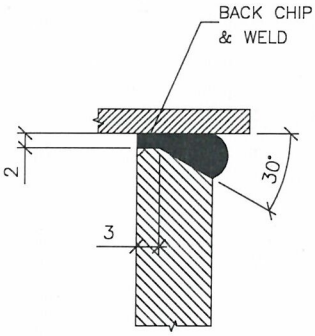
ELEVATION



VIEW 2–2



VIEW 1–1



DETAIL–X

NOTES :-

1. ALL DIMENSIONS ARE IN mm.
2. PARALLEL FLANGE SECTIONS SHALL CONFIRM TO IS 808.
3. STRUCTURAL STEEL FOR CONNECTION PLATES SHALL BE OF SAME GRADE AS THAT OF THE CONNECTING MEMBERS.
4. ENDS OF COLUMNS SHALL BE GROUND FLUSH, BEFORE WELDING TO THE BASE / CAP PLATES.
5. ERECTION BOLTS ARE DESIGNED FOR 5% MOMENT AND 5% AXIAL LOAD CAPACITY OF THE SMALLER SECTION.
6. ERECTION BOLT SHALL BE LEFT PERMANENTLY IN POSITION.
7. ERECTION BOLTS SHALL BE OF PROPERTY CLASS 4.6 CONFORMING TO IS 1367.
8. UPPER COLUMN SHALL BE SUITABLY HELD IN POSITION WITH THE HELP OF GUY–ROPES / TIES TILL THE BASE AND CAP PLATES ARE WELDED IN POSITION.
9. THE CONNECTION IS DESIGNED FOR FULL TENSION CAPACITY OR 75% OF THE MOMENT CAPACITY OF UPPER COLUMN.
10. REFER TABLE–1 FOR SECTION WISE MARKED DETAILS.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
2	02.03.26	REVISED & ISSUED AS STANDARD	JH/SS	SUDIP PAUL	ANURAG SINHA	NALIN KUMAR
1	22.09.20	REAFFIRMED & ISSUED AS STANDARD	JEETU	AVM	AS	SM
0	15.07.14	ISSUED AS STANDARD	VPS	AS	PKM	SC

Approved by

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DETAIL OF WELDED COLUMN SPLICE
(UNEQUAL PARALLEL FLANGE SECTION)

TABLE - 1 :

COLUMN SECTIONS SPLICED		BASE AND FLANGE PLATE DETAILS (UPPER COLUMN)						CAP AND FLANGE PLATE DETAILS (LOWER COLUMN)						WELD SIZE	ERECTION BOLT			
UPPER COLUMN	LOWER COLUMN	L1	B1	E1	t1	t3	S1	L2	B2	E2	t2	t4	S2	S3	ø	P1	P2	t5
ISMB600	WPB600x300x177.77	685	315	450	30	20	12	740	360	450	30	16	12	20	22	125	225	12
WPB600x300x128.79	WPB600x300x177.77	710	400	515	32	25	16	810	455	515	32	25	16	20	27	125	225	12
	WPB700x300x149.89																	
	WPB700x300x204.48																	
	WPB700x300x240.51																	
WPB600x300x177.77	WPB700x300x204.48	730	400	550	36	25	16	810	455	550	36	25	16	20	27	125	225	12
	WPB700x300x240.51																	
WPB700x300x149.89	WPB700x300x204.48	810	425	575	32	25	16	870	480	575	32	25	16	20	27	125	275	12
	WPB700x300x240.51																	
	WPB800x300x224.37	810	425	575	32	25	16	910	480	575	32	25	16	20	27	125	275	12
	WPB800x300x262.33																	
WPB700x300x204.48	WPB700x300x240.51	850	450	680	36	30	16	910	510	680	36	30	16	20	27	125	275	12
	WPB800x300x224.37																	
	WPB800x300x262.33																	
WPB700x300x240.51	WPB800x300x262.33	1050	500	755	40	30	16	1110	560	755	40	30	16	20	27	125	275	16
WPB800x300x262.33	WPB900x300x291.45	1200	500	755	40	30	16	1260	560	755	40	30	16	20	27	125	325	16

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NOTES:–

1. ALL HANDRAILS AND UPRIGHT SHALL BE AS PER RESPECTIVE TYPE.
2. ALL FILLET WELDS OF 3mm (MINIMUM) THICKNESS SHALL BE CONTINUOUS UNLESS NOTED OTHERWISE.
3. JOINTS IN HANDRAILS SHALL BE PROVIDED AT SUITABLE LOCATIONS, WELDED AND GROUND FLUSH.
4. FOR ADDITIONAL TYPE OF UPRIGHT FIXING DETAILS REFER EIL STD. 7–68–0061.
5. ALL M.S. TUBES SHALL CONFORM TO IS 1239.
6. FABRICATION OF TOP RAIL, INTERMEDIATE FLAT AND TOE PLATE SHALL ONLY BE STARTED AFTER TAKING ACTUAL DIMENSIONS AT SITE.
7. ADJUSTMENT IN SPACING OF VERTICAL POST SHALL BE DONE AT EITHER END OF PLATFORM.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
9	16.03.2026	REAFFIRMED & ISSUED AS STANDARD	RRY SP	SUDIP PAUL	ANURAG SINHA	NALIN KUMAR
8	28.09.2020	REAFFIRMED & ISSUED AS STANDARD	JG	AVM	AS	SM
7	16.12.2014	REVISED & ISSUED AS STANDARD	V.P.SINGH	V GOEL	PK MITTAL	S CHANDA

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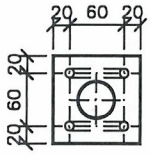
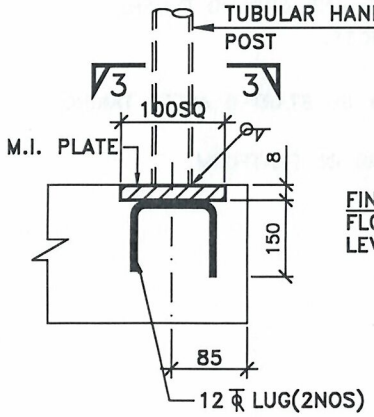
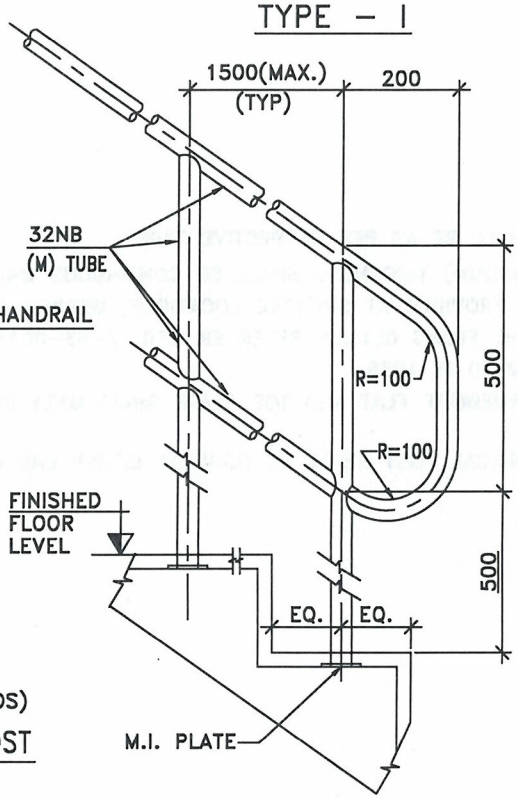


VIEW 3-3

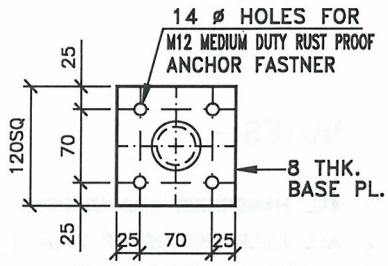


FIXING DET OF TUB. POST WITH M.I.PLATE (ALT-I)

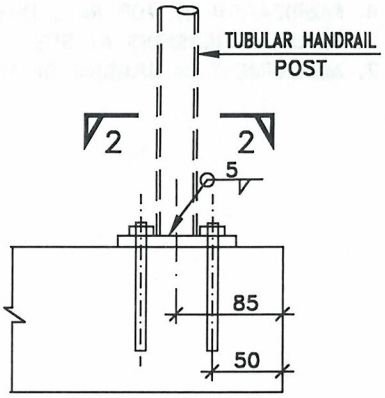
TYPE - I



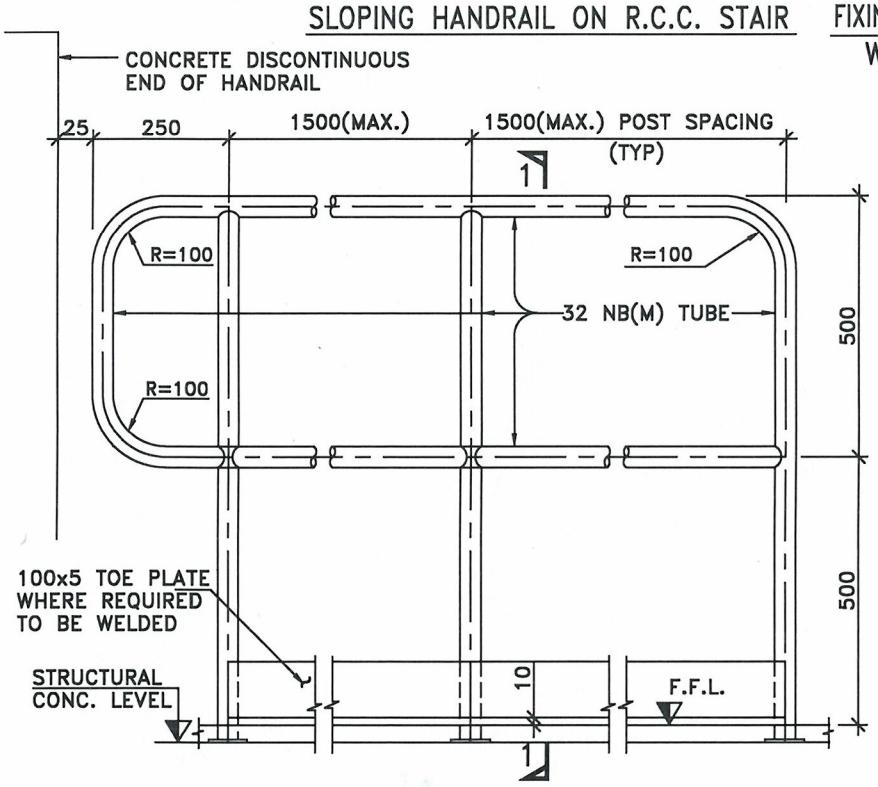
SLOPING HANDRAIL ON R.C.C. STAIR



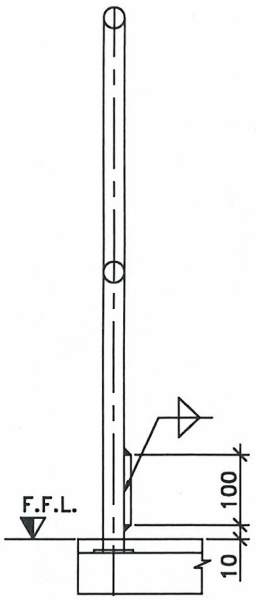
VIEW 2-2



FIXING DET OF TUBULAR POST WITH ANCHOR FASTNER ALT-II



HORIZONTAL HANDRAIL ON R.C.C. PLATFORM



SEC. 1-1

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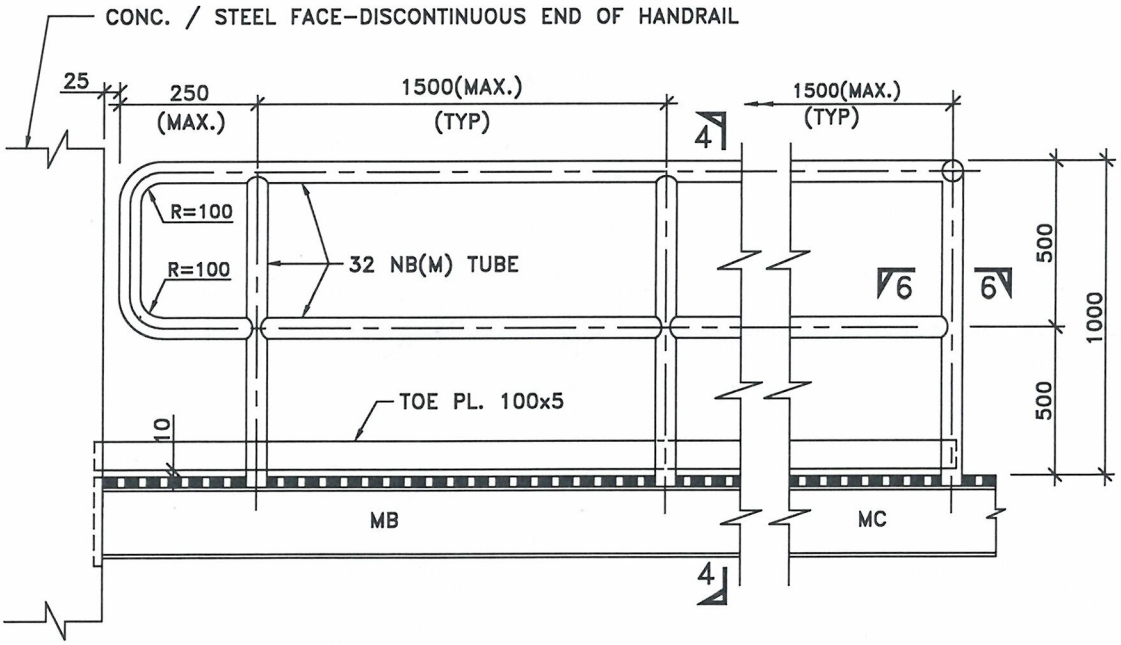
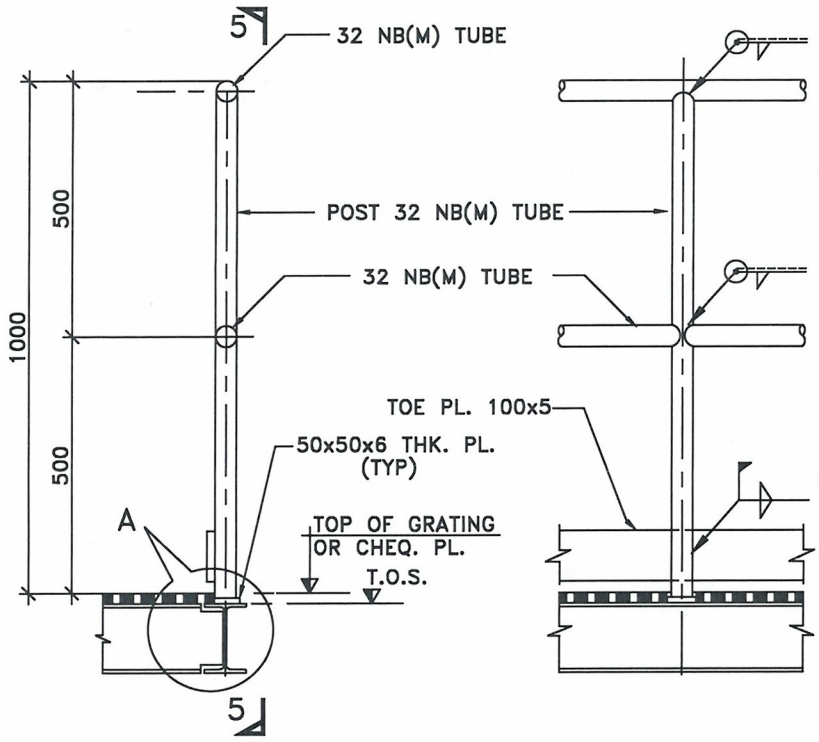
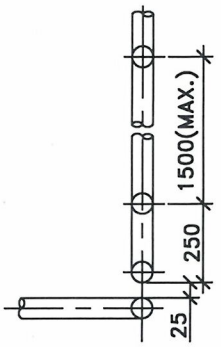
TYPE – II



HORIZONTAL HANDRAIL ON STEEL PLATFORM



SECTION 4–4
(FOR DETAIL (A) REFER PAGE 8 OF 8)



VIEW 5–5

VIEW 6–6
(AT CORNER)

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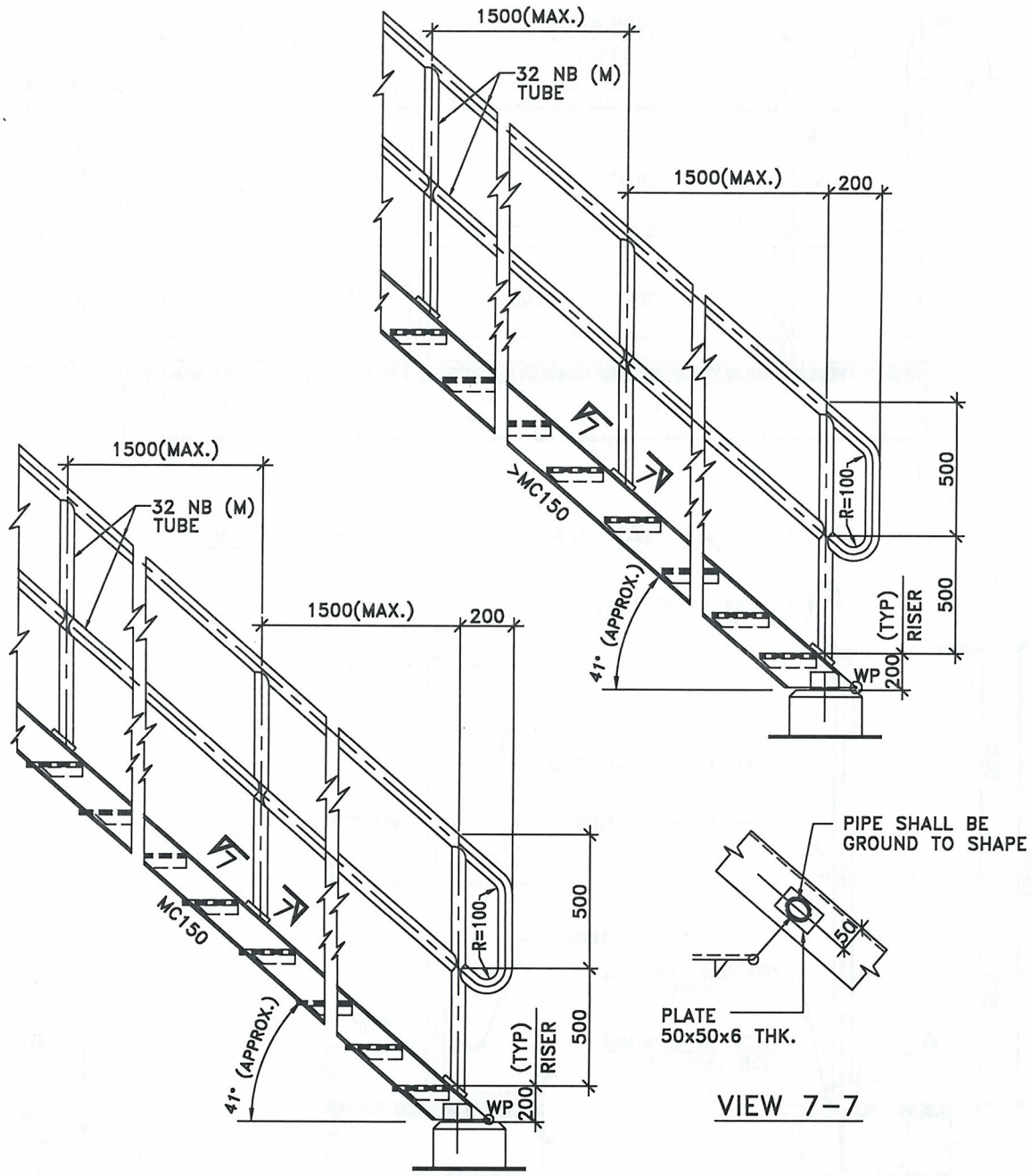
TYPE – II



VIEW 7–7

SLOPING HANDRAIL ON STEEL STAIR

WHEREVER HIGHER SIZE OF STRINGER BEAMS ARE REQUIRED AS PER DESIGN SIMILAR G.A. BE FOLLOWED FOR THE SAME.

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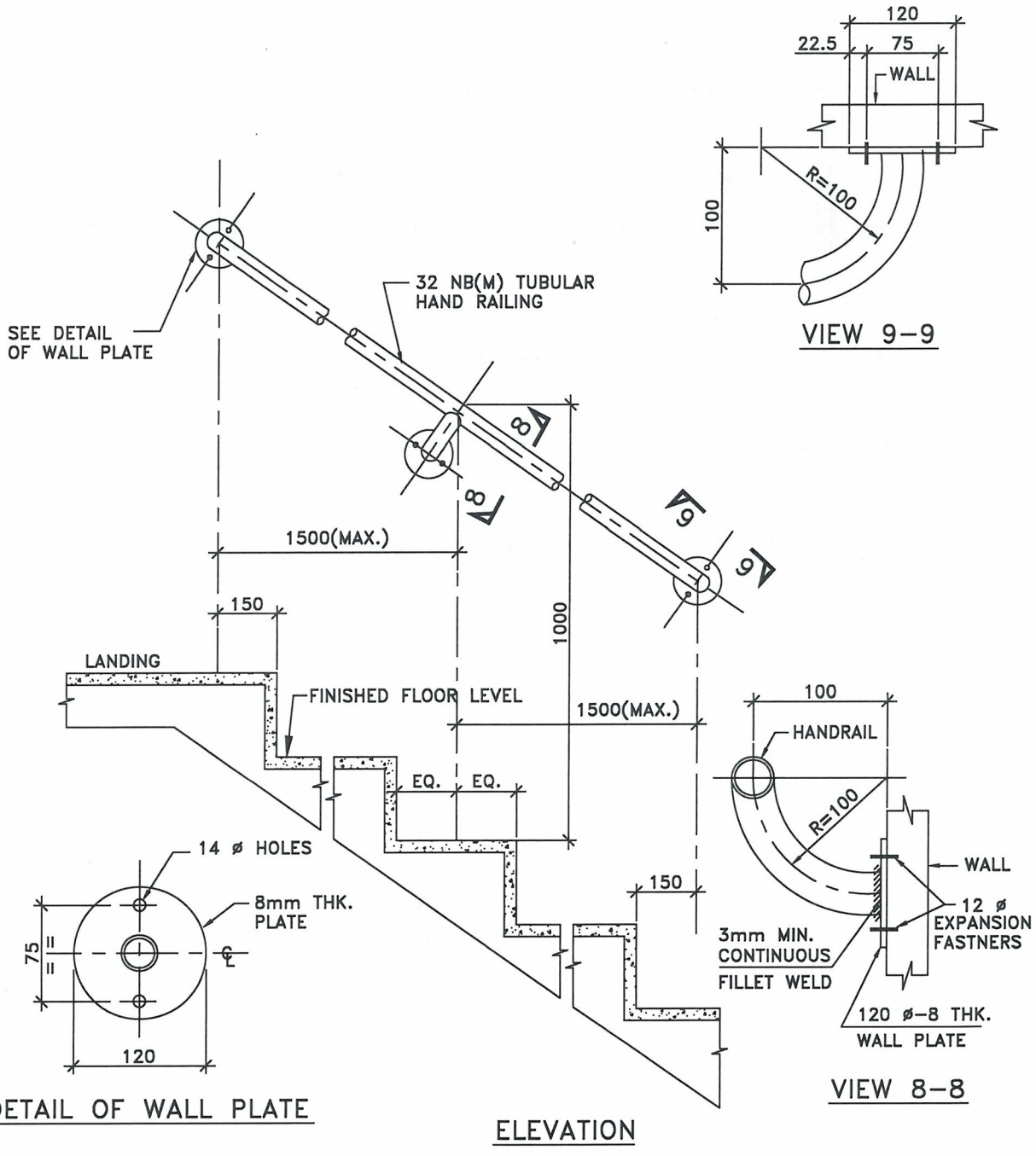
TYPE – III



HANDRAIL FIXED TO WALL DIRECT

Signature Not Verified
Digitally signed by ARITRA DE
Date: 2026.05.18 16:59:28 IST
Location: eProcure-EP ROC

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