A priming coat of whiting conforming to IS 63 shall be applied over the prepared surface. The priming coat shall be prepared by mixing 2.5 kg. of whiting and one litre of glue solution (prepared by mixing 250 gm. glue conforming to IS: 852 with boiling water) together and placing it in a covered vessel with enough water to cover the mixture which shall be left to cool until it becomes a jelly.

Priming coat shall be applied with "MOONJ" brush or roller to the specified number of coats. Minimum number of coats shall be minimum one. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke, similarly one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied.

8.3 Preparation of Distemper

1st quality Acrylic distemper having VOC content less than 50 gms/litre of approved brand and manufacture shall be used for preparation of distemper. The Acrylic distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared.

8.4 Application of Distemper

For new work, after the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the priming coat. All loose particles shall be dusted off after rubbing. One coat of distemper properly diluted with thinner (water or other liquid as stipulated by the manufacturer) shall be applied with brushes or roller in horizontal strokes followed immediately by vertical ones which together constitutes one coat.

The subsequent coats shall be applied in the same way. Two or more coats of distemper as are found necessary shall be applied over the primer coat to obtain an even shade.

A time interval of at least 24 hours shall be allowed between successive coats to permit proper drying of the preceding coat.

For old work, the distemper shall be applied over the prepared surface in the same manner as in new work. One or more coats of distemper as are found necessary shall be applied to obtain an even and uniform shade.

The finished surface shall be even and uniform without patches, marks, distemper drops etc.

9.0 WATERPROOF CEMENT PAINT

9.1 Preparation of Surface

Preparation of Surface shall be similar to clause no 6.1. The surface so prepared shall be thoroughly wetted with clean water before the paint is applied.

9.2 Preparation of Paint

Waterproof cement paint conforming to IS 5410 shall be mixed with water and stirred to obtain a thick paste which shall then be diluted to brushable consistency. The proportion of mixture shall be as per manufacturer's recommendation. The paint shall be mixed in such quantity which can be used up within an hour of mixing to avoid setting and thickening of the paint.

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9.3 Application of Paint

The surface shall be treated with waterproof cement paint in minimum three coats maintaining the coverage rate (kg/ square metre) as mentioned in approved Manufacturer's standard literature. No less than 24 hours shall be allowed between two coats and subsequent coats shall be applied only after the preceding coat has become hard to resist marking by subsequent brushing.

9.4 Curing

Curing shall be started after the paint has hardened. Curing shall be done as recommended by the approved Manufacturer and by sprinkling with water two or three times a day. This shall be done between coats and for at least two days following the final coat.

10.0 ACRYLIC/ PLASTIC EMULSION PAINTING (For interior surfaces)

10.1 Acrylic/ plastic emulsion paint (for interior surfaces) shall be of interior grade, premium quality conforming to IS: 15489 and having VOC less than 50 gm/ litre.

10.2 Preparation of Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. It shall then be sand papered and cleaned to give a smooth and even surface.

First coat of primer shall be applied over the surface and the surface shall be allowed to be dry for 6-8 hours.

All cracks, holes, undulations, unevenness shall be filled up and made even with putty. The surface then shall be allowed to be dry.

Once the surface is dried, second coat of primer shall be applied after sand papering and cleaning the surface.

After 6-8 hours, when the surface is dry, it shall again be sand papered and cleaned for a clean and smooth service.

In case of already painted surface, old paint and loose particles shall be removed before stating the above mentioned preparation process.

The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

10.3 Preparation of Paint

Preparation of paint shall be as per manufacturer's instructions.

10.4 Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be minimum two. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2 to 3 times and then finally brushing lightly in a direction at right angles to

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the same. In this process, no brush marks, no hair marks no clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat. The paint shall be applied by means of brush or roller.

The surface on finishing shall present a flat, velvety smooth finish, even and uniform shade without patches, marks, paint drops etc.

11.0 ACRYLIC BASED EXTERIOR EMULSION PAINT (For exterior surfaces)

11.1 Acrylic/ plastic emulsion paint (for exterior surfaces) shall be of exterior grade, premium quality conforming to IS: 15489 and having VOC less than 50 gm/ litre.

It shall be an acrylic based wall coating for exterior surfaces to form a crack free, flexible, tough, alkali & fungal resistant and UV resistant waterproof coating with silicone additives.

11.2 Preparation of Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. It shall then be sand papered and cleaned to give a smooth and even surface.

Any old paint shall be removed with removing agent as per manufacturer's instructions. The surface affected by moss, fungus, algae, efflorescence shall be treated in accordance with IS: 2395.

All cracks, holes, undulations, unevenness shall be filled up and made even with putty. The surface then shall be allowed to be dry.

1-2 coats of primer shall be applied over the surface and the surface shall be allowed to be dry for 6-8 hours.

After 6-8 hours, when the surface is dry, it shall again be sand papered and cleaned for a clean and smooth service.

The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

11.3 Preparation of Paint

Preparation of paint shall be as per manufacturer's instructions.

11.4 Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be minimum two. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2 to 3 times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks, no hair marks no clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat. The paint shall be applied by means of brush or roller.

The surface on finishing shall present a flat, velvety smooth finish, even and uniform shade without patches, marks, paint drops etc.

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12.0 ACRYLIC COPOLYMER AGGREGATE FINISH

12.1 It shall be an acrylic based textured wall coating system consisting of quartz and silica aggregate, inorganic pigments and other additives to form a crack free, flexible, tough, waterproof coating.

12.2 Preparation of Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. It shall then be sand papered and cleaned to give a smooth and even surface.

Any old paint shall be removed with removing agent as per manufacturer's instructions. The surface affected by moss, fungus, algae, efflorescence shall be treated in accordance with IS: 2395.

All cracks, holes, undulations, unevenness shall be filled up and made even with putty. The surface then shall be allowed to be dry.

The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

12.3 Preparation of coating

Preparation of coating using various components shall be in accordance with procedures recommended by the approved Manufacturer to achieve the desired finish.

12.4 Application

Application of the system shall be in accordance with procedures recommended by the approved Manufacturer to achieve the desired finish. Sealing coat, primer etc. as recommended by the approved Manufacturer shall also be provided.

13.0 SYNTHETIC ENAMEL PAINTING

13.1 Synthetic Enamel paint shall conform to IS 2933

13.2 Preparation of surface

A. Preparation of wood surface

The woodwork to be painted shall be dry and free from moisture and any foreign matter. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by griding red lead in water and mixing with strong glue sized and used hot. Appropriate filler material conforming to IS 345 with same shade as Paint shall be used. The surface treated for knotting shall be dry before paint is applied.

Plywood, Block board, Particle board etc. shall be treated in the same manner as for wood work.

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B. Preparation of Iron and steel surface

All rust and scales shall be removed by scrapping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface if any, shall be removed.

13.3 Priming

The primer shall be ready mixed primer and compatible to the paint.

Primer for wood work shall conform to IS 3536. Primer for Iron and steel shall be Red Oxide Zinc Chromate primer conforming to IS 2074, for cement, concrete and plastered surfaces primer shall conform to IS 109.

Dirt or any other extraneous material on the surface shall be removed and the priming shall be applied in minimum two coats.

13.4 Preparation of Paint

Preparation of paint shall be as per manufacturer's instructions.

13.5 Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be minimum two. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2 to 3 times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks, no hair marks no clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat. The paint shall be applied by means of brush or roller.

The surface on finishing shall present a flat, smooth finish, even and uniform shade without patches, marks, paint drops etc.

14.0 APPLICATION OF CLEAR FINISHES (Polishing, Varnishing)

14.1 For the application of clear finishes, the following procedures shall generally be adopted in accordance with IS: 2338 (Part-I)

A. Filling
B. Staining
C. Sealing
D. Finishing

14.2 Filling

Fillers shall be applied to prevent the excessive penetration of the finish to the surface for obtaining a smooth finish. Fillers shall be conforming to IS: 345.

Fillers shall be heavily applied to the wood surface by hand, using hessian or jute rag across the grain. It shall be rubbed when still wet to get better penetration. After 5-10 minutes it shall be wiped off by hand across the grain followed by a light wipe with the grain. The filled surface shall be dried preferably over night and smoothened with abrasive paper.

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14.3 Staining

A. Spirit Stains

Spirit stains are solutions of spirit soluble dyes in Industrial methylated spirit.

B. Oil Stains

Oil stains are solutions of oil soluble dyes in linseed oil, but, usually consist of insoluble, semi-transparent pigments ground in linseed oil and thinned with turpentine or other solvent.

14.4 Surface Preparation

Surface intended for staining shall be kept scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothing with fine abrasive paper used in the direction of the grain. Small cracks/nail holes shall be stopped with plastic wood/fine plaster of Paris. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a thinned knotting before staining. In case of oil staining stopping shall be done after staining using tinted putty or wood filler.

14.5 Application of Stains

Stains shall be applied by brushing and wiping or by spraying. The stain shall be so thinned that it can be applied fairly, liberally without over staining and over lapping.

14.6 Sealing

A suitable sealer shall be applied on the filled and sanded surface to prevent absorption by the wood of the succeeding coats of finish and to seal stain and filler and thus preclude their bleeding into the finish coat.

Sealer may be sprayed on taking care not to flood the surface and it shall be allowed to dry hard. When fully dry the surface shall be sanded taking care not to cut through at corners and edges. Dust shall be blown off and surface wiped with a clean rag.

14.7 Finishing

The stained surface shall be varnished, wax-polished or French polished as required after it is dried.

A. Varnishing

Varnishing of wood and wood based material shall be in accordance with IS: 2338 (Part-I).

Surfaces to be varnished shall be prepared to produce a smooth, dry and matt surface and all dust and dirt shall be removed from the surface.

The Varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing. It shall be allowed to flow out while the next section is being laid in. Excess Varnish shall be scraped out of the brush and then the first section be crossed, re- crossed and laid off lightly. The Varnish, once it has begun to set, shall not be retouched. In case of any mistake, the Varnish shall be removed and the work shall be started afresh.

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Where two coats of varnish are applied, the first coat shall be a hard drying under coating or flatting varnish which shall be allowed to dry hard and then be flatted down before applying the finishing coat. Sufficient time shall be allowed in between two coats.

When flat varnishing is used for finishing, a preparatory coat of hard drying undercoating of flatting varnish shall first be applied and shall be allowed to harden thoroughly. It shall then be lightly rubbed down before the flat varnish is applied. On larger areas, the flat varnish shall be applied rapidly, and the edges of each patch applied shall not be allowed to set, but shall be followed up whilst in free working conditions.

B. French Polish

French polish shall conform to IS :348. Suitable pigments shall be added to get the required colour.

The surface to be French polished shall be rubbed down to smoothness with sand paper and shall be well dusted. Pores in the surface shall be filled up with fillers.

A pad of woollen cloth covered by a fine cloth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may be used on the face of the pad for the purpose. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

15.0 MEASUREMENT

Painting/ polishing shall be measured by the area of actual painted/ polished surface.

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STANDARD SPECIFICATION FOR ROOFING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	04.03.22	REVISED & ISSUED AS STANDARD SPECIFICATION	ANISH MAHALA	ANISH KUNDU	SAMIR DAS	SANJAY MAZUMDAR
6	08.12.15	REVISED & ISSUED AS STANDARD SPECIFICATION	ANISH MAHALA	JKB	R SRIVASTAVA	S CHANDA
5	05.07.10	REVISED & ISSUED AS STANDARD SPECIFICATION	GR	JS	JKB	N DUARI
4	21.03.07	REVISED & ISSUED AS STANDARD SPECIFICATION	SD	JKB	ARVIND KUMAR	V CHATURVEDI
3	09.03.99	REAFFIRMED AS STANDARD SPECIFICATION	SD	MLB	SCJ	AS

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Abbreviations:

AS	: Australian Standards
ASTM	: American Society for Testing and Materials
BS	: British Standards
BS-EN	: British Standards European Norm
CGI	: Corrugated Galvanized Iron
EN	: European Standards
EPDM	: Ethylene Propylene Diene Monomer
GI	: Galvanized Iron
IS	: Indian Standards
ISO	: International Organization for Standardization
MS	: Mild Steel
NBC	: National building Code
SWG	: Standard Wire Gauge

Architecture Standards Committee
Convenor: Mr. Samir Das

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1.0 GENERAL

1.1 This Specification covers requirements of sheet roofing/ cladding and associated accessories for buildings and sheds. The specifications of metal sheets (with regards to material) are also applicable for barricades required during construction.

1.2 The roofing and cladding system shall ensure leak-proof enclosure by means lapping of sheets, closure of joints, junctions and gaps etc., efficient roof water drainage system etc. using necessary flashings, accessories and fittings.

1.3 The roofing and cladding system shall also have provisions for natural lighting and ventilation.

2.0 REFERENCES

2.1 The codes and standards listed below contain provisions which through reference in this specification constitute provisions of this standard specification if not specifically mentioned otherwise.

2.2 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NBC etc. conformity with any of the similar codes is acceptable.

2.3 Reference codes and standards:

Standards	Document title
IS: 277	Galvanized steel strips and sheets (Plain and corrugated)
IS: 513	Cold reduced carbon steel sheet and strip
IS: 737	Wrought aluminium and aluminium alloy sheet and strip for general engineering purposes
IS: 1254	Corrugated aluminium sheet
IS: 2676	Dimensions for wrought aluminium and aluminium alloys, sheet and strip
IS: 13592	Unplasticized Polyvinyl Chloride (PVC-U) Pipes for Soil and Waste Discharge System Inside and Outside Buildings Including Ventilation and Rainwater System
IS: 14871	Products in fibre reinforced cement - Long corrugated or asymmetrical section sheets and fittings for roofing and cladding - Specification
IS: 15961	Hot dip aluminium - Zinc alloy metallic coated steel strip and sheet (Plain)

3.0 CORRUGATED GALVANISED STEEL SHEET (C.G.S) ROOFING

3.1 Material

3.1.1 C.G.S. Sheets

C.G.S sheet shall conform to IS: 277.

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Unless otherwise specified in drawings, item descriptions, job specifications etc. the sheets shall be 1.00 mm thick and with zinc coating (total on both sides) not less than 275 gm/ sqm.

The sheets shall be free from cracks, split edges, twists, surface flaws etc. They shall be clean, bright and smooth. The galvanising shall be non-injured and in perfect condition. The sheets shall not show signs of rust or white powdery deposits on the surface. The corrugations shall be uniform in depth and pitch and parallel with the side.

3.1.2 Ridges, hips, valley, flashing and gutter of plain galvanised steel sheets

Leakproof roofing system with efficient rain water drainage of the roofing system shall be ensured by providing ridges, hips, valley, flashing and gutter etc. (all bent and fabricated to required shape) made of plain galvanized steel sheets.

Unless otherwise specified in drawings, item descriptions, job specifications etc. thickness and width etc. of these shall be as below:

Item	Thickness (mm)	Minimum overall width (mm)
Ridge	0.8	600
Hip	0.8	600
Valley	1.60	900
Flashing	1.00	400
Gutter	1.00 (minimum)	Profile, dimensions shall be as required for roof drainage

3.1.3 Rain water pipes

Unless otherwise mentioned specifically, rain water pipes shall be unplasticised rigid PVC rain water pipes conforming to IS : 13592 Type A with fittings/ accessories.

3.2 Laying and Fixing

3.2.1 The sheets shall be laid and fixed in accordance with Manufacturer's recommendations/ guidelines and in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

3.2.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

3.2.3 The sheets shall be laid with a minimum lap of 150 mm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 150 mm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 200 mm. The minimum lap of sheets with ridge, hip and valley shall be 200 mm measured at right angles to the line of the ridge, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

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3.2.4 Lapping in C.G.S. sheets shall be painted with a coat of approved steel primer and two coats of painting with approved paint suitable for G.S. sheet, before the sheets are fixed in place.

3.2.5 Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with anticorrosive polymer coated J or L hook bolts and nuts, 8 mm diameter, with polymer cap, seal and thrust washer. J hooks shall be used for fixing sheets on angle iron purlins, and L hooks shall be used for fixing the sheet to R.S. joists, timber or precast concrete purlins. The length of the hook bolt shall be varied to suit the particular requirements.

The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10 mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 300 mm. Coach Screws shall not be used for fixing sheets to purlins.

Number, spacing, length, location of hooks/ screws shall be in accordance with Manufacturer's recommendations/ guidelines.

3.2.6 Where slopes of roofs are less than 21.5 degrees (1 vertical to 2.5 horizontal) sheets shall be joined together at the side laps by bolts and nuts 25 × 6 mm size. As the overlap at the sides extends to two corrugations, these bolts shall be placed zig-zag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 600 mm along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheets are on the ground.

3.2.7 Ridges and hips of C.G.S. sheet roofing shall be covered with ridge and hip sections of plain G.S. sheet (properly bent in shape for fitting over roofing sheet) with a minimum lap of 200 mm on either side over the C.G.S. sheets. The end laps of the ridges and hips and between ridges and hips shall also be not less than 200 mm. They shall be fixed to the perlins with 8mm dia hooks, bolts, nuts and washers (similar to those used in laying the roofing sheets)

3.2.8 Valley shall lap with the C.G.S. sheets not less than 250 mm width on other side. The end laps of valley shall also be not less than 250 mm.

3.2.9 Flashings shall lap not less than 150 mm over the roofing sheets. The end laps between flashing pieces shall not be less than 250 mm.

3.2.10 Valley and flashings shall be fixed to roof structural members with 8mm dia hooks, bolts, nuts and washers (similar to those used in laying the roofing sheets)

3.2.11 Gutters shall be made leakproof and shall be supported on and fixed to mild steel flat iron (minimum size 40 mm x 3 mm) brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1000 mm.

Hooks/ bolts/ nuts (minimum 6 mm dia) and washers for fixing shall be similar to those used in laying the roofing sheets. Connecting bolts shall be above water line of the gutter.

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Gutters shall be provided with connection (drop ends/ nozzles/ funnels) to down take pipes, stop ends (made of G.S. sheets similar to the gutter) riveted to the gutter.

Gutters shall be laid with a minimum slope of 1 in 120.

3.2.12 Unless otherwise mentioned specifically, roof water drainage shall be through gutter and rain water pipes.

3.2.13 Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins.

3.2.14 The roof when completed shall be true to lines and slopes and shall be leak proof.

4.0 ALUMINIUM ALLOY SHEET ROOFING/ CLADDING

4.1 Material

4.1.1 Corrugated Aluminium alloy sheet

Unless otherwise specified in drawings, item descriptions, job specifications etc, the material of corrugated Aluminium alloy sheet for roofing and cladding shall conform to following specification.

Alloy Grade	31500 B, H4 as specified in IS: 737: 2008
Profile	Profiled/corrugated sheet shall be Industrial troughed sheet Conforming to IS: 1254 -2007
Thickness	20 SWG (0.91mm) for roofing 22 SWG (0.71mm) for wall cladding (Thickness, tolerances shall be as per IS: 2676-1981)
Pitch	125 mm
Crest Height	38 mm

Finishing of the sheets shall be plain mill or stucco embossed finish. Unless otherwise specified in drawings, item descriptions, job specifications etc, the finishing shall be stucco embossed finish in approved colour.

4.1.2 Accessories

The material for accessories like ridge, gutter, flashings etc. shall be of plain Aluminium alloy sheet of grade 31500 B / H2 conforming to IS: 737.

Unless otherwise specified in drawings, item descriptions, job specifications etc the dimensions and other specifications shall be as mentioned in the following table.

Accessory	Dimension
Ridge piece	0.91 mm thick, minimum 600 mm wide
Apron piece	0.71 mm thick, minimum 150 mm x 150 mm

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Eaves piece	0.71 mm thick, minimum150 mm x 150 mm
Corner piece	0.71 mm thick, minimum 150 mm x 150 mm
Gutter	2 mm thick, width as required.

Finishing of accessories shall be similar to that of the roofing/ cladding sheet.

4.1.3 Rain water pipes

Unless otherwise mentioned specifically, rain water pipes shall be unplasticised rigid PVC rain water pipes conforming to IS : 13592 Type A with fittings/ accessories.

4.2 Laying and fixing

4.2.1 The sheets shall be laid and fixed in accordance with Manufacturer's recommendations/ guidelines and in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

4.2.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

4.2.3 The sheets shall be laid and with side and end laps as recommended by the sheet manufacturer. End lap shall be minimum 150 mm on roofs and one corrugated for sides lap. If the roof slope is less than 15 degrees, end lap shall be increased to 230 mm. Overlap of sheets shall be minimum 150 mm. Care shall be taken to match profiles and maintain alignment of profiles while overlapping the sheets.

4.2.4 Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with stainless steel (SS 304 grade) or carbon steel or aluminium alloy hex head self-drilling screws and EPDM washer. For inserting the fasteners, screw driving machine to be used at permissible rpm, punching is not permissible. All drills shall be done on the crown/ crest of profile sheets.

If not mentioned specifically, carbon steel screws shall be used.

Number, spacing, length, location of hooks/ screws shall be in accordance with Manufacturer's recommendations/ guidelines.

4.2.5 Carbon steel screws shall be hex head, self drilling type with multi-layered high density anti-corrosive coating of Aluminium & Zinc (AZ), fitted with AZ150 GSM 0.8mm thick Alu-Zinc coated EPDM bonded washer.

4.2.6 Accessories like Ridges, apron pieces, corner pieces, flashings and eaves pieces etc. shall be provided at ridge, corners, eaves etc. (properly bent in shape for fitting over roofing sheet) for ensuring leakproof construction. They shall be fixed with screws and washers (similar to those used in laying the roofing sheets)

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4.2.7 Gutters shall be made leakproof and shall be supported on and fixed to mild steel flat iron (minimum size 40 mm x 3 mm) brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1000 mm.

Pieces of gutters shall be argon welded ensuring leak proof continuous gutter length.

Screws and washers for fixing shall be similar to those used in laying the roofing sheets.

Gutters shall be provided with connection (drop ends/ nozzles/ funnels) to down take pipes, stop ends (made of sheets similar to the gutter) riveted to the gutter.

Gutters shall be laid with a minimum slope of 1 in 120.

4.2.8 Unless otherwise mentioned specifically, roof water drainage shall be through gutter and rain water pipes.

4.2.9 Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. Wind ties shall be painted with synthetic enamel paint matching the colour of the roofing/ cladding sheets.

4.2.10 The roof when completed shall be true to lines and slopes and shall be leak proof.

5.0 PRECOATED GALVANIZED STEEL SHEET ROOFING / CLADDING

5.1 Material

5.1.1 Pre-coated galvanized steel sheet

Unless otherwise specified in drawings, item descriptions, job specifications etc, the material of pre-coated galvanized steel sheet for roofing and cladding shall conform to following specification and performance properties.

Base metal	Cold rolled steel sheet conforming to IS : 513, galvanized (275 g/SqM total on both side) by hot dip process as per IS : 277.
Profile	Profiled/corrugated sheet
Pitch	195 to 255 mm (with intermediate ribs)
Crest Height	Not less than 28 mm
Base metal thickness	0.60 mm (+/- 0.03)
Overall coated thickness	0.65 mm
Weight	Minimum 5.80 Kg/ SqM
Finishing – top surface	Regular modified polyester of minimum 20 (+/- 2) microns over primer coat of 5 microns.
Finishing – bottom surface	Polyester coat of minimum 5 microns over primer coat of 5 microns
Yield strength	Minimum 550 MPa
Pencil hardness	H-2H
Bending test	2-4 T

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Salt spray test	750 hours (exposed top side)
QUV – Wealterometer test	1000 hours
Humidity test	Minimum 750 hours

The sheets shall be of approved colour.

5.1.2 Accessories

The material for accessories like ridge, gutter, flashings etc. shall be of plain pre-coated galvanized steel sheet similar (except corrugation) to the sheet specified for roofing/ cladding.

5.1.3 Rain water pipes

Unless otherwise mentioned specifically, rain water pipes shall be unplasticised rigid PVC rain water pipes conforming to IS : 13592 Type A with fittings/ accessories.

5.2 Laying and fixing

5.2.1 The sheets shall be laid and fixed in accordance with Manufacturer's recommendations/ guidelines and in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

5.2.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

5.2.3 The sheets shall be laid and with side and end laps as recommended by the sheet manufacturer. End lap shall be minimum 150 mm to 250 mm for a slope more than 15 degree (1 in 4) and 200 mm to 300 mm for slope less than 15 degree. Overlap of sheets shall be minimum 150 mm. Care shall be taken to match profiles and maintain alignment of profiles while overlapping the sheets.

5.2.4 Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with self-drilling screws and EPDM washer. For inserting the fasteners, screw driving machine to be used at permissible rpm, punching is not permissible. All drills shall be done on the crown/ crest of profile sheets.

If not mentioned specifically, Zinc coated or Zinc- Tin alloy coated, hex head screws as per AS 3566 class -3 fasteners with EPDM washers shall be used.

Number, spacing, length, location of hooks/ screws shall be in accordance with Manufacturer's recommendations/ guidelines.

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5.2.5 Accessories like Ridges, apron pieces, corner pieces, flashings and eaves pieces etc. shall be provided at ridge, corners, eaves etc. (properly bent in shape for fitting over roofing sheet) for ensuring leakproof construction. They shall be fixed with screws and washers (similar to those used in laying the roofing sheets)

5.2.6 Gutters shall be made leak proof and shall be supported on and fixed to mild steel flat iron (minimum size 40 mm x 3 mm) brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1000 mm.

Pieces of gutters shall be argon welded ensuring leak proof continuous gutter length.

Screws and washers for fixing shall be similar to those used in laying the roofing sheets.

Gutters shall be provided with connection (drop ends/ nozzles/ funnels) to down take pipes, stop ends (made of sheets similar to the gutter) riveted to the gutter.

Gutters shall be laid with a minimum slope of 1 in 120.

5.2.7 Unless otherwise mentioned specifically, roof water drainage shall be through gutter and rain water pipes

5.2.8 Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. Wind ties shall be painted with synthetic enamel paint matching the colour of the roofing/ cladding sheets.

5.2.9 The roof when completed shall be true to lines and slopes and shall be leak proof.

6.0 PRECOATED ZINC ALUMINIUM STEEL SHEET ROOFING / CLADDING

6.1 Material

6.1.1 Pre-coated Zinc- Aluminium steel sheet

Unless otherwise specified in drawings, item descriptions, job specifications etc, the material of pre-coated galvanized steel sheet for roofing and cladding shall conform to following specification and performance properties.

Base metal	The base metal of the roofing shall be cold rolled steel sheet conforming to AS: 1397 or IS : 513. It shall be coated with Al-Zn alloy (55.00% Aluminium, 43.40% Zinc, 1.60% Si) / Zincalume by Hot-dip process as per IS :15961 or AS:1397 or ASTM : A792M. (class AZ 150, having minimum 150 g/SqM AZ coating mass total on both sides).
Profile	Profiled/corrugated sheet
Pitch	195 to 255 mm (with intermediate ribs)
Crest Height	Not less than 28 mm
Base metal thickness	0.45 mm (+/- 0.03)'

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Overall coated thickness	0.52 mm
Weight	Minimum 4.50 Kg/ SqM
Finishing top surface	Super durable polyester of minimum 20 (+/- 2) microns over polyester primer coat of 5 microns.
Finishing – bottom surface	Polyester coat of minimum 5 microns over primer coat of 5 microns.
Yield strength	Minimum 550 MPa
Pencil hardness	H-2H
T-Bending test	Maximum 5T
Salt spray test	1000 hours (exposed top side)
QUV – Wealterometer test	1000 hours
Humidity test	Minimum 1000 hours

6.1.2 Accessories

The material for accessories like ridge, gutter, flashings etc. shall be of plain Pre-coated Zinc- Aluminium steel sheet sheet similar (except corrugation) to the sheet specified for roofing/ cladding.

6.1.3 Rain water pipes

Unless otherwise mentioned specifically, rain water pipes shall be unplasticised rigid PVC rain water pipes conforming to IS : 13592 Type A with fittings/ accessories.

6.2 Laying and fixing

6.2.1 The sheets shall be laid and fixed in accordance with Manufacturer's recommendations/ guidelines and in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

6.2.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

6.2.3 The sheets shall be laid and with side and end laps as recommended by the sheet manufacturer. End lap shall be minimum 150 mm to 250 mm for a slope more than 15 degree (1 in 4) and 200 mm to 300 mm for slope less than 15 degree. Overlap of sheets shall be minimum 150 mm. Care shall be taken to match profiles and maintain alignment of profiles while overlapping the sheets.

6.2.4 Sheets shall be fixed to the purlins or other roof members such as hip or valley rafters etc. with self-drilling screws and EPDM washer. For inserting the fasteners, screw driving machine to be used at permissible rpm, punching is not permissible. All drills shall be done on the crown/ crest of profile sheets.

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If not mentioned specifically, Zinc coated or Zinc- Tin alloy coated, hex head screws as per AS 3566 class -3 fasteners with EPDM washers shall be used.

Number, spacing, length, location of hooks/ screws shall be in accordance with Manufacturer's recommendations/ guidelines.

6.2.5 Accessories like Ridges, apron pieces, corner pieces, flashings and eaves pieces etc. shall be provided at ridge, corners, eaves etc. (properly bent in shape for fitting over roofing sheet) for ensuring leak proof construction. They shall be fixed with screws and washers (similar to those used in laying the roofing sheets)

6.2.6 Gutters shall be made leakproof and shall be supported on and fixed to mild steel flat iron (minimum size 40 mm x 3 mm) brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1000 mm.

Pieces of gutters shall be argon welded ensuring leak proof continuous gutter length.

Screws and washers for fixing shall be similar to those used in laying the roofing sheets.

Gutters shall be provided with connection (drop ends/ nozzles/ funnels) to down take pipes, stop ends (made of sheets similar to the gutter) riveted to the gutter.

Gutters shall be laid with a minimum slope of 1 in 120.

6.2.7 Unless otherwise mentioned specifically, roof water drainage shall be through gutter and rain water pipes

6.2.8 Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. Wind ties shall be painted with synthetic enamel paint matching the colour of the roofing/ cladding sheets.

6.2.9 The roof when completed shall be true to lines and slopes and shall be leak proof.

7.0 FIBRE CEMENT CORRUGATED SHEET ROOFING/ CLADDING

7.1 Material

7.1.1 Fibre cement corrugated sheet

Fibre cement corrugated sheets shall conform to IS :14871 and following specification.

Composition	The sheets shall be asbestos free and reinforced by organic and /or inorganic synthetic fibres. The product shall be composed essentially of an inorganic hydraulic binder (in case of Portland pozzolana cement Portland slag cement, addition of pozzolanic materials and slag shall not be permitted) or a calcium silicate binder formed by the chemical reaction of a silicate binder formed by the chemical reaction of a.

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	siliceous (includes ground silica, pulverized fuel ash and amorphous silica) and calcareous material reinforced by organic and /or inorganic synthetic fibres. Pozzolanic materials process aids, fillers and pigments which are compatible with the fibre reinforced cement may be added. The inorganic hydraulic binder shall be either ; 33 grade ordinary Portland cement conforming to IS : 269 or 43 grade ordinary Portland cement conforming to IS :8112 or 53 grade ordinary Portland cement conforming to IS :12269 or Portland pozzolona (fly ash based) cement conforming to IS :1489 - part 1 or Portland pozzolona (calcined clay based) cement conforming to IS :1489 - part 2 or Rapid hardening cement conforming to IS :8041 or Portland slag cement conforming to IS :455 Fly ash used shall conform to IS 3812.
Thickness	Unless otherwise specifically mentioned, the thickness shall be 6 mm (tolerance : +/- 10%)
Pitch	146 mm (tolerance : + 6 mm, - 2 mm)
Depth	48 mm (tolerance : + 4 mm, - 5 mm)
Finishing	The sheets shall be free from cracks, chipped edges or corners and other damages. Top exposed surface shall have pre-painted finish with minimum 30 micron thick exterior grade premium quality acrylic emulsion paint. Bottom surface shall have factory finish.

7.1.2 Accessories

Accessories such as adjustable ridges, hips, finishing pieces, eaves filler pieces, north light and ventilator curves, barge boards, expansion joint sheets, "S" type louvers, gutters etc. shall be of the same Manufacturer (unless approved otherwise by Engineer- In- Charge) as the sheet used for roofing/ cladding and as per Manufacturer's standard specification.

7.1.3 In case, sizes of readymade non-metallic gutters by the same Manufacturer of the sheet are not adequate/ suitable for roof drainage, gutters of required size fabricated out of minimum 1 mm thick G.S. sheet (painted in same colour as that of roofing sheet or as approved) shall be provided.

7.1.4 Rain water pipes

Unless otherwise mentioned specifically, rain water pipes shall be unplasticised rigid PVC rain water pipes conforming to IS : 13592 Type A with fittings/ accessories.

7.2 Laying and fixing

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7.2.1 The sheets shall be laid and fixed in accordance with Manufacturer's recommendations/ guidelines and in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

7.2.2 The sheets shall be laid on the purlins to a true plane, with the lines of corrugations parallel or normal to the sides of the area to be covered unless otherwise required as in special shaped roofs.

7.2.3 The sheets shall be laid with side and end laps as recommended by the sheet manufacturer. End lap shall be minimum 150 mm in cases of roof with a pitch flatter than 1 vertical to 2.5 horizontal. In the cases of very exposed situations, minimum end lap shall be 200 mm. Side lap shall be minimum half a corrugation.

7.2.4 Sheets shall be fixed to the purlins or other roof members by means of 8 mm diameter polymer coated GI J or L hook bolts, nuts and EPDM washers or with self drilling fasteners and EPDM washers. For inserting the bolts/fasteners, screw driving machine to be used at permissible rpm, punching is not permissible. All drills shall be done on the crown of the sheets. Number, spacing, length, location of hooks/ screws shall be in accordance with Manufacturer's recommendations/ guidelines.

7.2.5 The free overhang of the sheets at the eaves shall not exceed 300mm.

7.2.6 Accessories like Ridges, apron pieces, corner pieces, flashings and eaves pieces etc. shall be provided at ridge, corners, eaves etc. (properly bent in shape for fitting over roofing sheet) for ensuring leak proof construction. They shall be fixed with screws and washers (similar to those used in laying the roofing/cladding sheets)

7.2.7 Unless otherwise mentioned specifically, roof water drainage shall be through gutter and rain water pipes.

7.2.8 Metal sheet gutters shall be made leak proof and shall be supported on and fixed to mild steel flat iron (minimum size 40 mm x 3 mm) brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1000 mm.

Pieces of gutters shall be argon welded ensuring leak proof continuous gutter length.

Screws and washers for fixing shall be similar to those used in laying the roofing sheets.

Gutters shall be provided with connection (drop ends/ nozzles/ funnels) to down take pipes, stop ends (made of sheets similar to the gutter) riveted to the gutter.

Gutters shall be laid with a minimum slope of 1 in 120.

7.2.9 Wind ties shall be of 40 x 6 mm flat iron section or of other size as specified shall be fixed at the eaves of the sheets. The fixing shall be done with the same hook bolts which secure the sheets to the purlins. Wind ties shall be painted with synthetic enamel paint matching the colour of the roofing/ cladding sheets.

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7.2.10 The roof when completed shall be true to lines and slopes and shall be leak proof.

8.0 MEASUREMENT

8.1 Measurement of sheets in roofing and cladding shall be the measurement of superficial area of the sheets on the flat without allowance for laps and corrugations. No deductions shall be made for openings upto 0.4 SqM. For opening areas exceeding 0.4 SqM, such areas shall be deducted.

8.2 If not mentioned otherwise, measurement of metal flashings, ridge/hip pieces, corner pieces, gutters (including all fittings and fixtures) etc. shall be the measurement of surface areas of these.

8.3 If not mentioned otherwise, measurement of readymade accessories and fittings (having standard size/profile) of fibre cement sheet shall be the measurement of their lengths.

8.4 If not mentioned otherwise, measurement of rain water pipes (including all fittings and fixtures) shall be the measurement of their actual lengths

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सेनिटेरी फिटिंगों और फिक्सचर का मानक विनिर्देश

STANDARD SPECIFICATION FOR SANITARY FITTINGS & FIXTURES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
7	13.10.23	REVISED & ISSUED AS STANDARD SPECIFICATION	AKHILESH MAURYA	ATUL GUPTA	SAMIR DAS	SANJAY MAZUMDAR
6	03.04.12	REVISED & ISSUED AS STANDARD SPECIFICATION	RH	RG	JKB	D MALHOTRA
5	03.04.12	REVISED & ISSUED AS STANDARD SPECIFICATION	RH	RG	JKB	D MALHOTRA

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Abbreviations:

ASTM	:	American Society for Testing & Materials
BS	:	British Standards
IS	:	Indian Standards
NBC	:	National Building Code of India
BIS	:	Bureau of Indian Standards
EN	:	European Standards
ISO	:	International Organization for Standardization
ABS	:	Acrylonitrile Butadiene Styrene
HDPE	:	High density polyethylene

Architecture Standards Committee

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1.0 GENERAL

1.1 This Specification covers requirements of sanitary fixtures and fittings such as Water Closets, Wash Basins, Urinals, Water Taps etc.

1.2 In case of Green rated buildings water efficient fixtures shall be used as required to reduce water consumption and for obtaining the green rating. All fixtures installed within the project shall have flow rates at 45 psi or 3.10 bar pressure.

1.3 Other than faucets, which are installed in spaces with water head heights less than 5m/17ft, in a gravity-fed system, flow rates for the fixtures shall not exceed as mentioned in the following table.

Plumbing Fixture	Flow rate
Water Closet (Solid Flush)	6 liter per flush
Water Closet (Liquid Flush)	3 liter per flush
Urinal	3.8 liter per flush
Shower head	10 liter per minute
Lavatory Faucet	8 liter per minute
Kitchen Faucet	8 liter per minute

1.4 The water closets/ cisterns/wash basins/ Urinals shall be of approved colour.

1.5 Stop cock/ valves shall be provided in all water supply lines for maintenance and operation purpose.

1.6 Associated plumbing works shall be concealed type.

1.7 Sanitary fittings and fixtures shall be procured from Manufacturer approved by the Engineer-In-Charge

2.0 REFERENCES

The codes and standards listed below contain provisions, which through reference in this specification constitute provisions of this standard specification, if not explicitly mentioned otherwise.

2.1 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NFPA, NBC etc. conformity with any of the similar codes is acceptable.

2.2 Reference codes and standards:

Standards	Document Title
IS : 2556 Part 1-17	Specification for Vitreous Sanitary appliances (Vitreous China, Part 1-17)
IS : 2267	Specification for Polystyrene Moulding and Extrusion Materials
IS : 407	Specification for Brass Tubes for General Purposes.
1S :774	Specification for Flushing cisterns for water closets and urinals (other than plastic cisterns)

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IS: 775	Specification for cast iron brackets and supports for wash basins and sinks
IS :781	Specification for Cast copper alloy screw down bib taps and stop valves for water services
IS : 1300	Specification for Phenolic moulding materials.
IS :2064	Code of Practice for Selection, Installation and Maintenance of Sanitary appliances
IS :2548 Part-1	Specification for Plastic Seats and Covers for water closets Part-1: Thermoset seats and covers
IS :2548 Part-2	Specification for Plastic Seats and Covers for water closets Part-2: Thermoplastic seats and covers
IS :2326	Specification for automatic flushing cistern for urinals (other than plastic cisterns)
IS : 3389	Specification for Urea-formaldehyde Moulding Materials.
IS :7231	Specification for plastic flushing cisterns for water closets and urinals.
IS : 7328	Specification for High Density Polyethylene Materials for Moulding and Extrusion.
IS : 9758	Specification for flush valves and fittings for water closets and urinals.
IS : 13983	Specification for stainless steel sinks for domestic purposes.

3.0 WATER CLOSET SYSTEMS

3.1 General

3.1.1 Water closet Systems shall be a water tight and leakage free system consisting of squatting pans/commodes complete with water supply, flushing and drainage/ disposal system including all fittings/ fixtures required to be connected to the water supply and waste disposal system.

3.1.2 Flushing and disposal of the waste shall be by means of water either from direct water supply line or from flushing cisterns/ tanks through flush valves as mentioned.

3.1.3 Stop cock/ valves shall be provided in all water supply lines for maintenance and operation purpose.

3.2 Flushing Cisterns/ Tanks

3.2.1 Flushing cisterns shall either be integral with the squatting pan/ commode and shall be open or concealed tank type as mentioned. Connection between cistern and closet shall be made by means of flush pipe/ bend. Flush pipe/ bend shall be firmly fixed with clamps etc. and shall be concealed both in wall and floor.

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3.2.2 The cisterns shall be complete with all necessary fittings/ fixtures etc. as required and mentioned in the table below.

Component	Material
Cisterns/ Tanks	Minimum 3 mm thick High density polyethylene (HDPE) conforming to IS 7328 or polystyrene, high impact or polypropylene conforming to IS 2267. (In case of cisterns integral with wash down type closets, the material shall be vitreous china)
Flush pipe/ bend	40mm dia High density polyethylene pipe conforming to IS 407 or unplasticised PVC plumbing pipe conforming to IS 2501
Siphon/ valve	High density polyethylene (HDPE) Conforming to IS 7328 or polystyrene, high impact or polypropylene conforming to IS 2267.
Operating mechanism/ lever	Non- ferrous, corrosion resistant material
Float valve	Polyethylene conforming to IS 7328
Coupling nut and lock-nut	Non- ferrous material
Capacity	Minimum 5 litre
Connection pipes/ tubes	Reinforced PVC/ Plastic with chrome plated non-ferrous metallic jacket matching with the finish of valves/ stop cocks etc.

3.2.3 Flushing cisterns shall be dual valve type with dual pushing button plates. In case of open type of cisterns, the valve shall be integral with the cistern. In case of concealed cistern/ tank, the valve plate (made of non ferrous metal or ABS (Acrylonitrile Butadiene Styrene) and having same finishing of the Faucets, taps etc.) shall be provided on the concealed surface at suitable location. Stop cocks/ valves shall be provided in the system for installation/ maintenance.

3.3 INDIAN WATER CLOSET (IWC)

3.3.1 Squatting Pan shall be of vitreous china and Orissa Pan type conforming to IS: 2556. The closet shall be fixed in the floor with 150 mm thick sand cushion and shall be connected with CI `S' or `P' trap with approximately 50 mm water seal.

3.3.2 Each pan shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flush pipes. The flushing rim and inlets hall be of the self draining type. It shall have weep hole at the flushing inlet to the pan. The inside of the bottom of the pan shall have sufficient slope from the front towards the outlet and the surface shall be uniform and smooth to enable easy and quick disposal while flushing.

3.3.3 Water tap or health faucet with stop cock, valve shall be provided near the closet at suitable location. Connection pipes/ tubes of health faucets shall be flexible and of reinforced PVC/ Plastic with chrome plated non-ferrous metallic jacket matching with the finish of valves/ stop cocks etc.

3.4 WASH DOWN TYPE EUROPEAN WATER CLOSETS (EWC)

3.4.1 The commode shall be of vitreous china conforming to IS: 2556.

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3.4.2 The closets shall be of one piece construction and shall have an integral flushing rim of suitable type. It shall also have an inlet or supply horn for connecting the flushing pipe. The flushing rim and inlet shall be of the self draining type. The water closet shall have a weep hole at the flushing inlet. Each water closet shall have an integral trap with either 'S' or 'P' outlet with at least 50 mm water seal. The inside surface of water closets and traps shall be uniform and smooth in order to enable an efficient flush.

3.4.3 The closets shall be floor or wall mounted with flushing cisterns either integral with the commode or separately mounted on wall or concealed cisterns/tanks connected with flush pipe as mentioned.

3.4.4 The commodes shall be provided with a hinged seat and cover/ lid. The seat and cover made of thermosetting or thermoplastic conforming to IS 2548. Thermosetting plastic used shall conform to grade 2 or 3 of IS 1300 when it is phenolic plastic or IS 3389 when it is of urea formaldehyde. The seat and cover shall be fitted with plastic buffers. The cover shall be hydraulically operated type.

3.4.5 Water tap or health faucet with stop cock, valve shall be provided near the closet at suitable location. Connection pipes/ tubes of health faucets shall be flexible and of reinforced PVC/ Plastic with chrome plated non-ferrous metallic jacket matching with the finish of valves/ stop cocks etc.

3.4.6 Superior quality EWCs shall be of approved design and shall have following features with respect to clause nos 3.4.1 to 3.4.5 :

Installation type	Wall hung
Commode/ Pan	Rimless with quite close seat cover having anti-bacterial coating.
Cistern	Concealed type, made of high density polyethylene, joint less construction. Water consumption – maximum 2 and 4 litre for partial and full flush respectively. Capacity – upto 10 litre. Valve/ Actuation plate – Separate pressing button for dual flushing, made of ABS (chromium plated)
Health faucet	Chromium plated ABS body with reinforced plastic/ PVC pipe in SS-304 grade jacket.

3.4.7 Premium quality EWCs shall be of approved design and shall have following features with respect to clause nos 3.4.1 to 3.4.5 :

Installation type	Wall hung
Commode/ Pan	Fully skirted (Traps not visible), Rimless with quite close seat cover having anti-bacterial coating.
Cistern	Concealed type, made of high density polyethylene, jointless construction. Water consumption – maximum 2 and 4 litre for partial and

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	full flush respectively. Capacity – upto 10 litre. Valve/ Actuation plate – Separate pressing button for dual flushing, made of ABS (chromium plated)
Health faucet	Chromium plated ABS body with reinforced plastic/ PVC pipe in SS-304 grade jacket.

4.0 URINAL SYSTEM

4.1 General

4.1.1 Urinals shall be a water tight and leakage free system consisting of urinals complete with water supply, flushing and drainage/ disposal system including all fittings/ fixtures required to be connected to the water supply and waste disposal system.

4.1.2 Flushing and disposal of the waste shall be by means of water from direct water supply line if not mentioned otherwise.

4.1.3 Stop cock/ valves shall be provided in all water supply lines for maintenance and operation purpose.

4.1.4 The urinals shall be made of vitreous China and half stall type conforming to IS 2556.

4.1.5 The urinals shall be of one piece construction, full stall type with integral flushing rim and of approved colour.

4.1.6 All pipe, fittings, plumbing of water supply connection to the urinals, drainage/ disposal pipes shall be concealed. Stop cock shall be provided just above the urinal for flushing.

4.1.7 Bottle trap and union fittings shall be provided for waste disposal from the urinals.

4.1.8 Urinal partitions shall be provided in between the urinals. If not mentioned specifically elsewhere, partitions made of polished granite stone shall be provided.

4.2 Sensor operated Urinals

4.2.1 With reference to clause no 4.1, in case of sensor operated urinals, the flushing system shall be by means of concealed type electronic type sensors. The power supply to the sensor shall be by means of direct electrical connection or by battery cell as decided by the Engineer- In-Charge.

4.2.2 Sensor operated urinals shall have pre-flush facility also.

4.3 Waterless Urinals

4.3.1 Waterless urinals shall be made of vitreous china having antibacterial /germs free ceramic surface, fixed with cartridge having debris catcher and hygiene seal.

5.0 WASH BASINS / SINKS

5.1 General

5.1.1 Wash basins and sinks shall be water tight and leakage free system complete with water supply and drainage/ disposal system including all fittings/ fixtures required to be connected to the water supply and waste disposal system.

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5.1.2 Stop cock/ valves shall be provided in all water supply lines for maintenance and operation purpose.

5.1.3 The wash basins shall be made of vitreous China conforming to IS 2556.

5.1.4 The wash basins/sinks shall be of one piece construction and of approved colour with nickel chromium plated brass waste fitting for connecting with waste pipe.

5.1.5 All pipe, fittings, plumbing of water supply connection to the basins/ sinks, drainage/ disposal pipes shall be concealed.

5.1.6 Wash basins/ sinks shall be wall mounted or mounted over/ under counters as mentioned in the tender document or construction drawings. In case of wall mounted fitting, the basin/ sink shall be fixed to wall with metal (painted) brackets.

5.1.7 Shape, design and size of the wash basins/ sinks shall be as approved by the Engineer-In-Charge.

5.1.8 Wash basins shall be provided with taps/ pillar cocks/ faucets of approved design. Mixer type tap/ pillar cock shall be provided in case of hot and cold water supply.

5.1.9 Bottle trap and union fittings shall be provided for waste disposal from the wash basins.

5.1.10 In case of Sinks, taps with long and swinging neck shall be provided so that water reaches in all the areas of the Sink.

5.1.11 Connection pipes/ tubes shall be of flexible and of reinforced PVC/ Plastic with chrome plated non-ferrous metallic jacket matching with the finish of valves/ stop cocks etc.

5.2 Superior quality Wash Basins and faucets

5.2.1 Superior quality Wash Basins shall be round or oval shaped under counter top type with either electronic sensor operated or pressmatic type faucets as mentioned.

5.2.2 In case of sensor operated basins, power supply to the sensor shall be by means of direct electrical connection or by battery cell as decided by the Engineer- In- Charge.

5.2.3 Faucets shall be of brass body, chromium plated of approved design and shall be mounted over the counter or mounted on the basin itself as decided by Engineer-In-Charge.

5.3 Premium quality Wash Basins and faucets

5.3.1 Premium quality Wash Basins shall be over the counter top and thin rim type, of approved shape with electronic sensor electronic sensor operated.

5.3.2 Power supply to the sensor shall be by means of direct electrical connection or by battery cell as decided by the Engineer- In- Charge.

5.3.3 Faucets shall be of brass body, chromium plated of approved design and shall be wall mounted or mounted over the counter as decided by Engineer-In-Charge.

5.4 Kitchen/ Pantry/ Laboratory sinks

Kitchen/ Pantry/ Laboratory sinks shall be of stainless steel (304 -18/8) conforming to IS 13983. Nominal thickness of SS sheet shall not be less than 1 mm before forming. Thickness

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at any point of the sink, after forming shall not be less than 0.75mm. Depth of the bowl shall not be less than 150 mm. Minimum internal dimensions, when measured on the bowl centre lines across the top of the bowl shall be 380mm x 340 mm for rectangular bowls and 360 mm for round bowls.

6.0 FITTINGS & FIXTURES

6.1 General

6.1.1 Fittings/ fixtures such as Taps/ Valves/ Faucets/Shower roses/ bib, stop, pillar cocks etc shall be of approved design and finish and shall be procured from approved Manufacturer.

6.1.2 Fittings/ fixtures shall be provided as per table below :

WC cubicles	Bib cock or health faucet, Coat/ Robe hook, Toilet paper holder
Shower cubicles	Towel rail, Coat/Robe hook, Soap tray, Shower rose
Wash Basins	Mirror and Faucets for each wash basin, Touch less type Soap dispenser (Tissue paper dispenser in locations decided by the Engineer-In-Charge) and Hand drier near wash basin.

6.1.3 Removable floor trap covers made of stainless steel shall be provided over all floor traps.

6.1.4 Fittings/ fixtures shall be made of non-ferrous anti corrosive metallic materials with chromium plated finish if not mentioned otherwise.

6.2 Specifications of sanitary fittings/ fixtures

6.2.1 Sanitary fittings/ fixtures shall meet the following specifications if not mentioned otherwise specifically in the tender/ bid documents and construction drawings.

Fittings/ fixtures	Specification
Bib Cocks, Stop Cocks, Pillar cocks, Taps, valves, Faucets, mixers etc.	15mm dia, chromium plated Brass body conforming to IS : 781 Faucets for superior and premium quality wash basins shall be as mentioned.
Health Faucets	Chromium plated Brass body with bracket
Shower rose	Chromium plated Brass body conforming to IS : 2064 with adjustable rose and supporting arm.
Toilet paper holder	Chromium plated Brass body or stainless steel (grade – 304)
Liquid soap dispenser	Plastic body
Towel ring/ rail/ rack	Stainless steel (grade – 304)
Mirror	Made of minimum 5mm thick glass with beveled/ rounded edge.
Coat/Robe hook	Stainless steel (grade – 304)

7.0 INSTALLATION

7.1 Sanitary fittings/ fixtures shall be installed by licensed plumber.

7.2 The fixtures/ fittings shall be installed in accordance with the Manufacturer's recommendation and as approved by the Engineer-In-Charge.

7.3 All fittings/ fixtures shall be installed ensuring water tightness using sealers/ gaskets etc. as required.

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7.4 All holes/ punctures in walls due to installation shall be concealed by stainless steel round covers matching with the fixture/ fittings.

7.5 Pedestals of WCs/ wash basins etc. in contact with the floor finish shall be suitably sealed.

7.6 All screws for fixing/ fitting etc. shall be of stainless steel fixed with anchor fasteners.

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बनावटी छत, बनावटी तल, अंडरडेक इन्सुलेशन और पार्टीशनिंग का मानक विनिर्देश

STANDARD SPECIFICATION FOR FALSE CEILING, FALSE FLOORING, UNDERDECK INSULATION & PARTITIONING

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
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Abbreviations:

ASTM	:	American Society of Testing of Materials
BS	:	British Standards
CISCA	:	Ceilings & Interior Systems Construction Association
CRCA	:	Cold Rolled Close Annealed
EN	:	European Standards
GI	:	Galvanized Iron
IS	:	Indian Standards
ISO	:	International Organization for Standardization
MS	:	Mild Steel
NABL	:	National Accreditation Board for Testing and Calibration Laboratories
NRC	:	Noise Reduction Coefficients
NBC	:	National Building Code
NFPA	:	National Fire Protection Association
PVC	:	Polyvinyl Chloride
RCC	:	Reinforced Cement Concrete
SS	:	Stainless Steel

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1.0 GENERAL

This standard specification lays down requirements of false ceiling, false flooring, under deck insulation, and partitioning system.

2.0 REFERENCES

2.1 The codes and standards listed below contains provisions which through reference in this specification constitute provisions of this standard specification if not specifically mentioned otherwise.

2.2 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NFPA, NBC etc. conformity with any of the similar codes is acceptable.

2.3 Reference codes and standards:

Sr. No.	Standards	Document Title
1	ASTM C423	Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
2	ASTM C635	Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings.
3	ASTM C636	Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels.
4	ASTM E1414	Standard Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum
5	ASTM E1477	Standard Test Method for Luminous Reflectance Factor of Acoustical Materials by Use of Integrating-Sphere Reflectometers
6	BS 476 part 6/7	Fire Test
7	CISCA	The Ceilings & Interior Systems Construction Association Acoustical ceilings: Use and Practice
8	IS 277	Galvanized Steel Sheets (Plain and Corrugated)
9	IS 2095	Gypsum plaster boards
10	IS 2676	Dimension for wrought aluminium and aluminium alloy sheet and strip
11	IS 12436	Specification for. Preformed rigid polyurethane (pur). And polyisocyanurate (pir) foams
12	IS 8183	Bonded mineral wool - specification.

3.0 FALSE CEILING SYSTEMS

3.1 GENERAL

3.1.1 False or suspended ceiling systems shall be complete with supporting frame work / suspension system and ceiling boards/ panels/ tiles. Following types of false ceiling systems (either with only one type or in combination of various types) shall be provided as specified in design basis, job specifications, item descriptions, drawings etc.

1. Mineral Fibre board false ceiling system.
2. Gypsum board seamless false ceiling system.

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3. Calcium Silicate board false ceiling system.
4. Calcium Silicate tile false ceiling system.
5. Aluminium false ceiling system. (square grid type)
6. Aluminium false ceiling system. (linear plank type)

If false ceiling type is not mentioned specifically, Mineral Fibre board false ceiling system shall be provided.

3.1.2 False or suspended ceiling systems shall be installed at desired heights and levels in designs, patterns and shapes in accordance with approved fabrication drawings. Fabrication drawings shall be prepared and submitted by the Contractor and approved by Engineer-In-Charge.

3.1.3 Fabrication drawings shall be prepared based on drawings issued by Engineer-In-Charge and in co-ordination with other system providers such as lighting, HVAC, Fire-fighting system components, fittings and fixtures of which are accommodated on the ceiling or above and below.

3.1.4 The ceiling system shall be sturdy, finished, levelled and aligned as per approved drawings without any undulations, sagging or other defects. Zig-zag alignment of visible supporting system or ceiling panels/ tiles shall not be permitted.

3.1.5 All components of the ceiling system shall be from the approved Manufacturers of the whole and full system only. Materials / components procured from other Manufacturers shall not be permitted.

3.1.6 The ceiling systems shall be installed by agencies approved by Engineer-In-Charge.

3.2 MINERAL FIBRE BOARD FALSE CEILING SYSTEM

The Mineral Fibre board ceiling system shall be in square grid (exposed) type with tiles having bevelled tegular edges.

3.2.1 Ceiling boards/ panels/ tiles

Ceiling boards/ panels/ tiles shall be standard product of the approved Manufacturer and as per following specification.

Sr. No.	Item/ Property	Specification
1	Base Material	Mineral Fiber
2	Panel Dimensions	600 mm x 600 mm
3	Panel Thickness	16 mm
4	Dimension tolerances	+- 0.5 mm
5	Noise Reduction co-efficient	0.55
6	Fire Properties	Class 0/1 as per BS 476 part 6/7
7	Light Reflectance	85%
8	Humidity Resistance	RH 99%

3.2.2 Suspension system

Suspension system/ framework of the ceiling system with all required components (grid work consisting of interlocked main, cross members and perimeter members etc suspended suitably from the ceiling/roof) shall be suitable/ compatible for the ceiling panels and shall be standard product of the Manufacturer and as per following specification.

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Members of the grid work shall be of galvanised steel (120 gsm on both sides as per IS: 277) mild steel, power pressed to required profile.

The exposed visible surfaces of the suspension system shall be finished with minimum 25 micron pre-painted polyester baked paint.

3.2.3 Installation

3.2.3.1 Installation of the system shall be in accordance with approved drawings, standard practice of the system Manufacturer and following specifications.

3.2.3.2 Main members shall be placed at the spacing of maximum 1200 mm securely fixed to the structural soffit using suspension arrangement (by means of threaded hanger rod and level adjuster) at 1200 mm maximum.

3.2.3.3 Cross members shall be interlocked between main runners at 600mm to form 1200 mm x 600mm module.

3.2.3.4 Short cross members shall be fixed between main runners at 600mm to form in the 1200 mm x 600 mm modules to form 600 mm x 600 mm modules.

3.2.3.5 Perimeter sections shall be secured to perimeter walls/ partitions.

3.2.3.6 Ceiling panels/ tiles shall be provided in the suspended grid work.

3.3 GYPSUM BOARD SEAMLESS FALSE CEILING SYSTEM

The gypsum board false ceiling system shall be of seamless finish.

3.3.1 Gypsum boards

Gypsum boards shall conform to IS : 2095 and shall have following properties.

Sr. No.	Item/ Property	Specification
1	Board Thickness	12.5 mm
2	Dimension tolerances	+- 0.5 mm
3	Fire Properties	Non combustible as per BS 476 part 4
4	Finishing	Acrylic emulsion paint or laminates as specified. If not specified otherwise, premium quality acrylic emulsion paint in approved colour shall be provided.

3.3.2 Suspension system

Suspension system/ framework of the ceiling system with all required components (grid work consisting of main, intermediate, cross members and perimeter members etc suspended suitably from the ceiling/ roof) shall be suitable/ compatible for the ceiling boards and shall be standard product of the Manufacturer.

The components shall be made of galvanized steel (120 gsm on both sides as per IS: 277) power pressed to required profile.

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3.3.3 Installation

3.3.3.1 Main members shall be placed at the spacing of maximum 1200 mm securely fixed to the structural soffit using suspension arrangement (by means of cleats and suspension angle member) at 1200 mm maximum.

3.3.3.2 Cross members shall be fixed main runners at the spacing of 450 mm .

3.3.3.3 Perimeter sections shall be secured to perimeter walls/ partitions.

3.3.3.4 Ceiling boards shall be fixed to the grid frame work by means of drywall screws. edges of the ceiling boards shall be jointed and finished flush with jointing tapes and compounds as recommended by the approved Manufacturer. The finished surface shall be seamless.

3.3.3.5 The ceiling board surfaces shall be finished with paint etc. as specified.

3.4 CALCIUM SILICATE BOARD FALSE CEILING SYSTEM

The Calcium Silicate board false ceiling system shall be of seamless finish by fixing the ceiling boards on the suspension system.

3.4.1 Calcium Silicate ceiling boards

The calcium Silicate ceiling boards shall be with durable tapper edge type board having following specification.

Sr. No.	Item/ Property	Specification
1	Board Thickness	8 mm
2	Dimension tolerances	+- 0.8 mm
3	Fire Properties	Class 0/1, Class A as per BS 476 part 6/7
4	Humidity Resistance	RH 99%
5	Finishing	Acrylic emulsion paint or laminates as specified. If not specified otherwise, premium quality acrylic emulsion paint in approved colour shall be provided.

3.4.2 Suspension system

Suspension system/ framework of the ceiling system with all required components (grid work consisting of main, intermediate, cross members and perimeter members etc suspended suitably from the ceiling/ roof) shall be suitable/ compatible for the ceiling boards and shall be standard product of the Manufacturer.

The components shall be made of galvanized (120 gsm on both sides as per IS: 277) mild steel, power pressed to required profile.

3.4.3 Installation

3.4.3.1 Installation of the system shall be in accordance with approved drawings, standard practice of the system Manufacturer and following specifications.

3.4.3.2 Main members of grid framework shall be suspended from the soffit @ 1200 mm maximum by means of angle hangers with nuts and bolts, angle hangers being fixed to angle cleats fixed on the soffit by means of dash fasteners.

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3.4.3.3 Intermediate members of grid framework shall be fixed to main members @ 450 mm maximum in a direction perpendicular to the main members with connecting clips.

3.4.3.4 Perimeter members shall be fixed on perimeter surfaces.

3.4.3.5 Ceiling boards shall be fixed to the grid frame work by means of drywall screws. Tapered and square edges of the ceiling boards shall be jointed and finished flush with jointing tapes and compounds as recommended by the approved Manufacturer. The finished surface shall be seamless.

3.4.3.6 The ceiling board surfaces shall be finished with paint etc. as specified.

3.5 CALCIUM SILICATE TILE FALSE CEILING SYSTEM

The Calcium Silicate tile false ceiling system shall be of square grid type laid on the suspension system.

3.5.1 Calcium Silicate ceiling tiles

The calcium Silicate ceiling tiles shall be of approved texture having following specification.

Sr.No.	Item/ Property	Specification
1	Tile thickness	8 mm
2	Tile size	595 mm x 595 mm or 610 mm x 610 mm
3	Humidity Resistance	RH 99%
4	Fire Properties	Non combustible as per BS 476, part -4 Class 1 as per BS 476 part 7
5	Finishing	Acrylic emulsion paint or laminates as specified. If not specified otherwise, premium quality acrylic emulsion paint in approved colour shall be provided.

3.5.2 Suspension system

Suspension system/ framework of the ceiling system with all required components (grid work consisting of main, cross members and perimeter members etc suspended suitably from the ceiling/ roof) shall be suitable/ compatible for the ceiling tiles and shall be standard product of the Manufacturer.

The components shall be made of galvanized (120 gsm on both sides as per IS: 277) mild steel.

Visible areas of the frame work shall be pre-painted with polyester paint.

3.5.3 Installation

3.5.3.1 Installation of the system shall be in accordance with approved drawings, standard practice of the system Manufacturer and following specifications.

3.5.3.2 Main and cross members of grid framework shall be interlocked (as required to form the square grid suitable for the tile size) and suspended from the soffit by means of slotted galvanized steel cleats, adjustable rods fixed to soffit with anchor fasteners in accordance with approved Manufacturer's standard practice.

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3.5.3.3 Perimeter members shall be fixed on perimeter surfaces.

3.5.3.4 Ceiling tiles shall be laid in the grid frame work.

3.5.3.5 The ceiling board surfaces shall be finished with paint etc. as specified.

3.6 ALUMINIUM FALSE CEILING SYSTEM (SQUARE GRID TYPE)

Aluminium false ceiling system (square grid type) shall be standard product of the approved Manufacturer, clip-in type in square grid consisting of Alumium alloy ceiling panels and suspension system.

3.6.1 Ceiling Panels

Ceiling panels shall be made of aluminium alloy AA 3003- 1114 (tempered) grade as per IS 2676 having following specification.

Sr.No.	Item/ Property	Specification
1	Panel type	Bevel edged, Perforated type with non-woven acoustical fleece
2	Panel dimension	600 mm x 600 mm
3	Panel thickness	0.7 mm
4	Dimension tolerances	+- 2 mm
5	Fire Properties	Class 0/1 as per BS 476 part 6/7 or class A2-s1, d0 according to EN 13501-1
6	Light Reflectance	63% as per ASTM 1477
7	Perforations	Hole diameter- 1.5 mm, open area- 18%, linear pitch 4.3 mm, diagonal pitch – 3 mm, border area – 9.5 mm
8	Finishing	Polyester powder coating (minimum 60 micron)
9	Salt spray test	750 hours as per ASTM B 117

3.6.2 Suspension system

Suspension system/ framework of the ceiling system with all required components (grid work consisting of main, intermediate, cross members and perimeter members etc suspended suitably from the ceiling/ roof) shall be suitable/ compatible for the ceiling boards and shall be standard product of the Manufacturer.

The components of the system shall be made of galvanized (90 gsm as per IS 277) steel and finishing shall be baked polyester paint.

3.6.3 Installation

3.6.3.1 Installation of the system shall be in accordance with approved drawings, standard practice of the system Manufacturer and following specifications.

3.6.3.2 Main members shall be placed at the spacing of maximum 1200 mm securely fixed to the structural soffit using suspension arrangement (by means of hanger wire/ threaded rod and level adjuster).

3.6.3.3 Cross members shall be interlocked between main runners to form 600 mm x 600 mm grid.

3.6.3.4 Perimeter sections shall be secured to perimeter walls/ partitions.

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3.6.3.5 Ceiling panels/ tiles shall be laid in the suspended grid work.

3.7 ALUMINIUM FALSE CEILING SYSTEM (LINEAR PLANK TYPE)

Aluminium false ceiling system (linear plank type) shall be standard product of the approved Manufacturer, single grid type in concealed system consisting of Aluminium alloy ceiling panels and suspension system.

3.7.1 Ceiling Panels

Ceiling panels shall be made of aluminium alloy AA 3105- H14 (tempered) grade as per IS 2676 having following specification.

Sr.No.	Item/ Property	Specification
1	Panel type	Perforated type with non-woven acoustical fleece with bevel edge and upturn
2	Panel dimension	150 mm (width)
3	Panel thickness	0.7 mm
4	Dimension tolerances	+- 2 mm
5	Fire Properties	Class 0/1 as per BS 476 part 6/7 or class A2-s1, d0 according to EN 13501-1
6	Light Reflectance	63% as per ASTM 1477
7	Perforations	Hole diameter- 1.5 mm, open area- 18%, linear pitch 4.3 mm, diagonal pitch – 3 mm, border area – 9.5 mm
8	Finishing	Polyester powder coating (minimum 60 micron) If not specified otherwise, premium quality acrylic emulsion paint in approved colour shall be provided.
9	Salt spray test	750 hours as per ASTM B 117

3.7.2 Suspension system

Suspension system/ framework of the ceiling system with all required components (grid work consisting of main members and perimeter members etc suspended suitably from the ceiling/ roof) shall be suitable/ compatible for the ceiling boards and shall be standard product of the Manufacturer.

The components of the system shall be made of galvanized (120 gsm as per IS 277) steel and finishing shall be baked polyester paint.

3.7.3 Installation

3.7.3.1 Installation of the system shall be in accordance with approved drawings, standard practice of the system Manufacturer and following specifications.

3.7.3.2 Main members shall be placed at the spacing of maximum 1200 mm securely fixed to the structural soffit using suspension arrangement (by means of hanger wire/ threaded rod).

3.7.3.3 Perimeter sections shall be secured to perimeter walls/ partitions.

3.7.3.4 Ceiling panels shall be clipped on to the main members of the suspended grid work.

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4.0 UNDERDECK INSULATION SYSTEM

Insulating material of underdeck insulation system shall be of glass wool boards or Polyisocyanurate (PIR) foam boards/slabs as specified in the design basis, item description, job specification drawings etc.

If nothing is mentioned specifically, glass wool boards shall be used.

4.1 POLY- ISOCYANURATE (PIR) FOAM INSULATION SYSTEM

4.1.1 Poly- Isocyanurate (PIR) foam

Poly-Isocyanurate (PIR) foam insulation shall be in the slab form with lining of glass fibre tissue or aluminium foil lining (having 50 mm overlap) on one side.

Poly-Isocyanurate (PIR) foam shall conform to IS: 12436 and shall have following specification.

Sr.No.	Item/ Property	Specification
1	Slab thickness	Minimum 30 mm
2	Density	Not less than 32 kg/ CuM
3	Thermal conductivity (K value)	Not more than 0.023 w/mk at 10 degree C
4	Fire Properties	Class 0/1 as per BS 476 part 6/7

4.1.2 Installation

4.1.2.1 Installation of the system shall be in accordance with standard practice of the approved Manufacturer`s and following specification.

4.1.2.2 Hot blown bitumen (grade 85/25) over a bituminous priming or approved cold adhesive shall be applied over the soffit and PIR board surface after cleaning the surfaces.

4.1.2.3 PIR slabs shall be pressed in position over the bitumen coat when it is still tacky or over the cold adhesive and shall be fixed to the soffit by means of approved fasteners (at four corners and at the centre of the slabs) without damaging the slabs.

4.1.2.4 Overlaps shall be covered with approved sealing compound.

4.1.2.5 The PIR shall be further secured by chicken wire mesh (24 gauge) fixed to the fasteners and tightened with lacing wire.

4.2 GLASS WOOL INSULATION SYSTEM

4.2.1 Glass wool insulation

Glass wool insulation shall be in rolls or boards and shall be pre-laminated on one side with aluminum foil.

Glass wool insulation shall conform to IS: 8183 and shall have following specification.

Sr. No.	Item/ Property	Specification
1	Thickness	Minimum 75 mm
2	Density	Not less than 24 kg/ CuM
3	Thermal conductivity (K value)	Not more than 0.034 w/mk at 25 degree C mean
4	Fire Properties	Class 0/1 as per BS 476 part 6/7

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4.2.2 Installation

4.2.2.1 Installation of the system shall be in accordance with standard practice of the approved Manufacturer's and following specification.

4.2.2.2 The insulation boards/roll shall fixed underside soffit with the help of polyamide based long insulation fasteners @ 450 mm c/c.

4.2.2.3 The joints shall be sealed with self-adhesive aluminum foil tape

5.0 FALSE (RAISED ACCESS) FLOORING SYSTEM

False flooring system shall be modular and removable type and shall consist of floor panels and supporting/ understructure system.

The system shall be factory made and the full system including all components shall be sourced from approved single Manufacturer.

The system shall be strong and durable for movement and other operations.

This specification is applicable for false floorings upto 1000 mm high.

The flooring system shall be capable of supporting following loading conditions when tested as per CISCA test procedure.

i. Concentrated load of 675 Kg. with maximum allowable deflection of 2.5mm and a factor of safety of 2.5.
ii. Uniform load of 2025 Kg/ Square meter.

For details reference shall be made to standard no 7-75-0049.

5.1 Floor panels

Sr. No.	Item/ Property	Specification
1	Material	CRCA steel with cementitious core with hemispherical and reverse cones and 1 mm thick epoxy painted CRCA steel sheet on top. The inner empty core shall be injected with light weight fire retardant non combustible cementitious compound.
2	Size	600 mm x 600 mm x 35 mm thick. (Dimensional tolerance : +- 0.8 mm).
3	Finishing	Top sheet shall be finished with 2 mm thick high pressure laminate or 2 mm thick conductive PVC or stone or other type of tiles as specified. If nothing is mentioned specifically, high pressure laminate shall be provided.
4	Edging	All edges of the panels shall have conductive PVC trims
5	Fire resistance/ property	Class 0 & class 1 conforming to BS 476-part-6 (Fire propagation) and BS 476-part-7 (Surface spread of flame).

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5.2 Understructure/ supporting system

False floor understructure shall be installed to support the panels and shall be suitable to achieve required cavity height from the existing floor level. The system shall ensure speedy assembly and removal for relocation and maintenance. The system shall also ensure easy adjustment of levelling (±25mm) and accurate alignment of panels in the vertical direction.
False floor understructure shall consist of Base plate, pedestals, pedestal head assembly, stringers and necessary fittings, fixtures and accessories as specified below.

Sr. No.	Item/ Property	Specification
1	Pedestal Base Assembly	Powder coated, hot dip galvanized (60-80 micron) mild steel base plate with not less than 150mm x 150mm x 4 mm of bearing area, mechanically riveted to a 32mm dia. of 2 mm thick CRCA steel pedestal designed to engage the head assembly
2	Pedestal Head Assembly	Zinc electroplated CRCA steel pedestal head assembly shall be 90mm x 90mm x 4 mm thick profiled head, mechanically riveted to a 19 mm dia. threaded bright rod, fixed to pedestal by specially designed zinc electroplated steel forged adjusting nut for leveling, locking and changing the height setting.
3	Stringers	Stringers shall be of hot dip galvanized (60-80 microns) steel, minimum 20mm x 32mm x 1.20mm thick CRCA steel.

5.3 Installation

5.3.1 False flooring systems shall be installed by agencies approved by Engineer-In-Charge.

5.3.2 False flooring systems shall be installed at desired heights and levels in designs, patterns and shapes in accordance with approved fabrication drawings. Fabrication drawings shall be prepared and submitted by the Contractor and approved by Engineer-In-Charge.

5.3.3 Fabrication drawings shall be prepared based on drawings issued by Engineer-In-Charge and in co-ordination with other system providers such as which are accommodated in the cavity of the false flooring.

5.3.4 Installation shall be done in accordance with approved system Manufaturer's standard practice, as directed by the Engineer-In-Charge and as mentioned below:

5.3.5 Installation of under structure

a) The base floor and cavity between false flooring and base floor shall be properly cleaned and made dust free and dry. The base cement concrete floor shall be treated with one component polyurethane based coating.

b) Pedestal base assembly shall be fixed to the base floor by fixing base plates to the base floor by minimum 50mm x 8mm anchor fasteners (4 nos. for each plate).

c) The pedestal stud locations shall ensure the grid work as per flooring pattern which in general shall be of 600 mm x 600 mm dimension. The length of the pedestal studs shall be such that clear cavity between false flooring and base flooring is of desired depth. Additional pedestals as needed to support panels where floor is disrupted by columns, walls and cutouts shall be provided. Perimeter pedestal studs shall be provided along the periphery. Pedestal assemblies including pedestal heads shall be weld-free construction, corrosive resistant and shall provide an adjustment range of ±25mm from the specified finished floor heights.

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d) The threaded bright rod with the top head attachments shall be inserted into the studs and shall be adjusted to obtain proper level of the finished floor panels by means of the adjustment nut. The nut shall provide location lugs to engage the pedestal base assembly, such that deliberate action is required to change the height setting. Threaded rod shall provide a specially designed anti-rotation device, such that when the head assembly is engaged in the base assembly, the head cannot freely rotate.

e) The pedestal head shall have an anti vibration PVC cap for panel and stringer location. Stringers shall support each edge of panel. The stringers shall have counter sunk holes at both ends to accommodate bolting of M6 machine screws to the pedestal head assembly. Stringers shall be individually and rigidly fastened to the pedestal with one machine screw for each end of stringer. Bolts shall provide positive electrical contact between the stringers and pedestals. Stringer grid shall ensure maximum lateral stability in all directions. All the field cut panels shall be installed with an appropriate PVC end cap specially designed to accommodate the stinger and arrest Panel beam movement and will ensure the integrity and stability of the system.

5.3.6 Installation of floor panels

a) Floor panels shall be placed over the stringer channels and bolted to pedestal head. All four edges of panels shall be finished with black conductive 5mm wide PVC edge beadings. These edge beadings are glued and sealed in place to avoid detachment.

Floor panels which are field cut (at ends, Console/ Rack location etc.) shall be marked with positional numbering on the underneath and the adjoining wall. The finished floor panels shall be perfectly levelled and aligned without any gaps in between the panels.

b) All accessories such as outlet boxes and grommets as required, Panel lifters (at least one for each building, one number for every 500 Square meter of access floor area) etc. shall be provided in accordance with approved Manufacturer's recommendations.

c) Each individual panel shall be removable for the purpose of maintenance of the cavity. Panel shall be easily removed by one person with a lifting device and shall be fully transferable and totally inter changeable and replaceable in any of the 4 directions at 90 degrees increments, except where cut for special conditions.

d) Necessary cut-outs shall be made in the panels for cable routing, control panel fixation etc. as per drawing.

e) Necessary ramps, slopes, steps etc. shall be also provided for as per drawing with raised access floor components as per approved manufacturer recommendations..

f) Around a control panel/rack, the residual space left out shall be filled up with cut panels of uniform size as required to fully close the gap between the adjacent full panel and the control panel base channel. In this case the part floor panel shall extend upto the full width of the base channel and the cut size shall be determined accordingly. An additional structural steel framework shall be provided along the cut out on which the edge of the floor panel shall rest and over which the base channel of control panel shall be placed.

g) Earth bonding of the system shall be in accordance with approved Manufacturer's standard practice as approved by the Engineer-In- Charge. After completion of the floor and association services, tests shall be arranged to demonstrate that the floor is electrically continuous and fully earth bonded. Points chosen for testing shall include randomly selected pedestals, stringers tops and bottoms of panels, etc.

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6.0 PARTITIONING

Partitioning shall rigid, stable, true to the plumb and in accordance with design and approved drawings for all heights.

6.1 GYPSUM BOARD PARTITIONING

Partitioning shall be of gypsum partition boards fixed on galvanized steel frame work. The partitions shall be rigid and stable.

6.1.1 Gypsum partition boards

Gypsum partition boards shall conform to IS : 2095 and shall have following properties. Overall thickness of the finished partition shall be minimum 75 mm.

Sr. No.	Item/ Property	Specification
1	Board Thickness	12.5 mm
2	Dimension tolerances	+- 0.5 mm
3	Fire Properties	Non combustible as per BS 476 part 4

6.1.2 Partition frame

Partition framework shall be in accordance with standard system of the approved Manufacturer and shall consist of profiled floor & ceiling sections and vertical sections of power pressed/ roll formed galvanized steel (minimum 120 gsm, both side inclusive as per IS:277). Minimum thickness of the sections shall be 0.5 mm.

6.1.3 Installation

6.1.3.1 Installation of the system shall be in accordance with standard practice of the approved Manufacturer's, approved fabrication drawings (prepared by the Contractor) and following specification.

6.1.3.2 Thickness, size, spacing of the frame sections shall be as required for desired height in accordance with recommendations/ standard practice of the approved Manufacturer.

6.1.3.3 Floor and ceiling sections shall be fixed with fasteners of 12.5 mm diameter, 50 mm length @ 600 mm c/c. Vertical sections shall be fixed in the floor and ceiling sections @ 610 mm c/c.

6.1.3.4 Gypsum partition boards shall be fixed on both sides of the framework by drywall screws @ 300 mm c/c.

6.1.3.5 All vertical and horizontal joints of the boards shall be staggered to avoid cracks with provisions of galvanized steel sections fixed to the vertical sections at the horizontal joints of the boards.

6.1.3.6 The jointing and finishing of the boards shall be finished using approved jointing compound, paper tape, metal corner tapes etc. and two coats of primer suitable for the boards.

6.1.3.7 Arrangements of wires/ conduits running through the cavity of the system shall be made. Cut/outs, openings for doors, windows, switches etc. shall be made with necessary framing/ stiffening of the openings.

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6.1.3.8 Gypsum plaster boards on both sides of the partition frame shall be finished with painting or laminates etc. as specified. If finishing type is not specifically mentioned anywhere, acrylic emulsion paint finish conforming to specification of masonry paint finish in adjoining masonry shall be provided in approved colour

7.0 MEASUREMENT

7.1 Measurement of false/ suspended ceiling system shall be measurement of actual surface area covered by the ceiling boards/ panels/ tiles.

7.2 Measurement of underdeck insulation system shall be measurement of actual surface area covered by insulation slab/ roll/ board.

7.3 Measurement of false/ raised floor system shall be measurement of actual surface area covered by floor panels.

7.4 Measurement of partitioning system shall be measurement of actual surface area covered by partition boards of one side.

7.5 Area of cut out/ openings for door/ window, various fittings etc. shall be deducted.

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अग्निरोधक दरवाजों, खिड़कियों व पार्टीशन के लिए मानक विनिर्देशन

STANDARD SPECIFICATIONS FOR FIRE CHECK/ FIRE RESISTANT DOORS, WINDOWS & PARTITIONS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
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Abbreviations:

ASTM	: American Society for Testing and Materials
BS	: British Standards
CBRI	: Central Building Research Institute
EN	: European Standards
IS	: Indian Standard
ISO	: International Organization for Standardization
GI	: Galvanized Iron
NABL	: National Accreditation Board for Testing and Calibration Laboratories
NBC	: National building Code
NFPA	: National Fire Protection Association
PVC	: Polyvinyl Chloride
PUF	: Polyurethane foam
SS	: Stainless Steel
UL	: Underwriters Laboratories
CuM	: Cubic Meter

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1.0 GENERAL

This standard specification lays down requirements of fire rated/ check/ resistant door, window and partition assemblies intended to provide safety and safe exit from buildings in case of fire.

2.0 REFERENCES

2.1 The codes and standards listed below contain provisions which through reference in this specification constitute provisions of this standard specification if not specifically mentioned otherwise.

2.2 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NFPA, NBC etc. conformity with any of the similar codes is acceptable.

2.3 Reference codes and standards:

Standards	Document title
IS 2095, Part-1	Gypsum plaster boards – plain gypsum plaster boards
IS 3614	Fire Doors and Doorsets - Specification
IS 16945 IS 16947	Fire resistance test for glass walls Fire resistance tests for doors with glass panes, openable glass, glass windows and sliding glass doors
IS 277	Galvanized steel sheets (plain and corrugated)-Specification
IS 287	Permissible moisture content for timber used for different purposes-Recommendations
IS 513	Cold reduced low carbon Steel sheet and strip
IS 8183	Bonded Mineral Wool - Specification
IS 14862	Fibre Cement Flat Sheets — Specification
BS 476, Part- 4	Fire tests on building materials and structures. Non-combustibility test for Materials.
BS 476, Part- 7	Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products.
BS 476, Part- 20	Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction. (general principles).
BS 476, Part- 22	Fire tests on building materials and structures. Method for determination of the fire resistance of non-load bearing elements of construction.
BS 6206	Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings.
SP-7 (Part-40)	National Building Code of India – part-4 – Fire & life safety
EN-1363-1	Fire resistance tests. General requirements
EN-1364-1	Fire resistance tests for non-load bearing elements. Walls
EN 1634-1	Fire resistance and smoke control tests for door and shutter assemblies, openable windows and elements of building hardware. Fire resistance test for door and shutter assemblies and openable windows
EN 10346	Continuously Hot Dip Coated Steel Strip And Sheet Products.
EN 12600	Specification for impact performance requirements for flat safety glass and safety plastics for use in buildings.
ISO 834-1	Fire resistance tests: Elements of Building construction- General requirement.
ISO 3008	Fire resistance tests: Door and shutter assemblies, Part 1: General requirements.
ISO 3009-1	Fire-resistance tests: Elements of building construction: Glazed elements.

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3.0 FIRE CHECK/ RESISTANT/ RATED DOORS, WINDOWS & PARTITIONS

3.1 Fire check/ resistant/ rated door, window & partition assemblies (termed as "Fire doors, windows, partitions" hereafter) shall be of fire resistance/ rating and type (wooden/ metallic/ glazed etc.) mentioned in the drawings, job specification, item descriptions etc. and shall be complete assembly with frame, shutter/ leaves, glazing, partition panel, hardware etc.

3.2 If type and fire resistance/ fire rating is not specifically mentioned in the drawings, job specification, item descriptions etc., following types of fire doors/ windows/ partitions shall be provided.

Doors:

Steel fire doors having fire resistance/ fire rating of two hours (120 minutes) for Integrity and 30 minutes for insulation.

Windows:

Fully glazed fire windows having fire resistance/ fire rating of two hours (120 minutes) for Integrity and 20 minutes for insulation.

Partitions:

Solid type fire partitions made of calcium silicate board having fire resistance/ fire rating of two hours (120 minutes) for Integrity and insulation.

3.3 The fire doors, windows and partitions shall be in accordance with test certificate or test validity or evaluation report or assessment report (termed as "test report" hereafter) with regards to fire resistance/ rating, material, design, construction, dimension, sizes etc. and shall be complete assembly with frame, shutter/ leaf, glazing, partition panels and hardware.

3.4 Each Fire door, window & partition shall be provided with appropriate label mentioning name of the Manufacturer, fire rating, and year of Manufacturing/ installation.

4.0 TESTING AND CERTIFICATION

4.0 Prototype/ type test repot shall be submitted for each type (such as wooden, steel, glazed etc.), size range and fire resistance / rating of fire doors, windows and partitions.

4.1 Testing for fire resistance / rating of steel and wooden doors shall be done by subjecting a full size construction to test in accordance with the procedures laid down in ISO 3008 or BS 476: part 22.

4.2 Testing for fire resistance/rating of glazed doors, windows and partitions shall be done by subjecting a full size construction to test in accordance with the procedures laid down in following codes as applicable:

1. EN 1634-1
2. EN-1364-1
3. ISO 3009
4. BS 476 ; part 20, part 22
5. IS 16945
6. IS 16947

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4.4 Testing for fire resistance / rating of solid type partition shall be done by subjecting a full size construction to test in accordance with the procedures laid down in BS 476 : part 20 and part 22.

4.5 Hardware if not tested with the door/ window/ partition, shall be type tested or shall be certified for use on specified fire rated door/ window/ partitions.

4.6 These prototype/ type test reports shall be issued by CBRI or NABL accredited laboratories or renowned National/ International Laboratories/ Test houses. Certifications of hardware shall be by renowned national/ international certification agencies.

4.7 The prototype/ type test certificate/ certifications etc. shall be valid at the time of submission and shall not be older than five years and shall be submitted by the supplier or manufacturer.

4.8 In case of change in design, material, construction, increase in dimensions (width, breadth, height, overall perimeter) or area of the complete assembly (including frame, shutter/leaves, glazing, partition panels and other individual components) as mentioned in the submitted prototype/ type test report, test reports appropriate to the changes shall be submitted.

4.9 However, refer to specific clauses of this specification pertaining to various type of doors, windows and partitions for allowable changes with respect to clause no 4.8

5.0 MATERIAL

5.1 Timber

Timber and timber boards/ composite material used in the construction of the fire doors shall be of thoroughly seasoned hardwood. The moisture content of any material used in the construction including frame and shutter shall not be more than 15 percent, in accordance with IS 287.

5.2 Calcium Silicate board

Calcium Silicate board shall conform to IS 14862 and shall have following properties:

Density	Not more than 900 kg/ cuM
Material class	Non-combustible, in accordance with BS 476: Part 4
Surface spread of flame	Class 1 in accordance with BS 476: Part 7
Thermal conductivity	K factor - 0.15W/mK
Nominal Mixture content (air-dried)	<15%

5.3 Fire Resistant Gypsum plaster board

Fire Resistant Gypsum Plaster boards shall conform to IS 2095 Part I and BS- 1230 (Part-1). Density shall be minimum 960 Kg/cuM (+/- 50).

5.4 Galvanized steel sheet

Galvanized steel sheet shall be zinc coated, alloyed type and shall conform to IS 277. The coating weight shall meet or exceed the minimum requirements for coatings of 120 gram/ square meter, total of both sides.

5.5 Cold rolled low carbon steel sheet

Cold rolled low carbon steel sheets shall conform to IS 513 or EN 10346. Drawing quality shall be DX52D and shall have following properties:

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Property	Value
Yield strength	Minimum 255 MPa
Tensile strength	Minimum 350 Mpa
Elongation	Minimum 38.5 %

5.6 Glass

The glass panels shall be clear, non-wired, interlayered and toughened type suitable for required fire rating/ resistance of the door/ window / partition assembly.

Each Glass panel shall carry a non-removable marking with the name of the product & the manufacturer inscribed on it.

Thickness of glass lesser than the thickness mentioned in the test report shall not be permitted.

Increase in width, height and overall area of the glass, when compared to dimensions mentioned in the test report shall also be not permitted.

Make, size and thickness of the glass panels shall be as mentioned in the test report for required assembly (door/ window/ partition) of required fire rating and shall have following properties.

Property	Value
Impact resistance	Minimum 2B2 category (When tested in accordance with EN 12600)
Light transmission ratio	Minimum 85% (When tested in accordance with EN 410)

5.7 Insulation

Insulation or infill material shall be resin bonded like resin bonded honeycomb paper core, mineral wool or ceramic wool as mentioned in the test report. Proprietary material may be used, provided they satisfy the requirement of fire resistance/ rating and is mentioned in the test certificate.

Polyurethane foam (PUF) shall not be permitted as infill or insulation material.

Mineral wool and Rock Wool used for insulation shall conform to IS 8183 and density shall be minimum 48Kg/ CuM. Higher density of insulation is permitted.

5.8 Fire & smoke seal

Fire & smoke seals shall be of the same dimensions and configuration as mentioned in the test report.

6.0 WOODEN FIRE DOORS

6.1 Wooden fire doors shall conform to IS: 3614 and this specification. In case of contradiction, this specification or decision by Engineer- In-Charge shall govern.

6.2 Door assembly

6.2.1 The door assembly including door frame, shutter/ leaf, insulation, fire & smoke seal etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/

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rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

6.2.2 Door frame

Door frames shall be of first grade teakwood and shall be fixed in position by means of anchor fasteners on jambs and head member. Sizes and profiles of the members of the frames shall be as mentioned in the test report. Intumescent fire and smoke seal shall be fitted in the frame in accordance with test certificate.

6.2.3 Door shutter/ leaves

Door shutters/ leaves shall be non-metallic and asbestos free type. They shall be composed of Calcium Silicate boards on both sides and insulation core. Overall thickness of the shutter, thickness of insulation and thickness of calcium silicate boards shall be as mentioned in the test report.

The shutter composition shall have painted/ polished teak wood lipping around the periphery fitted with intumescent fire & smoke seal in accordance with test certificate. The intumescent fire seal may not be required at the bottom of the door leaf.

If not mentioned otherwise, vision panels shall be provided in the door shutters.

6.3 Finishing

The door frames and teak wood lipping around the periphery of the shutters shall be finished with approved quality fire resistant paint conforming to IS 12777 including primer in desired colour.

Both sides of the door shutters/ leaves shall be faced with 3mm thick commercial ply finished with either 1mm thick laminate of approved color, texture and design, or teak ply (finished with fire retardant transparent paint conforming to IS 12777) as mentioned in the drawings, job specification, item descriptions etc.

If finishing of door shutter/ leaf is not specifically mentioned in the drawings, job specification, item descriptions etc., laminate finishing shall be provided.

6.4 Hardware

Reference shall be made to clause no 13.0

6.5 Fire resistance/ rating

If not mentioned otherwise, wooden fire doors shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and 30 minutes for insulation.

7.0 STEEL FIRE DOORS

7.1 Steel fire doors shall conform to IS: 3614 and this specification. In case of contradiction, this specification or decision by Engineer- In-Charge shall govern.

7.2 Door assembly

7.2.1 The door assembly including door frame, shutter/ leaf, insulation, fire/smoke seal etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/

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rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

7.2.2 Door frame

Door frames shall be of galvanized steel sheet press formed to required profile. The minimum sheet thickness for frames shall be 1.2 mm (18 gauge) for frame depth upto 150mm. for depth of frame higher than 150 mm, minimum sheet thickness shall be 1.6 mm (16 gauge).

Dimensions and profile of the door frames shall be as mentioned in the test report. However, increase in sheet thickness and frame profile size (compared to the test certificate) is permitted

Door frame shall be provided with stiffeners for hardware/ lock mounting and for fixing of fasteners. Necessary provisions for fixing fire/ smoke seal shall also be kept in the frame.

Hollow door frames shall be filled up with insulation as and if mentioned in the test certificate. Even if the insulation filling is not mentioned in the test certificate, such filling is permitted.

Door frames shall be fixed in position by means of anchor fasteners on jambs and head member.

7.2.3 Door Shutter/ leaf

Door shutters shall be minimum 45 mm thick with outer skins made of minimum 1.2 mm (18 gauge) thick galvanized steel sheet with infill/ insulation. Internal construction of the shutter shall be provided with rigid reinforcement in addition to the core/ infill. Rigid reinforcement pads shall be provided for receiving hardware like hinges, locks, door closers etc.

Higher thickness of the outer screens (compared to the test certificate) is permitted.

Double leaf shutters shall be provided with astragals.

Intumescent seals shall be provided on all three sides of the leaves and on the meeting stiles of the double leaf door or as per test certificate. Alternatively, the same can provided on the frame and meeting stile of the double leaf door.

If not mentioned otherwise, vision panels shall be provided in the shutters/ leaves.

Louvers shall be provided in the shutters/ leaves if mentioned specifically and test report of the doors with louver is available.

7.3 Finishing

The frame and the shutters shall be finished with minimum 50 microns powder coating in desired colour.

7.4 Fire resistance/ rating

If not mentioned otherwise, steel fire doors shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and 30 minutes for insulation.

7.5 Hardware

Reference shall be made to clause no 13.0.

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8.0 VISION PANEL

Glass for vision panels shall be in accordance with test certificate Maximum area of vision panel shall be 0.06 square meter. Maximum width shall be 200 mm, maximum height shall be 400mm.

In case of change in glass with respect to test report, the changed glass shall be appropriate to the specified fire resistance/ rating and supporting test report of the changed glass shall be submitted.

9.0 LOUVERS

Louvers shall be in accordance with test certificate when tested as a complete assembly on the fire door. Maximum area of the louvers shall not exceed 0.135 square metre. Maximum width and height shall be 300 mm and 450 mm respectively.

10.0 GLAZED FIRE DOORS

10.1 Door assembly

10.1.1 The door assembly including door frame, shutter/ leaf, stiles, rails, glazing, insulation, fire/smoke seal etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/ rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

10.1.2 The glazed fire doors shall be fully glazed type with required frame, shutter/ leaf, stiles, top and bottom rails, insulation, fire & smoke seal, hardware etc. Intermediate middle/ lock rails shall not be provided.

10.1.3 Door Frame

Door frame shall be either of galvanized steel sheet or cold rolled low carbon steel sheet press formed to requisite profile.

Minimum thickness of galvanized steel sheet for frames shall be 1.2 mm (18 gauge) for frame depth upto 150mm. for depth of frame higher than 150 mm, minimum sheet thickness shall be 1.6 mm (16 gauge).

Minimum thickness of cold rolled low carbon steel sheet for frames shall be 1.5 mm.

However, increase in steel sheet thickness (compared to the test certificate) is permitted.

Dimensions and profile of the door frames and frame members shall be as mentioned in the test report. Increase or reduction in dimensions and change in profile when compared to the test report shall not be permitted.

Hollow door frames shall be filled up with insulation as and if mentioned in the test certificate. Even if the insulation filling is not mentioned in the test certificate, such filling is permitted.

Door frame shall be provided with stiffeners for hardware/ lock mounting and for fixing of fasteners. Necessary provisions for fixing fire & smoke seal shall also be kept in the frame.

Door frames shall be fixed in position by means of anchor fasteners on jambs and head member.

10.1.4 Door Shutter/ leaf

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The shutter/ leaf frame (stiles and rails) shall be shall be either of galvanized steel sheet or cold rolled low carbon steel sheet press formed to requisite profile. Thickness of steel sheet shall be minimum 1.2 mm.

Dimensions and profile of the stiles and rails shall be as mentioned in the test report. Increase in dimensions and change in profile when compared to the test report shall not be permitted.

However, increase in steel sheet thickness (compared to the test certificate) is permitted.

Width of the stile and rail shall not exceed 100mm. In case of bottom rail width/ height may be upto 125mm.

Intermediate middle/ lock rails shall not be provided.

Hollow sections of stiles and rails shall be filled up with insulation as and if mentioned in the test certificate. Even if the insulation filling is not mentioned in the test certificate, such filling is permitted.

Glass shall be single piece and increase in glass panel size compared to the size mentioned in the test report shall not be permitted. Glass shall be fixed with beading, clips/ screw etc. in accordance with test reports.

10.2 Finishing

The frame and the shutters/ leaves shall be finished with minimum 50 microns powder coating in desired colour.

10.3 Hardware

Reference shall be made to clause no 13.0.

10.4 Fire resistance/ rating

If not mentioned otherwise, glazed fire doors shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and 20 minutes for insulation.

11.0 GLAZED FIRE WINDOW

11.1 Window assembly

11.1.1 The window assembly including frame, glazing, insulation, fire/smoke seal etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/ rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

11.1.2 Specification of window frame shall be similar to the specification of door frame as mentioned in clause 10.0

11.1.3 The glazed fire windows shall be fully glazed type (fixed glazing) with required frame, hardware etc. Glass shall be single piece and increase in glass panel size compared to the size mentioned in the test report shall not be permitted. Glass shall be fixed with beading, clips etc. in accordance with test reports.

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11.2 Finishing

The frame shall be finished with minimum 50 microns powder coating in desired colour.

11.3 Fire resistance/ rating

If not mentioned otherwise, glazed fire doors shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and 20 minutes for insulation.

12.0 GLAZED FIRE PARTITION

12.1 Partition assembly

12.1.1 The partition assembly shall consist of metal framework and glass panels in accordance with approved design and pattern.

12.1.2 The partition assembly including frame, glazing, insulation etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/ rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

12.1.3 Glazed fire partitions shall be fully glazed unless otherwise mentioned specifically. Specification of partition frame shall be similar to the specifications of door frame mentioned in clause no 10.0. Specification of glass shall be as mentioned in clause 5.5.

12.1.4 Glass shall be single piece in a panel and increase in glass size compared to the size mentioned in the test report shall not be permitted. Glass shall be fixed with beading, clips/ screws etc. in accordance with test reports.

12.1.5 Size of individual glass panels and overall size of the partition shall not exceed the sizes mentioned in the test report.

12.1.6 The partition shall cover the full height and length mentioned in the drawing etc and shall be fixed on top and bottom also. In case, the height and length mentioned in the drawing etc are more when compared to the test report, solid type partition or other construction having fire rating (120 minutes for both integrity and insulation) shall be provided as/ approved design so that dimensions of both glazed and solid partition/ other construction do not exceed the dimensions mentioned in the test report.

12.1.7 Doors provided in this partition system shall also be fire rated and shall meet the requirements mentioned in relevant causes in this specification.

12.1.8 The partition assembly shall be sturdy, rigid, stable and shall be installed plumb in true alignment.

12.2 Finishing

The partition frame shall be finished with minimum 50 microns powder coating in desired colour.

12.3 Fire resistance/ rating

If not mentioned otherwise, glazed fire partitions shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and 20 minutes for insulation.

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13.0 HARDWARE

13.1 Fire Doors, windows and partitions shall be provided with all required hardware for stability, proper operability and safety ensuring the fire resistance / rating.

13.2 All hardware used on Fire doors, windows and partitions shall be fire rated and certified except for hinges, if it is of minimum 100 mm x 75 mm x 3 mm size and in stainless steel of grade 304 and above. Similarly, pull handles may not require specific fire rating if it is in stainless steel of grade SS 304 and above.

13.3 All other hardware like locks, panic devices, lever handles, door closers etc. if not tested with the fire door, window or partition shall be type tested and certified for use on those specific fire rated doors, windows and partitions.

13.4 Tower/ flush bolts, Aldrops, side bolts and chain with padlocks shall not be provided in Fire doors. However, in case of double shutter/ leaf doors without panic bar, tower/ flush bolts shall be provided on inactive leaf.

13.6 Fire doors in exits (component of means of egress which is between the exit access and the exit discharge), doors opening into exits, staircase enclosure, exit access and exit discharge shall be provided with following hardware.

Sr. No	Hardware	Specific requirement
1	Hinges	Hinges shall be as per test report, If not mentioned in the test report, hinges shall be as per Manufacturer's standard practice. No. of hinges : 1. For doors upto 2400 mm height 04 Nos per leaf 2. For doors above 2400 mm height as per Manufacturer's practice.
2	Panic Bar	1. For single leaf door : - Single point panic bar "push to open" push bar, single leaf type 01 No. 2. For active leaf of double leaf door : - Single point panic bar "push to open" push bar type 01 No. 3. For inactive leaf of double leaf door Openable locks, trims with handle for panic bars to operate the bar from outside shall also be provided.
3	Door closer	Heavy duty type - 01 No. per leaf
4	Door Stopper	Floor mounted, 45 mm dia, half dome in SS 304 grade - 01 No. per leaf
5	Flush/ Tower bolt	Not required for Doors with Panic Bar, in case of double shutter/ leaf doors without panic bar, SS 304 grade, minimum 300mm long concealed tower/ flush bolts shall be provided on inactive leaf at top and bottom.

13.7 Internal fire doors which are not in the exits and do not open into the exits shall be provided with following hardware.

Sr. No	Hardware	Specific requirement
1	Hinges	Hinges shall be as per test report, If not mentioned in the test report, hinges shall be as per Manufacturer's standard practice. No. of hinges : 1. For doors upto 2400 mm height - 04 Nos per leaf 2. For doors above 2400 mm height – as per Manufacturer's

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		practice.
2	Mortice lock	Heavy duty mortice dead lock and D type (SS 304 grade, minimum length 300mm and 22mm dia) handle on both faces (Offset type handle For all Glazed fire doors) Note: Instead of door handle with mortice dead lock, SS 304 grade lever handle with mortice sash lock on both faces (Offset type handle For all Glazed fire doors) may be used.
3	Door closer	Heavy duty type - 01 No. per leaf
4	Door Stopper	Floor mounted, 45 mm dia, half dome in SS 304 grade - 01 No. per leaf
5	Flush/ Tower bolt	SS 304 grade minimum 300mm long concealed flush bolt (in inactive shutter of double shutter Doors) at top and bottom.

14.0 SOLID TYPE FIRE PARTITION (Calcium Silicate)

14.1 Partition assembly

14.1.1 The partition assembly shall be made of frame work of galvanized steel or cold rolled low carbon steel sheet profiled horizontal and vertical members, layers of calcium silicate partition boards on both sides and insulation in-fill all as mentioned in the test report in accordance with approved design and pattern. However, increase (when compared to test certificate) in sheet thickness or profile size of steel sections, thickness of insulation, thickness and number of layers of partition) is permitted.

14.1.2 The partition assembly including frame, partition boards, insulation, fire & smoke seal etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/ rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

14.1.3 Overall size of the partition shall not exceed the sizes mentioned in the test report.

14.1.4 Doors and windows provided in this partition system shall also be fire rated and shall meet the requirements mentioned in relevant causes in this specification.

14.1.5 The partition framework shall comprise of vertical studs, intermediate horizontal members, floor and ceiling channels as mentioned in test certificates with regards to material, sizes, thickness, spacing etc.

14.1.6 Minimum thickness of the calcium silicate boards shall be 12mm.

14.1.7 The board's joints shall be staggered, horizontally as well as vertically, to avoid through passage.

14.1.8 Minimum thickness of insulation shall be 50 mm. Insulation material, density etc. shall be as mentioned in test certificates.

14.1.9 Over all thickness of the partition shall not be less than 93 mm and shall be as mentioned in the as mentioned in test certificates. Increase in the thickness is permitted.

14.1.10 If mentioned specifically, this partition system may be used in combination of fire rated glazed partition system with suitable detailing for combining these two partition systems.

14.1.11 The partition assembly shall be sturdy, rigid, stable and shall be installed plumb in true alignment.

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14.2 Finishing

14.2.1 Calcium Silicate partition boards on both sides of the partition frame shall be finished with painting or laminates etc. as specified.

14.2.2 If finishing type is not specifically mentioned anywhere, acrylic emulsion paint finish conforming to specification of masonry paint finish in adjoining masonry shall be provided in approved colour.

14.2.3 The calcium silicate boards shall be jointed and finished with jointing compound, fibre tape etc. so as to have a flush and even look after finishing.

14.2.4 Any cut-out (such as for switchbox, AC duct etc.), gap in the periphery on the partition and joints between structural member and partition shall be properly sealed with fire sealant as mentioned in the test certificates or in accordance with Partition manufacturer's standard practice.

14.3 Fire resistance/ rating

If not mentioned otherwise, solid type partitions shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and insulation.

15.0 SOLID TYPE FIRE PARTITION (Gypsum Plaster Board)

15.1 Partition assembly

15.1.1 The partition assembly shall be made of frame work of galvanized steel or cold rolled low carbon steel sheet profiled horizontal and vertical members, layers of fire resistant Gypsum plaster boards on both sides and insulation in-fill all as mentioned in the test report in accordance with approved design and pattern. However, increase (when compared to test certificate) in sheet thickness or profile size of steel sections, thickness of insulation, thickness and number of layers of partition) is permitted.

15.1.2 The partition assembly including frame, partition boards, insulation, fire & smoke seal etc. shall be in accordance with test report which is appropriate to the required type, size and fire resistance/ rating (with regards to material, design, construction, dimensions, size range etc.) and following specification.

15.1.3 Overall size of the partition shall not exceed the sizes mentioned in the test report.

15.1.4 Doors and windows provided in this partition system shall also be fire rated and shall meet the requirements mentioned in relevant causes in this specification.

15.1.5 The partition framework shall comprise of vertical studs, intermediate horizontal members, floor and ceiling channels as mentioned in test certificates with regards to material, sizes, thickness, spacing etc.

15.1.6 Minimum thickness of the fire resistant Gypsum plaster boards shall be 12.5 mm.

15.1.7 The board's joints shall be staggered, horizontally as well as vertically, to avoid through passage.

15.1.8 Minimum thickness of insulation shall be 50 mm. Insulation material, density etc. shall be as mentioned in test certificates.

15.1.9 Even if insulation in-fill is not mentioned in the test certificate, minimum 50 mm thick insulation of density 48kg/cuM shall be provided in the cavity of the framework.

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15.1.10 Over all thickness of the partition shall not be less than 102 mm and shall be as mentioned in the as mentioned in test certificates. Increase in the thickness is permitted.

15.1.11 If mentioned specifically, this partition system may be used in combination of fire rated glazed partition system with suitable detailing for combining these two partition systems.

15.1.12 The partition assembly shall be sturdy, rigid, stable and shall be installed plumb in true alignment.

15.2 Finishing

15.2.1 Gypsum plaster boards on both sides shall be sealed with paper tape, corner edges with metal corner tape and with three-layers of all purpose jointing compound to reinforce the board joints so as to have a flush and even look.

15.2.2 Gypsum plaster boards on both sides of the partition frame shall be finished with painting or laminates etc. as specified.

15.2.2 If finishing type is not specifically mentioned anywhere, acrylic emulsion paint finish conforming to specification of masonry paint finish in adjoining masonry shall be provided in approved colour.

15.2.4 Any cut-out (such as for switchbox, AC duct etc.), gap in the periphery on the partition and joints between structural member and partition shall be properly sealed with fire sealant as mentioned in the test certificates or in accordance with Partition manufacturer's standard practice.

15.3 Fire resistance/ rating

If not mentioned otherwise, solid type partitions shall have fire resistance/ fire rating of two hours (120 minutes) for integrity and insulation.

16.0 INSTALLATION

16.1 Shop drawings of the Fire doors, windows and partitions in accordance to the prototype/ type test report and design drawings shall be prepared and submitted for approval by the Engineer-In-Charge. The shop drawings shall include all details of construction, anchoring, connections, fastenings etc. The fire doors, windows, partitions shall be fabricated in accordance with the approved shop drawings.

16.2 Fire doors, windows, partitions shall be installed by the Manufacturer or agency recommended by the Manufacturer and approved by the Engineer- In-Charge.

16.3 Frames shall be installed plumb, level, rigid and in true alignment and shall be fixed to the adjacent construction so as to retain their position and stability. Fixing of the frames with masonry/ concrete may be done with suitable fasteners. The complete assemblies shall also be installed plumb, level, rigid and in true alignment.

16.4 The maximum allowable gap between the frame and masonry/ concrete work shall not be more than 5-8 mm and shall be sealed with sealant as mentioned in the test certificates/codes & standards or in accordance with the manufacturer's standard practice if not mentioned in the certificates and codes/ standards.

16.5 The door shutters/ leaves, window and partition panels shall be installed and fastened to maintain alignment with frames to achieve maximum operational effectiveness and appearance.

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16.6 Installation of hardware shall be in accordance with hardware Manufacturer's recommendations.

16.7 When the smoke/ fire/ intumescent seals are fitted on site, they shall be fitted strictly in accordance with the Manufacturer's recommendations.

17.0 DELIVERABLES BY THE CONTRACTOR

Following documentation/ drawings shall be furnished by the Manufacturer:

1. Prototype/ type Test Certificate of the door, window and partition assembly from test laboratory/ house.
2. Shop drawings.
3. Specification/ Manufacturer's literature, Test certificates and other documentation for materials and items used in the system.
4. Certificate indicating that design and installation of Doors and hardware as per the test reports submitted.
5. Manufacturer's inspection report
6. Manufacturer's Guarantee.

18.0 GUARANTEE

The door/ window/ partition assembly including all hardware shall be guaranteed for a period of 12 months from the date of installation against any manufacturing defect.

In case of any such defect within the guarantee period, the defected part shall be replaced or repaired as required by the Contractor at his own cost.

19.0 MEASUREMENT

Unless otherwise mentioned, measurement of fire doors, windows and partition shall be as below:

19.1 Fire rated doors shall be measured by area of the doors (inclusive of the frame, fixing arrangement, glazing and all fittings).

19.2 Fire rated windows shall be measured by area of the windows (inclusive of the frame, fixing arrangement, glazing and all fittings).

19.3 Fire rated partition shall be measured by area of the partitions (only one side, inclusive of the frames, partition panels, fixing arrangement, glazing and all fittings. Area of doors, windows and other openings shall be deducted).

19.4 Hardware such as door closer, door stopper, locks and trims, panic bar etc., shall be measured in numbers.

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भवन अग्रभाग प्रशोधन हेतु संरचनात्मक ग्लेजिंग तथा अलुमिनियम कोम्पोसीट पैनल के लिए मानक विनिर्देशन

STANDARD SPECIFICATION FOR EXTERNAL FAÇADE SYSTEM WITH STRUCTURAL GLAZING AND ALUMINIUM COMPOSITE PANELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved By	
1	15.02.17	REVISED AND ISSUED AS STANDARD SPECIFICATIONS	MV	JS/ JKB	R. Srivastava	R. Nanda
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Abbreviations:

ACP	:	Aluminum Composite Panel
ASTM	:	American Society for Testing and Materials
BS	:	British Standards
ECBC	:	Energy Conservation in Building Code (India)
EPDM	:	Ethylene Propylene Dinine Monomer
IS	:	Indian Standards
PVC	:	Poly Vinyl Chloride
RCC	:	Reinforced Cement Concrete

Architectural Standards Committee

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1.0 GENERAL

The external façade works for a building shall be as per the detailed design of the external façade using glass and metal in combination to provide required aesthetic view of the building, perform desired functional parameters with respect to passive climate control and provide structural stability to the system with respect to various structural loading condition for which the building is designed including thermal and wind load. The external facade system shall comprise of structural glazing system or/ and Aluminium composite Panel or combination thereof as required by the design of façade. In certain cases, the external facade system may solely comprise of large glass panel with stainless steel patchworks only without use of any metal frame. Such facades shall be as per the proprietary design detail of the suppliers. The structural glazing shall form uninterrupted, water, air and weather tight glazed surface in accordance with the architectural elevation and layout drawings and specifications and the entire system shall be erected as per the same. The glazed surface shall be formed by framing system which shall be of structurally and mechanically designed technology for fabrication and erection with grid sizes as approved. The horizontal members shall span in length between vertical members. The perimeter of the frames shall be structurally integrated to form air and water proof movement joint on all four sides of each panel with pressure equalization chambers formed internally. Design and sealing of such joints shall ensure that there is no penetration of rainwater through these joints under heavy wind pressures.

The fabrication and erection of the system shall comply with all relevant Indian Standards, Code of Practice and technical literature relating to best practice pertaining to structural glazing. The equivalent or higher International Standards may be used.

A specialized agency/ sub-contractor with proven track record to execute this job shall be engaged for fabrication and erection of the system. Such an agency should have executed similar jobs for multistoried buildings.

This specification is not applicable for suspended point fixed glazing with patch bolts and shall be limited to the Semi unitized structural glazing system only.

2.0 STRUCTURAL GLAZING SYSTEM

The Structural Glazing System shall be Semi unitized structural glazing system punched/ strip type window units and the same shall be fabricated as per design and approved drawings.

The system shall consist of frame supporting system, the framing system to support vision panels (insulated glass) and spandrel panels either with monolithic glass (single or double glazed unit) or laminated sandwiched composite panel (ACP)/ openable top hung window panels/ punched strip windows/ decorative capping to any shape & profile, smoke seal, flashing including gaskets, sealants, necessary accessories, as part of the system on a continuous framing supported between floors as detailed below and as per the specification for external facade system.

The panels shall be supplied and fabricated with the specified glass on the secondary frame at factory, the system shall be erected on extruded main frame & transom fixed on supporting system at site as per approved shop drawings at all floor levels and for all heights.

The split framing semi unitized glazing system in case of punched windows with proposed vision panel with either insulated/ monolithic glass shall have groove width of maximum 16 mm both in horizontal and vertical direction.

Tests for the materials involved in the system, including the field test on the erected system at site as per the test criteria shall be as per this specification.

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A document on methodology for the materials and assembly (mock-up & field test) supported by the copy of relevant codes & Standards shall be as approved by the Engineer-In-Charge prior to testing.

Protection of the system and materials till handing over to the owner, removal of the unwanted materials, broken glass, screws, bolts, nuts, packing materials, debris etc regularly and keeping the premises neat and clean at all times shall be the responsibility of the agency executing the work.

The facade cleaning details shall be incorporated in the shop drawing submitted for approval. The system shall be maintained by means of periodical inspection at site (bi-monthly) and checking the system and materials involved in the system during the defects liability period of one year to ensure that the system and all materials are free from any defects during this period. Necessary guarantee for the entire external façade system to the specified period in an approved format supported with back to back guarantee from the specialized material supplier like glass, aluminium composite panel, gasket, sealant, hardware etc. complete as directed by Engineer- In- Charge shall be provided.

2.1 System Design

The external facade system with structural glazing is proprietary in nature, hence the onus of design, materials, all fixing details, methodology of execution etc. are the responsibility of the contractor. The contractor shall necessarily get the work done through authorized agency specializing in such works to comply to design intent, performance requirements, approved shop drawings etc. The execution of external facade system shall also include the site survey prior to and after preparation of shop drawings and accommodating the site conditions in the system and shop drawings. The design system shall include Designing, Fabricating, Testing, Protection, Installing of Semi (grid) unitized system of structural glazing (with open joints) for linear as well as curvilinear portions of the building for all heights & all levels.

System design in total, including aluminum extruded frames, type & thickness of glass pane, aluminium sleeves at connections, inserts, EPDM gaskets, adhesive tapes, sealant, supporting system/ bracket including fastening and anchoring system & materials specified in the system details as specified shall be deemed as tentative and is meant to set out a general outline of the proprietary system and minimum requirements/ properties of the system and component parts. The method of fixing is subject to the approval of Engineer- In- Charge

The pre-assembled aluminum semi unitized structurally glazed panel shall be designed with continuous framed panels/ strip window/ punched window system with split mullion to any shape and profile to withstand a minimum design wind pressure of 125 Kg/ Sq.M (Test pressure shall be 1.5 times of the design wind pressure) conforming to IS: 875-Part 3 and lateral forces as per IS: 1893 and fixed at horizontally/ vertically/ sloped/ curved position etc. as shown in the approved drawings by using aluminium extrusions, glass, spacer tape, gasket, sealant etc. as specified.

The system shall be designed with maximum design wind pressure and lateral forces, moments, stresses etc. Negative/ suction pressures if determined as per IS: 875-Part 3 and Lateral forces as per code IS: 1893 (Latest Revision) shall make allowances as described in the code for corner effects on the system. System design shall also include providing and making provision for drainage of moisture/ water that enters the glazing system to make it watertight by incorporating the principles of pressure equalization chamber and concealed continuous gutter vertically and horizontally at all levels as self-drainage barrier to achieve water tightness besides providing EPDM gaskets on the frame and EPDM gasket/ sealant on the external groove as air and water barrier.

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The system shall be designed to withstand a design wind pressure specified above with self-bearing modular elements supported between floors in the case of structural glazing and split mullion supported between sill & lintel/ beam in the case of punched windows, EPDM gaskets on the frame and gasket/ sealant on the groove to prevent the system from air & water penetration, double adhesive spacer tape, backer rod, sealant, supporting brackets (resistance to design wind pressure), separator gaskets for bi-metallic corrosion, Pressure equalization chamber in the system, built-in continuous internal drainage gutter for collection and facility at lowest floor level to drain out penetrated water, in built adjustability to accommodate thermal expansion, thermal movement and movement due to any other forces etc.

External groove shall be provided with gasket/ sealant with coloured anodized aluminium holder all-round the panel to the required width and thickness as per design as dead load support to the glass panel. Non staining sealant between glass & aluminium holder all-round the panel shall be provided. Glazing the panel with child frame shall be done only at factory at the controlled atmosphere to erect the panel on erected extruded aluminium main member and transom with supporting system at site fixed on the RC surface. Vertical in-situ glazing shall not be carried out during construction/ erection stage. System shall be designed in such a way that the outer surface of insulated glass unit, monolithic glass unit and aluminium composite panel shall be in the same plane or as per approved drawing.

The system shall be designed to accommodate movement due to any force including the movement resulting from the exterior skin temperature ranging from 15°C to 85°C, interior skin temperature ranging from 15°C to 30°C and to accommodate the horizontal building movement of 10 mm per panel & vertical movement of 20 mm between floors on the aluminium framing system with support brackets, glass, gaskets and fastening devices. The system shall be designed to accommodate the size and shape of the glass panels as per the approved drawings including approved modifications as may be required during execution as well as all other incidental forces and stresses likely to be experienced under service conditions i.e. lateral force, dead weight and thermal expansion due to building movement both vertical and horizontal etc.

The supporting system shall consist of brackets/ clamps, fastening straps, nuts, bolts, rivets, washers and other fastening materials etc. Extruded sections shall be designed to accommodate Insulated Glass Unit (IGU)/ monolithic (single) glass and aluminium composite panel as per the approved shop drawings. Extruded aluminium sections shall be 63400 (H9) grade conforming to IS: 8147, finished with AC25 grade architectural quality electrolytic anodic coating of approved colour conforming to IS: 1868.

The design system shall also include (where-ever shown in drawings or specified) providing extruded aluminum frames, shadow boxes, extruded aluminum section capping for fixing in the grooves of curtain glazing and vermin proof stainless steel wire mesh as required.

2.2 Materials

2.2.1 Glass

The infill panels shall be factory made glazed unit of size as per the approved design. The thickness of the glass shall be as specified in Job Specifications/ Schedule of Rates and as per the ECBC envelope design criteria and the same shall be as under:

a. Minimum 6mm thick soft coated reflective toughened glass in approved colour. The glass shall have a reflective coated surface. For the toughening of the glass the rolling direction shall be parallel to the width of the glass. The glass shall be cut by machine only to required size and the edges shall be ground smooth by dressing with corborandum file or equivalent.

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Typical Technical Characteristics of single glazing clear are given below:

Light Transmission	:	20 to 35%
Reflection (OUT) %LR	:	10 to 17%
Reflection (OUT) %ER	:	10 to 25%
Solar factor	:	0.35 to 0.42
Shading Co-efficient	:	0.34 to 0.46
U Value	:	5.3 to 5.6 W/sqmK

b. The vision glass panels shall be provided (with IGUs-assembled in the factory/workshop of glass processer) of overall thickness 24mm thick glass hermetically sealed (6mm + 12mm air gap + 6mm glass) insulated glass (double glazed) of size & shape as required & specified. The glass assembly shall comprise of an outer heat strengthened/ toughened glass 6mm thick of approved colour & shade with reflective coating on surface #2 of the approved colour and shade, an inner Heat strengthened/ toughened clear float glass 6mm thick. Spacer tube shall be 12mm wide, desiccants, including primary seal and secondary seal (structural silicone sealant) etc. for required performance shall be as per approved Architectural/ shop drawings, and as directed by the Engineer- in- charge.

Typical Technical Characteristics of double glazing clear are given below:

Light Transmission	:	20 to 40%
Reflection (OUT) %LR	:	10 to 15%
Reflection (OUT) %ER	:	10 to 20%
Solar factor	:	0.15 to 0.25
Shading Co-efficient	:	0.17 to 0.28
U Value	:	1.5 to 1.8 W/sqmK

c. Spandrel Glass Panels shall comprise of solar reflective 6mm thick heat strengthened/ toughened monolithic glass of approved colour & shade with reflective soft coating on surface #2 of approved colour and shade so as to match the colour & shade of IGUs in the vision panels etc. The glass shall meet the required performance as specified, as per approved Architectural/ shop drawings, as specified & as directed by the Engineer- in-charge.

The above data is provided as a reference to specific range of glass. However, the glass shall be selected based on its SHGC, U-Value and solar factor as specified in ECBC and shall fully conform to that code.

2.2.2 Processing of Glass

Details of the processor and their facilities shall be approved by Engineer-In-Charge before their procurement and execution. Laminated glazing unit shall be processed only by the approved Processor. All glass panes used in the glazing shall be heat treated and heat soak tested conforming to the relevant codes and standards. No tong marks shall be allowed in the processed glass. Necessary test certificate shall be produced by the processor to confirm the adherence of the parameters set out in the codes and standards for heat treated and heat soaked glass. It shall be the responsibility of the agency executing the work to make sure that the glass shall be processed as per specification and it shall be conforming to the criteria of the respective codes and standards. The certificate from the glass processor shall be submitted that the glass processing has been done as per specification and codal provisions have been observed and such copy of codes shall be made available for verification of Engineer-In-Charge.

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Processor shall provide removable safety clips on each corner of glass and PVC button corks on the surface of the glass as a safety measure prior to packing to avoid breakage of glass in the corners during transit and this safety clip shall be retained till the glass is taken for glazing in to the frame at factory. Glazed panel with broken or chipped off glass at the edges and with any scratch on the surface of the glass shall not be allowed to use in the facade and if any such damages are found in the glazed panel even after glazing/ erected in place shall be rejected and shall be replaced with new one after the approval of installation methodology by Engineer-In-Charge.

2.2.3 **Gaskets**

Ethylene Propylene Dinine Monomer (EPDM) gaskets as weather strip and barrier at minimum 3 stages shall be provided with adequate fixing details to ensure water and air tightness. Weather strip shall be EPDM gaskets with hardness (5 second) shore A with a typical value not less than 70, ultimate tensile strength of 70 (+/- 10%) kg/ sq.cm and ultimate elongation of 250% (+/- 10%). The gaskets shall be of approved make.

2.2.4 **Sealants**

Silicon adhesive structural sealant having excellent properties of adhesion, elasticity, long life (more than 10 years) and of approved make. Two part silicon shall be used having excellent properties of adhesion, elasticity, long life (more than 10 years). The thickness and bite of structural sealant shall be determined to withstand 3 times of the stress caused by the design wind pressure and to ensure the same; the design calculation of sealant manufacturer shall be submitted along with shop drawing. It shall be ensured by the agency executing the work that the bite and thickness of sealant as designed & determined by calculation, verified and tested by manufacture is followed in the shop drawing and the same shall be adopted for the glazing at factory after the approval of shop drawing. The sealant and double adhesive spacer tapes for glazing the panel shall be supplied and fixed as per specification at factory. Spacer tape shall be open cell polyethylene of approved make. Jointing/ sealing of the glazed panel at factory shall be done with non-structural (weather) sealant/ non staining sealant of approved make with polyurethane baker rods of approved make. Acetoxy sealant shall not be used for structural glazing application.

2.2.5 **System Supports**

The supporting system shall be provided and fixed with brackets/ clamps including fastening straps, nuts, bolts, rivets, washers etc as per design requirement and as per approved shop drawings. Brackets/ clamps shall be of hot dip galvanized steel and fastening materials shall be non- magnetic stainless steel 300 series- 316 grade of approved make. Galvanizing thickness shall be in accordance with IS 2629 and 4759. Serrated plates or serrated washer wherever required shall be provided as per the system requirement and as shown in the approved shop drawing.

2.2.6 **Smoke Seal**

Smoke seal/ fire stop using extruded aluminium channel with cap shall be provided for continuous structurally glazed framing system and in general the thickness of channel and cap shall be 2 mm and to a width as required between transom and sill finish material and it shall be 63400 (H9) grade conforming to IS: 8147, finished with AC25 grade architectural quality electrolytic anodic coating conforming to IS 1868 of approved colour. Aluminium colour anodized extruded channel shall be supported with the help of aluminium bracket as designed and this bracket to be fixed on the wall/ RCC surface with necessary stainless steel anchor bolt and fastener of approved make. This channel with cap shall be provided between sill finish material and structural glazing member at sill level and between RCC member face and

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structural glazing member at soffit level/ false ceiling. All the joints between the capping channel and any other finish material at both sill and soffit level shall be sealed with intumescent sealant of approved make. The gap on the vertical surface between the face of column/ wall/ partition and structural glazed frame/ glass shall be closed by using extruded aluminium channel with cap with chromotised finish aluminium bracket supported on the column/ wall/ partition and in general the thickness of channel and cap as specified above of approved matching colour to the mullion & transom.

2.2.7 **Flashing**

In addition to the smoke seal as specified above for horizontal gap between frame and sill finish material, flashing shall be provided at all floor levels as part of the system (applicable only for continuous structural glazing portion) made to profile as shown in the approved drawings and the profile shall be made out of hot dip galvanized sheet 1.2 mm thick and galvanizing coating thickness shall be in accordance with IS 2629 & 4759. In general, the flashing shall be provided to the entire length of structural glazing portion horizontally at all floor levels and at terrace level with necessary anchoring system with stainless steel fastening devices of approved make.

2.2.8 **Insulation on Spandrel Panel**

Spandrel panel conforming to the minimum spectral parameters shall be provided as specified. Spacer for insulated glazing unit shall be aluminium extruded profile and finished with AC 25 grade electrolytic anodic coating of black colour conforming to IS: 1868 and filled with dry desiccant. Primary sealant shall be poly-isobutylene (PIB) and secondary seal shall be structural silicon sealant of approved make.

Rock wool Insulation- 50 mm thick - 64 kg/ cum and having 'K' value of 0.023 w/ M deg k of approved make shall be provided conforming to IS - 8183/ BS 3958/ ASTM C 612 on the spandrel panel area i.e. behind the ACP/ glass and for smoke seal at sill level. These wool should be covered with black tissue factory pressed - 0.50 mm thick (Nominal Mass - 60 Kg/ cum) to conform non combustibility class - fire rating to BS 476 - Part 7 & IS 3808 and fixed by using GI angle/ channel of required size as base and the wool shall be tied with 22 gauge GI wire in criss-cross manner into galvanized angle/ channel to the structure and shall be covered GI sheet tray of 1mm thick and all exposed surface shall be painted with 2 coats of synthetic enamel paint over a coat of epoxy primer. Insulation shall be fixed to the main aluminium frame work between mullion & transom on each side with the gap of 25 to 30 mm from the inner surface of the glass (i.e. behind the spandrel panel glass area). All the edges between powder coated GI tray and frame to be sealed with non-staining weather silicon sealant of approved make.

Shadow Box: Shadow boxes of required size & shape shall be provided for fixing in the spandrel portion of structural glazing system, in linear as well as curvilinear portions of building. The shadow boxes shall be provided with semi-rigid, inorganic, non-combustible fiber glass wool insulation 50mm thick, confirming to IS - 8183/ BS 3958/ ASTM C 612. Insulation as per the description described above shall be fixed using 1.5mm thick solid aluminum sheet backing using 6mm thick cement board including SS rivets, nuts, bolts, washers etc. all complete.

2.2.9 **Top Hung Openable Window Hardware**

Top/ side hung shutters shall be provided with operating hardware and as per details and requirements of location to facilitate ventilation, cleaning/ maintenance of the glass. The hardware shall be provided for the shutter with heavy duty self-balancing stainless steel friction hinges, corner transmission, detachable restrictor stay assembly and multi point

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locking with heavy duty mechanism (minimum 9 points including corner locking point), handle with key at centre of the transom having a ceremony. Handle/ ceremony shall be made out of aluminium die cast with powder coat finish- 65 microns, matching to the transom profile colour. The shutter frame shall be designed to accommodate the hinge, stay arm and multi point lock, EPDM gaskets, fastening materials including all other necessary materials etc. Hinge shall have thermoplastic asymmetric end cap to ensure weather tight sealing at the ends.

Heavy duty self-balancing stainless steel friction hinges, corner locking point and restrictor stay arm assembly with release key of approved make and multi point lock (minimum 9 point) and handle with key of approved make shall be considered. Shutter shall have a provision for hold open option and to restrict the opening not more than 200 mm and to keep the vent weather tight while closing the shutter. Gaskets shall be provided to ensure the air and water tight including noise control while the shutter is closed in position and the gasket shall be silicon synthetic rubber of required strength. Master key- 3 sets (floor wise) & Grand master key - 3 sets (building wise) shall be provided for openable parts with necessary code engraved on the keys.

2.2.10 Swing/ Openable Door

System design in total, shall have the provision to fix the sliding/ openable door (patch fittings door) integrating with system with necessary structural supports cladded with specified materials and necessary hardware etc. all complete to necessitate fixing the doors as a part of the overall system.

The openable double/ single leaf door with patch fittings, hold open heavy duty floor spring, stainless steel handle, corner lock at both top and bottom of approved make shall be provided wherever necessary as per design Stainless strip on the edges shall be provided to protect the laminated exposed face.

2.2.11 Aluminium Decorative Capping

Extruded / powder coated finish aluminium decorative capping of approved colour shall be provided on the unitized structurally glazed system using aluminium extruded clip on section made to profile and shape as shown in the drawing including providing support profile to fix the decorative capping for a projection not less than 150 mm or as per drawing from facade line and shall be fixed as part of the main system including aluminium chromotised finish support and aluminium cleat at required spacing to form a shape & profile as per drawing and act as structural support to the decorative capping. The support shall be designed and provided as per the approved structural calculation and drawing ensuring the screws and fastener shall not be visible on the external surface of capping. Groove width and line of spacing shall be maintained as in structural glazing system.

2.3 Visual Mock-up

A full scale visual mock-up with minimum 3 bays and for 2 floor height with combination of vision, spandrel, spandrel on vision area, openable window, ACP cladding (if specified), smoke seal and other special architectural features etc. shall be set up to establish the actual system design prior to proceeding with full scale production of the materials involved in the system in case of façade design of a multistoried building in excess of four floors. A water test shall be conducted on the installed visual mock up system (only water using hose real to the specified pressure in the technical specification) and the test result of the system shall be submitted for review. Any improvements required on the system based on the test result shall be incorporated.

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2.4 Tests

a) Off-Site proto type Test:

Necessary shop drawings and design calculation shall be provided to carry out the full scale off site proto type at an approved accredited laboratory based on the design criteria set out in the specification and confirming to ASTM E 330 at any approved laboratory in India and the test specimen shall be provided for minimum 3 bays and for 2 floor heights with the combination of vision, spandrel and openable window with Glass/ ACP and any other special features on the system as proposed to be installed and the specimen to be tested to the design wind pressure of 125 kg/ sq.m (Testing pressure shall be 1.5 times of the design wind pressure) conforming to IS 875 and the lateral displacement as specified above. Fabrication at site shall commence only after the satisfactory completion of the test and submission of test report to Engineer- In- Charge.

b) Field Test:

Field test at site on the installed glazing system shall be conducted as per the criteria set out in the specification and as per the Methodology described in ASTM 501-2. Test shall be carried out in the presence of Engineer- In- Charge. Methodology for carrying out the test shall be submitted to Engineer- In- Charge for approval prior to testing. The results shall be recorded and the reports shall be submitted to the Engineer-in-charge for approval. If field test fails, the rectification methodology shall be submitted to correct the defects as per the performance data set out in the specification and as per the methodology described in the relevant code for the approval of Engineer-In-Charge. Defects, if any noticed shall be rectified to the satisfaction of Engineer-In-Charge.

c) The performance test:

The performance test shall be conducted on structural glazing system if the area of structural glazing exceeds 2500 Sq. m from the certified laboratories by NABL (National Accreditation Board for Testing & Calibration Laboratories), Department of science & Technology India. The cost proposed shall include the cost of testing also and shall be done in consideration to the importance of work. Performance Testing of the structural glazing system tests to be conducted in NBL certified laboratory.

(i) Performance Laboratory Test for Air leakage Test (-50pa to -300pa) & (+50pa to +300pa) as per ASTM E-283-04 testing method for a range of testing limit 1 to 200 mVhr
(ii) Static Water Penetration Test. (50pa to 1500pa) as per ASTME-331-09 testing method range up to 200ml".
(iii) Dynamic Water Penetration (50pa to 1500pa) as per AAMA 501.01-05 testing method for a range upto 200ml".
(iv) Structural Performance Deflection & deformation by static air pressure test (1.5 times design wind pressure without any failure) as per ASTME-330-10 testing method for a range up to 50mm".
(v) Seismic Movement Test (upto 30mm) as per AAMA 501.4-09 testing method for Qualative test" Test to be conducted on site.
(vi) Onsite Test for water Leakage for pressure range 50kpa to 240 kpa (35psi) upto 2000ml".

2.5 Facade Cleaning Platform/ Façade Access System/ Gondola:

All the structural/ curtain glazing surfaces of the buildings shall be provided with façade access system designed for man-riding application and to international safety systems. The

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equipment shall be aesthetically designed in keeping with the building Architecture. The façade access system shall include of floor/ slab & parapet mounted runners having collapsible/ telescopicarm including epoxy finished tracks in structural steel frame work, stainless steel (non-magnetic type of grade 316) monorail system suspended from pergola/ space frame & fixed davits installed at suitable intervals in epoxy finished structural steel frame.

2.6 Workmanship

The framing system and fixing arrangements to the RCC framed structure shall be with aluminium brackets. All the joints in aluminium framing system and factory glazed panels (also between metal sections and between glass and metal sections and between glass and metal sections) as well as joints between aluminium frame with concrete and/ or masonry meeting surrounds shall be fully sealed and made air, water and weather tight preventing seepage of rain water under heavy wind pressures with provision of adhesive silicon sealant and superior quality approved make EDPM gaskets. The EDPM gasket shall be free from any contract or migration strain and shall be compatible with all substrates. Sealant and finishes, which are likely to come in contact shall comply with provision of IS code. The EPDM gasket shall be purpose made by approved manufacturer.

Space at each floor level between the external face of the building frame and the internal face of the structural glazed spandrel panel shall be sealed air tight by horizontal barrier to prevent passage of smoke/ fire, conditioned air from one floor level to another. There shall be continuous seal for stopping fire and smoke between the structural glazing and the building face in cavities formed in spandrel panels between the sill wall level at external edge of one floor and RCC/ false ceiling of the lower floor. Fire rating of the stoppers between floors shall be minimum 2 hours.

2.7 Design Criteria

The fixing arrangement of factory formed infill glazed grid unitized framing system shall be designed by the structural glazing agency to withstand all external forces due to worst condition of wind loads as per IS code applicable for the region of the proposed buildings, earthquake forces occurring in the zone as per the IS code, building frame movement forces due to wind and earth-quake, outside temperature experienced during last 10 years.

The structural bite or contact dimensions of silicon adhesive structural sealant to the glass required, that is the amount of silicon adhesive structural sealant (contact width and thickness) required to support the glass externally and internally in the panel against action of the worst condition of the external forces such as wind earthquake forces, building movement forces, temperature forces including their combinations etc as well as to prevent penetration of rain water under heavy wind conditions experienced during the last 10 years in the region. It shall be designed in accordance with the requirement of the silicon adhesive structural sealant manufacturer and supplier, mentioning the factor of safety obtainable as per the design. In any case the factor of safety shall not be less than 1.5.

Framing system shall fulfill the design criteria/ specifications as under:

Vertical Mullions : Indicate spacing, size and shape to comply with the requirements of the design parameters.

: Maximum Tensile Strength 19 Kg/mm2

: Maximum allowable deviation in length from a straight line of 0.5mm.

: Maximum allowable deviation from the straight of 1°

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	:	Maximum twist of Maximum variation in flatness of not more than 0.125 x width/ 25
Horizontal Transom	:	Indicate spacing, size and shape.
Alloy	:	Extrusion shall be 6063 T6 Alloy and temper (ASTM B221 alloy G.S.10A-T6)
Fixing Bolts	:	All exposed bolts, nuts, screws shall be of stainless steel 304 or 306 grade.
Gaskets	:	EDPM with shore hardness of 70+/- 5

Approved make Glazing tape shall be used.

2.8 Design Data

Temperature range	:	60° C Ambient, 100° C for Materials.
Wind Load	:	150 kg/sq. m (Entire system and each component including glass in edge zones on each side of building corners shall be designed for heavier wind suction as required by design code)
Seismic Load	:	As per IS codes
Deflections	:	
Mullions	:	Max. L/240 or 15mm whichever is less
Transoms	:	Max. L/300

Permanent deflection in Mullions
: Max. L/3000 at 300 Kg/ sq.m wind pressure

Permanent deflection in transoms
: Nil at 1.5 times dead load

Permanent deflection in cladding frame members
: Nil at 300 Kg/ sq.m/ wind pressure

Glass panels	:	Max. 15mm or as recommended by glass by glass manufacturer whichever is less (for each typical panel)
R.C.C. Grade	:	M 25 or higher as per specifications.

2.9 Performance Criteria of the Structural Glazing

The agency executing the work shall be responsible for the quality and efficiency of the design and application of the structural glazing technology offered. The system offered shall be structurally sound, aesthetically pleasing and pretested in accredited laboratories certifying performance of the whole system in accordance with the international structural glazing standards. All necessary test certificates etc. proving compliance to all design and performance criteria specified shall be submitted.

The following criteria shall be fulfilled for performance:

(a) Movement: The system shall be capable of accommodating all stress and movements that

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are likely to occur during normal life of 20 years of structural glazing members and not less than 10 years for the structural silicon sealant.

(b) Composition of structural glazing members shall be fully adequate to totally resist any distortion such that no distortion takes place.

(c) Deflection: Deflection shall not be more than 1/175 of the span of the members

(d) Plumb and alignment: All the members at each joint shall be in perfect plumb line and alignment. Tolerances for plumb of structural glazing installed shall be within +/- 3mm.

2.10 Performance Guarantee

A warranty for the entire installation carried out and for structural silicon sealant proposed to be used vis-à-vis similar guarantee from the manufacturer of the silicon sealant to fulfill the quality standards stipulated above shall be offered. The performance guarantee shall cover for replacement of any or all members and components by the agency executing the work at its own cost in case of any deficiency or failure in performance of the structural glazing component as per the design requirement during the warranty period.

2.11 Drawings and Details

Detail drawings of the structural glazing system showing framing system, connections to building RCC frame, main framing grid unitized system comprising of male mullion, female mullion, transoms, all connection details like bracket connection to the building RCC frame, connection between transoms and mullions etc. (also indicating the sizes of the sections proposed) details of the weatherproofing with EDPM gaskets, infixing details of glass/ glass panels, joint details to withstand severe conditions of winds and rains, insulation of corrosion proof smoke seals of flexible design and construction shall be furnished for the approval of the Engineer-In-Charge. All necessary test certificates, documentation etc. proving all the stipulated parameters of the performance shall be produced. Wherever required and asked for, necessary calculations shall be provided by the agency executing the work to establish the design and performance criteria. Company profile of the proposed sub-contractor/ agency proposed to be engaged for executing this job shall be submitted for owner's/ EIL's approval.

2.12 Measurement & Payment

For the purpose of payment, the measurement shall be done on Sq. Meter basis of the executed and finished (in all respects) work. Length and breadth of the superficial area of the finished work shall be measured centre to centre of the grooves on the external surface viewed externally correct to a centimeter under the respective items. Areas shall be calculated in a square meter correct to two places of decimal.

Rate shall include the cost of all materials and labour involved in all the operations as specified, to execute the work as per approved drawings/ shop drawings including scaffolding, infrastructure facility, tools and plants etc. necessary for execution of the respective item for all height and for all floor levels. Items shall be measurable in sq. m. Rate shall include all components and procedure including all fixing as described in this specification including supply of glass, supply of hardware for top hung window, aluminium decorative capping, cost of offsite proto type test and insulation tray on spandrel.

Rate shall be for all heights and locations. Contractor shall refer the relevant drawings for assessment of the same.

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3.0 ACP CLADDING SYSTEM

3.1 General:

The external facade system with aluminium composite panels (ACP) is proprietary in nature, hence the onus of design, materials, all fixing details, methodology of execution etc. are the responsibility of the contractor. The contractor shall necessarily get the work done through authorized agency specializing in such works to comply to design intent, performance requirements, approved shop drawings etc. The execution of ACP system shall also include the site survey prior to and after preparation of shop drawings and accommodating the site conditions in the system and shop drawings.

3.2 System Design:

The design system shall include Designing, Fabricating, Testing, Protection, Installing of ACP system (with open joints) for linear as well as curvilinear portions of the building for all heights & all levels. The work shall include Structural analysis & design and preparation of shop drawings for pressure equalization or rain screen principle as required, proper drainage of water to make it watertight including checking of all the structural and functional design.

The ACP works shall consist of Designing, fabricating, testing, installing and fixing in position Curtain Wall with ACP Cladding, of 'Alstone' 'AluDecor' 'Alucobond'/ 'Eurobond'/ 'Reynobond'/ 'Alstrong' or approved equivalent with open grooves for linear as well as curvilinear portions of the building, for all heights and all levels etc. including:

3.3 Materials:

a) ACP cladding panels shall be pan shaped in metallic or other approved shades 4mm thick consisting of 3mm thick FR grade mineral core sandwiched between two Aluminium sheets (each 0.5mm thick). The aluminium composite panel cladding sheet shall be coil coated, with "Kynar 500" based PVDF/ "Lumiflon" based fluoropolymer resin coating of approved colour and shade on face # 1 and polymer (Service) coating on face # 2 as specified using stainless steel screws, nuts, bolts, washers, cleats, weather silicone sealant, backer rods etc.

b) The fastening brackets of Aluminium alloy 6005 T5 / MS with Hot Dip Galvanised with serrations and serrated washers to arrest the wind load movement, fasteners, SS 316 Pins and anchor bolts of approved make in SS 316, Nylon separators to prevent bi-metallic contacts all complete required to perform as per specification and drawing The item includes cost of all material & labour component, the cost of all mock ups at site, cost of all samples of the individual components for testing in an approved laboratory, field tests on the assembled working curtain wall with aluminium composite panel cladding, cleaning and protection of the curtain wall with aluminium composite panel cladding till the handing over of the building for occupation. Base frame work for ACP cladding is payable under the relevant aluminium items The Contractor shall provide curtain wall with aluminium composite panel cladding, having all the performance characteristics all complete as per the Architectural drawings, as per item description, as specified, as per the approved shop drawings and as directed by the Engineer-in-Charge.

3.4 Workmanship

The framing system and fixing arrangements to the RCC framed structure shall be with aluminium brackets. All the joints in aluminium framing system and ACP panels as well as joints between aluminium frame with concrete and/ or masonry meeting surrounds shall be fully sealed and made air, water and weather tight preventing seepage of rain water under

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heavy wind pressures with provision of adhesive silicon sealant and superior quality approved make EDPM gaskets. The EDPM gasket shall be free from any contract or migration strain and shall be compatible with all substrates. Sealant and finishes, which are likely to come in contact shall comply with provision of IS code. The EPDM gasket shall be purpose made by approved manufacturer.

Space at each floor level between the external face of the building frame and the internal face of the ACP panels shall be sealed air tight by horizontal barrier to prevent passage of smoke/ fire, conditioned air from one floor level to another. There shall be continuous seal for stopping fire and smoke between the ACP panels and the building face in cavities formed in spandrel panels between the sill wall level at external edge of one floor and RCC/ false ceiling of the lower floor.

3.5 Performance Guarantee:

A warranty for the entire installation carried out and for ACP System used vis-à-vis similar guarantee from the manufacturer of the panels to fulfill the quality standards stipulated above shall be offered. The performance guarantee shall cover for replacement of any or all members and components by the agency executing the work at its own cost in case of any deficiency or failure in performance of the ACP components as per the design requirement during the warranty period.

3.6 Drawings and Details

Detail drawings of the ACP system showing framing system, connections to building RCC frame, all connection details like bracket connection to the building RCC frame, connection between transoms and mullions etc. (also indicating the sizes of the sections proposed) details of the weatherproofing with EDPM gaskets, infixing details of panels, joint details to withstand severe conditions of winds and rains shall be furnished for the approval of the Engineer-In-Charge. All necessary test certificates, documentation etc. proving all the stipulated parameters of the performance shall be produced. Wherever required and asked for, necessary calculations shall be provided by the agency executing the work to establish the design and performance criteria. Company profile of the proposed sub-contractor/ agency proposed to be engaged for executing this job shall be submitted for owner's/ EIL's approval.

3.7 Measurement & Payment

For the purpose of payment, the measurement shall be done on Sq. Meter basis of the executed and finished (in all respects) work. Length and breadth of the superficial area of the finished work shall be measured centre to centre of the grooves on the external surface viewed externally correct to a centimeter under the respective items. Areas shall be calculated in a square meter correct to two places of decimal.

Rate shall include the cost of all materials and labour involved in all the operations as specified, to execute the work as per approved drawings/ shop drawings including scaffolding, infrastructure facility, tools and plants etc. necessary for execution of the respective item for all height and for all floor levels. Items shall be measurable in sq. m. Rate shall include all components and procedure including all fixing as described in this specification including supply of panels, supply of hardware/ accessories etc.

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यूपीवीसी दरवाजे, खिड़कियो एवं रोशनदान के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR uPVC DOORS, WINDOWS & VENTILATORS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
2	31.05.22	REVISED & ISSUED AS STANDARD SPECIFICATION	SANDEEP SHARMA	ANISH KUNDU	SAMIR DAS	SANJAY MAZUMDAR
1	10.03.17	REVISED & ISSUED AS STANDARD SPECIFICATION	MKV	JKB	R. SRIVASTAVA	R. NANDA
0	07.11.11	ISSUED AS STANDARD SPECIFICATION	MKV	SM	JKB	DM

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Abbreviations:

ASTM	:	American Society for Testing and Materials
BS	:	British Standard
BIS	:	Bureau of Indian Standards
EN	:	European Standards
EPDM	:	Ethylene Propylene Diene Monomer (rubber)
IS	:	Indian Standards
ISO	:	International Organization for Standardization
NBC	:	National Building Code of India
NFPA	:	National Fire Protection Association
PVC	:	Plasticized Polyvinyl Chloride
PVDF	:	Polyvinylidene fluoride
uPVC	:	Unplasticised Polyvinyl Chloride

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1.0 GENERAL

This standard specification lays down requirements of uPVC door, window and ventilator assemblies for buildings.

2.0 REFERENCES

2.1 The codes and standards listed below contain provisions which through reference in this specification constitute provisions of this standard specification if not specifically mentioned otherwise.

2.2 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NFPA, NBC etc. conformity with any of the similar codes is acceptable.

2.3 Reference codes and standards:

Standards	Document title
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D732	Standard Test Method for Shear Strength of Plastics by Punch Tool
BS 456 - PART 7	Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products
BS 456 - PART 5	Fire Tests on Building Materials and Structures Part 5: Method of Test for Ignitability
EN 514	Plastics - Poly(vinyl chloride) (PVC) based profiles - Determination of the strength of welded corners and T-joints.
EN 12608	Unplasticized poly(vinyl chloride) (PVC-U) profiles for the fabrication of windows and doors - Classification, requirements and test methods - Part 1: Non-coated PVC-U profiles with light coloured surfaces.
EN ISO 178	Plastics — Determination of flexural properties
EN ISO 179-2	Plastics — Determination of Charpy impact properties — Part 2: Instrumented impact test
EN ISO 306	Plastics — Thermoplastic materials — Determination of Vicat softening temperature (VST)
EN ISO 527	Plastics — Determination of tensile properties — Part 1: General principles
EN ISO 8256	Plastics — Determination of tensile-impact strength
IS 204	Tower Bolts- Specification
IS 205	Non-Ferrous Metal Butt Specification
IS 208	Door Handles-Specification
IS 513	Cold reduced low carbon steel sheets and strips
IS 875 (part-3)	Design Loads (Other than Earthquake) for Buildings and Structures - Code of Practice Part 3 Wind Loads
IS 1079	Hot Rolled Carbon Steel Sheet and Strip
IS 1341	Steel Butt Hinges — Specification
IS 2209	Specifications for Mortice Locks (Vertical Type)
IS 3564	Hydraulically Regulated Door Closers - Specification
IS 6315	Floor Springs (Hydraulically Regulated) For Heavy Doors - Specification
IS 4985	Specification for UPVC pipes for potable water supplies
IS: 10428	Glossary of terms relating to doors
ISO 105-X12	Textiles — Tests for color fastness — Part X12: Color fastness to rubbing

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3.0 MATERIALS

3.1 uPVC profiles

uPVC (un-plasticised polyvinyl chloride) is PVC resin blended with acrylic modifier, titanium dioxide and other chemicals.

uPVC doors/ windows/ ventilators shall have extruded hollow uPVC profiles with reinforcement.

Extruded hollow uPVC profiles shall conform to EN 12608 and following specifications.

Property	Specification	Testing method
Vicat softening temperature	Not less than 75 degree C	EN ISO 306
Charpy impact strength	Not less than 20 KJ / square meter	EN ISO 179-2
Flexural modulus elasticity	Not less than 2200 N/ square mm	EN ISO 178
Tensile impact strength	Not less than 600 KJ / square meter	EN ISO 8256
Mean breaking stress for welded corner		
- For tensile bending test	Not less than 25 N/ square mm	EN 514
- For compression bending test	Not less than 30 N/ square mm	EN 514
Heat reversion test	Not more than 02.00 %	IS 4985
Surface spread of flame	Class- 1	BS 476 - part 7
Ignitability evaluation	"P" not easily ignitable	BS 476 - part 5
Tensile modulus	Not less than 35 MPa	ASTM D 638
Shear modulus	Not less than 220 MPa	ASTM D 732
Tensile strength	Not less than 30 MPa	EN ISO 527
Percentage of titanium dioxide	Not less than 07.00 %	-
Percentage of calcium carbonate	Not more than 10 %	-

Sizing of uPVC profiles shall be as specified or required depending upon the size of the assemblies and wind load calculation(if applicable). However minimum profile wall thickness shall be 1.9 +/- 0.2 mm.

3.2 Finishing of uPVC profiles

uPVC profiles shall be legibly and visibly marked in unobtrusive position not visible when the door/ window/ ventilators are in closed position. At least once every one meter along the length of the profile and shall contain brand name, Manufacturer's name, profile code and date/ month/ year of manufacturing.

White colored uPVC profiles are extruded with white compound and no external finishing or coating is required.

For other desired colors on the profiles, they shall be laminated with external film of minimum 170 µm (+/- 20) thickness with 3 layers of coating (Top layer- PVDF, Inner layer- Acrylic & Base layer - Pigmented - acrylic base film) having abrasion resistance of Grade-5 when tested in accordance with ISO 105-X12

If not mentioned specifically, profiles shall be in desired color (other than white) and texture.

3.3 Reinforcement

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The profiles shall be reinforced with non- hygroscopic material conforming to any grade of IS: 1079 or IS: 513.

Mild steel section reinforcement shall be made from roll forming process and shall be hot dip galvanized in accordance with IS 277 with minimum coating mass of 120 gram/ square meter.

Thickness of the reinforcement shall be such that the door/ window/ ventilators meet the design wind pressure in accordance with IS: 875 (part-3). Minimum thickness should be as below subjected to the validation of design by vendor :

a. From ground floor upto 5th floor level = 1.60 +/- 0.2 mm
b. From 5th floor level onwards = 2.20 +/- 0.2 mm

The reinforcement shall be inserted in the uPVC profiles in required length within 6-15 mm distance from the face of the welds and then shall be screwed at 150 mm from the end at every 400 mm (maximum) pitch to the profiles so that it does not move or rattle.

3.4 Glazing

Glass shall be as specified in the design basis or job specification or drawings. If nothing is mentioned specifically, 6 mm thick toughened clear glass shall be used.

Specification of such glass shall be in accordance with specification no : 6-75-0003.

4.0 DOOR/ WINDOW/ VENTILATOR ASSEMBLY

4.1 uPVC profiles shall be procured from approved Manufacturers. Assembling and installation of Door/ window/ ventilator assemblies shall be done by the agencies approved by the Engineer-In- charge

4.2 Door/ window/ ventilator assemblies shall be fully glazed type and complete with requisite frame, shutter and hardware.

4.3 The composition, design, size etc. of the door/ window / ventilators shall be as per approved drawings.

4.4 Size and thickness of uPVC profiles shall be as required for the door/ window/ ventilator sizes and wind load (if applicable).

4.5 Contractor shall do the structural analysis and design considering the design wind pressure/ load and provide required sizes as per the analysis and design approved by the Engineer-In-Charge.

4.6 The profiles shall be mitred cut to required sizes and reinforced.

4.7 The profiles shall be fusion welded at all corners to form the door/ window/ ventilator assembly design to prevent any ingress of water or air in the reinforcement chamber.

4.8 Each corner and joints shall be neatly cleaned by removing all excess material. The weld shall be finished by grooving, knifing etc. at exposed welded portion only.

4.9 Minimum overlap of 6 mm shall be provided at joints to ensure effective sealing.

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4.10 Drainage/ ventilation slots shall be provided in the profiles to permit the escape of entrapped water/ moisture. A minimum of 2 nos. slots shall be provided at least at every 500 mm.

4.11 Door/ window/ ventilator assemblies shall be fixed to the openings ensuring the stability and proper operation in accordance with standard practice of the approved Manufacturer and as approved by the Engineer-In- Charge.

4.12 Glass panes shall be placed after fitting EPDM gasket and uPVC beading of approved quality. Plastic spacers shall be used to support the glass.

4.13 The assembly shall be made in such a manner that glazing and re-glazing is possible at site without the need to remove the outer frame.

4.14 There shall be a maximum gap of 3 to 5 mm in between door/ window/ ventilator frames and finished opening and plastic packers shall be provided to maintain the level.

4.15 The gap between door/ window/ ventilator frames and adjoining work shall be filled with weatherproof silicon sealant of approved make to maximum 5 mm depth & width to allow expansion/ contraction of uPVC profiles.

4.16 The door/ window/ ventilator assembly shall be true to the plane and shall ensure smooth operation.

5.0 HARDWARE

5.1 Doors, windows and ventilators shall be provided with all required hardware for stability, proper operability. Hardware shall be fixed truly vertical or horizontal as the case may be.

5.2 Hardware used shall be well made, reasonably smooth, and free from all sharp edges and corners, flaws and other defects.

5.3 Hardware shall be of brass body (chromium plated) or powder coated Aluminum alloy or of Stainless Steel (SS-304) as mentioned in the drawings and as mentioned in the following table.

If not mentioned specifically, Stainless Steel (SS-304) hardware shall be provided.

S. No.	Hardware	Specification
1	Hinges	Hinges shall be butt type conforming to IS: 205/ IS: 1341. Size of hinges shall be minimum 125mm long.
2	Overhead Hydraulic Door Closer:	Overhead hydraulic door closers shall be of heavy duty type and shall conform to IS: 3564.
3	Floor Mounted Door Closer	Mounted door closers shall be of heavy duty type and hydraulically operated and shall conform to IS: 6315
4	Mortice Lock	Mortice locks shall conform to IS: 2209.
5	Door Handles	Door handles shall conform to IS: 208.
6	Aldrop	Aldrop shall be 300 mm long and minimum 18mm dia.
7	Tower Bolt	Tower bolts shall conform to IS: 204.
8	Door Stopper	Stoppers shall consist of heavy duty rubber shoes spring loaded type with zinc alloy pressure die cast chromium plated holders.

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5.4 Hardware of each shutter shall be as mentioned in drawing.

If not mentioned specifically:

Each door shutter shall be provided with hinges, tower bolts, overhead hydraulic door closer, door stopper, lock and door handles (on both side).

Open type window/ ventilator shall be provided with handles, friction stays and tower bolts.

Touch hooks (made of zinc alloy, finished with minimum 90 micron powder coating with SS-304 grade spring for internal lever & striker/ keeper/ hook) shall be provided in sliding windows for single point locking.

Single wheel needle pin roller with minimum 11 pins to be used in sliding windows with weight capacity of 40kgs. The wheel shall be made of PA6 NYLON.

Adjustable double wheel door roller with ball bearing wheels made of PA6 NYLON & SS304 grade body shall be provided in sliding doors.

6.0 DELIVERABLES BY THE CONTRACTOR

6.1 Contractor shall do the structural analysis and design for sizing, thickness of profiles considering the design wind pressure/ load (if applicable) and submit the same for approved by the Engineer-In-Charge.

6.2 Supporting backup evidence for sizing of profile and details of reinforcement.

6.3 Contractor shall also prepare fabrication drawings and submit the same for approval by the Engineer-In-Charge.

6.4 Test reports from third party laboratories in support of various specified parameters and properties.

7.0 WARRANTY

The Contractor shall provide warranty of 10 years for the uPVC doors/ windows/ ventilators. Any manufacturing and operational defect detected during this warranty period shall be rectified by the Contractor to the satisfaction of the Engineer-In-Charge at his own cost.

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प्री-इंजीनियर्ड भवन का मानक विनिर्देशन (वास्तुकला)

STANDARD SPECIFICATION FOR PRE-ENGINEERED BUILDING (ARCHITECTURAL)

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	01.06.20	ISSUED AS STANDARD SPECIFICATION	ATUL GUPTA	SAMIR DAS	RAJANJI SRIVASTAVA	SUNIL KUMAR SAXENA

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Abbreviations:

HVAC : Heating, Ventilation, Air-conditioning
PEB : Pre Engineered Building

Structural Standards Committee

Convenor : Mr. Rajanji Srivastava

Members : Mr. Anurag Sinha
Mr. VK Panwar
Mr. Samir Das
Mr. Amitabh Kishore
Mr. Gyasuddin
Mr. Charanjit Singh (Projects)
Mr. Ravindra Kumar (Construction)

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1.0 GENERAL

1.1 This specification pertains to Architectural design, detail engineering and construction/ execution/ installation/ assembly of Pre Engineered Buildings (PEB).

1.2 For civil-structural, electrical, mechanical and other works, reference shall be made to relevant specifications.

2.0 DESIGN, DETAIL ENGINEERING, CONSTRUCTION etc.

2.1 Architectural design, detail engineering and construction/ execution/ installation/ assembly of pre-engineered works of buildings (i.e. pre-engineered super and roof structure, pre-engineered building envelope including roof drainage system, ventilation and natural lighting system of roof and side sheeting/ cladding/ panelling, related accessories etc. shall be done by approved agency.

2.2 Design, detail engineering and construction/ execution/ installation/ assembly of remaining building works (such as foundations, non-pre-engineered works, other building works etc.) shall also be done by the approved agency if included in his scope.

2.3 If such remaining building works is not in the scope of the approved agency, the agency shall co-ordinate with other agencies and incorporate necessary input by other agencies in activities in his scope as well as provide required input to these agencies for carrying out their works.

2.4 Remaining building works other than pre-engineered works and not mentioned in this specification shall be in accordance with approved design basis and other requirements, drawings etc. of the project.

3.0 DESIGN (ARCHITECTURAL)

3.1 Design Basis

Architectural design shall be in accordance with approved design basis and other requirements, drawings etc. of the project.

3.2 Lay-out

Lay-out of PEBs shall be finalized based on requirements, drawings, design basis, requirements, related specifications etc. of the project.

3.3 Building Envelope

Building envelope i.e. roofing and external peripheral masonry/ block work or sheeting/ cladding/ panelling shall be a leak-proof and weather tight system.

3.4 Roofing System

3.4.1 Roofing system shall be of metal sheet supported on pre-engineered steel structure and shall comprise of roof sheeting, roof drainage system, facias and accessories such as flashings, trims etc.

3.4.2 Roof lighting sheets, HVAC/ ventilation system and provisions for installation of solar panels shall also be incorporated in roofing system as required.

3.4.3 Profile, shape and Architectural design of the roof shall be as per approved design.

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3.4.4 Slope of the roof shall be 1:10 if not specified otherwise.

3.4.5 All joints, expansion joints, junctions, gaps in the roofing shall be closed by means of accessories and flashings for leak-proof and weather tight roofing system.

3.4.6 Provisions for supporting HVAC or other ducting/ piping, suspended ceiling system etc. shall be kept in roofing system if required.

3.4.7 Staircases or ladders in suitable numbers and locations shall be provided for roof access.

3.5 External Masonry Wall/ Block Work/ Sheeting/ Cladding

3.5.1 External masonry wall/ block work, sheeting/ cladding/ paneling system shall be as per building type based on project requirements, drawings, design basis, related specifications etc.

3.5.2 For open type sheds, generally external sides shall be either open type or open up to some height with metal sheeting/ cladding/ panelling for balance height. Low height masonry wall/ bock work up to 1000mm height shall be provided at floor level if required.

3.5.3 For closed type buildings, generally masonry walls/ block work shall be provided up to minimum 3000mm height or as required. Metal sheeting/ cladding shall be provided for balance height.

3.5.4 For wet areas such as toilet, kitchen, pantry etc. where piping/ plumbing is required, masonry wall / block work shall be provided as required for accommodating piping/ plumbing in both open type or closed buildings.

3.5.5 External Masonry wall/ block work shall be supported on separate (other than PEB structure) RCC column/ beam system.

3.5.6 Metal sheeting/ cladding/ panelling and external masonry wall/ block work shall have transparent sheeting, windows for natural lighting, windows/ ventilators, louvers for natural ventilation, projections for rain protection for openings etc. as required.

3.5.7 Metal sheeting/ cladding/ panelling shall also have accessories such as flashings, trims, facias etc. for closing junctions, gaps etc. for leak-proof and weather tight system.

3.5.8 Steel structural system (columns, beams, bracings etc.) visible inside offices and associated facilities, Rooms, Toilets etc. shall be suitably hidden/ concealed with masonry/ block work/ paneling etc. for aesthetics purpose.

3.5.9 The external facades of the buildings shall be as per approved Architectural design incorporating above.

3.6 Building Aesthetics

3.6.1 Buildings shall be aesthetically pleasant as approved. Roof profile, sky-line and external facades (including door-window/ transparent sheet configuration, projections etc.) and colour scheme (with alternatives) shall be designed accordingly.

3.6.2 For this purpose, necessary facias, trims, and other accessories shall be incorporated in design.

3.7 Conceptual Design

3.7.1 Minimum two alternative conceptual designs shall be prepared with rendered 3D views (acrial and eye-level views showing roof and all sides). The approved design shall be adopted for

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detail engineering incorporating observations/ comments/ modifications by Owner/ Project Management Consultant (PMC)

3.8 Roof Drainage System

3.8.1 Roof drainage system shall comprise of valley/ eaves gutters and rain water down takes as per roofing profile.

3.8.2 Gutters shall be sized on the basis of rainfall data, roof catchment area and outlets.

3.8.3 In case of valley gutters, rain water shall be drained out of building by means of rain water down takes from valley gutters and floor drain inside the building. Floor drains shall be sized and routed on the basis of rain water to be drained, outlet points and shall be with suitable removable covers. Drain covers shall be suitable for vehicular movement over them if applicable.

3.8.4 Eaves/ valley gutters and down takes and their supporting system shall be visually concealed by suitable facia as per approved Architectural design.

3.9 Roof Light Sheets

3.9.1 Transparent roof light sheets shall be provided in roofing for natural lighting. These may be avoided in places where false/ suspended ceiling is provided just below the roofing and natural lighting through roof is not available.

3.9.2 If not mentioned otherwise, area of transparent sheeting shall be minimum 10% of roof area. Part of this required area of transparent sheeting may also be provided in the metal side sheeting/ cladding as per approved Architectural design. Size, profile and configuration of transparent sheeting in metal side sheeting/ cladding/ panelling shall also be as per approved Architectural design.

3.10 Roof Ventilation System

3.10.1 For naturally ventilated buildings or areas of buildings, combination of wind driven turbo ventilators/air extractors and ridge ventilators shall be provided in the roofing.

3.10.2 These turbo ventilators/air extractors and ridge ventilators shall be sized and numbered as per requirement of air changes corresponding to type of building indicated in National Building Code of India (NBC).

3.11 Flashings and Other Accessories

3.11.1 Flashings and other accessories such as trims, facias, flashings for gable, corner, openings/gaps, parapet flashing, transition trims, expansion joint trims, ridge caps, gutters, rain water down takes, fixing windows/ ventilators etc, shall be provided on roofing and side sheeting/ cladding/ panelling for weather tightness, roof water drainage and building aesthetics etc.

3.11.2 These shall be profiled to match with the sheeting and approved Architectural design.

3.11.3 If not mentioned otherwise, colour, finishing of these shall be similar to the top sheet of roofing/ side sheeting/ cladding/ panelling.

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4.0 DETAIL ENGINEERING

4.1 Detail engineering of pre-engineered works shall include detailing of approved conceptual design, calculation of rain water gutters, down take and drain sizing for roof drainage, calculation of ridge/ turbo ventilator required for natural ventilation, preparation of construction drawings and fabrication drawings.

4.2 Other than general standard drawings of PEB works, details of laying/ fixing of various flashings, gutters, down takes, facias, accessories etc. shall also be prepared.

5.0 FABRICATION/ INSTALLATION/ CONSTRUCTION

5.1 Fabrication/ Installation/ Construction of PEB works shall be done in accordance with approved drawings, specifications and directions of Engineer-In-Charge complying with necessary Health, Safety & Environmental norms and requirements.

6.0 CO-ORDINATION

6.1 Design, detail engineering and Fabrication/ Installation/ Construction shall be done in co-ordination with Owner/ PMC and other agencies involved in the buildings and associated activities.

6.2 Necessary input required for completing the works shall be obtained from / given to other agencies involved in the building works and associated activities by the approved agency for pre-engineered works.

7.0 DELIVERABLES/ SUBMITTALS BY PEB AGENCY/ CONTRACTOR

7.1 If not mentioned otherwise, PEB agency/ Contractor shall deliver/submit following:

Serial No.	Deliverable/ Submittal
1	Two alternatives of Conceptual Architectural drawings including : - Floor plans, Roof Plan - Site Plan - Sections - Elevations - 3D rendered views
2	Architectural construction drawings including: - Floor plans, Roof Plan - Site Plan - Sections - Elevations - Schedules of Finishes, Door-windows - Door-Window details - Any other drawings, details required for complete understanding and fabrication/ installation/construction
3	Fabrication drawings of roofing and side sheeting/ cladding/ panelling drawings etc including details of accessories, flashings, trims, facias etc,
4	Design calculations for roof drainage system i.e. sizing/ number of gutters, down takes, floor drains etc.
5	Design calculations for natural ventilation system i.e. sizing/ number of ridge ventilators, turbo ventilators etc.
6	As-built drawings
7	Drawings/ documents for Statutory approvals

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Note:

1. PEB agency shall prepare the drawings complete in all respect. For this purpose, necessary input/activity not done by the agency shall be obtained from other involved agencies.

8.0 MATERIALS

8.1 Materials shall conform to project specifications and procured from approved Manufacturers included in the tender/bid document.

8.2 Roofing and Side Sheeting/ Cladding / Panelling

8.2.1 Roofing and side sheeting/ cladding/ panelling shall be either of following as mentioned in project specification.

1. Pre-profiled and pre-coated steel sheet.
2. Profiled Aluminium sheet.
3. Insulated double skin pre-profiled and pre-coated steel sheet done at site.
4. Insulated factory made panels.

8.2.2 If not mentioned otherwise, pre-profiled and pre-coated steel sheet shall be provided.

8.2.3 For specifications of above, reference shall be made to specification nos 6-75-0001 & 6-75-0008.

8.3 Trims, Gutters, Flashings and Other Accessories

8.3.1 These shall be fabricated, bent, and profiled to match with the sheeting, including all cutting, profiling, crimping, curving, fabrication, riveting, fasteners, stitching etc. all complete.

8.3.2 Material, finishing of these shall be as similar to the specification of top sheet of the roofing/ side sheeting/ cladding.

8.3.3 Other details of these shall be as per approved Manufacturers approved standard specification.

8.3.4 If not mentioned colour of these shall be similar to the roofing/ side sheeting/ cladding.

8.3.5 Down takes/ rain water pipes shall be of uPVC or as per approved Manufacturers standard specification and concealed or cladded as per approved Architectural design.

8.4 Windows/ Louvers

8.4.1 If not mentioned otherwise, windows/ louvers in the sheeting/ cladding/ panelling shall be of powder coated Aluminium sections. Glazing shall be of 6mm thick toughened glass.

8.4.2 Junction/ joints/gaps of Windows/ Louvers and sheeting shall be closed ensuring leak and weather tightness by suitable flashing, sealant etc.

8.5 Roof light sheet

8.5.1 Roof light sheet on roofing/ side sheeting/ cladding shall be of transparent poly-carbonate sheet compatible to profile of roofing/ side sheeting/ cladding/ panelling.

8.5.2 Junction/ joints/gaps of this sheet and roofing/ side sheeting/ cladding shall be closed ensuring leak and weather tightness by suitable flashing, sealant etc.

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8.5.3 Reference shall be made to specification no. 6-75-0008 for specification of Roof light sheet.

8.6 Ridge Ventilator/ Air Extractor/ Turbo Ventilator

8.6.1 Reference shall be made to specification no. 6-75-0008 for specification of Ridge ventilator/ Air extractor/ Turbo ventilator

8.6.2 Junction/ joints/gaps of these and roofing/ side sheeting/ cladding shall be closed ensuring leak and weather tightness by suitable flashing, sealant etc.

8.7 Other Materials

For other materials, reference shall be made to following specifications:

Serial No.	Specification No	Title
1	6-75-0001	Standard specification for architectural works general
2	6-75-0002	Standard specification for floor finishing
3	6-75-0003	Standard specification for wood works
4	6-75-0004	Standard specification for steel / aluminium doors, windows and ventilators
5	6-75-0005	Standard specification for plastering and pointing
6	6-75-0006	Standard specification for roof treatment
7	6-75-0007	Standard specification for white / colour washing, distempering, painting and polishing
8	6-75-0008	Standard specification for roofing
9	6-75-0009	Standard specification for sanitary fittings and fixtures
10	6-75-0010	Standard specification for false ceiling, false flooring underdeck insulation & partitioning
11	6-75-0011	Standard specification for fire check / fire resistant doors, windows & partitions

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एल्यूमीनियम समग्र पैनल (एसीपी) क्लैडिंग सिस्टम के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR ALUMINIUM COMPOSITE PANEL (ACP) CLADDING SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
0	03.03.23	ISSUED AS STANDARD SPECIFICATION	SANDEEP	ANISH MAHALA	SAMIR DAS	SANJAY MAZUMDAR

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Abbreviations:

ASTM	:	American Society for Testing and Materials
AAMA	:	American Architectural Manufacturers Association
ACP	:	Aluminium Composite Panel
BS	:	British Standard
BIS	:	Bureau of Indian Standards
EN	:	European Standards
IS	:	Indian Standards
NBC	:	National Building Code of India
PVDF	:	Polyvinylidene Fluoride
RCC	:	Reinforced Cement Concrete
SS	:	Stainless Steel

Architecture Standards Committee

Convenor: Mr. Samir Das

Members:
Mr. Rajesh Gujral
Mr. Anish Kundu
Mr. Sandeep Sharma
Mr. Maitrayee Majumdar (Strl)
Mr. Charanjeet Singh (Proj.)
Mr. Ravindra Kumar (Construction)

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1.0 GENERAL

This Specification covers requirements of ACP cladding on building facades, building or Architectural or structural elements and as interior or exterior finishing or decorations etc. This specification shall be read in conjunction with project specific job specification.

2.0 REFERENCES

The codes and standards listed below contain provisions which through reference in this specification constitute provisions of this standard specification if not specifically mentioned otherwise.

2.1 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NFPA, NBC etc. conformity with any of the similar codes is acceptable.

2.2 Reference codes and standards:

Standards	Document title
ASTM E 330	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
AAMA 501.1	Standard Test Method For Water Penetration Of Windows, Curtain Walls And Doors Using Dynamic Pressure
AAMA 501.4	Recommended static testing method for evaluating curtain wall & storefront systems subjected to seismic & wind induced interstory drift
AAMA 501.2	Quality assurance & Diagnostic Water leakage field check of Installed storefronts, curtain walls , and sloped glazing systems
ASTM E547	Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Differential.
ASTM E283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E331	Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E547	Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Differential.
EN 485	Aluminium and aluminium alloys - Sheet, strip and plate - Part 1: Technical conditions for inspection and delivery
EN 13501-1	Fire classification of construction products and building elements - Part 1
IS 1608	Metallic materials - tensile testing at ambient temperature
IS 8402	Methods of Sampling and Test for Pressure Sensitive Adhesive Tapes
IS 17682	Aluminium Composite Panel Specification
ISO 868	Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness)

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3.0 MATERIALS

3.1 Aluminium Composite Panel (ACP)

ACP shall be external grade mineral core fire retardant type. The panels shall consist of two outer aluminium alloy skins and mineral filled core in between the skins and shall meet the requirements below:

Property	Specification
Grade of the panel	Grade 3 (external grade mineral core fire retardant ACP) conforming to IS 17682 Or Grade B- s1, d0 conforming to EN- 13501-1
Thickness	Overall thickness – 4 mm (+/- 0.2mm)
Outer skins	0.5 mm thick aluminium alloy sheets of any of the following designations. 1. 3150B with conditions H x 6 or H x 8 conforming to IS 737 2. 3105 with H14/16 conforming to EN485
Mineral core	Minimum 3 mm thick, Non combustible type, comprising of 70% inorganic compound 30% virgin polymer laminated and bonded to outer skins. Density of core – 1.5-1.7 gram/ cubic centimeter
Weight of the panel	Minimum 7.5 Kg per square metre
Tensile strength	Minimum 45 N/ square mm when tested as/ IS 1608 (part 1)
Yield strength	Minimum 38 N/ square mm when tested as/ IS 1608 (part 1)
Elongation %	Minimum 5 when tested as/ IS 1608 (part 1)
Peel strength N/10 mm width	Minimum 6 when tested as/ IS 8402
Coating on front side of aluminium alloy skin	PVDF – Minimum 25 microns Pencil hardness – 2H The coating shall consist of chromate conversion, inhibitive primer and fluoropolymercolour coats in approved colour, texture.
Finishing on backside of aluminium alloy skin	Bare aluminium finish
Peel-off protection	The finished surfaces of ACP shall be factory protected with self adhesive peel-off foil having a thickness of 80 microns.
Profiling of panels	The panels shall be in tray/pan profiles. They shall be adequately reinforced at their back side meeting structural design and deflection criteria.

3.2 Supporting frame work

Materials for supporting framework shall be as tabulated below:

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Aluminium sections and profiles	Aluminium profiles shall be of Aluminium (6063 T 5 grade as per EN 485-2).Permissible deflection shall be L/175. They shall be coated with PVDF (minimum 45microns).
Brackets	Mild steel or Aluminium
Screws and fasteners	Stainless steel (SS), 304 grade
Anchor bolts	Stainless steel (SS), 316 grade
Weather sealant	Non bleeding and non staining type having minimum tearing strength of 4.00 N/ mm and shore A hardness of 24 (as/ ISO 868) as approved by the Engineer-In- Charge.
Structural sealant	In accordance with design load as approved by the Engineer-In-Charge.

Other components of the frame work not listed in the table shall be in accordance with the detail design and specification of the system prepared by the Contractor and approved by Engineer- In- Charge.

4.0 DESIGN AND DETAILING OF ACP CLADDING SYSTEM

4.1 Design, structural analysis and detailing including preparation of fabrication drawings of the complete system shall be done by the Contractor or agencies engaged by the Contractor subjected to approval by the Engineer- In- Charge.

4.2 The design, finished surface (pattern, shape, colour, texture etc.)and detailing shall be in accordance with the drawings, requirements of this specification and other requirements issued by Engineer-In-Charge for the purpose.

4.3 ACP cladding system shall comprise of ACP fixed on background (such as masonry, block-work, RCC, steel etc) by means of supporting framework in accordance with approved design and drawings.

4.4 Design shall also include structural analysis and design of the supporting frame work in accordance with relevant Indian or International codes as mentioned or as agreed by the Engineer-In-Charge considering stability, durability, water tightness and other design conditions.

4.5 Contractor or agency engaged by him shall do and submit all necessary structural analysis, calculations and prepare all detailed fabrication drawings for approval by the Engineer-In-Charge.

4.6 The finished surface shall be either with open type grooves or with closed grooves (silicone filled grooves) as mentioned in drawings, item descriptions etc.

If not mentioned specifically, open type grooves shall be provided.

In both the cases grooves shall be in the pattern / design in accordance with approved design and drawing.

5.0 INSTALLATION

5.1 Installation of the complete system shall be done by agency approved by the Engineer-In-Charge.

5.2 Installation shall be done in accordance with design and drawings approved by the Engineer-In- charge.

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5.3 The finished surface shall be true to the plane, water-tight. The groove lines of panels shall be uniform and truly aligned in the continuity.

5.4 The aluminium profiles of framework shall be fixed to background surface by means of fixing to brackets (fixed to the background surface) with SS bolts and nuts. The brackets shall be with serrations and serrated washers for arresting wind load movement.

5.5 Nylon separators shall be provided to prevent bi-metallic contacts in the system.

5.6 The panels shall be cut to size and shape, routed, corners notched and bent as required. Aluminium cleats shall be fixed to the backside edges of the panels using aluminium pop rivets. The panels shall be fixed to the framework using SS screws.

5.7 The gaps (12 – 16 mm) in between the panels shall be uniform in width.

5.8 In case of closed groove system, the gaps between panels shall be filled up with closure profile, backer rod and weather sealant.

5.9 Gaps upto 10 mm between the peripheral panels and backing surface shall be sealed by inserting adequate sized backer rod and sealant. Gaps more than 10 mm shall be sealed by providing and fixing of 2 mm thick aluminium sheet (finished with 60-8- micron thick super durable polyester coating) flashing profiled as per site requirement.

5.10 The termination of the panels shall be suitably detailed and executed using flashing, bending/ continuing the panels etc. for stopping water ingress.

5.11 Necessary weep holes shall be provided in the system for draining out trapped water/ moisture.

5.12 After the installation is completed, peel-off foils shall be removed from the panels and the panel surfaces shall be cleaned and washed with mild soap water with soft dry cotton cloth.

6.0 TESTING

The completed ACP system shall be tested for water tightness as per following method.

Testing Method	Document title
ASTM E283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen
ASTM E331	Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
ASTM E 330	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference
AAMA 501.1	Standard Test Method For Water Penetration Of Windows, Curtain Walls And Doors Using Dynamic Pressure
AAMA 501.4	Recommended static testing method for evaluating curtain wall & storefront systems subjected to seismic & wind induced interstory drift
AAMA 501.2	Quality assurance & Diagnostic Water leakage field check of Installed storefronts, curtain walls , and sloped glazing systems
ASTM E547	Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Differential.

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In case water penetrations are noticed, necessary rectifications shall be done by the Contractor to stop such water ingress as acceptable to the Engineer- In – Charge.

7.0 DELIVERABLES BY THE CONTRACTOR

With regards to documents and drawings, the Contractor shall furnish following deliverables:

1. Structural analysis and calculations
2. Fabrication or shop drawings
3. Test certificates in support of compliance with the specifications.

8.0 WARRANTY

The complete system including ACP, framework, sealants, fittings and fixtures and all components shall be warranted by the Contractor for a period of 5 years. Any defective work or material found within this period shall be repaired/ replaced/ re-done by the Contractor at his own cost.

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STANDARD SPECIFICATION FOR STRUCTURAL GLAZING SYSTEM

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
0	03.03.23	ISSUED AS STANDARD SPECIFICATION	SANDEEP	ANISH MAHALA	SAMIR DAS	SANJAY MAZUMDAR

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Abbreviations:

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AAMA	:	American Architectural Manufacturers Association
BS	:	British Standard
BIS	:	Bureau of Indian Standards
EN	:	European Standards
EPDM	:	Ethylene propylene diene monomer
IS	:	Indian Standards
NBC	:	National Building Code of India
NFPA	:	National Fire Protection Act
PVDF	:	Polyvinylidene Fluoride
RCC	:	Reinforced Cement Concrete
SS	:	Stainless Steel
SHGC	:	Solar Heat Gain Coefficient
UV	:	Ultra Voilet
WWR	:	Window Wall Ratio
VLT	:	Visual Light Transmittance

Architecture Standards Committee

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Mr. Rajesh Gujral
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Mr. Charanjit Singh (Proj.)
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1.0 GENERAL

This Specification covers requirements of the semi-unitized and unitized Curtain wall Structural Glazing System of buildings. This specification shall be read in conjunction with project specific job specification.

2.0 REFERENCES

The codes and standards listed below contain provisions which through reference in this specification constitute provisions of this standard specification if not specifically mentioned otherwise.

2.1 In case of similar codes of different organizations such as IS, ISO, BS, EN, BS-EN, ASTM, NFPA, NBC etc. conformity with any of the similar codes is acceptable.

2.2 Reference codes and standards:

Standards	Document title
ASTM E 330	Standard Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference.
ASTM E 331	Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference
AAMA 501.1	Standard Test Method for Water Penetration of Windows, Curtain Walls and Doors Using Dynamic Pressure.
AAMA 501.4	Recommended static testing method for evaluating curtain wall & storefront systems subjected to seismic & wind induced inter story drift.
AAMA 501.2	Quality assurance & Diagnostic Water leakage field check of Installed storefronts, curtain walls, and sloped glazing systems.
ASTM E283	Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
BS 1474	Specification for Wrought Aluminium and Aluminium Alloys for General Engineering Purposes: Bars, Extruded Round Tubes and Sections.
BS 4255	Rubber Used in Preformed Gaskets for Weather Exclusion from Buildings - Part 1: Specification for non-cellular gaskets.
EN 573 -3	Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 3: Chemical composition and form of products.
EN 13501-1	Fire classification of construction products and building elements - Part 1
IS 3400	Methods of Test for Vulcanized Ruber
IS 8183	Bonded Mineral Wool - Specification
IS 15601	Automotive Vehicles – Flammability requirements
ISO 868	Plastics and ebonite — Determination of indentation hardness by means of a durometer (Shore hardness).

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3.0 MATERIALS

3.1 Aluminium Extrusions

3.1.1 Aluminium alloy extrusions, sections and profiles such as Transom, Transom Connector, Mullion, Mullion Sleeve, Glazing insert, Toggle cleat, Pressure plate, Pressure cap, Aluminium bracket, etc. shall be made of Aluminium alloy and temper 6063 T5 or T6 grade as per BS 1474 or EN AW 6060 T66 conforming to EN 573 part-3 as mentioned in drawings, item descriptions or job specifications.

If not mentioned specifically, they shall be made of Aluminium alloy and temper 6063 T5 or T6 grade as per BS 1474.

3.1.2 All extruded aluminium sections exposed to outside environment shall be anodized in approved color to a minimum thickness of 20 microns or shall be PVDF coil / spray coated in approved colour and shade with metallic colours to a minimum thickness of 35 microns as mentioned in drawings, item descriptions or job specifications.

If not mentioned specifically they shall be PVDF coil / spray coated in approved colour and shade with metallic colours to a minimum thickness of 35 microns.

3.1.3 The colour and the finish shall be uniform and free of streaks. The aluminium sections, before coating, shall be suitably cleaned, rinsed, buffed properly and sealed and protected after anodizing / PVDF coating, till the completion of the work.

3.1.4 The members of aluminum extruded sections for mullions, transoms, members of sub frames & sash frames shall be in single piece. Jointing of pieces in length and height shall not be permitted excepting the cases where the required length is more than maximum length as manufactured.

3.2 Glass

3.2.1 The infill glazing panel shall be factory made glazed unit of size, thickness and type and in compliance with climatic zones, vertical fenestration requirements (as mentioned below) for all three incremental energy efficiency levels, i.e. ECBC, ECBC+, and Super ECBC as mentioned in drawings, item descriptions or job specifications.

a) Maximum allowable Window Wall Ratio (WWR) is 40% (applicable to buildings showing compliance using the Prescriptive Method, including Building Envelope Trade-off Method)
b) Minimum allowable Visual Light Transmittance (VLT) is 0.27
c) Assembly U-factor includes both frame and glass area weighted U-factors.

Vertical Fenestration Assembly U-factor and SHGC Requirements for ECBC Buildings in various climates:

	Composite	Hot and dry	Warm and humid	Temperate	Cold
Maximum U-factor ($W/m^2.K$)	3.00	3.00	3.00	3.00	3.00
Maximum SHGC Non-North	0.27	0.27	0.27	0.27	0.62
Maximum SHGC North for latitude $\geq$ 15°N	0.50	0.50	0.50	0.50	0.62
Maximum SHGC North for latitude < 15°N	0.27	0.27	0.27	0.27	0.62

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Vertical Fenestration U-factor and SHGC Requirements for ECBC+ buildings and Super ECBC buildings in various climates:

	Composite	Hot and dry	Warm and humid	Temperate	Cold
Maximum U-factor ($W/m^2.K$)	2.20	2.20	2.20	3.00	1.80
Maximum SHGC Non-North	0.25	0.25	0.25	0.25	0.62
Maximum SHGC North for latitude $\geq$ 15°N	0.50	0.50	0.50	0.50	0.62
Maximum SHGC North for latitude < 15°N	0.25	0.25	0.25	0.25	0.62

3.2.2 However, as a minimum requirement, glass shall be toughened type and 6mm thick.

3.3 Gaskets

3.3.1 Gaskets and seals shall be of approved quality compatible with substrates, finishes and other components they are in contact with. All gaskets exposed directly on the exterior face shall be silicon gaskets, which are UV resistant. They shall not degenerate, discolour or leach on exposure to solar radiations/ rains/ pollutants etc.

3.3.2 Gaskets shall have following properties:

Property	Value	Reference code/ standard
Material	Microwave cured EPDM	BS 4255
Performance capability	Temperature range of -40 Deg C to +120 Deg C	-
Fire resistance (Horizontal burning)	Not exceeding 35 mm/Minute	IS 15601
Fire resistance (Vertical burning)	Not exceeding 15 mm/Minute	IS 15601
Heat stability, mechanical properties etc	Compliance with reference code/ standard	IS 3400
Ozone resistance	Passing the test for 200 hours	-

3.4 Sealants

3.4.1 Sealants shall be in conformity with the performance requirements specified in job specification etc. as per the recommendations of the sealant manufacturer and as approved by the Engineer-In-Charge.

3.4.2 Structural sealant

The silicone bite for the structural sealant shall be designed for the design loads as specified and likely to come during the life of the curtain glazing system. It shall be two part pump-filled Silicone sealant.

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3.4.3 Weather sealant

Weather sealant shall be Non bleeding and non staining type silicone sealant having minimum tearing strength of 4.00 N/ mm and shore A hardness of 24 (as/ ISO 868) as approved by the Engineer-In- Charge.

3.5 Fire smoke seal

Smoke seal/fire stop using extruded aluminum channel with cap shall be provided for continuous structurally glazed framing system. The thickness of channel shall be 2 mm and material and coating finish shall be similar to extruded profile section as per clause no. 3.1.

3.6 Insulation on spandrel panel

Insulation on spandrel system shall be 50 mm thick semi-rigid fibre glass wool insulation panel of minimum density of 48 kg per cubic metre conforming to IS 8183 and 1.5 mm thick anodized (10 microns) solid aluminium sheet tray by using suitable stainless steel rivets/ nuts, bolts and washers to hold the insulation panel in position.

3.7 Flashing

All flashings shall be made from minimum 1.0 mm thick solid aluminium sheet anodized to a minimum thickness of 10 microns. It shall be fixed using stainless steel screws dipped in weather silicone sealant or by welding,

3.8 Aluminium decorative capping

Aluminium decorative capping etc. shall be made out of extruded profile section and material and coating finish per clause no. 3.1 and as per approved design.

3.9 Brackets/supports

The brackets shall have suitable lengths and sections to align curtain glazing in one face, as required as per the Architectural drawings. The brackets shall be fabricated from M.S rolled sections / plates to have the design strength. The quality of the weld shall also be ensured as per the standards. These shall be provided corrosion protection treatment by Hot Dipped Galvanizing. The mass of the zinc coating to be not less than 610 gm. per sqm of steel area to be galvanized.

Each bracket shall be fixed to the R.C.C using anchor fasteners of suitable capacities and in numbers as required as per the design requirements. The brackets shall be fixed to the structural steel members of the building using stainless steel bolts & nuts / fasteners of required capacity and in numbers as per the design requirement.

3.10 Fasteners

Bolts, anchors and other fastening devices like screws, nuts, washers etc. shall be of stainless steel and of approved types as required for the strength of the connections, shall be self-locking, unless otherwise specified.

Anchor fasteners shall be of stainless steel grade 316. Screws, Nuts, Bolts, Washers shall be of stainless steel grade 304. Rivets, toggles and the like shall be of stainless steel grade 304.

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3.11 Fittings

All hardware and fittings such as patch fittings, handles, locks, stay-arms, floor springs, friction stays etc. for doors , windows and open able panels shall be of heavy duty type and of approved make as specified.

Hinges for open able panels shall be heavy duty top hung stainless steel friction hinges selected for specified wind load and dead loads.

3.12 Others

Other materials not mentioned above shall be in accordance with the detail design and specification of the system prepared by the Contractor and approved by Engineer- In- Charge.

4.0 DESIGN AND DETAILING OF STRUCTURAL GLAZING SYSTEM

4.1 Design, structural analysis and detailing including preparation of fabrication drawings of the complete system shall be done by the Contractor or agencies engaged by the Contractor subjected to approval by the Engineer- In- Charge.

4.2 The design and detailing shall be in accordance with the drawings, requirements of this specification and other requirements issued by Engineer-In-Charge for the purpose.

4.3 Design shall also include structural analysis and design of the supporting frame work in accordance with relevant Indian or International codes as mentioned or as agreed by the Engineer-In-Charge considering stability, durability, water tightness and other design conditions.

4.4 Contractor or agency engaged by him shall do and submit all necessary structural analysis, calculations and prepare all detailed fabrication drawings for approval by the Engineer-In-Charge.

4.5 The system shall consist of structural framing and supporting system to support glazed/non glazed panels including transoms, mullions, vision panels and spandrel panels, openable top hung window, swing glazed doors, decorative capping, fire & smoke seal, flashing including gaskets, sealants, fasteners, brackets, necessary fittings & accessories as part of the system in accordance with approved design and drawings.

4.6 The System shall be designed for maximum design wind pressure and lateral forces, moments, stresses, deflections, thermal expansion, weather resistant etc. (test pressure equivalent to 1.5 time the maximum design wind pressure) considering stability, durability, water tightness and other design conditions.

4.7 The System shall be designed with air pressure equalization chamber and concealed continuous gutter vertically and horizontally at all levels as self drainage barrier to achieve water tightness besides providing EPDM gaskets on the frame and EPDM gasket/ sealant on the external groove as air and water barrier.

4.8 The system shall be designed to meet the requirements of thermal performance.

4.9 The system shall be aesthetically pleasant and in accordance with approved design.

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5.0 FABRICATION, PROCURMENT & TRANSPORTATION

5.1 Fabrication including procurement & transportation of all material shall be done in accordance with the approved system design, detailing & drawings and requirements the specification (s).

5.2 Before fabrication, Contactor or agency shall conduct the site survey prior to and after preparation of shop drawing and accommodating the site conditions in the system at appropriate levels etc shall lies solely with the agency executing the work.

5.3 Before the fabrication and site installation is taken up and after the approval of shop drawings by the Engineer-in-Charge, a mock-up of the system shall be prepared by the Contractor. The mock-up shall be essentially put up at site for final approval of all materials and installation details by the Engineer-in-Charge. It shall be dismantled and taken away by the contractor as directed by the Engineer-in-Charge.

5.4 The system shall be erected on extruded main frame & transom fixed on supporting system at site. The panels shall be supplied and fabricated with the specified glass on the secondary frame at factory.

5.5 Factory made glazing units /components shall be transported , handled, stored in a manner to prelude damage of any nature.

5.6 All materials delivered to site shall be stored in allocated spaces where it shall not be exposed to rainwater, moisture or damage. All Material shall be stored neatly and properly handled . Defective/damaged components shall be replaced by contractor.

6.0 INSTALLATION

6.1 Installation of the complete system shall be done by agency approved by the Engineer-In-Charge.

6.2 Installation shall be done in accordance with approved design and drawings.

6.3 The finished surface shall be true to the plane and water-tight. The lines of panels shall be truly aligned in the continuity or as per drawings.

6.4 The aluminium profiles of framework shall be fixed to building structure and background surface by means of fasteners as per approved design and drawing.

6.5 Nylon/ inert polymeric material separators shall be provided to prevent bi-metallic contacts in the system.

6.6 Transom connectors shall be fixed to the mullions using screws/ other suitable method as recommended by the system supplier. Mullion Sleeve shall be used in mullion-mullion joints.

6.7 Glazing gaskets shall be installed and compressed into the cavity as applicable.

6.8 The glazing panels shall be cut to size and shape, routed. Glass shall be fixed using pressure plate (with gaskets)/ any other approved vendor detail on horizontals and verticals. There shall be provisions of Horizontal and Vertical Capping as per the design intent.

6.9 The gaps (12 – 20 mm) in between the panels shall be uniform in width.

6.10 The gaps upto 10 mm between the peripheral panels and backing surface shall be sealed by inserting adequately sized backer rod and weather sealant. Gaps more than 10 mm shall be

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sealed by providing and fixing of 2 mm thick aluminium sheet (finished with 60-8- micron thick super durable polyester coating) flashing profiled as per site requirement.

6.11 The cover caps shall be clipped on to the pressure plates and secured by screws where recommended by manufacturer.

6.12 The termination of the panels shall be suitably detailed and executed using flashing, bending/ continuing the panels etc. for stopping water ingress.

6.13 All the joints in aluminium framing system and factory glazed panels shall be fully sealed and made air, water and weather tight preventing seepage of rain water under heavy wind pressures.

6.14 Gap between the building face and structural glazing system at soffit level between the successive floors shall be closed with required fire rated fire stop cum smoke seal.

6.15 After the installation is completed, panel surfaces shall be cleaned with soft dry cotton cloth.

7.0 DELIVERABLES BY THE CONTRACTOR

With regards to documents and drawings, the Contractor shall furnish following deliverables:

1. Structural analysis and calculations
2. Fabrication or shop drawings
3. Test certificates in support of compliance with the specifications.
4. Samples for materials, components, accessories.
5. Product data sheets, installation & maintenance manuals.
6. Mock-up of complete structural glazing system including glass depicting all important components
7. U-Value Calculation for the proposed Glazing.
8. U-Value (composite) calculation for the proposed structural glazing system including glazing and framework.
9. Report on Stability analysis of Glazing panel of all sizes.

8.0 TESTING

The following performance tests are to be conducted on structural glazing system if area of structural glazing exceeds 2500 Sqm from the certified laboratories accredited by NABL (National Accreditation Board for Testing and Calibration Laboratories) or Department of Science & Technologies, India.

1.	Performance Laboratory Test for Air Leakage Test (-50pa to -300pa) & (+50pa to + 300 pa) as per ASTM E-283-04 testing method for a leakage limit of 1 to 200 mVhr.
2.	Static Water Penetration Test (50 pa to 1500 pa) as per ASTM E -331-09 testing method for a range up to 2000 ml.
3.	Dynamic Water Penetration (50 pa to 1500 pa) as per ASTM E -331-09 testing method for a range upto 2000 ml.
4.	Structural Performance Deflection and deformation by static air pressure test (1.5 times design wind pressure without any failure) as per ASTME-330-10 testing method for a range upto 50 mm.
5.	Seismic Movement Test (upto 30 mm) as per AAMA 501.4-09 testing method for Qualitative test. Tests to be conducted at site.
6.	Onsite Test for water leakage for a pressure range 50kpa to 240 kpa (35psi) upto 2000ml.

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9.0 WARRANTY

The complete structural glazing system including Glazing, framework, sealants, fittings and fixtures and all components shall be warranted by the Contractor for a period of 10 years. Any defective work or material found within this period shall be repaired/ replaced/ re-done by the Contractor at his own cost. In case of any damage, water leakage etc. due to deficiencies in design, materials and workmanship, the contractor shall replace or rectify the damaged works at his own cost to the acceptance of approving authority.

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STANDARD SPECIFICATION FOR ERECTION OF EQUIPMENT & MACHINERY

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	30.03.2019	Reaffirmed & Reissued	RJ	MI	RP	RKT
3	21.01.2013	Revised & Reissued	MA	RS	VK	DM
2	03.09.2008	Revised & Reissued	DM	PKR	AA	VC
1	30.05.2008	Revised & Reissued	DM	PKR	AA	VC
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Abbreviations:

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

General Engineering Standards Committee

Convenor : Ms R Priyamvada

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

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1.0 SPECIFICATION FOR ERECTION OF EQUIPMENT AND MACHINERY

1.1 Scope

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

1.2 General

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

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

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

1.3 Preparation for Erection

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

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

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

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

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

2.1 Scope of work of Erection Contractor

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

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

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

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

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

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

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

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

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

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

2.2 General Conditions of Erection

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.4 Inspection and Acceptance Limits for Level and Alignment

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

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

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

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

2.5 Additional requirements for Underground buried vessels

2.5.1 Underground vessels for operating temp upto 60°C

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

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

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

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

3.0 ERECTION OF MECHANICAL EQUIPMENT

3.1 Scope of Work of Erection Contractor

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

3.2 Details of Owner Supplied Equipments

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

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

3.3 Technical Requirements

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3.3.17 Safety devices shall be correctly installed.

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

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

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

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

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

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

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

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

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3.4 Trial Runs

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

3.5 System Start-up

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

4.0 HEAT AND MASS TRANSFER EQUIPMENT

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

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

4.1 Scope of Work of Erection Contractor

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2 General Conditions of Erection

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.2.24 Refer section 1.0 (General) for additional requirements.

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4.3 Hydrotesting of Shell and Tube Exchangers including Condensers

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

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

4.3.3 Stacked exchangers shall be hydrotested in stacked conditions.

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

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

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

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

4.4 Hydrotesting Procedure

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

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

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

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

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

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

4.5 Flushing & Cleaning

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

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

4.6 Inspection and Acceptance Limits for Level & Alignment

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

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

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

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

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

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

4.7 Safety, Health & Environment

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

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

5.0 ERECTION OF ROTATING EQUIPMENT

5.1 Scope of Work of Erection Contractor

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

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

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

5.2 General Conditions of Erection

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

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

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

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

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

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

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

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

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

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

5.3 Special Instructions

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

5.3.1 Pumps

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

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

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

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

5.3.2 Reciprocating Type Compressors

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

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

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

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

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

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

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

5.3.3 Centrifugal Compressors & Expanders

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

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

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

5.4 Trial Runs of Machinery

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

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

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

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

5.5 System Start up

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

6.0 EQUIPMENT GROUTING

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

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

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6.1 Grout (Material)

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

6.1.1 **Non-Shrink Grout**

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

It shall have the following features:

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

It should have the following physical properties:

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

6.1.2 **Epoxy Grout**

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

It should have the following physical properties :

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

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6.2 Grouting (Placement)

6.2.1 **Surface Preparation**

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

6.2.2 **Preparation of Grout**

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

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

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

6.2.3 **Placement of Grout**

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

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

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

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

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

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

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7.0 REFERENCE EIL STANDARDS/ SPECIFICATIONS

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

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

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

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
3	30-06-2021	Revised and reissued for Implementation	PVK	PG	VM	SM
2	04-05-2016	Issued for Implementation	PG	SVRS	RP	RN
1	26-05-2008	Issued for Implementation	PG	KPS	AA	VC
0	15-05-2003	Issued for Implementation	PG	KPS	VC	SKG

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Abbreviations:

ASME	American Society of Mechanical Engineers
PMS	Piping Material Specification

General Engineering Standards Committee

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Members :
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Mr. VK Tonger
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1.0 PURPOSE

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

2.0 SCOPE

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

3.0 REFERENCES

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

4.0 DEFINITIONS

None.

5.0 METHODOLOGIES AND CONTROL

5.1 Identification of joints for controlled bolt tightening

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

5.1.1 Hydraulic Bolt tensioning

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

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Table 1: Criteria for Bolt Tensioning – Not applicable for flange joints in category 'D' services

Nominal Bolt diameter	Condition	Remarks
All	When specified by the Process licensor/ vendor / project specifications	
50 mm and above	All joints	
38 mm and above, but less than 50 mm	Class 600 and above	
	Hydrogen service	(See Note-1 below)
	Category 'M' fluid services	Refer ASME B31.3
	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)
25 mm and above, but less than 38 mm	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)

Note-1: Hydrogen Service

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

Note-2: Joints with leakage potential shall include

a) Joints involving tapped holes.
b) Joints not subjected to hydro test e.g. joints for equipment manholes, equipment mounted temperature, pressure and level instruments, line mounted temperature connections, on line instrument joints like control valves and safety valves, compressor volume bottles.
c) Items involving two sets of gaskets with one set of bolt e.g. orifice flange joint, joints with spectacle blind, spacer, flangeless wafer check valve, wafer type butterfly valves.
d) Tie-in joints with other contractors and package vendors.
e) High temperature (above 371°C) joints in hydrocarbon services.

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

5.1.2 Application of torque

Controlled bolt torque, with calculated torque values, shall be applied using calibrated torque wrench. Joints those qualify for hydraulic bolt tensioning per 5.1.1 shall not be considered for torque application. Controlled bolt torque should be applied for the joints meeting the criteria given in Table 2. Joints fulfilling the criteria for Hydraulic bolt tensioning need not be checked for these criteria

Table 2: Criteria for Bolt Torque application

Service	Joints
Hydrogen service	All joints (Note-1)
Category 'M' services	All joints (Note-1)
Other services	Class 600 and above

Note-1: Joints, those qualify for hydraulic bolt tensioning as per cl. 5.1.1, shall not be considered for torque application.

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5.2 Pre-bolting Operations

5.2.1 Design

a) Flange connection with bolting of nominal diameter 25 mm and above shall have sufficient clearances and access to allow the use of hydraulic tensioning equipment (wherever hydraulic bolt tensioning is being used).

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

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

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

5.2.2 General

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

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

c) All non-ring joint gaskets shall be replaced with the new ones whenever an opened joint is to be re-closed during construction and commissioning stage. Ring joint gaskets normally can be re-used provided they are inspected and are free from any damage

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

5.2.3 Visual inspection

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

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

c) Visual examination of gaskets should be carried out prior to installation to ensure that these are free of any defects such as bends, crease or loose spiral windings etc.

d) Gasket position should be checked.

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

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

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5.2.4 Corrective measures

a) Faces with pitting, indentations or radial tool marks, or scratches that form leakage paths or with the surface finish not in accordance with design requirements shall be replaced or re-machined to specified surface finish.

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

c) Damaged gaskets shall be replaced.

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

5.2.5 Lubrication/anti-seize compound

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

b) Gaskets should not be lubricated.

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

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

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

5.2.6 Assembly

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

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

c) Balance studs should be inserted next.

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

5.2.7 Torque/tension calculation

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

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

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

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

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

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

Table 3: PMS classes included in this specification

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

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5.2.9 Torque and tension values

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

5.2.10 Notes to Torque and tension values in Table 4

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

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

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

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

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

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

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

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

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

5.3 Bolting Operation

5.3.1 General

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

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

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

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5.3.2 Hydraulic bolt tension application

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

b) 4 load cells equally spaced should be used.

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

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

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

5.3.3 Stud bolt torque application

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

b) Properly calibrated torque wrenches should be used.

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

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

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

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

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

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

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

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

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

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

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

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

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5.3.4 Testing of joints

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

6.0 RESPONSIBILITIES / APPROVALS

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

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

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

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

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

7.0 DOCUMENTATION

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

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

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

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

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

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

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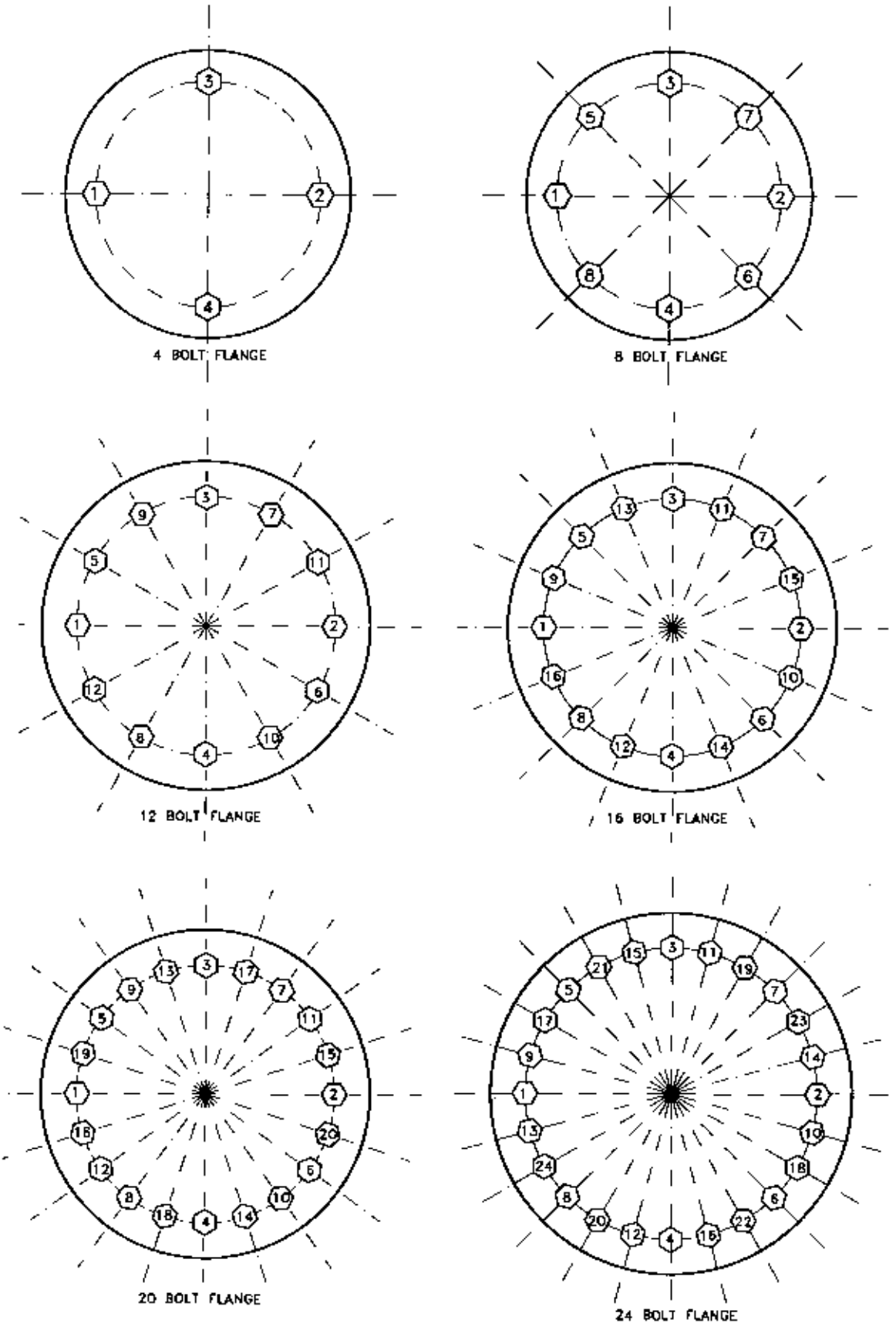

Figure 1 Typical "Criss-cross" Bolt tightening/Torque application pattern

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Table 4: Bolt Tension and Torque Values

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

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-1													
A1A	PMS rated Temperature / Pressure		371 / 7.73	Up to 48"	7.73	371	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	3/4	1/2	4	855	2.6
				A672 Gr. B60	7.73	371	30.05	150S	1	1/2	4	1027	3.1
A2A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150S	1-1/2	1/2	4	1597	4.8
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	2	5/8	4	2562	9.4
				A672 Gr. B60	7.73	371	30.05	150S	3	5/8	4	3020	11.1
A6A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	4	5/8	8	2471	9.1
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	6	3/4	8	3972	17.2
				A672 Gr. B60	7.73	371	30.05	150S	8	3/4	8	4931	21.3
A7A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	10	7/8	12	5135	25.5
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	12	7/8	12	5326	26.5
				A672 Gr. B60	7.73	371	30.05	150S	14	1	12	6249	35.2
A9A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150S	16	1	16	5999	33.8
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	18	1-1/8	16	8583	53.7
				A672 Gr. B60	7.73	371	30.05	150S	20	1-1/8	20	8583	53.7
A11A	PMS rated Temperature / Pressure		371 / 7.5	Up to 48"	7.73	371	30.05	150S	24	1-1/4	20	11379	78.3
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	26	3/4	36	4111	17.7
				A672 Gr. B60	7.73	371	30.05	150B	28	3/4	40	4111	17.7
A13A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150B	30	3/4	44	4385	18.9
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	32	3/4	48	4522	19.5
				A672 Gr. B60	7.73	371	30.05	150B	34	7/8	40	6274	31.2
A19A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150B	36	7/8	44	6274	31.2
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	38	1	40	7750	43.7
				A 672 Gr.B 60 Cl.22	7.73	371	30.05	150B	40	1	44	7750	43.7
					7.73	371	30.05	150B	42	1	48	7750	43.7
					7.73	371	30.05	150B	44	1	52	7750	43.7
					7.73	371	30.05	150B	46	1-1/8	40	11230	70.3
					7.73	371	30.05	150B	48	1-1/8	44	10670	66.2

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Piping Class	PMS class data: Temperature, pressure, materials and size range				Calculation Data: Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	30.05	150B	50	1-1/8	48	10870	66.2
					7.73	371	30.05	150B	52	1-1/8	52	10240	64.1
					7.73	371	30.05	150B	54	1-1/8	56	10240	64.1
					7.73	371	30.05	150B	56	1-1/8	60	10240	64.1
					7.73	371	30.05	150B	58	1-1/4	48	13488	92.8
					7.73	371	30.05	150B	60	1-1/4	52	13488	92.8
LIST A-2													
A4Y	PMS rated Temperature / Pressure		50 / 10.55	Up to 12"	10.55	186	15.80	150S	1/2	1/2	4	684	2.1
	A105	A307 GR.B	BUTYL RUBBER	API 5L GR.B PSL1	10.55	186	15.80	150S	3/4	1/2	4	855	2.6
					10.55	186	15.80	150S	1	1/2	4	1027	3.1
					10.55	186	15.80	150S	1-1/2	1/2	4	1255	3.8
					10.55	186	15.80	150S	2	5/8	4	2013	7.4
					10.55	186	15.80	150S	3	5/8	4	2013	7.4
					10.55	186	15.80	150S	4	5/8	8	2013	7.4
					10.55	186	15.80	150S	6	3/4	8	3014	13.0
					10.55	186	15.80	150S	8	3/4	8	3014	13.0
					10.55	186	15.80	150S	10	7/8	12	4184	20.8
					10.55	186	15.80	150S	12	7/8	12	4184	20.8
					10.55	186	15.80	150S	14	1	12	5499	31.0
					10.55	186	15.80	150S	16	1	16	5499	31.0
					10.55	186	15.80	150S	18	1-1/8	16	7263	45.6
					10.55	186	15.80	150S	20	1-1/8	20	7263	45.5
					10.55	186	15.80	150S	24	1-1/4	20	9272	63.8
LIST A-3													
A4A	PMS rated Temperature / Pressure		204 / 14.06	Up to 48"	14.06	204	27.95	150S	1/2	1/2	4	684	2.1
	A 350 GR.LF2 CL.1	A320 GR.L7	Spiral wound SS	A 333 GR.6	14.06	204	27.95	150S	3/4	1/2	4	855	2.6
				A 671 GR.CC60 CL.32	14.06	204	27.95	150S	1	1/2	4	1027	3.1
					14.06	204	27.95	150S	1-1/2	1/2	4	1597	4.8
					14.06	204	27.95	150S	2	5/8	4	2562	9.4
					14.06	204	27.95	150S	3	5/8	4	3020	11.1
					14.06	204	27.95	150S	4	5/8	8	2471	9.1
					14.06	204	27.95	150S	6	3/4	8	3972	17.2
					14.06	204	27.95	150S	8	3/4	8	4931	21.3

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

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
A33A	PMS rated Temperature / Pressure		65 / 18.9	Up to 48"	8.78	343	30.05	150S	16	1	16	5999	33.8
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	18	1-1/8	16	8583	53.7
				IS-3589 GR.410	8.78	343	30.05	150S	20	1-1/8	20	8583	53.7
A33Y	PMS rated Temperature / Pressure		65 / 18.9	Up to 48"	8.78	343	30.05	150S	24	1-1/4	20	11379	78.3
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150B	26	3/4	36	4111	17.7
				IS-3589 GR.410	8.78	343	30.05	150B	28	3/4	40	4111	17.7
					8.78	343	30.05	150B	30	3/4	44	4385	18.9
					8.78	343	30.05	150B	32	3/4	48	4522	19.5
					8.78	343	30.05	150B	34	7/8	40	6274	31.2
					8.78	343	30.05	150B	36	7/8	44	6274	31.2
					8.78	343	30.05	150B	38	1	40	7750	43.7
					8.78	343	30.05	150B	40	1	44	7750	43.7
					8.78	343	30.05	150B	42	1	48	7750	43.7
					8.78	343	30.05	150B	44	1	52	7750	43.7
					8.78	343	30.05	150B	46	1-1/8	40	11230	70.3
					8.78	343	30.05	150B	48	1-1/8	44	10570	66.2
					8.78	343	30.05	150B	50	1-1/8	48	10570	66.2
					8.78	343	30.05	150B	52	1-1/8	52	10240	64.1
					8.78	343	30.05	150B	54	1-1/8	56	10240	64.1
					8.78	343	30.05	150B	56	1-1/8	60	10240	64.1
					8.78	343	30.05	150B	58	1-1/4	48	13488	92.8
					8.78	343	30.05	150B	60	1-1/4	52	13488	92.8
LIST A-5													
A16A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	1/2	1/2	4	884	2.1
	A105	A193 Gr. B7M	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	3/4	1/2	4	856	2.6
				A672 Gr. B60	7.73	371	30.05	150S	1	1/2	4	1027	3.1
					7.73	371	30.05	150S	1-1/2	1/2	4	1597	4.8
					7.73	371	30.05	150S	2	5/8	4	2562	9.4
					7.73	371	30.05	150S	3	5/8	4	3020	11.1
					7.73	371	30.05	150S	4	5/8	8	2471	9.1
					7.73	371	30.05	150S	6	3/4	8	3972	17.2
					7.73	371	30.05	150S	8	3/4	8	4931	21.3
					7.73	371	30.05	150S	10	7/8	12	5135	25.5

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	30.05	150S	12	7/8	12	5326	26.5
					7.73	371	30.05	150S	14	1	12	6249	35.2
					7.73	371	30.05	150S	16	1	16	5999	33.8
					7.73	371	30.05	150S	18	1-1/8	16	8583	53.7
					7.73	371	30.05	150S	20	1-1/8	20	8583	53.7
					7.73	371	30.05	150S	24	1-1/4	20	11379	78.3
LIST A-6													
A4F	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.57	150S	1/2	1/2	4	798	2.4
	A182 Gr.F5	A193 Gr.B16	Spiral wound SS	A 335 GR.P5	7.73	371	30.57	150S	3/4	1/2	4	970	2.9
				A 691 GR.5Cr CL.42	7.73	371	30.57	150S	1	1/2	4	1141	3.4
					7.73	371	30.57	150S	1-1/2	1/2	4	1540	4.6
					7.73	371	30.57	150S	2	5/8	4	2745	10.1
					7.73	371	30.57	150S	3	5/8	4	3020	11.1
					7.73	371	30.57	150S	4	5/8	8	3020	11.1
					7.73	371	30.57	150S	6	3/4	8	5205	22.6
					7.73	371	30.57	150S	6	3/4	8	5274	22.8
					7.73	371	30.57	150S	10	7/8	12	6277	31.2
					7.73	371	30.57	150S	12	7/8	12	6277	31.2
					7.73	371	30.57	150S	14	1	12	8249	46.5
					7.73	371	30.57	150S	16	1	16	7249	40.9
					7.73	371	30.57	150S	18	1-1/8	16	11885	74.4
					7.73	371	30.57	150S	20	1-1/8	20	11564	72.4
					7.73	371	30.57	150S	24	1-1/4	20	14751	101.5
					7.73	371	30.57	150B	26	3/4	36	4109	17.7
					7.73	371	30.57	150B	28	3/4	40	4383	18.9
					7.73	371	30.57	150B	30	3/4	44	4520	19.5
					7.73	371	30.57	150B	32	3/4	48	4794	20.7
					7.73	371	30.57	150B	34	7/8	40	6847	34.0
					7.73	371	30.57	150B	36	7/8	44	7037	35.0
					7.73	371	30.57	150B	38	1	40	8748	49.3
					7.73	371	30.57	150B	40	1	44	8748	49.3
					7.73	371	30.57	150B	42	1	48	8496	47.9

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-7													
A4G	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.57	150S	1/2	1/2	4	798	2.4
	A182 Gr.F9	A193 Gr.B16	Spiral wound SS	A 335 GR.P9	7.73	371	30.57	150S	3/4	1/2	4	970	2.9
				A 691 GR.9Cr CL.42	7.73	371	30.57	150S	1	1/2	4	1255	3.8
					7.73	371	30.57	150S	1-1/2	1/2	4	1825	5.5
					7.73	371	30.57	150S	2	5/8	4	3203	11.8
					7.73	371	30.57	150S	3	5/8	4	3386	12.4
					7.73	371	30.57	150S	4	5/8	8	3386	12.4
					7.73	371	30.57	150S	6	3/4	8	5342	23.1
					7.73	371	30.57	150S	8	3/4	8	5342	23.1
					7.73	371	30.57	150S	10	7/8	12	7037	35.0
					7.73	371	30.57	150S	12	7/8	12	6847	34.0
					7.73	371	30.57	150S	14	1	12	8748	49.3
					7.73	371	30.57	150S	16	1	16	7999	45.1
					7.73	371	30.57	150S	18	1-1/8	16	12215	76.6
					7.73	371	30.57	150S	20	1-1/8	20	11886	74.4
					7.73	371	30.57	150S	24	1-1/4	20	15594	107.3
					7.73	371	30.57	150B	26	3/4	36	4383	18.9
					7.73	371	30.57	150B	28	3/4	40	4589	19.8
					7.73	371	30.57	150B	30	3/4	44	4726	20.4
					7.73	371	30.57	150B	32	3/4	48	5137	22.2
					7.73	371	30.57	150B	34	7/8	40	7132	35.5
					7.73	371	30.57	150B	36	7/8	44	7132	35.5
					7.73	371	30.57	150B	38	1	40	9123	51.4
					7.73	371	30.57	150B	40	1	44	9123	51.4
					7.73	371	30.57	150B	42	1	48	8998	50.7
LIST A-8													
A2K	PMS rated Temperature / Pressure		120 / 15.32	Up to 24"	15.32	120	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	15.32	120	29.00	150S	3/4	1/2	4	855	2.6
				A 358 GR.304	15.32	120	29.00	150S	1	1/2	4	1141	3.4
					15.32	120	29.00	150S	1-1/2	1/2	4	1597	4.8
					15.32	120	29.00	150S	2	5/8	4	2379	8.7
					15.32	120	29.00	150S	3	5/8	4	3203	11.8

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					15.32	120	29.00	150S	4	5/8	8	2837	10.4
					15.32	120	29.00	150S	6	3/4	8	4383	18.9
					15.32	120	29.00	150S	8	3/4	8	5068	21.9
					15.32	120	29.00	150S	10	7/8	12	5516	27.4
					15.32	120	29.00	150S	12	7/8	12	5896	29.3
					15.32	120	29.00	150S	14	1	12	7499	42.3
					15.32	120	29.00	150S	16	1	16	6749	38.1
					15.32	120	29.00	150S	18	1-1/8	16	9574	59.9
					15.32	120	29.00	150S	20	1-1/8	20	9574	59.9
					15.32	120	29.00	150S	24	1-1/4	20	12644	87.0
					15.32	120	29.00	150B	26	3/4	36	4109	17.7
					15.32	120	29.00	150B	26	3/4	40	4248	18.3
					15.32	120	29.00	150B	30	3/4	44	4383	18.9
					15.32	120	29.00	150B	32	3/4	48	4520	19.5
					15.32	120	29.00	150B	34	7/8	40	5896	29.3
					15.32	120	29.00	150B	36	7/8	44	5991	29.8
LIST A-9													
A1K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1/2	1/2	4	670	1.7
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	7.73	371	29.00	150S	3/4	1/2	4	798	2.4
				A 358 GR.304	7.73	371	29.00	150S	1	1/2	4	913	2.7
A6K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1-1/2	1/2	4	1141	3.4
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	7.73	371	29.00	150S	2	5/8	4	2562	9.4
				A 358 GR.304L	7.73	371	29.00	150S	3	5/8	4	3020	11.1
A11K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	4	5/8	8	2471	9.1
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	7.73	371	29.00	150S	6	3/4	8	3972	17.2
				A 358 GR.304L	7.73	371	29.00	150S	8	3/4	8	4931	21.3
					7.73	371	29.00	150S	10	7/8	12	5135	25.5
					7.73	371	29.00	150S	12	7/8	12	5326	26.5
					7.73	371	29.00	150S	14	1	12	6249	36.2
					7.73	371	29.00	150S	16	1	16	5999	33.8
					7.73	371	29.00	150S	18	1-1/8	16	8583	53.7
					7.73	371	29.00	150S	20	1-1/8	20	8583	53.7
					7.73	371	29.00	150S	24	1-1/4	20	11379	78.3

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

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

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
				A672 Gr.B60 CL.22	28.82	427	79.10	300S	3	3/4	8	3972	17.2
					28.82	427	79.10	300S	4	3/4	8	5205	22.5
					28.82	427	79.10	300S	6	3/4	12	5205	22.5
					28.82	427	79.10	300S	8	7/8	12	7608	37.8
					28.82	427	79.10	300S	10	1	16	8748	49.3
					28.82	427	79.10	300S	12	1-1/8	16	11554	72.4
					28.82	427	79.10	300S	14	1-1/8	20	8913	55.8
					28.82	427	79.10	300S	16	1-1/4	20	10958	75.4
					28.82	427	79.10	300S	18	1-1/4	24	11801	81.2
					28.82	427	79.10	300S	20	1-1/4	24	14330	98.6
					28.82	427	79.10	300S	24	1-1/2	24	17849	144.9
					28.82	427	79.10	300B	26	1-1/4	32	13065	89.9
					28.82	427	79.10	300B	28	1-1/4	36	13065	89.9
					28.82	427	79.10	300B	30	1-3/8	36	16197	114.0
LIST B-3													
B1D	PMS rated Temperature / Pressure		538 / 15.11	Up to 24"	15.11	538	79.10	300S	1/2	1/2	4	741	2.2
	A182 Gr. F11 Cl. 2	A193 Gr. B16	Spiral wound SS	A335 Gr. P11	15.11	538	79.10	300S	3/4	5/8	4	1007	3.7
				A691 Gr.1.25Cr Cl.42	15.11	538	79.10	300S	1	5/8	4	1647	6.0
B5D	PMS rated Temperature / Pressure		538 / 15.11	Up to 24"	15.11	538	79.10	300S	1-1/2	3/4	4	3014	13.0
	A182 Gr. F11 Cl. 2	A193 Gr. B16	Spiral wound SS	A335 Gr. P11	15.11	538	79.10	300S	2	5/8	8	2196	8.1
				A691 Gr.1.25Cr Cl.42	15.11	538	79.10	300S	3	3/4	8	4794	20.7
B3F	PMS rated Temperature / Pressure		538 / 14.06	Up to 24"	15.11	538	79.10	300S	4	3/4	8	5205	22.5
	A 182 GR.F5	A193 GR.B16	Spiral wound SS	A 335 GR.P5	15.11	538	79.10	300S	6	3/4	12	5205	22.5
				A 691 GR5CR CL.42	15.11	538	79.10	300S	8	7/8	12	7228	35.9
B4F	PMS rated Temperature / Pressure		538 / 14.06	Up to 24"	15.11	538	79.10	300S	10	1	16	9498	53.6
	A 182 GR.F5	A193 GR.B16	Spiral wound SS	A 335 GR.P5	15.11	538	79.10	300S	12	1-1/8	16	11885	74.4
				A 691 Gr. 5CR CL.42	15.11	538	79.10	300S	14	1-1/8	20	9574	59.9
					15.11	538	79.10	300S	16	1-1/4	20	11801	81.2
					15.11	538	79.10	300S	18	1-1/4	24	12222	84.1
					15.11	538	79.10	300S	20	1-1/4	24	14751	101.5
					15.11	538	79.10	300S	24	1-1/2	24	17849	144.9
					12.09	538	63.28	300B	26	1-1/4	32	10958	75.4
					12.09	538	63.28	300B	28	1-1/4	36	10958	75.4

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					12.09	538	63.28	300B	30	1-3/8	36	12577	94.3
					12.09	538	63.28	300B	32	1-1/2	32	15937	129.4
					12.09	538	63.28	300B	34	1-1/2	36	15299	124.2
					12.09	538	63.28	300B	36	1-5/8	32	19819	173.2
					12.09	538	63.28	300B	38	1-5/8	36	22106	193.2
					12.09	538	63.28	300B	40	1-5/8	40	21343	186.5
					12.09	538	63.28	300B	42	1-3/4	36	26937	252.3
LIST B-4													
B1E	PMS rated Temperature / Pressure		538 / 18.63	Up to 24"	18.63	538	79.10	300S	1/2	1/2	4	855	2.6
	A 182 GR.F22 CL.3	A193 Gr. B16	Spiral wound SS	A335 Gr. P22	18.63	538	79.10	300S	3/4	5/8	4	1098	4.0
				A691 Gr.2.25Cr Cl.42	18.63	538	79.10	300S	1	5/8	4	1830	6.7
B4G	PMS rated Temperature / Pressure		538 / 17.92	Up to 24"	18.63	538	79.10	300S	1-1/2	3/4	4	3287	14.2
	A 182 GR.F9	A193 GR.B16	Spiral wound SS	A 335 GR.P9	18.63	538	79.10	300S	2	5/8	8	2288	8.4
				A 691 GR9CR CL.42	18.63	538	79.10	300S	3	3/4	8	4931	21.3
					18.63	538	79.10	300S	4	3/4	8	5342	23.1
					18.63	538	79.10	300S	6	3/4	12	5342	23.1
					18.63	538	79.10	300S	8	7/8	12	7418	36.9
					18.63	538	79.10	300S	10	1	16	9748	55.0
					18.63	538	79.10	300S	12	1-1/8	16	12215	76.5
					18.63	538	79.10	300S	14	1-1/8	20	10234	64.1
					18.63	538	79.10	300S	16	1-1/4	20	12644	87.0
					18.63	538	79.10	300S	18	1-1/4	24	13065	89.9
					18.63	538	79.10	300S	20	1-1/4	24	15173	104.4
					18.63	538	79.10	300S	24	1-1/2	24	18487	150.1
					14.90	538	63.28	300B	26	1-1/4	32	11801	81.2
					14.90	538	63.28	300B	28	1-1/4	36	11801	81.2
					14.90	538	63.28	300B	30	1-3/8	36	13625	102.2
					14.90	538	63.28	300B	32	1-1/2	32	17212	139.8
					14.90	538	63.28	300B	34	1-1/2	36	16574	134.6
					14.90	538	63.28	300B	36	1-5/8	32	21343	186.5
					14.90	538	63.28	300B	38	1-5/8	36	23630	206.5
					14.90	538	63.28	300B	40	1-5/8	40	22868	199.9
					14.90	538	63.28	300B	42	1-3/4	36	28733	269.1

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size Inch	Bolt Dia Inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST B-5													
B6K	PMS rated Temperature / Pressure		427 / 24.25	Up to 24"	24.25	427	63.27	300S	1/2	1/2	4	570	1.7
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	24.25	427	63.27	300S	3/4	5/8	4	915	3.4
				A 358 TP304L CL.1	24.25	427	63.27	300S	1	5/8	4	1281	4.7
					24.25	427	63.27	300S	1-1/2	3/4	4	2192	9.5
					24.25	427	63.27	300S	2	5/8	8	1464	5.4
					24.25	427	63.27	300S	3	3/4	8	2466	10.8
					24.25	427	63.27	300S	4	3/4	8	2740	11.8
					24.25	427	63.27	300S	6	3/4	12	3150	13.6
					24.25	427	63.27	300S	8	7/8	12	4945	24.6
					24.25	427	63.27	300S	10	1	16	5249	29.6
					24.25	427	63.27	300S	12	1-1/8	16	7283	45.5
					24.25	427	63.27	300S	14	1-1/8	20	6933	43.4
					24.25	427	63.27	300S	16	1-1/4	20	8851	60.9
					24.25	427	63.27	300S	18	1-1/4	24	9694	66.7
					24.25	427	63.27	300S	20	1-1/4	24	11379	78.3
					24.25	427	63.27	300S	24	1-1/2	24	14662	119.1
LIST B-6													
B1K	PMS rated Temperature / Pressure		454 / 27.77	Up to 24"	5.97	704	75.93	300S	1/2	1/2	4	798	2.4
	A 182 GR F304	A193 GR.B7	Spiral wound SS	A 312 TP304	5.97	704	75.93	300S	3/4	5/8	4	1281	4.7
				A 358 TP304 CL.1	5.97	704	75.93	300S	1	5/8	4	1464	5.4
B2K	PMS rated Temperature / Pressure		120 / 40.14	Up to 24"	5.97	704	75.93	300S	1-1/2	3/4	4	2740	11.8
	A 182 GR F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	5.97	704	75.93	300S	2	5/8	8	2105	7.7
				A 358 TP316L CL.1	5.97	704	75.93	300S	3	3/4	8	3561	15.4
B4K	PMS rated Temperature / Pressure		704 /8.08	Up to 24"	5.97	704	75.93	300S	4	3/4	8	3972	17.2
	A 182 GR.F304H	A453 GR.660CL.A	Spiral wound SS	A 312 TP304H	5.97	704	75.93	300S	6	3/4	12	4109	17.7
					5.97	704	75.93	300S	8	7/8	12	6086	30.3
B5K	PMS rated Temperature / Pressure		704/8.08	Up to 24"	5.97	704	75.93	300S	10	1	16	7499	42.3
	A 182 GR.F304H	A453 GR.660CL.A	Spiral wound SS	A 312 TP304H	5.97	704	75.93	300S	12	1-1/8	16	9574	59.9
					5.97	704	75.93	300S	14	1-1/8	20	8263	51.7
					5.97	704	75.93	300S	16	1-1/4	20	10537	72.5
					5.97	704	75.93	300S	18	1-1/4	24	11379	78.3
					5.97	704	75.93	300S	20	1-1/4	24	12644	87.0

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					5.97	704	75.93	300S	24	1-1/2	24	15937	129.4
					4.78	704	60.74	300B	26	1-1/4	32	10537	72.5
					4.78	704	60.74	300B	28	1-1/4	36	11801	81.2
					4.78	704	60.74	300B	30	1-3/8	36	12677	94.3
					4.78	704	60.74	300B	32	1-1/2	32	15937	129.4
					4.78	704	60.74	300B	34	1-1/2	36	15937	129.4
					4.78	704	60.74	300B	36	1-5/8	32	19819	173.2
					4.78	704	60.74	300B	38	1-5/8	36	20681	179.9
					4.78	704	60.74	300B	40	1-5/8	40	19819	173.2
					4.78	704	60.74	300B	42	1-3/4	36	25142	235.5
LIST B-7													
B1M	PMS rated Temperature / Pressure		427 / 29.52	Up to 24"	26.66	538	75.95	300S	1/2	1/2	4	570	1.7
	A 182 GR.F316	A193 GR.B7	Spiral wound SS	A 312 TP316	26.66	538	75.95	300S	3/4	5/8	4	1373	5.0
				A 358 TP316 CL.1	26.66	538	75.95	300S	1	5/8	4	1373	5.0
B3M	PMS rated Temperature / Pressure		538 / 25.66	Up to 24"	26.66	538	75.95	300S	1-1/2	3/4	4	2192	9.5
	A 182 GR.F321	A453 GR.660CL.A	Spiral wound SS	A 312 TP321	26.66	538	75.95	300S	2	5/8	8	1556	5.7
				A 358 TP321 CL.1	26.66	538	75.95	300S	3	3/4	8	2603	11.2
B5M	PMS rated Temperature / Pressure		538 / 24.60	Up to 24"	26.66	538	75.95	300S	4	3/4	8	3972	17.2
	A 182 GR.F316H	A453 GR.660CL.A	Spiral wound SS	A 312 TP316H	26.66	538	75.95	300S	6	3/4	12	3972	17.2
					26.66	538	75.95	300S	8	7/8	12	5706	28.4
					26.66	538	75.95	300S	10	1	16	6999	39.5
					26.66	538	75.95	300S	12	1-1/8	16	8253	51.7
					26.66	538	75.95	300S	14	1-1/8	20	7593	47.5
					26.66	538	75.95	300S	16	1-1/4	20	9694	66.7
					26.66	538	75.95	300S	18	1-1/4	24	10537	72.5
					26.66	538	75.95	300S	20	1-1/4	24	12222	84.1
					26.66	538	75.95	300S	24	1-1/2	24	16256	132.0
					20.53	538	60.82	300B	26	1-1/4	32	10537	72.5
					20.53	538	60.82	300B	28	1-1/4	36	10537	72.5
					20.53	538	60.82	300B	30	1-3/8	36	11791	88.4
					20.53	538	60.82	300B	32	1-1/2	32	14981	121.6
					20.53	538	60.82	300B	34	1-1/2	36	14343	116.5
					20.53	538	60.82	300B	36	1-5/8	32	17913	156.6

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Piping Class	PMS class data: Temperature, pressure, materials and size range				Calculation Data								
	Flange	Bolt	Gasket	Pipe	Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
					20.53	538	60.82	300B	38	1-5/8	36	19056	186.6
					20.53	538	60.82	300B	40	1-5/8	40	18294	159.9
					20.53	538	60.82	300B	42	1-3/4	36	22897	214.4
LIST B-8													
B1N	PMS rated Temperature / Pressure		454 / 23.90	Up to 24"	23.90	454	63.27	300S	1/2	1/2	4	570	1.7
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	23.90	454	63.27	300S	3/4	5/8	4	916	3.4
				A 358 TP 316L CL.1	23.90	454	63.27	300S	1	5/8	4	1281	4.7
B6N	PMS rated Temperature / Pressure		427 / 24.25	Up to 24"	23.90	454	63.27	300S	1-1/2	3/4	4	2192	9.6
	A 182 GR F316L	A193 GR B7	Spiral wound SS	A 312 TP316L	23.90	454	63.27	300S	2	5/8	8	1464	5.4
				A 358 TP 316L CL.1	23.90	454	63.27	300S	3	3/4	8	2488	10.6
					23.90	454	63.27	300S	4	3/4	8	2740	11.8
					23.90	454	63.27	300S	6	3/4	12	3150	13.6
					23.90	454	63.27	300S	8	7/8	12	4946	24.6
					23.90	454	63.27	300S	10	1	16	5249	29.6
					23.90	454	63.27	300S	12	1-1/8	16	7263	45.5
					23.90	454	63.27	300S	14	1-1/8	20	6933	43.4
					23.90	454	63.27	300S	16	1-1/4	20	8851	60.9
					23.90	454	63.27	300S	18	1-1/4	24	9694	66.7
					23.90	454	63.27	300S	20	1-1/4	24	11379	78.3
					23.90	454	63.27	300S	24	1-1/2	24	14662	119.1
LIST D-1													
D1A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	1/2	1/2	4	970	2.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	3/4	5/8	4	1373	5.0
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	1	5/8	4	2013	7.4
D2A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	1-1/2	3/4	4	4520	19.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	2	5/8	8	3112	11.4
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	3	3/4	8	5205	22.5
D5A	PMS rated Temperature / Pressure		230 / 86.96	Up to 24"	58.00	427	156.08	600S	4	7/8	8	7228	36.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	6	1	12	8998	50.7
				A 672 GR.B60 CL.32	58.00	427	156.08	600S	8	1-1/8	12	12875	80.6
D9A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	10	1-1/4	16	14751	101.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	12	1-1/4	20	14751	101.5
				A 672 GR B60 CL 12	58.00	427	156.08	600S	14	1-3/8	20	17294	129.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia Inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
D16A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	16	1-1/2	20	21037	170.8
	A105	A193 GR.B7M	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	18	1-5/8	20	27441	239.8
				A 672 GR.B60 CL.22	58.00	427	156.08	600S	20	1-5/8	24	26679	233.2
D19A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	24	1-7/8	24	34482	343.7
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	46.40	427	124.90	600B	26	1-5/8	28	25917	226.5
				A 672 GR.B60 CL.22	46.40	427	124.90	600B	28	1-3/4	28	28733	269.1
					46.40	427	124.90	600B	30	1-7/8	28	35527	354.2
					46.40	427	124.90	600B	32	2	28	39708	420.7
					46.40	427	124.90	600B	34	2-1/4	24	55895	661.8
					46.40	427	124.90	600B	36	2-1/4	28	49684	588.1
					46.40	427	124.90	600B	38	2-1/4	28	54342	643.2
					46.40	427	124.90	600B	40	2-1/4	32	51237	606.4
					46.40	427	124.90	600B	42	2-1/2	28	66195	865.9
LIST D-2													
D4A	PMS rated Temperature / Pressure		204 / 86.47	Up to 24"	86.47	204	147.05	600S	1/2	1/2	4	970	2.9
	A 350 GR.LF2 CL.1	A320 GR.L7	Spiral wound SS	A 333 GR.6	86.47	204	147.05	600S	3/4	5/8	4	1373	6.0
				A 671 GR.CC60 CL.32	86.47	204	147.05	600S	1	5/8	4	2013	7.4
					86.47	204	147.05	600S	1-1/2	3/4	4	4520	18.5
					86.47	204	147.05	600S	2	5/8	8	3112	11.4
					86.47	204	147.05	600S	3	3/4	8	5205	22.5
					86.47	204	147.05	600S	4	7/8	8	7228	35.9
					86.47	204	147.05	600S	6	1	12	8998	50.7
					86.47	204	147.05	600S	8	1-1/8	12	12875	80.6
					86.47	204	147.05	600S	10	1-1/4	16	14751	101.5
					86.47	204	147.05	600S	12	1-1/4	20	14751	101.5
					86.47	204	147.05	600S	14	1-3/8	20	17294	129.7
					86.47	204	147.05	600S	16	1-1/2	20	21037	170.8
					86.47	204	147.05	600S	18	1-5/8	20	27441	239.8
					86.47	204	147.05	600S	20	1-5/8	24	26679	233.2
					86.47	204	147.05	600S	24	1-7/8	24	34482	343.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST D-3													
D1D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	1/2	1/2	4	1084	3.3
	A 182 GR F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	3/4	5/8	4	1373	5.0
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	1	5/8	4	2196	8.1
D2D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	1-1/2	3/4	4	4246	16.3
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	2	5/8	8	3296	12.1
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	3	3/4	8	5342	23.1
D5D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	4	7/8	8	7798	38.8
	A 182 GR F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	6	1	12	9498	53.6
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	8	1-1/8	12	13535	84.8
					30.23	538	158.20	600S	10	1-1/4	16	16016	119.2
					30.23	538	158.20	600S	12	1-1/4	20	15594	107.3
					30.23	538	158.20	600S	14	1-3/8	20	18342	137.6
					30.23	538	158.20	600S	16	1-1/2	20	21674	176.0
					30.23	538	158.20	600S	18	1-5/8	20	28986	253.2
					30.23	538	158.20	600S	20	1-5/8	24	28203	246.5
					30.23	538	158.20	600S	24	1-7/8	24	36572	354.6
					24.19	538	126.56	600B	26	1-5/8	28	26679	233.2
					24.19	538	126.56	600B	28	1-3/4	28	30529	266.9
					24.19	538	126.56	600B	30	1-7/8	28	35527	354.2
					24.19	538	126.56	600B	32	2	28	40911	433.4
					24.19	538	126.56	600B	34	2-1/4	24	55695	661.6
					24.19	538	126.56	600B	36	2-1/4	28	49584	588.1
LIST D-4													
D6E	PMS rated Temperature / Pressure		538 / 37.61	Up to 24"	37.61	538	158.20	600S	1/2	1/2	4	1255	3.8
	A182 Gr. F22 Cl. 3	A193 Gr. B16	Spiral wound SS	A335 Gr. P22	37.61	538	158.20	600S	3/4	5/8	4	1556	5.7
				A 691 GR2.25CR CL.42	37.61	538	158.20	600S	1	5/8	4	2471	9.1
					37.61	538	158.20	600S	1-1/2	3/4	4	4857	20.1
					37.61	538	158.20	600S	2	5/8	8	3478	12.8
					37.61	538	158.20	600S	3	3/4	8	5479	23.7
					37.61	538	158.20	600S	4	7/8	8	7798	38.8
					37.61	538	158.20	600S	6	1	12	9748	55.0
					37.61	538	158.20	600S	8	1-1/8	12	13535	84.8

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					37.61	538	158.20	600S	10	1-1/4	16	16437	113.1
					37.61	538	158.20	600S	12	1-1/4	20	16437	113.1
					37.61	538	158.20	600S	14	1-3/8	20	19914	149.3
					37.61	538	158.20	600S	16	1-1/2	20	22949	186.3
					37.61	538	158.20	600S	18	1-5/8	20	29728	259.8
					37.61	538	158.20	600S	20	1-5/8	24	28966	253.2
					37.61	538	158.20	600S	24	1-7/8	24	38662	385.4
					30.09	538	126.60	600B	26	1-5/8	28	28203	246.5
					30.09	538	126.60	600B	26	1-3/4	28	32325	302.7
					30.09	538	126.60	600B	30	1-7/8	28	37617	375.0
					30.09	538	126.60	600B	32	2	28	43318	458.9
					30.09	538	126.60	600B	34	2-1/4	24	59000	598.3
					30.09	538	126.60	600B	36	2-1/4	28	62789	624.8
LIST D-5													
D1K	PMS rated Temperature / Pressure		454 / 55.54	Up to 24"	55.54	454	114.00	600S	1/2	1/2	4	627	1.9
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	55.54	454	114.00	600S	3/4	5/8	4	915	3.4
				A 358 TP304 CL.1	55.54	454	114.00	600S	1	5/8	4	1281	4.7
D2K	PMS rated Temperature / Pressure		120 / 80.12	Up to 24"	55.54	454	114.00	600S	1-1/2	3/4	4	2466	10.6
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	55.54	454	114.00	600S	2	5/8	8	1647	6.0
				A 358 TP304 CL.1	55.54	454	114.00	600S	3	3/4	8	3150	13.6
					55.54	454	114.00	600S	4	7/8	8	6135	25.6
					55.54	454	114.00	600S	6	1	12	6249	35.2
					55.54	454	114.00	600S	8	1-1/8	12	8913	55.8
					55.54	454	114.00	600S	10	1-1/4	16	9272	63.8
					55.54	454	114.00	600S	12	1-1/4	20	10115	69.6
					55.54	454	114.00	600S	14	1-3/8	20	12053	90.4
					55.54	454	114.00	600S	16	1-1/2	20	15299	124.2
					55.54	454	114.00	600S	18	1-5/8	20	19056	166.6
					55.54	454	114.00	600S	20	1-5/8	24	19056	166.6
					55.54	454	114.00	600S	24	1-7/8	24	25078	250.0
					44.44	454	91.20	600B	26	1-5/8	28	18294	169.9
					44.44	454	91.20	600B	28	1-3/4	28	20652	193.4
					44.44	454	91.20	600B	30	1-7/8	28	24033	239.6

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

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					56.24	538	237.28	900S	16	1-5/8	20	28203	235.8
					56.24	538	237.28	900S	18	1-7/8	20	36572	348.7
					56.24	538	237.28	900S	20	2	20	44521	451.1
					56.24	538	237.28	900S	24	2-1/2	20	66142	852.6
					56.24	538	189.83	900B	26	2-1/2	20	64248	803.9
					56.24	538	189.83	900B	28	2-3/4	20	73966	1013.8
					56.24	538	189.83	900B	30	3	20	83211	1238.2
LIST F-1													
F1A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	1/2	3/4	4	3014	12.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	3/4	3/4	4	3972	16.4
				A 672 GR.B60 CL.12	144.83	427	390.74	1500S	1	7/8	4	4945	23.5
F2A	PMS rated Temperature / Pressure		427 / 144.46	Up to 24"	144.83	427	390.74	1500S	1-1/2	1	4	7489	40.4
	A105	A193 GR B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	2	7/8	8	6467	30.7
				A 672 GR.B60 CL.22	144.83	427	390.74	1500S	3	1-1/8	8	12215	73.2
F5A	PMS rated Temperature / Pressure		230 / 217.79	Up to 24"	144.83	427	390.74	1500S	4	1-1/4	8	16016	105.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	6	1-3/8	12	19914	142.8
				A672 Gr. B60 Cl. 22	144.83	427	390.74	1500S	8	1-5/8	12	29728	248.5
F9A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	10	1-7/8	12	41797	398.5
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	12	2	16	43318	439.0
				A 672 GR B60 CL.12	144.83	427	390.74	1500S	14	2-1/4	16	56695	632.6
F19A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	16	2-1/2	16	70089	877.0
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	18	2-3/4	16	85684	1177.3
				A672 Gr. B60 Cl. 22	144.83	427	390.74	1500S	20	3	16	103296	1537.0
					144.83	427	390.74	1500S	24	3-1/2	16	142889	2487.4
LIST F-2													
F2D	PMS rated Temperature / Pressure		538 / 75.93	Up to 24"	75.93	538	395.48	1500S	1/2	3/4	4	3972	16.4
	A 182 GR.F11 CL.2	A193 GR.B16	RTJ - 5Cr-0.5Mo	A 335 GR.P11	75.93	538	395.48	1500S	3/4	3/4	4	4931	20.4
				A 691 GR.1.25Cr CL.42	75.93	538	395.48	1500S	1	7/8	4	6277	29.8
					75.93	538	395.48	1500S	1-1/2	1	4	9248	49.9
					75.93	538	395.48	1500S	2	7/8	8	7037	33.5
					75.93	538	395.48	1500S	3	1-1/8	8	13205	79.1
					75.93	538	395.48	1500S	4	1-1/4	8	16868	110.9
					75.93	538	395.48	1500S	6	1-3/8	12	20962	160.4

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					75.93	538	395.48	1500S	8	1-5/8	12	30490	254.9
					75.93	538	395.48	1500S	10	1-7/8	12	41797	398.5
					75.93	538	395.48	1500S	12	2	16	46927	475.5
					75.93	538	395.48	1500S	14	2-1/4	16	55895	632.8
					75.93	538	395.48	1500S	16	2-1/2	16	72036	901.3
					75.93	538	395.48	1500S	18	2-3/4	16	88270	1210.0
					75.93	538	395.48	1500S	20	3	16	106185	1579.7
					75.93	538	395.48	1500S	24	3-1/2	16	146858	2535.9
LIST F-3													
F2G	PMS rated Temperature / Pressure		538 / 127.95	Up to 24"	127.95	538	395.48	1500S	1/2	3/4	4	3972	16.4
	A182 Gr. F91	A193 GR.B16	RTJ - 9Cr-1Mo	A 335 GR.P91	127.95	538	395.48	1500S	3/4	3/4	4	4931	20.4
				A 691 GR.P91 CL.42	127.95	538	395.48	1500S	1	7/8	4	6277	29.8
					127.95	538	395.48	1500S	1-1/2	1	4	9248	49.9
					127.95	538	395.48	1500S	2	7/8	8	7037	33.5
					127.95	538	395.48	1500S	3	1-1/8	8	13205	79.1
					127.95	538	395.48	1500S	4	1-1/4	8	16858	110.9
					127.95	538	395.48	1500S	6	1-3/8	12	20962	150.4
					127.95	538	395.48	1500S	8	1-5/8	12	30490	254.9
					127.95	538	395.48	1500S	10	1-7/8	12	41797	398.5
					127.95	538	395.48	1500S	12	2	16	46927	475.5
					127.95	538	395.48	1500S	14	2-1/4	16	55895	632.8
					127.95	538	395.48	1500S	16	2-1/2	16	72036	901.3
					127.95	538	395.48	1500S	18	2-3/4	16	88270	1210.0
					127.95	538	395.48	1500S	20	3	16	106185	1579.7
					127.95	538	395.48	1500S	24	3-1/2	16	146858	2535.9
LIST G-1													
G2G	PMS rated Temperature / Pressure		538 / 213.02	Up to 12"	213.02	538	510.00	2500S	1/2	3/4	4	5068	20.9
	A182 Gr. F91	A193 GR.B16	RTJ - 5Cr-0.5Mo	A 335 GR.P91	213.02	538	510.00	2500S	3/4	3/4	4	5479	22.6
				A 691 GR.P91 CL.42	213.02	538	510.00	2500S	1	7/8	4	7228	34.4
					213.02	538	510.00	2500S	1-1/2	1-1/8	4	13535	81.1
					213.02	538	510.00	2500S	2	1	8	9748	52.6
					213.02	538	510.00	2500S	3	1-1/4	8	15594	102.6
					213.02	538	510.00	2500S	4	1-1/2	8	24224	188.1

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					213.02	538	510.00	2500S	6	2	8	46927	475.8
					213.02	538	510.00	2500S	8	2	12	46927	475.8
					213.02	538	510.00	2500S	10	2-1/2	12	70089	877.0
					213.02	538	510.00	2500S	12	2-3/4	12	95426	1308.1

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HISTORY SHEET FOR FLANGE JOINTS

Annexure - I

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

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

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

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

Acceptance by Licensor/Owner.

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

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Annexure - II

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

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

ACCEPTANCE BY OWNER / EIL

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WELDING SPECIFICATION FOR FABRICATION OF PIPING

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

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ABBREVIATIONS

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

Welding Standard Committee

Convenor : Mr. Rajesh Chitara (SMMS)

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

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CONTENTS

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1.0 GENERAL

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

The welded pipe joints shall include the following:

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

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

c) Welded manifold headers and other sub-assemblies.

d) Welded branch connections with or without reinforcing pads.

e) Joints in welded/fabricated piping components.

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

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

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

2.0 APPLICABLE CODES & STANDARDS

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

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

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

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

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

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

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

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

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

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

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

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3.0 BASE METAL

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

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

4.0 WELDING PROCESS

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

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

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

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

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

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

5.0 WELDING CONSUMABLES

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

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

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

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

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

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

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

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

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

6.0 SHIELDING & PURGING GAS

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

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

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

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

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

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

7.0 EQUIPMENTS & ACCESSORIES

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

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

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

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8.0 EDGE PREPARATION

8.1 General

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

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

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

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

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

8.3 Cleaning

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

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

9.0 ALIGNMENT & SPACING

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

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

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

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

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

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

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

10.0 WEATHER CONDITIONS

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

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

11.0 WELDING TECHNIQUE

11.1 Root Pass

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

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

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

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

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

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

(g) Peening shall not be used.

11.2 Joint Completion

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

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

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

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

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

11.3 Dissimilar Welds

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

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

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

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

12.0 HEAT TREATMENT

12.1 Preheating and Interpass Temperature

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

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

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

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

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

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

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

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

12.2 Post Heating

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

12.3 Post-Weld Heat Treatment (PWHT)

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

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

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

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

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

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

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

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

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

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

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

13.0 CLEANING OF THE WELD JOINT

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

14.0 INSPECTION AND TESTING

14.1 General

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

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

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

ii) To witness the welding procedure qualification.

iii) To witness the welder performance qualification.

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

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

14.2 Welding Procedure Qualification

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

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

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

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

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

14.3 Welder's Qualification

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

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

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

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

14.4 Visual Examination

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

14.5 Radiographic Examination

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

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

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

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

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

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

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

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

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

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

14.5.1 Check shots

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

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

14.6 Liquid Penetrant and Magnetic Particle Examination

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

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

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14.7 Ultrasonic examination (UT)

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

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

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

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

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

14.8 Hardness Test

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

14.9 Proof Tests

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

15.0 REPAIRS OF WELDS

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

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

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

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

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

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

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

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

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

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

(d) Heat Treatment Charts.

(e) Weld joint hardness test results.

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

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

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

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

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

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

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EXHIBIT – A: ELECTRODE QUALIFICATION TEST RECORD

Date:

Test started on:

Test completed on:

A: DETAILS

CONTRACTOR

Tested at (Site name)

Code of Reference (used for testing) :

Special Requirements (if any) :

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

B : All-weld Tensile Test

Base Material used :

Buttering used : Yes/No

Pre-heat temperature :

Inter-pass temperature :

Post weld heat treatment details :

Visual examination :

Radiographic examination results :

Tensile test results :

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

C. Impact Test Results

Test Temperature : Notch in :

Type of Specimens (Charpy) : Size of Specimens :

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

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D. Chemical Analysis Results

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

E. Fillet Weld Test Results :

Base Materials :

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

F. Other Test Results :

1. Transverse tensile test :

In combination with :

Base material used :

Position of welding :

Preheat temperature :

Post weld heat treatment :

Radiography :

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

2. Guided Bend Test :

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

G. Any other tests :

H. Conclusions :

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

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EXHIBIT – B: STRESS RELIEF HEAT TREATMENT PROCEDURE

LSTK CONTRACTOR : _____

Name of the Heat treater : _____

Name of the Project : _____

Specification /Reference No. :

Line no./Joint No.

1. General Details — Other Details

Name of the Equipment : _____

Material : _____

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

Maximum Permissible Temp at Uncovered Parent Metal _____

Width of heated band _____
Width of Insulation _____

No. of Themo couples (dia wise)
_____

Type of Thermo couples _____

3. Heat Treatment Cycle Details

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

4. Other details, if any _____

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

Company Name _____ By _____

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

Revision No. _____ Date _____

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

JOINTS

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

BASE METALS

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

OR

Specification type and grade _____
to Specification type and grade _____

OR

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

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FILLER METALS

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

WPS NO. _____ Rev. _____

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

ELECTRICAL CHARACTERISTICS

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

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

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TECHNIQUE

String or Weave Bead _____

Orifice or Gas Cup Size _____

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

_____

Method of Back Gouging _____

Oscillation _____

Contact Tube to Work Distance _____

Multiple or Single Pass (per side) _____

Multiple or Single Electrodes _____

Travel Speed (Range) _____

Peening _____

Other _____

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

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

RECORD OF ACTUAL CONDITIONS USED TO WELD TEST COUPON

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

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

JOINTS

Groove Design of Test Coupon

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

_____

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

SHEET 1 OF 3

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TENSILE TEST

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

GUIDED BEND TESTS

Type of Figure No.	Result

TOUGHNESS TESTS

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

FILLET WELD TEST

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

Marco - Results _____

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OTHER TESTS

Type of Test _____

Deposit Analysis _____

Other _____

_____

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

Test Conducted by _____ Laboratory Test No. _____

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

Date _____ Manufacturer _____

By _____

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

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

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

Using WPS No. _____ Rev. _____

The above welder is qualified for the following ranges

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

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Guided Bend Test Results

Type and Fig. No.	Result

Radiographic Test Results
For alternative qualification of groove welds by radiography

Radiographic Results _____

Fillet Weld Test Results

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

Test Conducted by _____ Laboratory - Test No. _____

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

Date _____ Organization _____
By _____

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

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

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EXHIBIT – F: RADIOGRAPHIC PROCEDURE QUALIFICATION RECORD FOR PIPE WELDING

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

4 A. Technique: DWSI/SWSI/DWDI

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

16.* Type of penetrameter: (Source side)

17.* Type of penetrameter: (Film side)

Signature of LSTK CONTRACTOR/Agency with Seal

Approval of OWNER/ PMC's Inspector

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

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

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EXHIBIT – G: WELDER'S IDENTIFICATION CARD

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

Photograph

Approved by:

Employer's Signature with Seal

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

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

Note: Integral to above table

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

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

COMPARISON OF FILMS FROM DIFFERENT MANUFACTURERS

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

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

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EXHIBIT – I: ULTRASONIC TESTING (UT)

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1.0 INTRODUCTION

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

2.0 REFERENCE DOCUMENTS

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

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

3.0 AUT SYSTEM

3.1 Instrument Requirement

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

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

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

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

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

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

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

3.2 Probes

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

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3.3 Wedge

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

3.4 Encoder

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

4.0 COUPLANT

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

The same couplant shall be used during calibration and examination.

5.0 CALIBRATION/DEMONSTRATION BLOCK

5.1 Calibration/Demonstration Block Material

5.1.1 Material selection

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

5.1.2 Heat treatment

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

5.1.3 Reflectors

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

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

5.1.4 Quality of calibration and demonstration blocks

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

5.1.5 Cladding

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

5.1.6 Surface roughness of calibration and demonstration blocks

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

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5.2 Calibration Blocks

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

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

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

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

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

5.3 Demonstration Block

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

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

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

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

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

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

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

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

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

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

6.0 CALIBRATION

6.1 General Calibration Requirements

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

6.2 PA Instrument Linearity

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

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

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

6.3 Phased array system calibration

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

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

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

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

7.0 PROCEDURE

7.1 Safety

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

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

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

7.3 Lamination Check

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

7.4 Examination Coverage

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

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

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

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

7.5 Examination side

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

7.6 Surface condition

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

7.7 Scanning

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

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

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

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

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

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

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

8) TOFD channel

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

7.8 Data Recording

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

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

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

7.9 Reflectors Transverse to the Weld Seam

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

7.10 Re-examination

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

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

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

8.0 TRAINING AND QUALIFICATION

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

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

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

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

9.0 EVALUATION AND ACCEPTANCE CRITERIA

9.1 Evaluation

9.1.1 Data analysis criteria

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

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

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

9.1.2 Geometric

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

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

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

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

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

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

9.1.3 Flaw sizing

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

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

9.1.4 Flaw evaluation

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

9.2 Acceptance criteria

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

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EXHIBIT – J: COMPUTED RADIOGRAPHY

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1.0 COMPUTED RADIOGRAPHY- INTRODUCTION

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

2.0 REFERENCE DOCUMENTS

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

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

3.0 COMPUTED RADIOGRAPHY SYSTEM

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

3.2 Imaging Plates/Cassettes

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

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

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

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

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

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

3.3 Software & High performance Laptop (Computer)

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

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

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

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

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

It should have wall thickness measurement tools and software.

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

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

4.0 SYSTEM CHARACTERIZATION

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

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

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

5.0 QUALIFICATION PLANS

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

5.2 The qualification plans should include the following minimum details:

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

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

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

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

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

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

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

6.0 TECHNIQUES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7.0 FILE FORMAT AND STORAGE

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

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

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

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

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

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

8.0 PERSONNEL REQUIREMENTS

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

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SPECIFICATION FOR QUALITY MANAGEMENT SYSTEM REQUIREMENTS FROM BIDDERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
					Approved by	
2	12.06.20	General Revision	QMS Standards Committee	QMS Standards Committee	SKB	SKS
1	12.03.15	General Revision	QMS Standards Committee	QMS Standards Committee	MPJ	SC
0	04.06.09	Issued as Standard Specification	QMS Standards Committee	QMS Standards Committee	SCT	ND

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Abbreviations:

ISO	-	International Organization for Standardization
MR	-	Material Requisition
PO	-	Purchase Order
PR	-	Purchase Requisition
QMS	-	Quality Management System

QMS Standards Committee

Convener: Mr. S.K. Badlani

Members: Mr. Sanjay Mazumdar (Engg.)
Mr. R.K. Singh (SCM)
Mr. B. Biswas (SCM)
Mr. Ravindra Kumar (Const.)
Mr. Vinod Kumar (CQA)
Mr. Swapnil Vaishnav (Projects)

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1.0 SCOPE

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

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

2.0 DEFINITIONS

2.1 Bidder

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

2.2 Project Quality Plan

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

2.3 Owner

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

3.0 REFERENCE DOCUMENTS

6-78-0002	Specification for Documentation Requirements from Contractors
6-78-0003	Specification for Documentation Requirements from Suppliers

4.0 QUALITY MANAGEMENT SYSTEM – GENERAL

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

5.0 QUALITY SYSTEM REQUIREMENTS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.17 BIDDER should follow the standards, specifications and approved drawings. Concessions / Deviations shall be allowed only in case of unavoidable circumstances. In such situations Concession / deviation request must be made by the BIDDER through online system of EIL eDMS. URL of EIL eDMS is http://edocx.eil.co.in/vportal.

5.18 BIDDER shall have documented procedure for control of documents.

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

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6.0 AUDITS

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

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

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

7.0 DOCUMENTATION REQUIREMENTS

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

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

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

- Quality Manual
- Certificate of approval for compliance to ISO: 9001 standard
- Procedure for Control of Non-conforming Product
- Procedure for Control of Documents
- Sample audit report of the QMS internal and external audits conducted during last one year
- Customer satisfaction reports from at least 2 customers,
- Project QMS audit report
- Technical audit reports for the project
- Corrective action report on the audits

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

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SPECIFICATION FOR DOCUMENTATION REQUIREMENTS FROM CONTRACTORS

Rev. No	Date	Purpose	Prepared by	Checked by	Approved by: Standards Committee Convener	Approved by: Standards Bureau Chairman
2	12.06..20	General Revision	QMS Standards Committee	QMS Standards Committee	SKB	SKS
1	12.03.15	General Revision	QMS Standards Committee	QMS Standards Committee	MPJ	SC
0	04.06.09	Issued as Standard Specification	QMS Standards Committee	QMS Standards Committee	SCT	ND

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Abbreviations:

DCI	-	Document Control Index
FOA	-	Fax of Acceptance
IC	-	Inspection Certificate
IRN	-	Inspection Release Note
ITP	-	Inspection and Test Plan
LOA	-	Letter of Acceptance
QMS	-	Quality Management System
URL	-	Universal Resource Locator
V Portal	-	Vendor Portal

QMS Standards Committee

Convener: Mr. S.K. Badlani

Members:
Mr. Sanjay Mazumdar (Engg.)
Mr. R.K. Singh (SCM)
Mr. B. Biswas (SCM)
Mr. Ravindra Kumar (Const.)
Mr. Vinod Kumar (CQA)
Mr. Swapnil Vaishnav (Projects)

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1.0 SCOPE

This specification establishes the Documentation Requirements from Contractors

All documents / data against the Tender / Contract shall be developed and submitted to EIL / Owner by the contractor for review / records, in line with this specification.

2.0 DEFINITIONS

2.1 Contractor

For the purpose of this specification, the word "CONTRACTOR" means the person(s), firm, company or organization who has entered into a contract with EIL / Owner for delivery of some products and services. The word is considered synonymous to bidder, supplier or vendor.

2.2 Owner

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

3.0 REFERENCE DOCUMENTS

6-78-0001	Specification for Quality Management System Requirements from Bidders

4.0 DOCUMENTATION AND DATA REQUIREMENTS

4.1 Order Acknowledgement and Assigning Project Manager

After placement of order, Contractor shall acknowledge order through V-Portal within 7 days of receipt of FOA / PO. Contractor shall assign a Project Manager for that order though online portal and provide requisite details. Project Manager details shall include e-mail address, mailing address, mobile / telephone nos., fax nos. and name of Project Manager. All the system generated emails pertaining to that order shall be sent to the assigned Project Manager.

4.2 Documents / Data to be submitted by the Contractor

4.2.1 The contractor shall submit the documents and data against the Tender / Contract as per the list specified in respective Tender / Contract.

4.2.2 Review of the contractor drawings / Documents by EIL would be only to review the compatibility with basic designs and concepts and in no way absolve the contractor of his responsibility / contractual obligation to comply with Tender / Contract requirements, applicable codes, specifications and statutory rules / regulations. Any error / deficiency noticed during any stage of manufacturing / execution / inspection / installation shall be promptly corrected by the contractor without any extra cost or time, whether or not comments on the same were received from EIL during the drawing review / inspection stage.

4.2.3 Unless otherwise specified, submission of documents for Review / Records shall commence as follows from the date of Fax of Intent / Letter of Intent/ Fax of Acceptance (FOA) / Letter of Acceptance (LOA):

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QMS	- 1 week
Document Control Index	- 2 weeks
Other Documents/Drawings	- As per approved Document Control Index

4.2.4 Documents as specified in Tender / Contract are minimum requirements. Contractor shall submit any other document / data required for completion of the job as per EIL / Owner instructions.

4.3 Style and Formatting

4.3.1 All Documents shall be in ENGLISH language and in M.K.S System of units.

4.3.2 Before submitting the drawings and documents, contractor shall ensure that the following information are properly entered in each drawing:

Tender Number
Name of Equipment / Package
Equipment / Package Tag No.
Name of Project
Owner
Main Contractor (if work is sub-contracted)
Drawing / Document Title
Drawing / Document No.
Drawing / Document Revision No. and Date

4.4 Review and Approval of Documents by Contractor

4.4.1 The Drawing / Documents shall be reviewed, checked, approved and duly signed / stamped by contractor before submission. Revision number shall be changed during submission of the revised contractor documents and all revisions shall be highlighted by clouds. Whenever the contractor require any sub- contractor drawings to be reviewed by EIL, the same shall be submitted by the contractor duly reviewed, approved and stamped by the contractor. Direct submission of sub- contractor's drawings without contractor's approval shall not be entertained.

4.5 Document Category

4.5.1 **Review Category**

Following review codes shall be used for review of contractor Drawings / Documents:

Review Code 1	-	No comments. Proceed with Manufacture / Fabrication / Construction as per the document.
Review Code 2	-	Proceed with Manufacture / Fabrication / Construction as per commented document. Revised document required.
Review Code 3	-	Document does not conform to basic requirements as marked. Resubmit for review.
R	-	Document is retained for Records. Proceed with Manufacturing / fabrication as per Tender/ Contract Requirement.
V	-	Void

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4.6 Methodology for Submission of Documents to EIL / Owner

4.6.1 Document Control Index (DCI)

Contractor shall create and submit Document Control Index (DCI) for review based on PO / PR / MR along with schedule date of submission of each drawing / document on EIL Vendor Portal. The DCI shall be specific with regard to drawing / document no. and the exact title. Proper sequencing of the drawings / documents should be ensured in schedule date of submission.

4.6.2 Submission of Drawings / Documents / Data

Drawings / documents, data and DCI shall be uploaded on the EIL Vendor Portal. The detail guidelines for uploading documents on EIL Vendor Portal are available on following URL

http://edocx.eil.co.in/vportal

4.6.3 Statutory Approvals

Wherever approval by any statutory body is required to be taken by Contractor, the Contractor shall submit copy of approval by the authority to EIL.

4.6.4 Schedule and Progress Reporting

Contractor shall submit monthly progress report (MPR) and updated procurement, engineering and manufacturing status (schedule vs. actual) and highlight constraints, if any, along with action plan for mitigation, to the EIL / Owner by 1st week of every month. One month Look-ahead schedule including the mobilization plan shall be submitted within 2 weeks from FOA / LOA. In case of exigencies, EIL / Owner can ask for report submission as required on weekly / fortnightly / adhoc basis depending upon supply status and contractor shall furnish such reports promptly without any price implication. Format for progress report shall be submitted by the contractor during kick off meeting or within one week of receiving FOA / LOA, whichever is earlier.

4.6.5 Quality Assurance Plan / Inspection and Test Plan

Inspection and test plans attached if any, to the tender are generic and indicative only. Immediately after receipt of the order, contractor shall submit within one week of receiving FOA / LOA, job specific ITPs based on the indicative ITPs. Further, contractor shall also submit Quality Assurance Plan for project activities in the scope of contract, starting from manufacturing to handing over / commissioning, these plans shall cover / identify the activities, relevant procedure, if any, code of conformance, resources for performance and checking / monitoring, approval requirements and authority, records to be generated and audit scope by EIL/Owner.

For EPCC / LSTK / Package contracts, the contractor shall prepare a list of items / equipment and their inspection categorization plans for all items included in the scope of supply immediately after receipt of order and obtain approval for the same from EIL. The items shall be categorized into different categories depending upon their criticality for the scope of inspection of TPIA and / or EIL.

4.6.6 Inspection Release Note (IRN)/ Inspection Certificate (IC)

Contractor shall ensure that all documents viz. documents reviewed, manufacture's test certificate etc., mentioned in Inspection Release Note (IRN), issued by EIL / third party against the materials supplied by contractor, are sent to EIL along with the IRN.

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IRN / IC shall be issued by EIL Inspector / third party inspection agency only after all the drawings/documents as per DCI are submitted and are accepted under review code-1 & code R. Material / Equipment dispatch from contractor's / sub vendor's works shall not commence till above condition is met.

Note 1: Non fulfilling above requirement shall result into appropriate penalty or with- holding of payment as per conditions of Tender / Contract.

Note 2: For items where IRN/IC is issued by TPIA, supplier to ensure that following as a minimum must be mentioned by TPIA in IRN/IC

a) Tender document number
b) List of drawings / documents with EIL approval code
c) Tests witnessed, documents reviewed
d) Compliance statement by TPIA that product meets the requirement as specified in EIL standard specifications, Inspection Test Plan / QAP and approved documents.

4.6.7 **Pre Commissioning & Commissioning Activities Management System (PCAMS)**

Pre Commissioning & Commissioning activities management system software shall be followed for Mechanical completion, check listing of loops, punch points, hydro test and issue of Formats during the Pre Commissioning and Commissioning activities and the same can be accessed on following URL

https://pcams.eil.co.in/

4.7 Final Documentation

4.7.1 **As built Drawings**

Minor Shop / Site changes made by contractor after approval of drawings under 'Code 1' by EIL and deviations granted through online system , if any, shall be marked in hard copies of drawings which shall then be stamped 'As-built' by the contractor. These 'As-built' drawings shall be reviewed and stamped by EIL Inspector / Site engineer / TPIA also, as the case may be. Format for completeness of final documents (Format No. 3-78-0004) is attached with this specification. Contractor shall prepare scanned images files of all marked – up 'As – built' drawings. Simultaneously contractor shall incorporate the shop / site changes in the native soft files of the drawings also.

4.7.2 **As built Final Documents**

As built final documents shall be submitted as listed in Tender / Contract

4.7.3 **Packing / Presentation of Final Documents**

Final Documents shall be legible photocopies in A4, A3 size only. Drawings will be inserted in plastic pockets (both sides transparent, sheet thickness minimum 0.1 mm) with an extra strip of 12 mm wide for punching so that drawings are well placed.

Final Documentation shall be bound in hard board plastic folder(s) of size 265 mm x 315 mm ($10^1/_2$ inch x $12^1/_2$ inch) and shall not be more that 75 mm thick. It may be of several volumes and each volume shall have a volume number, index of volumes and index of contents of that particular volume. Where numbers of volumes are more, 90mm thickness can be used. Each volume shall have top PVC sheet of minimum 0.15 mm thick duly fixed and pressed on folder cover and will have 2 lever clips. In case of imported items documents, 4 lever clip shall also be accepted. All four corners of folders shall be properly metal clamped. Indexing of contents with page numbering must be incorporated by contractor. Spiral / Spico bound documents shall not be acceptable. As mentioned above, books should be in hard board plastic folders with sheets punched and having 2/4 lever clips arrangement.

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Each volume shall contain on cover a title block indicating Tender No., name of project, name of customer, package equipment tag no. & name (if applicable). Each volume will have hard front cover and a reinforced spine to fit thickness of book. These spines will also have the title printed on them. Title shall include also volume number (say 11 of 15) etc.

4.7.4 **Submission of Soft copies**

Contractor shall submit to EIL, the scanned images files as well as the native files of drawings / documents, along with proper index.

In addition to hard copies, contractor shall submit soft copies of all the final drawings and documents in pen drive or any other specified medium with proper identification tag, all text documents prepared on computer, scanned images of all important documents (not available as soft files), all relevant catalogues, manuals available as soft files (editable copies of drawings / text documents, while for catalogues / manuals / proprietary information and data PDF files can be furnished).

All the above documents shall also be uploaded on the EIL Vendor Portal and if applicable on Client Server also.

4.7.5 **Completeness of Final Documentation**

Contractor shall get the completeness of final documentation verified by EIL / TPIA and attach the Format for Completeness of Final Documentation (Format No. 3-78-0004) duly signed by EIL or TPIA as applicable to the final document folder.

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COMPLETENESS OF FINAL DOCUMENTATION

Name of Supplier/Contractor	:	
Customer	:	
Project	:	
EIL's Job No.	:	
Purchase Order No./ Contract No.	:	
Purchase Requisition No./ Tender No.	:	Rev. No. :
Name of the Work/ Equipment	:	
Tag. No.	:	
Supplier's / Contractor's Works Order No.	:	

Certified that the Engineering Documents / Manufacturing & Test Certificates submitted by the supplier (as per Index sheet mentioned in Annexure-1) are complete in accordance with the Vendor Data Requirements of Purchase Requisition / Tender.

Signature	: …….	Signature	: …….
Date	: …….	Date	: …….
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……
	Supplier / Contractor		EIL / TPIA

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Annexure-1

Final Documentation Index Sheet			
PR/PO/Tender No.		Rev. No.	
Serial No.	Document Title	Page/ Folder No.	No. of Pages

Signature	: …….	Signature	: …….
Date	: …….	Date	: …….
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……

Supplier / Contractor

EIL / TPIA

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आपूर्तिकर्ताओं से प्रलेखन अपेक्षाओं हेतु विनिर्देश

SPECIFICATION FOR DOCUMENTATION REQUIREMENTS FROM SUPPLIERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committe Convener	Standards Bureau Chairman
					Approved by	
2	12.06.20	General Revision	QMS Standards Committee	QMS Standards Committee	SKB	SKS
1	12.03.15	General Revision	QMS Standards Committee	QMS Standards Committee	MPJ	SC
0	04.06.09	Issued as Standard Specification	QMS Standards Committee	QMS Standards Committee	SCT	ND

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Abbreviations:

DCI	-	Document Control Index
eDMS	-	Electronic Document Management System
FOA	-	Fax of Acceptance
IC	-	Inspection Certificate
IRN	-	Inspection Release Note
ITP	-	Inspection and Test Plan
LOA	-	Letter of Acceptance
MR	-	Material Requisition
PO	-	Purchase Order
PR	-	Purchase Requisition
PVC	-	Polyvinyl Chloride
QAP	-	Quality Assurance Plan
QMS	-	Quality Management System
RPO	-	Regional Procurement Office
TPIA	-	Third Party Inspection Agency
URL	-	Universal Resource Locator
V-Portal	-	Vendor Portal

QMS Standards Committee

Convener: Mr. S.K. Badlani

Members: Mr. Sanjay Mazumdar (Engg.)
Mr. R.K. Singh (SCM)
Mr. B. Biswas (SCM)
Mr. Ravindra Kumar (Const.)
Mr. Vinod Kumar (CQA)
Mr. Swapnil Vaishnav (Projects)

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1.0 SCOPE

This specification establishes the Documentation Requirements from Suppliers.

All documents / data against the PO / PR / MR shall be developed and submitted to EIL / Owner by the suppliers for review / records, in line with this specification.

2.0 DEFINITIONS

2.1 Supplier

For the purpose of this specification, the word "SUPPLIER" means the person(s), firm, company or organization who has entered into a contract with EIL / Owner for delivery of some products (including service). The word is considered synonymous to bidder, contractor or vendor.

2.2 Owner

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

3.0 REFERENCE DOCUMENTS

6-78-0001	Specification for Quality Management System Requirements from Bidders

4.0 DOCUMENTATION REQUIREMENTS

4.1 Order Acknowledgement and Assigning Project Manager

After placement of order, Supplier shall acknowledge order through V-Portal within 7 days of receipt of FOA / PO. Supplier shall assign a Project Manager for that order though online portal and provide requisite details. Project Manager details shall include e-mail address, mailing address, mobile/telephone nos., fax nos. and name of Project Manager. All the system generated emails pertaining to that order shall be sent to the assigned Project Manager.

4.2 Documents / Data to be submitted by the Supplier

4.2.1 The Supplier shall submit the documents and data against the PO / PR / MR as per the list given in respective PO / PR / MR.

4.2.2 Review of the supplier drawings / documents by EIL would be only to review the compatibility with basic designs and concepts and in no way absolve the supplier of his responsibility / contractual obligation to comply with PR requirements, applicable codes, specifications and statutory rules / regulations. Any error / deficiency noticed during any stage of manufacturing / execution / inspection/ installation shall be promptly corrected by the supplier without any time and cost implications, irrespective of comments on the same were received from EIL during the drawing review stage or not.

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4.2.3 Unless otherwise specified, submission of documents for Review / Records shall commence as follows from the date of Fax of Intent / Letter of Intent / Fax of Acceptance (FOA) / Letter of Acceptance (LOA):

QMS	- 1 week
Document Control Index	- 2 weeks
Other Documents / Drawings	- As per approved Document Control Index

4.2.4 Documents as specified in PO / PR / MR are minimum requirements. Supplier shall submit any other document / data required for completion of the job as per EIL / Owner instructions.

4.3 Style and Formatting

4.3.1 All Documents shall be in ENGLISH language and in M.K.S System of units.

4.3.2 Before forwarding the drawings and documents, contractor shall ensure that the following information are properly mentioned in each drawing:

Purchase Requisition Number
Name of Equipment / Package
Equipment / Package Tag No.
Name of Project
Client
Drawing / Document Title
Drawing / Document No.
Drawing / Document Revision No. and Date

4.4 Review and Approval of Documents by Supplier

4.4.1 The Drawing / Documents shall be reviewed, checked, approved and duly signed / stamped by supplier before submission. Revision number shall be changed during submission of the revised supplier documents and all revisions shall be highlighted by clouds. Whenever the supplier require any sub-supplier drawings to be reviewed by EIL, the same shall be submitted by the supplier duly reviewed, approved and stamped by the supplier. Direct submission of sub-supplier's drawings without contractor's / suppliers' approval shall not be entertained.

4.5 Document Category

4.5.1 **Review Category**

Following review codes shall be used for review of supplier Drawings / Documents:

Review Code 1	-	No comments. Proceed with Manufacture / Fabrication as per the document.
Review Code 2	-	Proceed with Manufacture / Fabrication as per commented document. Revised document required.
Review Code 3	-	Document does not conform to basic requirements as marked. Resubmit for review.
R	-	Document is retained for Records. Proceed with Manufacturing / Fabrication as per PR / Tender requirements.
V	-	Void

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4.6 Methodology for Submission of Documents to EIL/Owner

4.6.1 Document Control Index (DCI)

Supplier shall create and submit Document Control Index (DCI) for review based on PO / PR / MR along with schedule date of submission of each drawing / document on EIL Vendor Portal. The DCI shall be specific with regard to drawing / document no. and the exact title. Proper sequencing of the drawings / documents should be ensured in schedule date of submission.

4.6.2 Submission of Drawings / Documents / Data

Drawings / documents, data and DCI shall be uploaded on the EIL Vendor Portal as per approved DCI. The detailed guidelines for uploading documents on EIL Vendor Portal are available on following URL

http://edocx.eil.co.in/vportal

4.6.3 Statutory Approvals

Wherever approval by any statutory body is required to be taken by Supplier, the Supplier shall submit copy of approval by the authority to EIL.

4.6.4 Manufacturing Schedule

Supplier shall prepare manufacturing schedule for the order, with key milestone activities (such as document submission, sub ordering, manufacturing, Inspection, dispatches, etc) to meet delivery as per FOA / PO terms. Supplier shall submit manufacturing schedule to concerned Regional Procurement Office (RPO) of EIL / Owner for review within 2 weeks from date of FOA / PO.

4.6.5 Schedule and Progress Reporting

Supplier shall submit monthly progress (MPR) report and updated procurement, engineering, manufacturing status, Inspection and dispatch status (schedule vs. actual) and highlight constraints, if any, along with action plan for mitigation, to the concerned Regional Procurement Office (RPO) of EIL / Owner by 1st week of every month., First MPR shall be submitted within 2 weeks from FOA / LOA. In case of exigencies, EIL / Owner can ask for report submission as required on weekly / fortnightly / adhoc basis depending upon supply status and supplier shall furnish such reports promptly without any price implication. Format for progress report shall be submitted by the Supplier during kick off meeting or within 2 weeks of receiving FOA / LOA, whichever is earlier.

4.7 Inspection and Testing

4.7.1 Quality Assurance Plan / Inspection and Test Plan

If Inspection and test plans (ITP) are attached with MR / PR same shall be followed along with additional tests requirement (if any) mentioned in MR/ PR. However for cases wherein EIL Standard ITPs not available / have not been attached with MR / PR, Supplier shall submit within one week of receiving FOA / LOA, the Quality Assurance Plan for inspection & testing at various stages of production, quality control records for critical bought out items / materials and site assembly & testing as may be applicable to the specific order and obtain approval from concerned Regional procurement Office of EIL / third party inspection agency, as applicable.

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For Package equipment contracts, the supplier shall prepare a list of items / equipment and their inspection categorization plan for all items included in the scope of supply immediately after receipt of order and obtains approval for the same from EIL. The items shall be categorized into different categories depending upon their criticality for the scope of inspection of TPIA and / or EIL.

4.7.2 **Inspection Requisition:**

Supplier shall perform internal inspection as per ITP/ approved QAP at their works based on approved documents / drawings. Upon satisfactory internal inspection, supplier shall raise inspection call to concerned Regional Procurement Office (RPO) of EIL / TPIA / Owner with advance notice as per contract along with Internal test reports.

All changes w.r.t. PR shall be recorded through agreed variations or Concessions & Deviations. Conflict, if any, between PR / Job specifications and approved drawings, shall be brought to the notice of EIL / owner by the supplier / contractor. Decision of EIL / owner will be binding on the supplier and to be complied without time and cost implications.

Identified bought out items/ raw material shall be procured under TPIA as per ITP.

4.7.3 **Inspection Release Note (IRN)/ Inspection Certificate (IC)**

IRN / IC shall be issued by EIL Inspector / third party inspection agency on successful inspection, review of test reports / certificates as per specifications & ITP / agreed quality plan (as applicable) and only after all the drawings / documents as per DCI are submitted and are accepted under review code-1 or code R. Supplier shall ensure that necessary documents / manufacturing and test certificates are made available to EIL / TPIA as and when desired.

Note 1: Non fulfilling above requirement shall result into appropriate penalty or with- holding of payment as per conditions of PO / PR / MR.

Note 2: For items where IRN/IC is issued by TPIA, supplier to ensure that following as a minimum must be mentioned by TPIA in IRN / IC

a) PR document number
b) List of drawings / documents with EIL approval code
c) Tests witnessed, documents reviewed
d) Compliance statement by TPIA that product meets the requirement as specified in EIL PR, standard specifications, Inspection Test Plan / QAP and approved documents.

4.8 Transportation Plan

Transportation Plan for Over Dimensional Consignments (ODC), if any, shall be submitted within 2 weeks of receiving FOA / LOA, for approval. Consignment with parameters greater than following shall be considered as over dimensional.

Dimensions: 4 meters width x 4 meters height x 20 meters length

Weight : 32 MT

Dimensions and weight provided above are inclusive of all nozzles, attachments, transportation saddles etc.

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Physical Rout survey for ODC movement shall be submitted to EIL within 8 weeks of receiving FOA / LOA.

4.9 Dispatch Details

Upon receipt of IRN / IC from EIL inspector / TPIA, supplier shall dispatch items within 2 days. Supplier shall submit dispatch details to concerned RPO of EIL / Owner within a day of dispatch. Dispatch details shall include Lorry Receipt (LR) number / Dispatch Number, Transporter Name, Date of dispatch, Packing list, Invoice copy etc.

4.10 Final Documentation

4.10.1 Supplier shall prepare final documents in line with VDR (Vendor Document Requirements) attached with PR/Tender. A copy of final document along with filled in Format for Completeness of Final Documentation (Format No. 3-78-0004) to be submitted to EIL Inspector / TPIA for review & approval within 2 weeks from dispatch. Upon receipt of EIL/TPIA endorsement on Completeness of Final Documents, supplier shall submit soft / hard copies of Final documents to EIL / Owner in requisite quantity as per PO / PR details, along with covering letter. A copy of covering letter to be submitted to the concerned Regional Procurement Office (RPO) of EIL/Owner.

4.10.2 **As Built Drawings**

Minor Shop changes made by Supplier after approval of drawings under 'Code 1' by EIL and deviations granted through online system ,if any, shall be marked in hard copies of drawings which shall then be stamped 'As-built' by the supplier. These 'As-built' drawings shall be reviewed and stamped by EIL Inspector / TPIA. Supplier shall prepare scanned images files of all marked – up 'As – built' drawings. Simultaneously Supplier shall incorporate the shop changes in the native soft files of the drawings also.

4.10.3 **Packing / Presentation of Final Documents**

Final Documents shall be legible photocopies in A4, A3 size only. Drawings will be inserted in plastic pockets (both sides transparent, sheet thickness minimum 0.1 mm) with an extra strip of 12 mm wide for punching so that drawings are well placed.

Final Documentation shall be bound in Hard board Plastic folder(s) of size 265 mm x 315 mm ($10^1/_2$ inch x $12^1/_2$ inch) and shall not be more that 75 mm thick. It may be of several volumes and each volume shall have a volume number, index of volumes and index of contents of that particular volume. Where number of volumes are more, 90mm thickness can be used. Each volume shall have top PVC sheet of minimum 0.15 mm thick duly fixed and pressed on folder cover and will have 2 lever clip. In case of imported items documents, 4 lever clip shall also be accepted. All four corners of folders shall be properly metal clamped. Indexing of contents with page numbering must be incorporated by supplier. Spiral/Spico bound documents shall not be acceptable. As mentioned above, books should be in hard board plastic folders with sheets punched and having 2/4 lever clips arrangement.

Each volume shall contain on cover a Title Block indicating package Equipment Tag No. & Name, PO / Purchase Requisition No., Name of Project and Name of Customer. Each volume will have hard front cover and a reinforced spine to fit thickness of book. These spines will also have the title printed on them. Title shall include also volume number (say 11 of 15) etc.

4.10.4 **Submission of Soft Copies**

Supplier shall submit to EIL, the scanned images files as well as the native files of drawings / documents, along with proper index.

In addition to hard copies, Supplier shall submit soft copies of all the final drawings and documents in pen drive or any other specified medium with proper identification tag, all text documents prepared on computer, scanned images of all important documents (not available

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as soft files), all relevant catalogues, manuals available as soft files (editable copies of drawings/text documents, while for catalogues / manuals / proprietary information and data, PDF files can be furnished).

All the above documents shall also be uploaded on the EIL Vendor Portal and if applicable on Client Server also.

4.10.5 **Completeness of Final Documentation**

Supplier shall get the completeness of final documentation verified by EIL / TPIA, as applicable, and attach the Format for Completeness of Final Documentation (Format No. 3-78-0004) duly signed by EIL Inspector or TPIA as applicable to the final document folder.

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COMPLETENESS OF FINAL DOCUMENTATION

Name of Supplier/Contractor	:	
Customer	:	
Project	:	
EIL's Job No.	:	
Purchase Order No./ Contract No.	:	
Purchase Requisition No./ Tender No.	:	Rev. No. :
Name of the Work/ Equipment	:	
Tag. No.	:	
Supplier's / Contractor's Works Order No.	:	

Certified that the Engineering Documents / Manufacturing & Test Certificates submitted by the supplier (as per Index sheet mentioned in Annexure-1) are complete in accordance with the Vendor Data Requirements of Purchase Requisition / Tender.

Signature	: …….	Signature	: …….
Date	: …….	Date	: …….
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……
	Supplier / Contractor		EIL / TPIA

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Annexure-1

Final Documentation Index Sheet			
PR/PO/Tender No.		Rev. No.	
Serial No.	Document Title	Page/ Folder No.	No. of Pages

Signature	: …….	Signature	: …….
Date	: …….	Date	: …….
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पेट्रोलियम रिफाइनरी वातावरण में सॉर सर्विस में इस्तेमाल होने वाले कार्बन स्टील अवयवों हेतु सामग्री अपेक्षा

MATERIAL REQUIREMENTS FOR CARBON STEEL COMPONENTS USED IN SOUR SERVICE IN PETROLEUM REFINERY ENVIRONMENTS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
2	05.07.19	REAFFIRMED AND RE-ISSUED	SM	DD	SG	RKT
1	07.10.11	REVISED & ISSUED AS STANDARD SPECIFICATION	AR	SG	PPL	DM
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Abbreviations:

ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing and Materials
ISO	:	International Organization for Standardization
NACE	:	National Association of Corrosion Engineers

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1.0 SCOPE

1.1 In general, for refinery services, NACE International Standard MR0103 shall be applicable. For refinery services where Hydrogen Induced Cracking (HIC) resistant carbon steel is specifically mentioned in the process documents, this specification shall be followed.

1.2 This specification lays down the requirements related to the chemical composition, manufacture, fabrication and testing requirements for carbon steel components intended to be used in sour service in petroleum refinery environments. These requirements are specified in order to make the carbon steel component resistant to the various forms of material damage in a sour environment, such as Sulfide Stress Cracking (SSC), Hydrogen Induced Cracking (HIC), Stress Oriented Hydrogen Induced Cracking (SOHIC), Blistering etc. These requirements can be used for resisting Alkaline Stress Corrosion Cracking (ASCC) also. This specification is applicable for corrosive petroleum refining facilities.

1.3 The service medium is defined as "Sour" when the service environment conforms to one of the following conditions, as defined in NACE International Standard MR0103:

Service environments containing free water (in liquid phase) and

(a) >50 ppmw dissolved H_2S in the free water,

(b) Free water pH < 4 and some dissolved H_2S present,

(c) Free water pH >7.6 and 20 ppmw dissolved hydrogen cyanide (HCN) in the water and some dissolved H_2S present,

(d) >0.003 MPa absolute (0.05psia) partial pressure H_2S in the gas in processes with a gas phase.

2.0 REFERENCED CODES/STANDARDS

NACE MR 0103	ASTM A 694	ASTM A 770
NACE RP 0472	ASTM A 216	ASTM A 370
NACE Publication 8X194 & 8X294	ASTM A 106	ASTM A 578
NACE TM 0284	API 5 L	ASME SEC II PART C
ASTM A 20	API 6 A	ASME SEC VIII-DIV.I
ASTM A 516	ASTM E 18	ASME SEC IX
ASTM A 105	ASTM E 45	ANSI B 16.34
ASTM A 234	ASTM E 92	ANSI B 31.3

All ASTM Standard designations shall be applicable for corresponding ASME designations which would be read as ASME SA XXX instead of ASTM A XXX.

3.0 GENERAL REQUIREMENTS

3.1 The steel for sour service shall be manufactured by either basic oxygen or electric arc furnace route and shall be fully killed and fine grained.

3.2 Carbon steel shall not contain intentional additions of elements such as lead, selenium or sulphur to improve machinability.

3.3 Carbon steel shall be used in one of the following heat treatment conditions.

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(i) Hot-rolled
(ii) Annealed
(iii) Normalised
(iv) Normalised and tempered
(v) Normalised, austenitised, quenched and tempered
(vi) Austenitised, quenched and tempered.

3.4 All material after cold forming shall be thermally stress relieved to meet a hardness requirement of 200 BHN maximum.

3.5 All products shall be free of low temperature transformation microstructures such as bainite bands or islets of martensite.

4.0 MATERIAL SPECIFICATION

All items are required to conform to the chemical composition of the respective specification as listed below.

Plate: ASME SA516 Gr.60

Pipe: ASME SA106 Gr. B or SA333 Gr.1 or 6

Forgings: ASME SA105 or SA350 Gr.LF1 or LF2 or SA266 Class 1

Fittings: ASME SA234 Gr. WCB or SA420 Gr.WPL6

Castings: ASME SA216 Gr. WCA, WCB or WCC or SA352 Gr. LCA, LCB or LCC

Tubing: ASME SA179 or SA214

5.0 PRODUCT SPECIFIC REQUIREMNTS

5.1 Plates and Rolled Products

All rolled products such as plates and sheets and fittings / pipes made of rolled products shall meet the following specific requirements.

5.1.1 The steel shall be made through a clean steel making route and shall have minimum of inclusions.

5.1.2 The sulphur level shall be restricted to 0.003 wt%.

5.1.3 The steel shall be calcium treated for inclusion morphology control and the Ca/S ratio shall be in the range of 2 to 3. When sulphur content is less than 0.0015%, then Ca/S ratio is not applicable and calcium can be present up to 50 ppm.

5.1.4 For plates including and above 25 mm thick, through-thickness tensile testing shall be carried out in accordance with ASTM A770, with minimum reduction in area being 35% as determined in accordance with ASTM A370, on one plate per heat.

5.1.5 No repair welding shall be permitted on plated.

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5.1.6 When the fabrication of the components from the previously HIC tested plates involves no heavy wall thickness reduction or material flow, such as bending, spinning or welding, no fresh HIC test would be required on the final product. However, for fabrication of products where heavy reduction of thickness and heavy flow of material is encountered while forming such as like forging, extrusion or drawing, metallographic examination of the final product shall be required to be carried out to ensure absence of elongated inclusions.

5.1.7 The plates shall be procured only from pre-qualified manufacturers.

5.2 Pre-qualification criteria for manufacturers/suppliers with prior experience track record

The manufacturers/suppliers who have proven track record of supplying materials for sour service applications in petroleum refineries to any of the process licensors such as UOP/IFP/EXXON/BP/CHEVRON or any of the reputed operating companies/consultants like ONGC/IOCL/HPCL/BPCL/EIL will be considered as 'pre-qualified manufacturers", on production of the relevant purchase orders and test certificates, certified by a witnessing third party inspection agency such as DNV/LLOYDS/BV/ABSTECH/TUV/SGS/CEIL for the conformance of the materials to the respective materials specification of the mentioned operators/engineering consultants. For pre-qualified vendors, Clause No. 5.4 is not applicable.

5.3 Pre-qualification criteria for new manufacturers/suppliers without track record

The manufacturers/suppliers who have no track record of supplying sour service materials to any of the process licensors or the reputed operating companies/consultants as mentioned in Clause No. 5.2 above, shall be considered as new manufacturers and shall be subjected to the elaborate pre-qualification by any one of the reputed third party inspection agencies like DNV/LLOYDS/BV/ABSTECH/TUV/SGS/CEIL as per the requirements.

5.4 Hydrogen Induced Cracking (HIC) Test

The requirements for HIC test shall be as follows.

(i) This test is required for manufacturers pre-qualification only.

(ii) This test shall be performed on a set of three specimens representing each production batch/heat of rolled products in accordance with NACE TM0284 with the following acceptance criteria:

(a) Crack Length Ratio (CLR) $\leq$ 10.0%
(b) Crack Sensitivity Ratio (CSR) $\leq$ 1%

(iii) In case of failure of any one of the specimens, three (3) more specimens from the same product shall be retested and all the specimens shall meet the acceptance criteria. In case of failure of any retest sample, the material shall be rejected.

6.0 POST WELD HEAT TREATMENT (PWHT) AND HARDNESS REQUIREMENT

All the weld joints, irrespective of thickness, shall be given a post weld heat treatment. The temperature range for PWHT is 595-650°C with a close control. Other aspects such as rate of heating, holding time etc. for PWHT shall be as per ASME Sec.VIII, Div.I /ANSI B31.3 requirements. The hardness of the weldment after PWHT shall be 200 BHN maximum.

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ध्वनिक रोधन के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR ACOUSTIC INSULATION

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	24-09-2018	ISSUED AS STANDARD SPECIFICATION	PP	BS	PS	RKT

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Abbreviations

ASTM	:	American Society for Testing and Materials
CINI	:	Committee Industrial Insulation
dB	:	Decibel
ISO	:	International Organization for Standardization
ITP	:	Inspection Test Plan
LRB	:	Light Resin Bond
MAR	:	Material Approval Request

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FIGURES

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1.0 INTRODUCTION

1.1 Scope

This specification outlines the design and installation aspects of acoustic insulation and provides guidance for selection of acoustic class and extent of insulation needed for meeting a desired noise reduction.

This standard is applicable for acoustic insulation of cylindrical steel pipes attached to a noise source (such as valves, compressor, pumps, ejectors etc.) The standard is not applicable for rectangular ducting and vessels or machinery.

1.2 Definitions

Acoustic insulation: Insulation applied with an objective to reduce the noise level radiated from pipes

Acoustic class: A predefined insulation system consisting of sound absorbing / resilient material (rock wool/ glass wool/ ceramic fiber) and impermeable outer cover (cladding) with defined minimum insertion loss across frequency spectrum of the noise

Noise level dB(A): Cumulative of A-weighted average of sound radiated across the octave band spectrum, expressed in decibel dB(A)

Loudness of the sound in decibels dB(A) can be expressed in terms of sound pressure level measured at specified location with respect to sound source or in sound power (cumulative of sound pressure across the pipe length). In this specification, sound is expressed in power level.

Sound spectra: Frequency distribution of the sound in decibels (dB) at different frequency (Hz) across octave band of the sound.

Insertion loss: Difference in sound power in decibels dB(A) across the octave band (frequency spectrum) before and after application of the acoustic insulation

2.0 INFORMATION REQUIRED FROM VENDOR

The equipment supplier (valves, compressor, pumps, ejectors etc. to which the pipe is attached) shall specify the below information of the unsilenced noise source

a) **overall sound level in decibels *dB(A)*** and
b) **octave band spectrum** (frequency distribution of the sound in decibels (dB) at middle of different octave band (Hz)

Note: In case, frequency distribution is not provided and overall noise level in decibels is the only information available, the octave band spectrum shall be derived by subtracting the spectral shape from overall dB(A) for specific for the source given in Table-3.

3.0 ACOUSTIC CLASSES

Acoustic insulation shall essentially consist of a sound absorbing / resilient fibrous material (e.g. rock wool) and impermeable outer cover (metal cladding). There are three insulation classes defined. Each class shall have specified minimum insertion loss across frequency spectrum of the noise.

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3.1 Description of Acoustic Classes

Three insulation classes denoted by A, B and C are referred in this specification. Physical description of the insulation classes and their acoustic performance (minimum insertion loss, when the specific insulation is applied) are given Table-1 and Table-2 respectively.

TABLE-1
PHYSICAL DESCRIPTION OF INSULATION CLASSES A, B & C

Acoustic Class	Pipe Diameter OD (mm)	Insulation		Cladding		
		Material	Minimum Thickness (mm)	Material	Minimum mass (kg/m2)	Indicative thickness (mm)
A	-	Rockwool/ glass wool/ ceramic fiber (see Note-2)	50	Stainless steel A240 TP 304	4.5	0.6
B	-		100		6.0	0.8
C	< 300		100		7.8	1.0
	300-649		100		10	1.3
	> 650 (Note-1)		Two layer 50+50		6	on 1st layer
					10	outer cladding

Notes:

1. *For pipe diameter ≥ 650 mm, two layer insulation shall be used with one intermediate cladding between the two layers and one final cladding on outer layer. Minimum mass for two types of cladding as specified shall be applicable.*

2. *Insulation material for acoustic purpose shall be mineral fiber (rock wool/ glass wool/ ceramic fiber) of appropriate density having mechanical stiffness less than $10^5/t$ N/m^3 (t=insulation thickness) and air flow resistivity in the range 25000-75000 N-sec-m^{-4}. Refer detail specification in section 6.0*
3. *For acoustic class-A, valve, flanges and extended pipe supports need not be insulated.*

4. *For acoustic class-B & C, valve and flanges shall be insulated with same class that of the pipes. Extended pipe supports shall be insulated up to the concrete or steel base or alternatively to the vibration isolator.*

5. *Wherever a high mass per unit area is required (e.g. Insulation Class-C), the cladding may be composed of stainless steel/ aluminized steel/ aluminium (aluminium not an option for fire safe insulation) of appropriate thickness with mass loaded anti drumming heavy vinyl/ flexible plastic sheet as inner layer meeting the specified overall mass per unit area.*

3.2 Acoustic Performance

Insertion loss is the reduction in sound across various frequencies when the particular insulation class is applied. The insertion loss is also dependent on the pipe diameter. Minimum insertion losses of the three acoustic classes at various pipe diameters are defined in Table-2.

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TABLE-2
MINIMUM INSERTION LOSS FOR INSULATION CLASSES A, B & C

Acoustic Class	Pipe diameter OD (mm)	Octave band centre frequency (Hz)						
		125	250	500	1000	2000	4000	8000
Correction factor*		16	9	3	0	-1	-1	1
		Minimum insertion loss (dB)						
A	< 300	-4	-4	2	9	16	22	29
	300-649	-4	-4	2	9	16	22	29
	650-1000	-4	2	7	13	19	24	30
B	< 300	-9	-3	3	11	19	27	35
	300-649	-9	-3	6	15	24	33	42
	650-1000	-7	2	11	20	29	36	42
C	< 300	-5	-1	11	23	34	38	42
	300-649	-7	4	14	24	34	38	42
	> 650	1	9	17	26	34	38	42

4.0 DESIGN ASPECTS FOR ACOUSTIC INSULATION

4.1 Painting Under Insulation

Piping to be applied acoustic insulation shall have under insulation painting for corrosion protection as it would normally have for other insulation purposes as per relevant codes / standards / specification applicable for the temperature.

4.2 Spacers & Support Rings

Where insulation is composed of semi-rigid sections (such as preformed pipe sections) and the pipe is horizontal, spacer or support ring may be avoided.

In all other cases, where soft blankets or LRB mattress is used and piping is vertical and cladding supports are necessary, the pacers/ support ring wherever used shall contain resilient elements for vibration isolation.

4.3 Insulation of Valves & Fittings

Valves, flanges etc. shall be designed with removable enclosure type insulation with lifting lugs.

4.4 Vibro-acoustic Seals

Appropriate vibro-acoustic seals to be applied between cladding and piping so that the cladding is isolated from vibrating pipes. There shall be no direct contact between cladding and pipes/ encasing.

4.5 Acoustic Insulation for Hot Service

When insulation is required for hot as well as acoustic purpose, the insulation material meeting acoustic requirements of this specification shall be used. Thickness of the insulation

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shall be determined by most stringent of the two requirements. For low operating temperature (upto 125^{0}C) services a suitable moisture barrier shall be used over insulation.

4.6 Acoustic Insulation for Cold Service

Where insulation is required for cold and acoustic service, the cold insulation system (without cladding, but primary vapour barrier applied) shall be applied first to the pipe and the acoustic insulation shall be applied over it.

An additional vapour barrier layer shall be applied to the outside layer of the acoustic insulation underneath metal cladding. The metal cladding shall be secured the same manner a cold insulation cladding is used so that the underneath vapour barrier layer is not punctured (screws rivets etc. which may cause puncture of the underneath layer shall not be used).

5.0 SELECTION OF ACOUSTIC CLASS

5.1 The contractor shall to select one of these three acoustic classes from section 3.1 as per following guideline:

Obtain unsilelcned sound level from equipment supplier data (valves, compressor, pumps, ejectors etc.) to which the pipe is attached

a) overall sound level in decibels dB(A)
b) frequency distribution at middle of octave bands

If frequency distribution is not given, the octave band spectrum shall be derived by subtracting the standard spectral shape from overall dB(A). The standard spectral shape to be subtracted for various sources given in Table-3 below:

TABLE-3
SPECTRAL SHAPE OF NOISE FROM PIPES ATTACHED TO VARIOUS SOURCES

Source	Octave band centre frequency (Hz)						
	125	250	500	1000	2000	4000	8000
	Difference from overall dB(A) to linear octave band level dB						
Control valve	20	16	17	9	6	5	7
Centrifugal compressor	15	12	9	7	3	10	12
Centrifugal pump	4	2	4	5	7	9	12
Reciprocating compressor	3	4	5	6	8	8	8

5.2 Correction Factor (A-weighting)

Noise at different octave bands shall be corrected for A-weighting for relative weightages. A-weighting correction factor is irrespective of acoustic class and pipe diameter and given in Table-4.

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TABLE-4
CORRECTION FACTOR FOR A-WEIGHTING

Acoustic Class	Pipe diameter OD (mm)	Octave band centre frequency (Hz)						
		125	250	500	1000	2000	4000	8000
Correction factor*(dB)		16	9	3	0	-1	-1	1

5.3 Required Noise Level Reduction

Determine the required noise level reduction from unlicensed sound level to the required target level in decibels dB(A).

5.4 Check and select the most optimum class from A, B & C

For a given acoustic class (A, B or C), subtract the minimum insertion loss from frequency distribution (provided by supplier OR derived using Table-3) and A-weighting correction (Table-4) against each octave band and determine the overall decibel level dB(A) for each class separately. Select the most optimum class for required noise reduction.

NOTE: In the event no information is available for original noise level and frequency distribution but acoustic insulation is to be applied the default system shall be class C.

5.5 Length of Acoustic Insulation

The length of the pipe to be insulated depends on pipe OD and whether the pipe is carrying gas vapour or liquid is to be determined using Table-5.

TABLE-5
CORRECTION FACTOR FOR A-WEIGHTING

Pipe OD (meter)	Required reduction In decibels dB(A)	Service	length (L) to be insulated (meter)
D	S	Gas/ Vapour	S x D/0.06
		Liquid	S x D/0.02

Note: In case the calculated length to be insulated is higher than the total length of the pipe, entire length have to be insulated from the noise source to the next silencer, vessel, heat exchanger, filter etc.

6.0 MATERIAL SPECIFICATION

Minimum technical specification of the major insulation materials and accessories are specified in this section. Based on the minimum technical requirement, the contractor shall select appropriate materials and submit MAR (material approval request at beginning of the job).

6.1 Insulation Material

Insulation material for the acoustic service can be rock wool/ glass wool/ ceramic fiber of appropriate density having mechanical stiffness less than 105/t N/m3 (t=insulation thickness) and air flow resistivity in the range 25000-75000 N-sec-m4 as per respective standards/ codes given below:

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Insulation material	Class	Density
Rock wool	ASTM C 547 (preformed section)/ IS 9842 ASTM C 592 (LRB mattress) /IS 8183	100-150 kg/m^3
Glass wool	ASTM C 547/IS 8183	80 kg/m^3
Ceramic Fiber blanket	ASTM C 892	128 kg/m^3

Note: Additional requirement for chloride limits for carbon steel and stainless steel piping and/ or any other parameters for respective mineral fiber insulation as would normally be applicable for thermal insulation shall be complied.

6.2 Metal Cladding

Metal cladding for acoustic insulation shall be as per Table-1.

In case the cladding is used in combination with an anti drumming layer, the later may be a membrane of mass loaded sheet of flexible plastic with mineral fibers (2300 kg/m3, min thickness 3mm).

6.3 Ancillary Materials

Minimum technical requirement for the common ancillary materials required for acoustic insulation are specified below.

Material	Type	Description
End caps	SS304	Thickness min 1.3 mm
Retaining bands for insulation	ASTM A167 TP 304L	20 mm wide & 0.8 mm thick
Wires for insulation	ASTM A167 TP 304L	1mm
Retaining bands for cladding	ASTM A167 TP 316	20 mm wide & 0.8 mm thick
Adhesive/Sealing material/Mastic seal	Two component epoxy adhesive	
Resilient pads / Anti-vibration seal *(Note-1)*	Synthetic/ natural rubber base material	Width 50 mm x Thk 3 mm
Self strapping screw for cladding *(Note-2)*	SS 304/ cadmium plated steel	8 mm dia & 12 mm long with neoprene under head

Notes:

1. *In case the synthetic / natural rubber to be used for vibrating seals is incompatible for the operating temperature, a layer of compressed mineral fiber blanket to be used underneath of the seals.*

2. *For acoustic insulation over cold insulation/hot insulation, where an underneath vapour barrier/ moisture barrier layer is used, cladding shall be secured the same manner a cold insulation cladding is used (screws rivets etc. which may cause puncture of the underneath layer shall not be used).*

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6.4 Moisture Barrier

(for application on outer surface of the insulation underneath cladding for operating temperature up to 175°C or less)

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.

Typical acceptable moisture barrier for application over insulation surface are: Foster 46-50 / Childlers AK-CRYL CP9/ TIC 2030.

Other products if considered shall have been evaluated and comply with the following minimum characteristics, for which contractor shall submit relevant credential and test reports for review/ approval:

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

6.5 Primary Vapour Barrier

Primary vapour barrier shall be chlorosulfonated polyethylene rubber (or hypalon) based elastomeric polymer mastic, fire retardant, compatible with base insulation, stable in the range of -40 to +100 deg C.

The mastic shall be applied in two coats reinforced with glass fiber cloth (approx at centre of the coating). The coating shall be applied in two coats to appropriate wet thickness to obtain the specified dry film thickness. When cured, the layer shall be durable and have good dry film strength and puncture resistance. Minimum technical requirement for primary vapour barrier is specified below.

Characteristics	Parameter	Typical material (see Note)
Consistency	Thixotropic soft paste	Foster 60-38/39 TIC 4015 /16
Water vapour permeance	0.02 metric perms (max) with DFT 1.2-1.3mm as per ASTM E-96 procedure-E	
Combustibility/ fire resistance	FSI (flame spread index) $\leq$ 25 as per ASTM E-84, tested on a 6.3mm inorganic reinforced cement board with DFT 1.1-1.2 mm	

Note: Typical materials are indicative only. Products meeting specified requirements as per ASTM E84 and E96 and proven under similar services may be used subject to approval of owner/ Engineer-in-charge.

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7.0 APPLICATION

The insulation contractor shall adhere to the minimum technical requirements for quality control given in this specification:

7.1 The contractor's personnel shall be fully conversant and responsible for meeting the specified HSE requirements and shall strictly adhere to safety instructions and MSDS requirements of the insulation/ ancillary products and application.

7.2 The contractor shall select appropriate materials and submit MAR (material approval request) at beginning of the job. The contractor shall undertake guarantee of materials supplied against deviation or deterioration of any kind in respect of quality.

7.3 The contractor shall arrange for its personnel adequate personnel protection and safety gears like hand gloves, masks, spectacles etc.

7.4 Ensure painting under insulation is applied as per applicable painting & coating specification before start of insulation work.

7.5 The insulation system needs to be installed in dry condition.

7.6 The installation contractor shall prepare an ITP identifying stage inspections for which shall be approved by Engineer-in-charge of the insulation job.

7.7 Material shall be stored properly as per the instruction of supplier. Material shall preferably be stored in covered shed and protected against water ingress.

7.8 Insulation shall be applied snugly around piping, flanges, fittings and around shells and fronts of equipment. In case of double layer insulation, both the longitudinal and circumferential joints shall be staggered.

7.9 Bends, reducers and T-pieces, etc. shall be insulated with preformed insulation pipe sections or segments of the same insulation material.

7.10 Flange and valve boxes shall be provided with the same insulation thickness and cladding as indicated for the classification of the insulated system. The insulation shall be installed at the inside of the boxes. The inner surface layer shall be at least 10mm away from the flange or valve.

7.11 Removable insulation boxes shall overlap the adjacent pipeline insulation over a distance of at least the pipe insulation thickness of the piping insulation.

7.12 In case of preformed pipe section, every layer shall be separately fixed with at least 3 stainless steel wires, slab and blanket shall be fastened by steel band at interval of 300mm.

7.13 Joints in cladding shall be sealed with a band acoustic sealing material. Cladding joints shall have minimum 50 mm overlap and shall be secured by band at interval of 300mm.

7.14 At exposed flanges, acoustical insulation shall be terminated with an end cap. This cap shall be located as close to the flange as possible, however it will still allow bolt removal. The end cap shall be isolated from the pipe ends.

7.15 All termination points shall be sealed properly. Any protrusion shall be sealed to prevent any moisture ingress.

7.16 The contractor shall mobilize all required tools & tackles and carry out the insulation installation as per approved procedure.

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7.17 Materials shall be stored properly to protect damage from adverse environments, such as humidity, moisture, rain, dust, dirt, sand, mud, salt air, etc.

7.18 Details of insulation work executed each day shall be maintained in a log book approved by the Engineer-in-charge which shall include the types and quality of insulation materials, name of the manufacturer, section numbers etc.

7.19 Sufficient number of qualified and experienced supervisors to be deployed in each shift to take care of all activities at site. One exclusive supervisor shall be engaged to take care of the quality aspect of insulation job.

7.20 The client/ Engineer-in-charge may inspect the insulation application at various stages during execution, any rectification suggested need to be taken care by the Contractor, without any time or cost implication.

8.0 INFORMATION REQUIRED FROM VENDOR

Following information is required from the contractor before start of acoustic insulation:

8.1 Calculation supporting selection of appropriate acoustic class complying guideline of 5.0 of this specification.

8.2 MAR (material approval request) for insulation, cladding ancillary materials.

8.3 Application procedure and ITP for stage inspections.

8.4 Details of qualification, experience and HSE exposure of the personnel going to be engaged for insulation supervision, inspection and quality control

8.5 List of equipments tools and tackles to be mobilized during the execution of the job.

8.6 Material test certificates relevant to physical and chemical tests (duly endorsed by the inspection agency) for insulation and ancillaries materials.

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9.0 REFERENCE CODES AND STANDARDS

This specification refers standard practices of following codes and standards

ASTM Standards

ASTM A167	Specification for stainless and heat-resisting chromium nickel steel plate, sheet and strip
ASTM C547	Standard specification for Mineral fiber pipe insulation
ASTM C592	Standard specification for Mineral fiber blanket insulation and blanket-type pipe insulation (metal-mesh covered) (industrial type)
ASTM E96	Standard test methods for Water vapor transmission of materials
ASTM C892	Standard specification for High temperature fiber blanket thermal insulation
ASTM A240	Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet and strip for Pressure Vessels

BS Standards and Specifications

BS 1902 Prt 6	Ceramic fibre products
BS 2972	Method of test for Inorganic thermal insulating materials

IS Standards and Specifications

IS 8183	Bonded mineral wool-Specification
IS 9842	Preformed fibrous pipe insulation- Specification

Others

ISO 15665:	Acoustic insulation for Pipes, Valves and flanges
IEC 534-8-2:	Industrial process control valves - Part-8: Noise considerations
CINI Manual:	Insulation for industries

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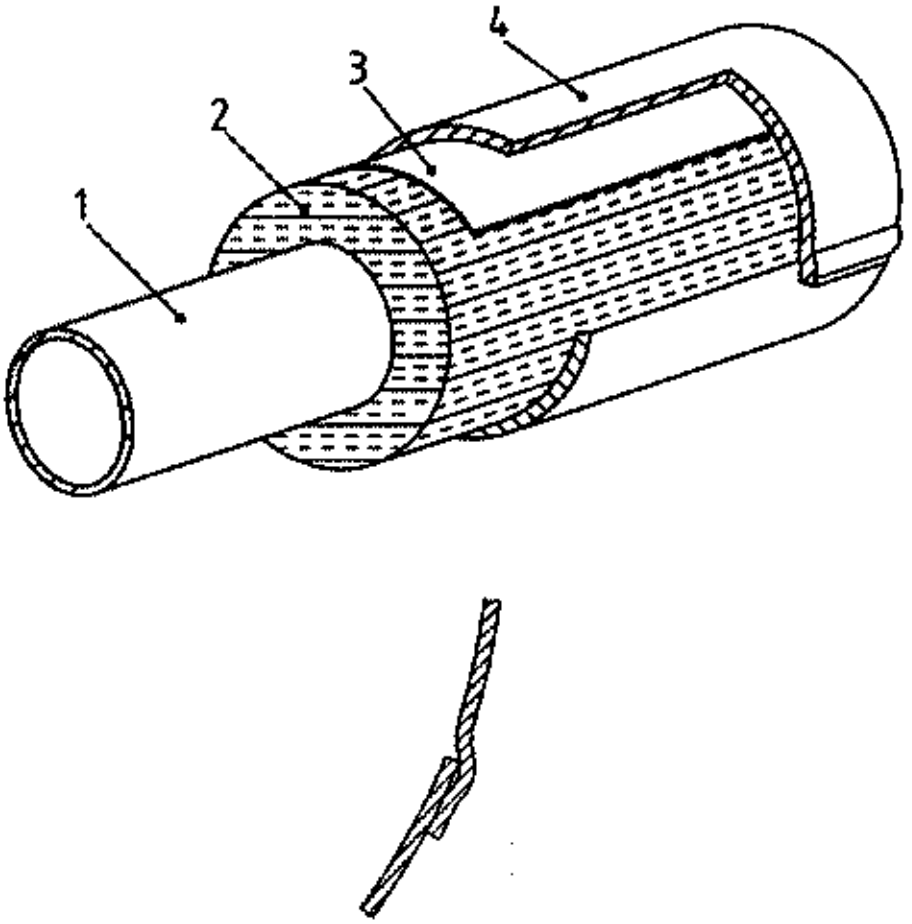

OVERLAP (SUCH THAT INGRESS OF RAIN WATER IS PREVENTED)

1. PIPE
2. MINERAL FIBER INSULATION
3. ADDED MASS OR DAMPING LAYER
4. CLADDING

CLADDING MAY BE FIXED IN POSITION WITH RIVETS, SELF-TAPPING SCREWS, OR STAINLESS-STEEL RETAINING BANDS.

FIGURE- 01
GENERAL CONSTRUCTION OF ACOUSTIC INSULATION

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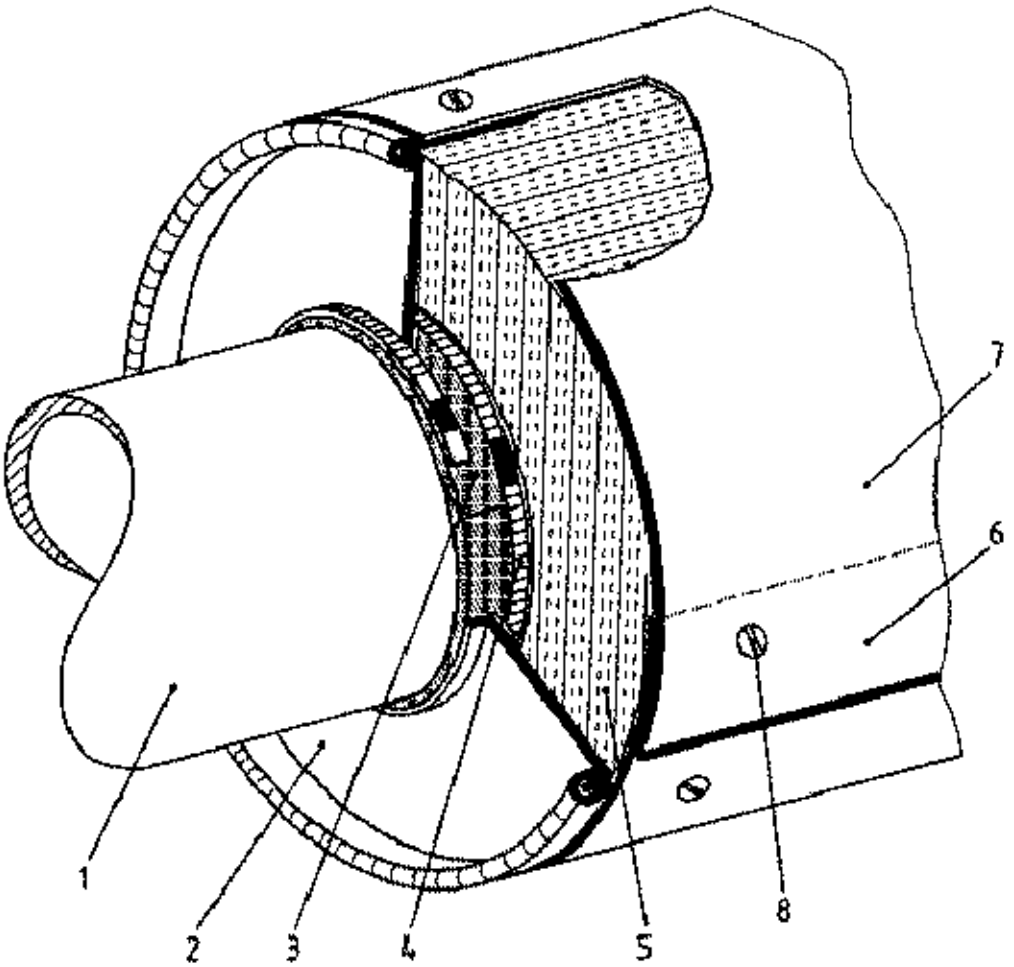

1. PIPE
2. END CAP, MAY CONSIST OF TWO OVERLAPPING HALVES WITH OVERLAP IN THE HORIZONTAL PLANE
3. VIBRO-ACOUSTIC SEAL
4. RETAINING BANDING
5. POROUS LAYER
6. OVERLAP (LONGITUDINAL SEAMS SHALL BE LOCATED IN THE 4 TO 5 O'CLOCK POSITION TO PREVENT MOISTURE INTRUSION)
7. CLADDING
8. FIXING SYSTEM OF THE CLADDING: RIVETS, SCREWS (THESE SHALL NOT BE USED WHEN CLADDING IS DIRECTLY OVER A VAPOUR BARRIER) OR STAINLESS-STEEL STRAPS

FIGURE- 02
TYPICAL ARRANGEMENT OF ACOUSTIC INSULATION WITH CLADDING AND END CAP

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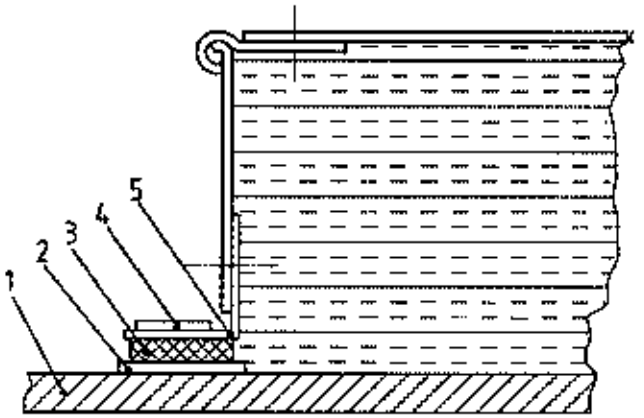
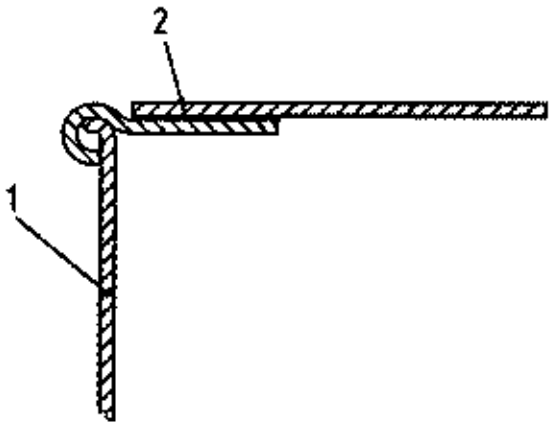


A) VIBRO-ACOUSTIC SEAL

1. PIPE
2. ADHESIVE/SEALING LAYER
3. VIBRO-ACOUSTIC SEAL
4. RETAINING BAND
5. SHAPED PROFILE COLLAR



B) END CAP TO CLADDING SEAL

1. END CAP
2. MASTIC SEAL

FIGURE - 03
END CAP OF PIPE INSULATION

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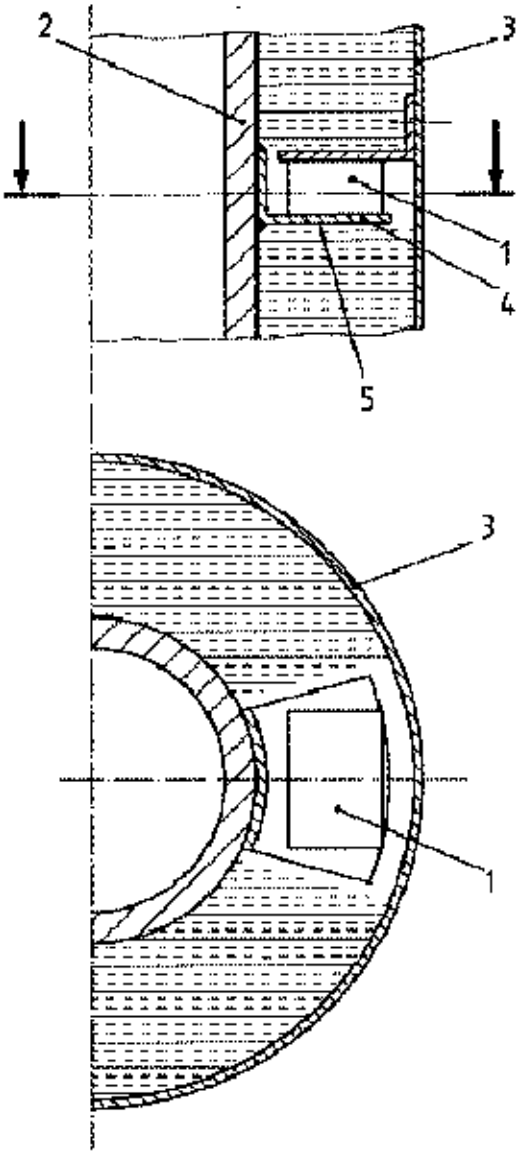

1. VIBRATION-ISOLATING PAD
2. PIPE WALL
3. CLADDING
4. VULCANIZED LAYER
5. SUPPORT ON STRAPPING BAND (OR WELDED)

FIGURE - 04
TYPICAL ARRANGEMENT FOR VIBRATION-ISOLATED CLADDING AND INSULATION SUPPORTS IN VERTICAL PIPES

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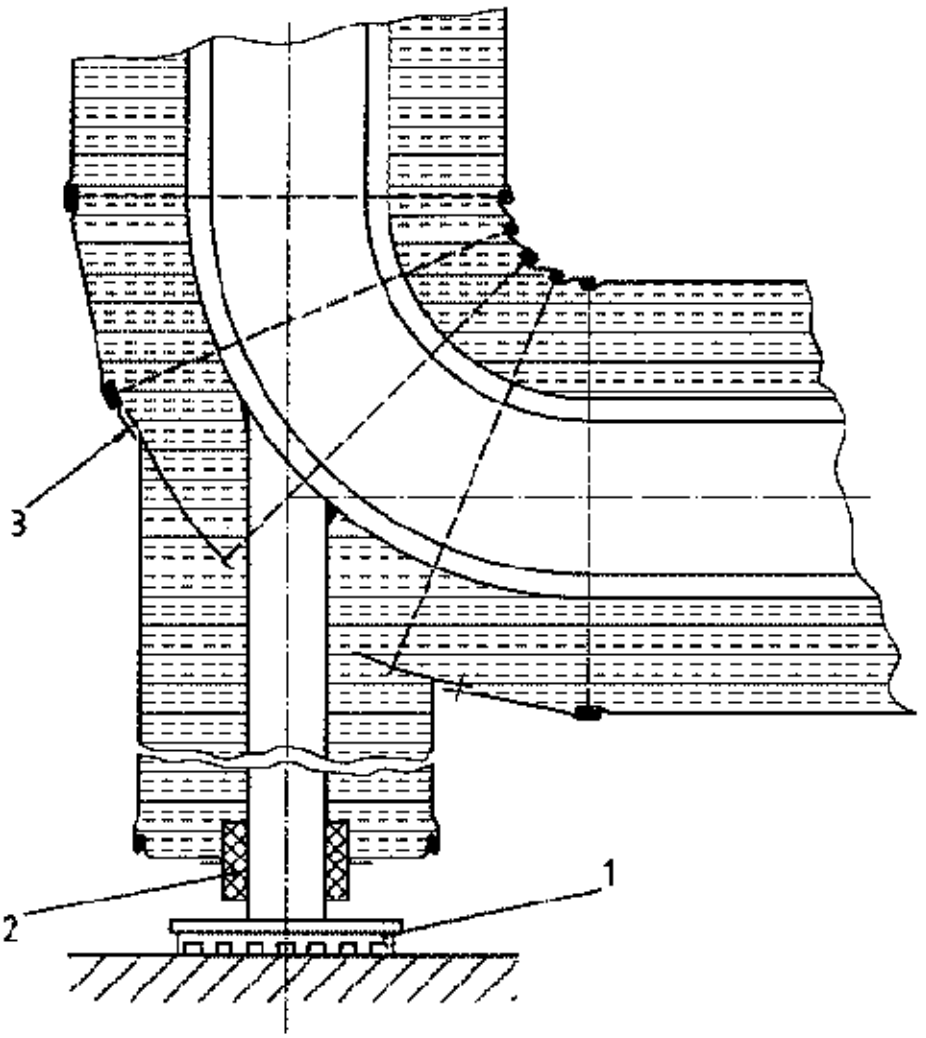

1. VIBRATION-ISOLATING PAD
2. VIBRO-ACOUSTIC SEAL
3. MASTIC SEAL

FIGURE- 05
SUPPORT FOR VERTICAL PIPE

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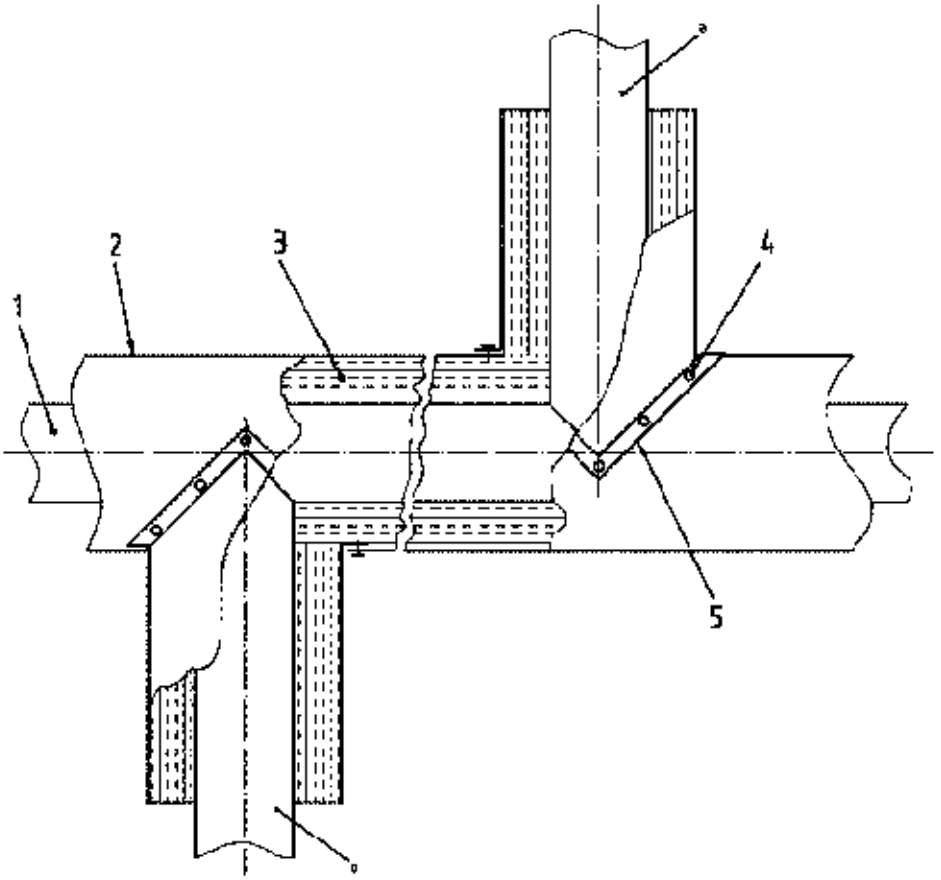

a) UPPER CONNECTION, b) LOWER CONNECTION

1. PIPE
2. CLADDING
3. POROUS LAYER
4. SCREWS OR RIVETS
5. MASTIC SEAL

FIGURE -06
TYPICAL ARRANGEMENT FOR BRANCHES AND TEES

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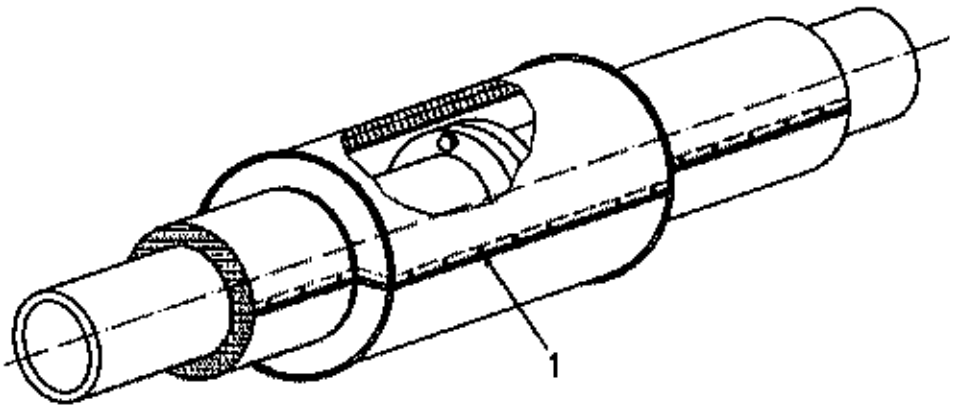
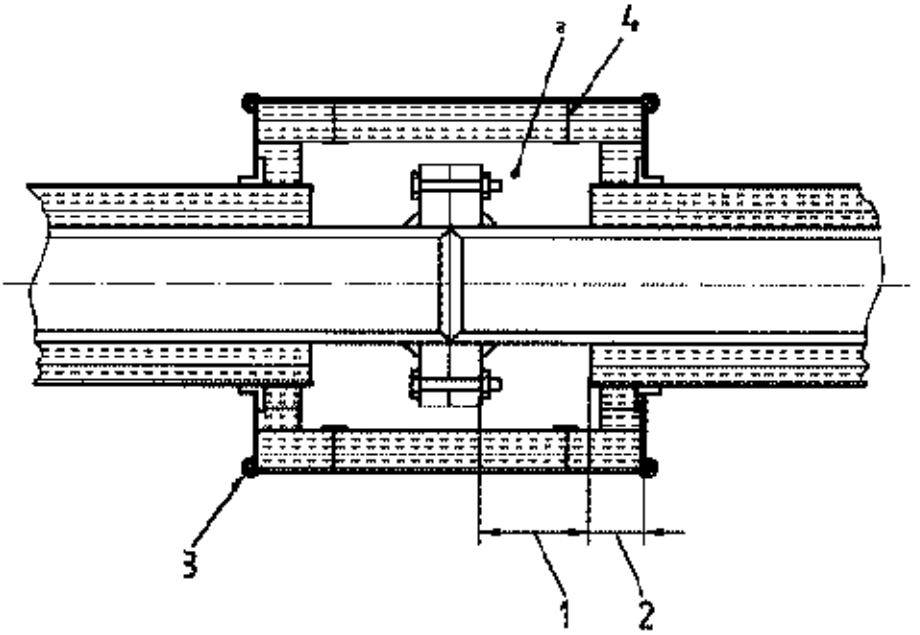


FIXING OF THE CLADDING: RIVETS, SCREWS
(STAINLESS-STEEL STRAPS TO BE USED WHEN A VAPOUR BARRIER IS USED UNDERNEATH)



1. BOLT LENGTH + 30 MM
2. OVERLAP = INSULATION THICKNESS
3. LOCK FORMED
4. CLIP TO FIX POROUS LAYER
5. SPACE SHALL BE FILLED WITH POROUS MATERIAL

FIGURE - 07
ARRANGEMENT FOR THE ACOUSTIC INSULATION OF FLANGED JOINTS

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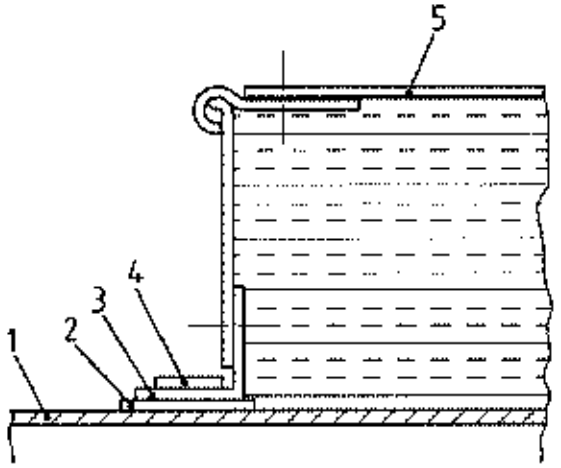
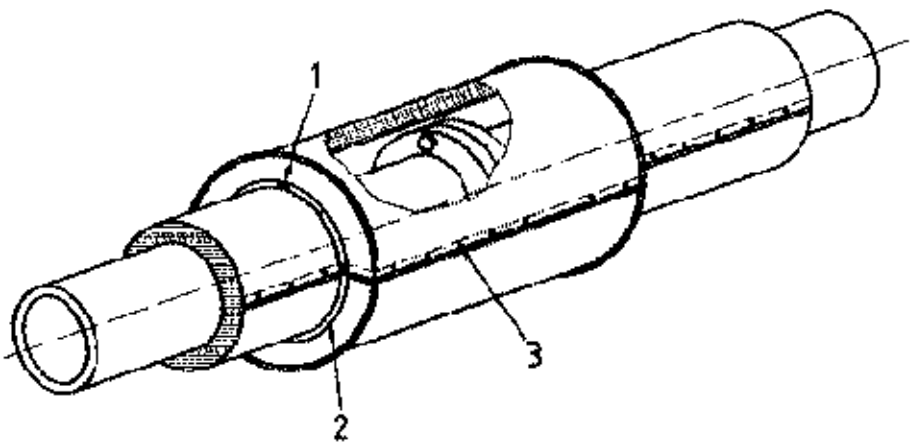


1. PIPE INSULATION CLADDING
2. ADHESIVE SEALING MASTIC LAYER
3. SHAPED PROFILE
4. RETAINING BAND (STAINLESS)
5. CLADDING (BOX)

FIGURE - 08
CONSTRUCTION DETAILS: END CAP OF ENCLOSURE



1. support
2. venting aperture
3. fixing system of the cladding: rivets, screws (these shall not be used when
4. cladding is directly over a vapour barrier) or stainless-steel straps

FIGURE - 09
VENTED ACOUSTIC INSULATION OF FLANGED JOINTS AND BELLOWS

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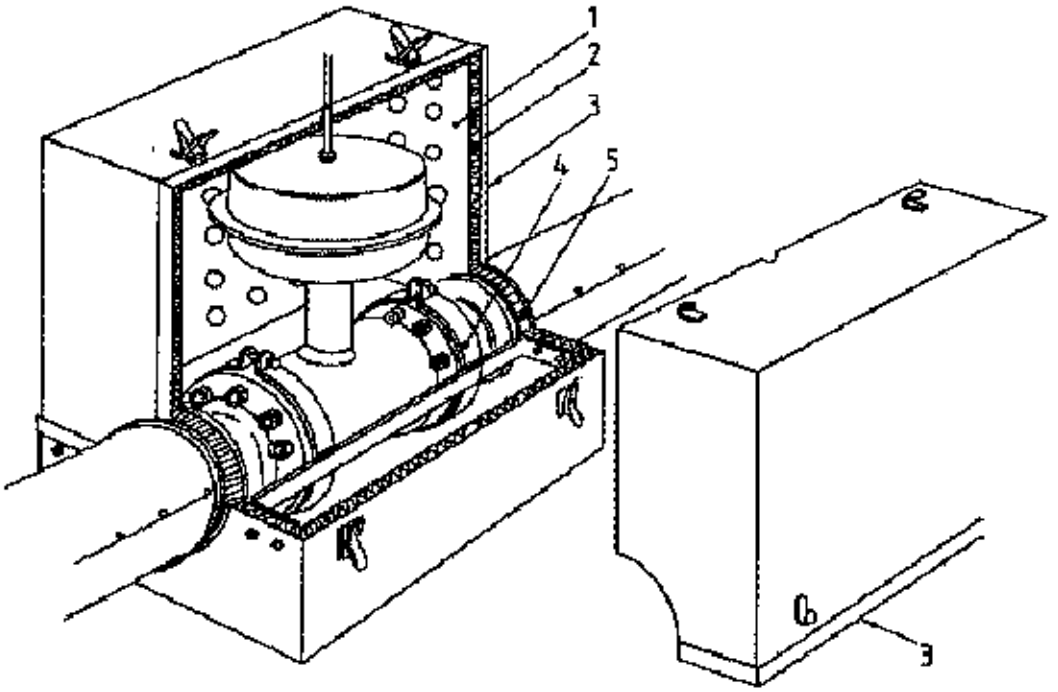

1. perforated sheet
2. porous layer
3. locating edge to help locate upper portions
4. supporting framework clamped to flanges (over vibration isolation pad)
5. vibro-acoustic seal

FIGURE -10
EXAMPLE OF AN ACOUSTIC ENCLOSURE FOR A VALVE

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Example: Selection of acoustic class

Find acoustic class and length of the insulation to be applied on 250 mm OD steel pipe in gas/vapour service attached to control valve radiating 100 dB(A), to be reduced to 85 dB(A).

Unsilenced sound level is 100 dB(A), required reduction (100-85) =15dB(A)
Noise source: Control valve, Octave band spectrum: not given

Step-1: Acoustic class selection

1. Derive octave band spectrum by subtracting differential dB specific to the source type using Table-3.

2. For an acoustic class, apply (subtract) the insertion loss for each octave band using data given for specific pipe OD in Table-2.

3. Apply (subtract) A-weighting correction factor (Table-4) from each octave band.

4. Calculate A-weighted decibel level of overall sound radiated from insulated pipe separately for each acoustic class using formula, check noise reduction achieved and select the most optimum class

   dB(A)insulated=10x log (antilog D125/10 + antilog D250/10 + ... + antilog D8000/10)

Calculation table with acoustic Class-A:

Octave band (Hz)	Bare Pipe dB(A)	Control valve data (Table-3) dB	Octave band estimate dB	Insertion loss for Class-A (Table-2) dB	Apply insertion loss dB	A-weighting correction (Table-4) dB	Insulated Pipe noise dB	Total Noise reduction
125		20	80	-4	84	16	68	
250		16	84	-4	88	9	79	
500		17	83	2	81	3	78	
1000		9	91	9	82	0	82	
2000		6	94	16	78	-1	79	
4000		5	95	22	73	-1	74	
8000		7	93	29	64	1	63	
dB(A)	100						86	14

Calculation table with acoustic Class-B:

Octave band (Hz)	Bare Pipe dB(A)	Control valve data (Table-3) dB	Octave band estimate dB	Insertion loss for Class-B (Table-2) dB	Apply insertion loss dB	A-weighting correction (Table-4) dB	Insulated Pipe noise dB	Total Noise reduction
125		20	80	-9	89	16	73	
250		16	84	-3	87	9	78	
500		17	83	3	80	3	77	
1000		9	91	11	80	0	80	
2000		6	94	19	75	-1	76	
4000		5	95	27	68	-1	69	
8000		7	93	35	58	1	57	
dB(A)	100						84	16

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Calculation table with acoustic Class-C

Octave band (IIz)	Bare Pipe dB(A)	Control valve data (Table-3) dB	Octave band estimate dB	Insertion loss for Class-C (Table-2) dB	Apply insertion loss dB	A-weighting correction (Table-4) dB	Insulated Pipe noise dB	Total Noise reduction
125		20	80	-5	85	16	71	
250		16	84	-1	85	9	76	
500		17	83	11	72	3	69	
1000		9	91	23	68	0	68	
2000		6	94	34	60	-1	61	
4000		5	95	38	57	-1	58	
8000		7	93	42	51	1	50	
dB(A)	100						78	22

Therefore, Class-A is found to be ineffective. Class-B is the optimum insulation that can be chosen for the required noise reduction of 15 dB(A).

Step-2 Calculate length of the pipe to be insulated using Table-5

Using Table-5, length to be insulated can be found

L = S x D/0.06, S=15 dB(A) (required noise reduction) and D=0.25m (pipe OD)
= 15 x 0.25/0.06
– 62.5 meter

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रीफ्रैक्टरी के लिए स्वास्थ्य, सुरक्षा और पर्यावरण आवश्यकताओं हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR HSE REQUIREMENTS FOR REFRACTORY

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
0	19-07-2019	ISSUED AS STANDARD SPEC	PP	BS	PS	RKT

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Abbreviations

HSE	:	Health Safety and Environment
MSDS	:	Material Safety Datasheet
PPE	:	Personal Protective Equipment
RCF	:	Refractory Ceramic Fibre

Refractory & Insulation Standards Committee

Convenor : Mr Prasenjit Saha

Members :

Mr Biswarup Sarkar
Mr P. Pal
Mr Udayan Chakravarty (Piping)
Mr Prag Goel (Fired Heaters)
Mr Ayush Mathur (Projects)
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Page 5202 of 6631 : B957-TENDER_DOC-B957-420-80-44-PG-T-7410 : Rev. A

1.0 INTRODUCTION

1.1 Scope

This specification outlines the Health and safety issues pertaining to handling refractory materials and waste generated during installation of refractory and /or removal of spent lining after service with an objective to minimize risk of the potential hazards.

The guideline mentioned in this specification is meant for compliance by the contractors who are involved in supply, installation, removal of refractory lining.

2.0 GENERAL

Refractory materials are generally composed of non metallic oxides like Al_2O_3,SiO_2, MgO, Na_2O, K_2O etc. which may contain varying degree of other constituents like high alumina cement and chemical binders. Risks associated are different with different materials depending on its mineralogical constituents, fineness etc.

The potential risks associated in handling a particular material are usually addressed in the MSDS (material safety datasheets) provided by refractory supplier. The contractor responsible for the job must categorize the materials according to the risks involved and comply to the requirements specified in MSDS with respect to HSE requirements for the employees and environment.

The contractor shall submit MSDS to owner/ PMC for review and carry out a job safety analysis for compliance to MSDS and project/ client specific HSE requirements.

3.0 REFRACTIORY TYPES

3.1 Refractory Brick

Refractory bricks which are used in Oil and gas are generally based on aluminosilicate. Respirable dust from these products may contain crystalline silica, which is known to cause respiratory disease. With respect to hazardous material identification system, the material is not reactive, non-flammable and no adverse effects of this material on the environment are anticipated.

3.2 Refractory Castable

Refractory castable which are generally used, are based on aluminosilicate cement bonded castable or High alumina chemically bonded castable. Prolonged or repeated inhalation of dusts of this product may cause lung disease (Silicosis). The product is stable under normal conditions and hazardous decomposition or polymerization does not occur. No adverse effects of this material on the environment are anticipated.

3.3 Ceramic Fiber Material

Refractory ceramic fibre (RCF) which is used for insulation, particularly in kilns and furnaces, is a form of man-made vitreous (silicate) fibre and consists of alumino-silicate fibres which can irritate the skin, eyes and upper respiratory tract but the main concern is that the individual fibres are small enough to penetrate deep into the lungs and possibly lead to the development of lung cancer and mesothelioma. An additional problem for users with ceramic fiber is that after being exposed to high temperatures for prolonged periods as can happen in kilns and furnaces, it is known that RCF at the surface of the lining devitrifies to crystalline phases including cristobalite, a form of crystalline silica which can cause silicosis.

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Ceramic fiber is inert, stable and it is not soluble with water and as such does not pose detrimental effect on environment.

4.0 HSE FOR REFRACTORY HANDLING

4.1 General

The contractor executing the job shall be responsible for hazard identification and job safety analysis with respect to handling and application of various refractory types. All staff involved with refractory works and related activities should be provided safety induction and briefed about the risks and mitigation, first aid as per MSDS by refractory supplier.

4.2 All the staff will be provided with overalls, and anti-dust mask, in order to avoid inhalations of noxious dust. All the staff in charge of the works will wear necessary PPE like helmet, accident-prevention shoes, eye protection and protective gloves, etc.

4.3 Environmental protection should minimize the waste generated and impact by a specific segregation of difference type of waste, compaction and storage.

4.4 Barriers need to be installed around the installation area and area destined for handling of such material. Signage indicating danger and no-entry for unauthorized persons need to be put up at the barriers. General transit should not be allowed in the installation area, due to possible falling down of harmful elements.

4.5 Operators of gunning machine or paddle mixer and brick cutting machine must be competent, experienced people, and operate strictly as per approved operation procedure or manuals. The machines need to be checked regularly for good condition as per check list and certificate

5.0 JOB SAFETY ANALYSIS FOR REFRACTORY WORK

The refractory lining in furnace or high temperature equipment broadly includes lining materials like refractory brick, castable and ceramic fiber. The general risks associated during execution of those refractory works, potential hazard and current precautionary measures are tabulated below. The entire work force should be trained for fall protection and confined space working. Scaffolding should be checked and tagged prior to use, and related safety manual shall be implemented according to the project HSE requirement. While working in confined space air condition should be checked by certified tester.

Description of the Job	Potential HSE hazard	People at risk	Current precautionary measures
Refractory material transport from storage	Stumble and slip when carrying the material	Working people and site personnel	• Ensure that access is not blocked by the other materials, meanwhile keep the view clear and be careful of the loading the material. • Pay attention to loading the material in good order and the stack of the container not higher than the plate of the truck • Assign Flag man with the red vest to guide the driver • Use the correct tie connection of the rope to secure the material to prevent the material fall from the truck.

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Description of the Job	Potential HSE hazard	People at risk	Current precautionary measures
Surface preparation	Suffocated injury and hurt by pressure in case blasting	Operator	• Blasting work should be by experienced person, and operate strictly as operation procedure • Regularly check that the sandblasting machine is in good condition • Ensure mechanical ventilation, and use respirators
Castable mixing	Injury hurt by machine, bad ventilation, bags catching fire, Skin contamination, Inhalation	Operator, Site worker and personnel	• All the castable material should be well stored with good ventilation conditions • Regularly check the condition of the machine as per check list and certificate • Put warning signs on the storage and keep fire extinguishers • Put MSDS at the working and storage location
Castable gunning, casting, hand packing, Vibracasting etc.	Injury hurt by machine, bad ventilation, Skin contamination, Inhalation	Site workers and Personnel	• The operator of Refractory gunning machine should be an experienced person, and operate strictly as operation procedure • Regularly check the condition of the machine as per check list and certificate • The working area should be barricaded, and have suitable signage • Worker should wear correct PPE and dust mask
Ceramic fiber Installation	Occupational diseases (Eyes and skin irritation, respiratory mucous membrane irritation)	Site workers and Personnel	• Check the effect with respect to MSDS • Worker should wear correct PPE and proper respiratory mask • Good housekeeping and material management
Brick installation	Skin contamination, Inhalation	Site workers and Personnel	• During brick installation the silica dust is created by the use of power saws cutting the bricks. Silica dust is a serious health threat. Use wet saws whenever possible when cutting brick. • Worker should wear correct PPE and proper respiratory mask • Good housekeeping and material management

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6.0 WASTE MANAGEMENT PLAN AND DISPOSAL

6.1 General

Material safety datasheet of refractory materials should be checked and there should be awareness about the effect to people and environment, hazardous identification, first aid and fire fighting measures. Management of waste is an integral component of management of environment. Waste refractories which are intended to be disposed can be done with the following manners:

(a) Reusable portion of salvaged refractories can be recycled

(b) Broken pieces can be recycled/sold to outside parties

(c) Remaining debris can be dumped as a waste at some authorized disposal sites.

6.1.1 Do not handle the waste until all the safety precautions have been read and understood. Dispose the waste in accordance with local/regional/national/international HSE regulations.

6.1.2 The waste should be removed from site as soon as possible.

6.1.3 The cleaner should wear proper PPE when entering site.

6.1.4 The waste should be thrown into the assigned area; and should not set on fire.

6.1.5 Barriers need to be installed around the disposing area and area destined for handling of such material. Signage indicating danger and no-entry for unauthorized persons need to be put up at the barriers, while the work is in progress.

6.2 Disposal of Waste Refractory Bricks

6.2.1 The unused refractory brick is not considered a hazardous waste. The material may be recycled back to manufacturer or can be used for land filling.

6.2.2 For used refractory brick (for example in revamp work), disposal method shall be consulted with client. Refractory exposed to the furnace environment may have contaminations due to exposure to fuels and process conditions, hence client shall advise specific disposal method.

6.2.3 Avoid creating dust during handling, use or storage of this product. Do not breathe dust that may be created during the handling or use of this product.

6.3 Disposal of Waste Refractory Castable

6.3.1 The as manufactured refractory, dust or hydraulically set castable is not considered as hazardous waste. The material can be used for land filling.

6.3.2 For used refractory castable (for example in revamp work), disposal method shall be consulted with client. Refractory exposed to the furnace environment may have contaminations due to exposure to fuels and process conditions, hence client shall advise specific disposal method.

6.3.3 During handling, minimize dust, sweep, shovel or vacuum. Watch footing if particles fall onto walkways. Avoid direct contact with the product by wearing protective clothing, using approved respiratory protection and wearing gloves of the impermeable type.

6.4 Disposal of Waste Ceramic Fiber

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6.4.1 Wastes generated during fabrication, installation or removal of RCF's is not defined as hazardous. Waste fibre should be carefully placed directly into heavy duty plastic bags and clearly labelled to indicate the contents and placed into deep landfills.

6.4.2 Because of the possible presence of crystalline silica in used RCF, particular care should be exercised during tear-out to minimize the generation of dust.

6.4.3 Whenever practical, used RCF products should be wetted with water from a fine spray nozzle and hose prior to removal. Effective use of the wetting procedures will reduce the cristoballite exposure hazard of RCF products.

6.4.4 All activities involving the cutting of RCF products shall be restricted to a designated area. Caution signs must be posted before work begins. Local exhaust ventilation must be employed.

6.4.5 Removal and demolition of RCF insulation should begin at the top of a structure and progress downward. Do not drop insulation from elevated areas to ground levels.

6.4.6 Handling can be source of dust emission and therefore the process should be designated to limit the amount of handling. Whenever possible handling should be carried out under controlled condition i.e. using dust exhaust system.

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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
					Approved by	
0	24-11-2020	ISSUED AS STANDARD SPEC.	PP	BS	PS	SM

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Abbreviations:

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

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

Refractory & Insulation Standards Committee

Convenor : Mr Prasenjit Saha

Members : Mr Biswarup Sarkar
Mr Prasenjit Pal
Mr Udayan Chakravarty (Piping)
Mr Prag Goel (Fired Heaters)
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1.0 SCOPE

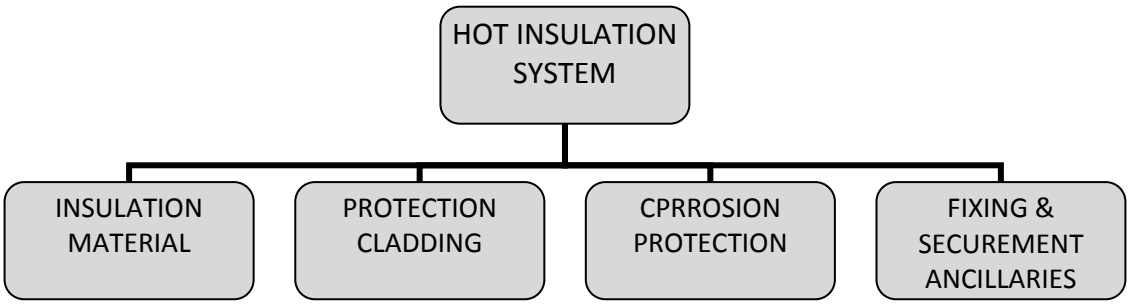
This specification covers the design and material aspects of external insulation of above ground piping, vessels and equipment having operating (process fluid) temperature from ambient to 760^{O}C for the purpose of heat conservation, process stabilization, temperature maintenance, personnel protection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



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
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

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

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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

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.

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

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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.
- Nameplates of all equipment items.

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

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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.

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

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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

Unless otherwise specified, for impulse lines of austenitic stainless steel, insulation material shall be sodium silicate inhibited ceramic fiber rope (min density 250 Kg/m^3). 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.

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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 1mm cladding sheet with insulation installed inside the box. Removable covers box for valves shall cover the body, bonnet, and flanges as applicable.

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.
- 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:

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Form of Fibrous Material	Quality standard	Max service temperature
Preformed pipe sections	ASTM C547 TYPE-II / IS 9842	760^{0}C
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^{0}C
Resin bonded mattress (max 2% resin)	ASTM C612/ IS 8183	760^{0}C

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 as per ASTM E84, max	25	
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

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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	
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.

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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 sample) at 5% deformation, kPa	IS 5688 OR	415	
	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, max	345	
Leachable Chloride as per ASTM C871, ppm, max		50	
Thermal conductivity (W/mK) at mean temperature as per IS 9490 / AST C-177	(+) 200 ^{0}C, max	0.072	Note-2
	(+) 300 ^{0}C, max	0.078	
	(+) 400 ^{0}C, max	0.084	
	(+) 500 ^{0}C, max	0.088	
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

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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	
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

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	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 100^0C, whereas PIR can be used to little higher, up to 125^0C. 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.

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 125^0C 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 100^0C 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

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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
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^{o}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*			

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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 1038^0C.

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.

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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)

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

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5.1 Weather Protection Jacket (Cladding)

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

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

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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^{o}C
Heat Transfer Coefficient to Equipment wall: 114-227 W/m^{2o}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) $\leq$ 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 permeability 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

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:

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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 permeability in acc. with ASTM E 96, procedure E (37.8°C, 90% RH)	max. 10.10-6 g / (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 permeability in acc. with ASTM E 96, procedure E (37.8°C, 90% R.H.)	Max. 10.10-6 g / (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

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’.).

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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. 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^{o}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-

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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.

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

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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.
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

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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 (mm)
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.

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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)

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.

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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

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.

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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.

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.

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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.

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

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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

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

d) 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

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

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.

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- 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

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.

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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/m³, 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

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 and 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.

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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.

- 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.

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- 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 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.

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- 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 & selftapping screws at 150mm pitch.
- Cladding shall be secured to support ring by bolting. Bolts are provided by tank fabricator at 300mm centres on angles provided at every 1175 centres vertically. Felt washer, aluminium washer and nut shall be supplied by insulation contractor for all bolted connections at shell, roof and curb angle.
- Insulation shall be tucked into the skirt portion of the curb angle. Shell cladding and extended roof cladding shall be secured to curb angle by bolting as per 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

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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.

  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.

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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.

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)

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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.
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.

8.0 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

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ASTM C177 Standard test method for Steady-state heat flux measurements & thermal transmission properties by means of the 'guarded-hot-plate' apparatus

ASTM C240 Standard test methods of testing Cellular glass insulation block

ASTM C302 Standard test method for Density and dimensions of preformed pipe-covering-type thermal insulation

ASTM C303 Standard test method for Density and dimensions of preformed block and board type thermal insulation

ASTM C335 Standard test method for Steady-state heat transfer properties of horizontal pipe insulation

ASTM C356 Standard test method for Linear shrinkage of preformed high-temperature thermal insulation subjected to soaking heat

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

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

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

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

ASTM C547 Standard specification for Mineral fiber pipe insulation

ASTM C552 Standard specification for Cellular glass thermal insulation

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

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

ASTM C610 Standard specification for block and pipe thermal insulation

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

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

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

ASTM C892 Standard specification for High temperature fiber blanket thermal insulation

ASTM D1622 Test method for apparent density of rigid cellular plastics

ASTM 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

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6-79-0022	Standard specification for acoustic insulation
6-79-0027	Standard specification for cold insulation of vessels, piping and equipment

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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9.0 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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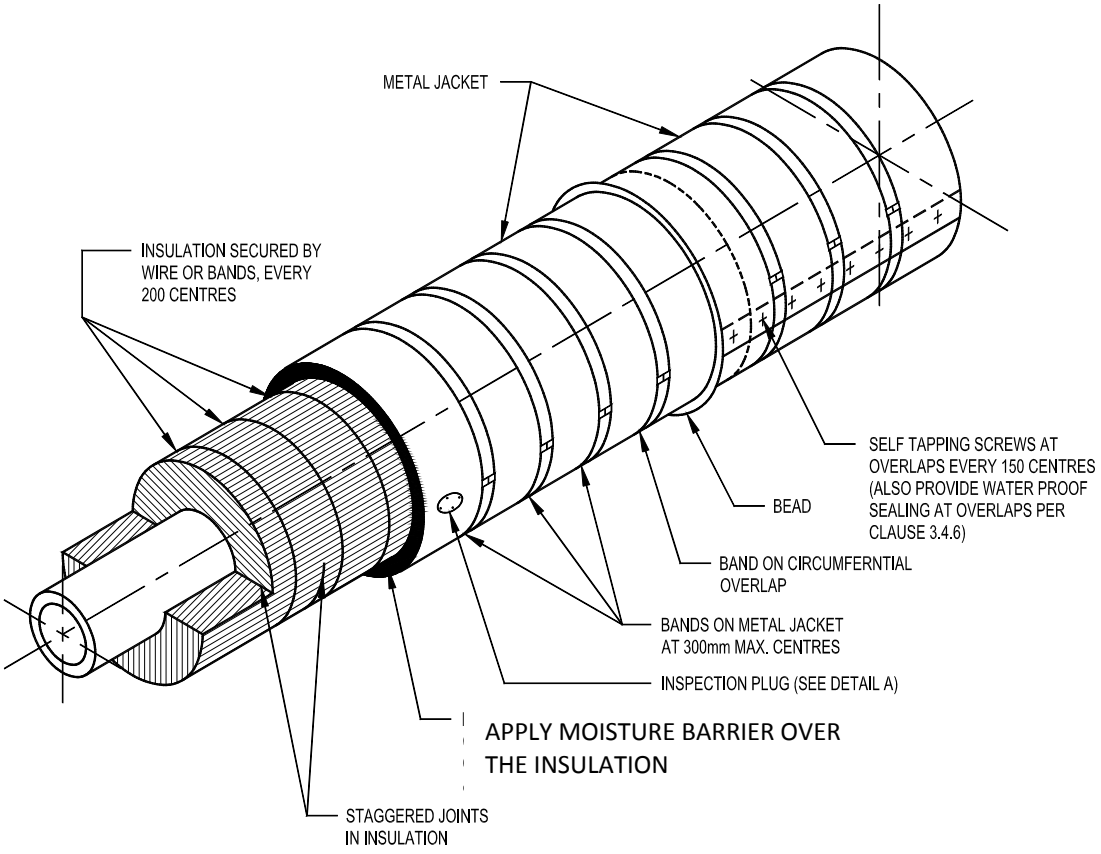

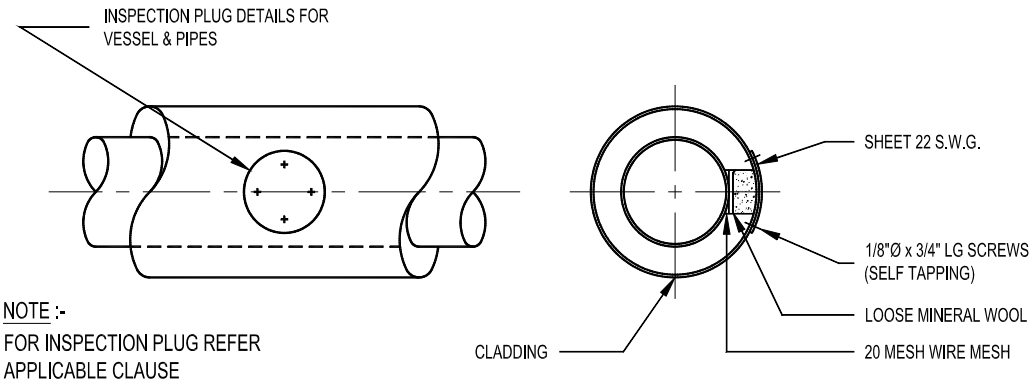

DETAIL 'A'

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

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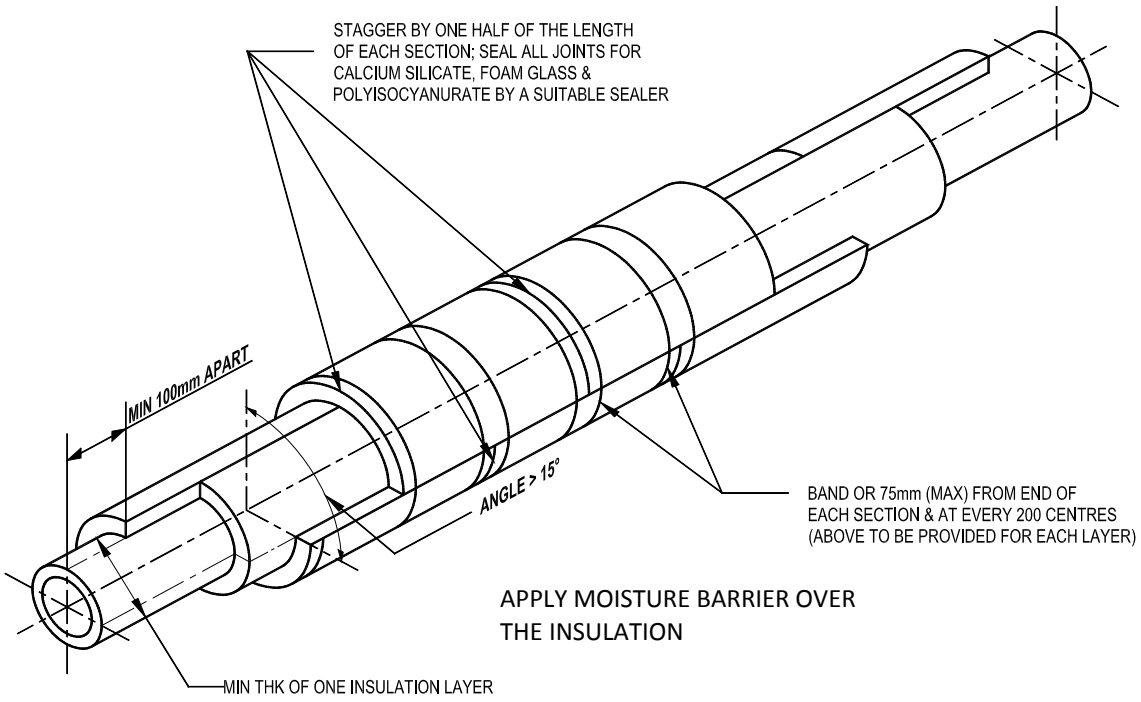

FIGURE – 02
PIPE INSULATION METHOD OF STAGGERING OF SECTIONS
RIGID & FIBROUS INSULATION (PREFORMED PIPE SECTIONS ONLY)

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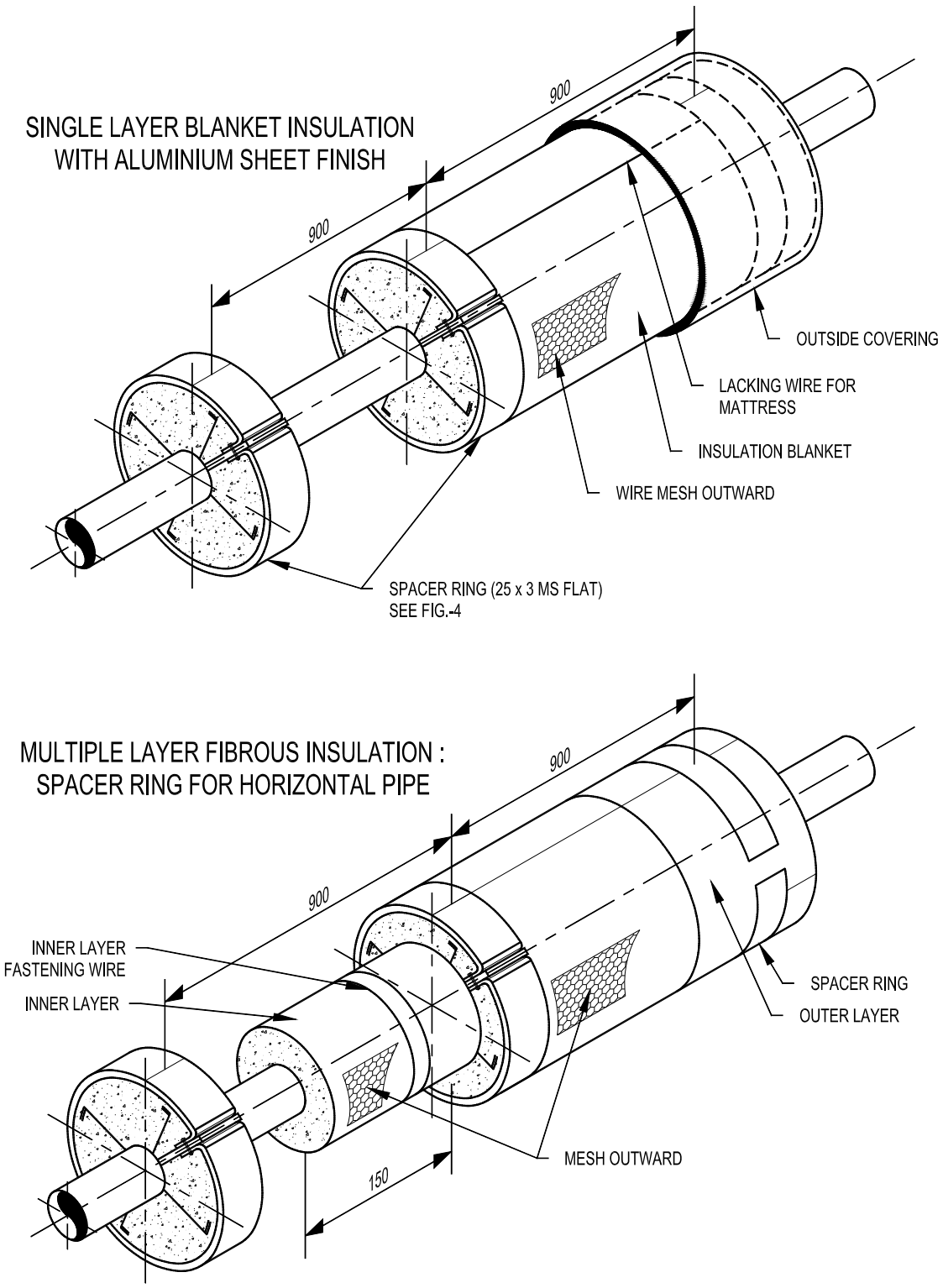

FIGURE – 03
HORIZONTAL PIPE : FIBROUS INSULATION; DETAIL OF SPACER RINGS FOR CLADDING SUPPORT

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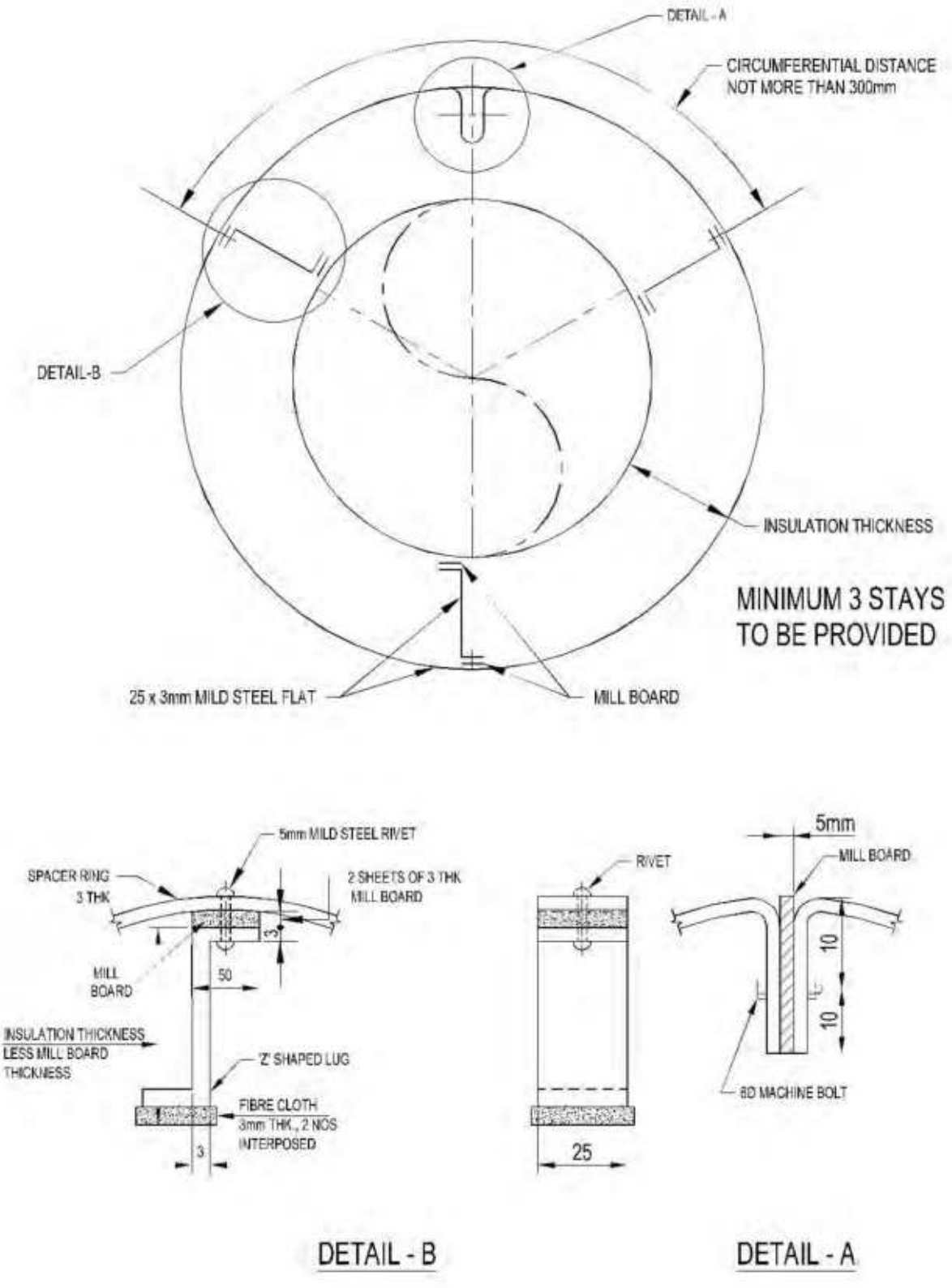

FIGURE – 04
DETAIL OF SPACER RING FIBROUS INSLUATION (MATTRESS)

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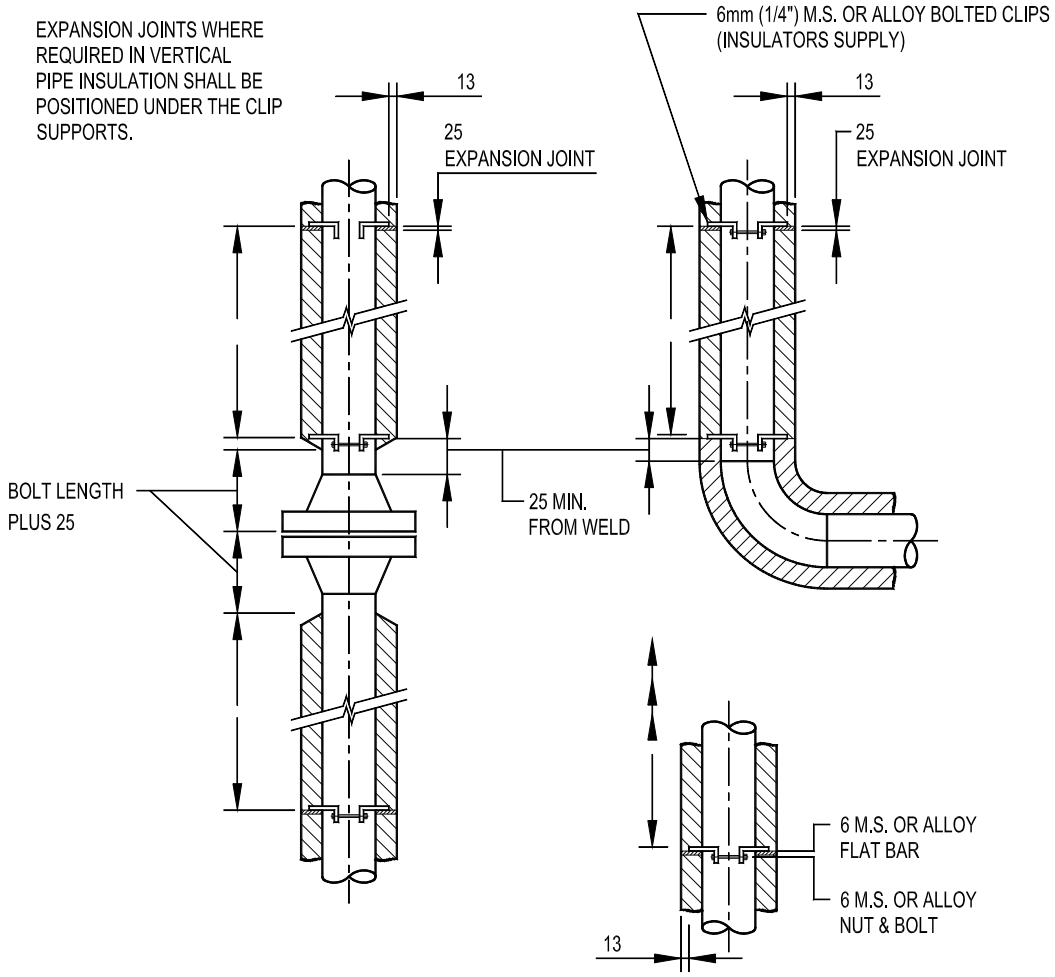

CLIP SPACING

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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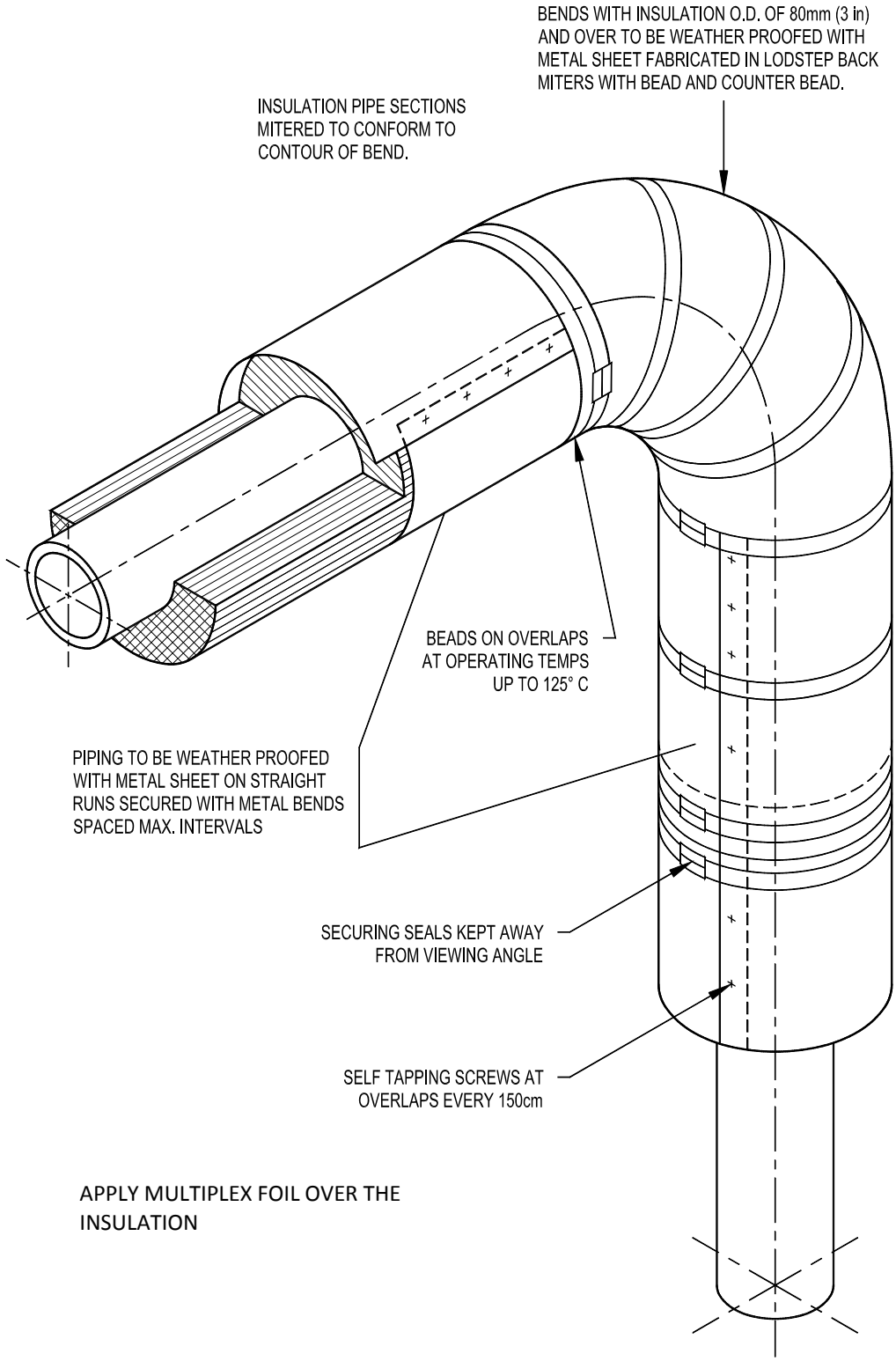

FIGURE – 06
INSULATION DETAILS FOR BENDS / ELBOWS

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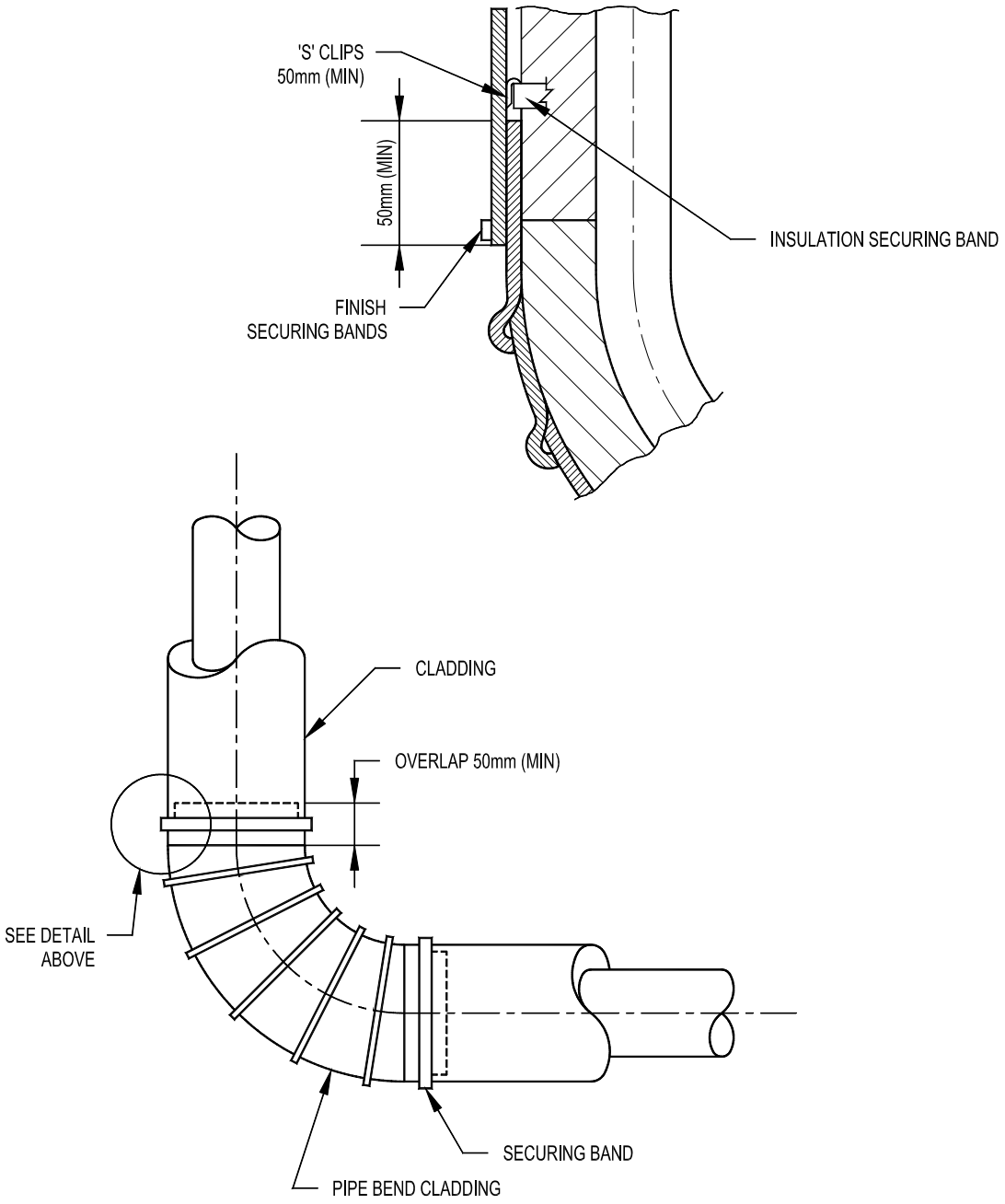

FIGURE – 07
INSULATION DETAILS : PIPE BENDS & ELBOWS

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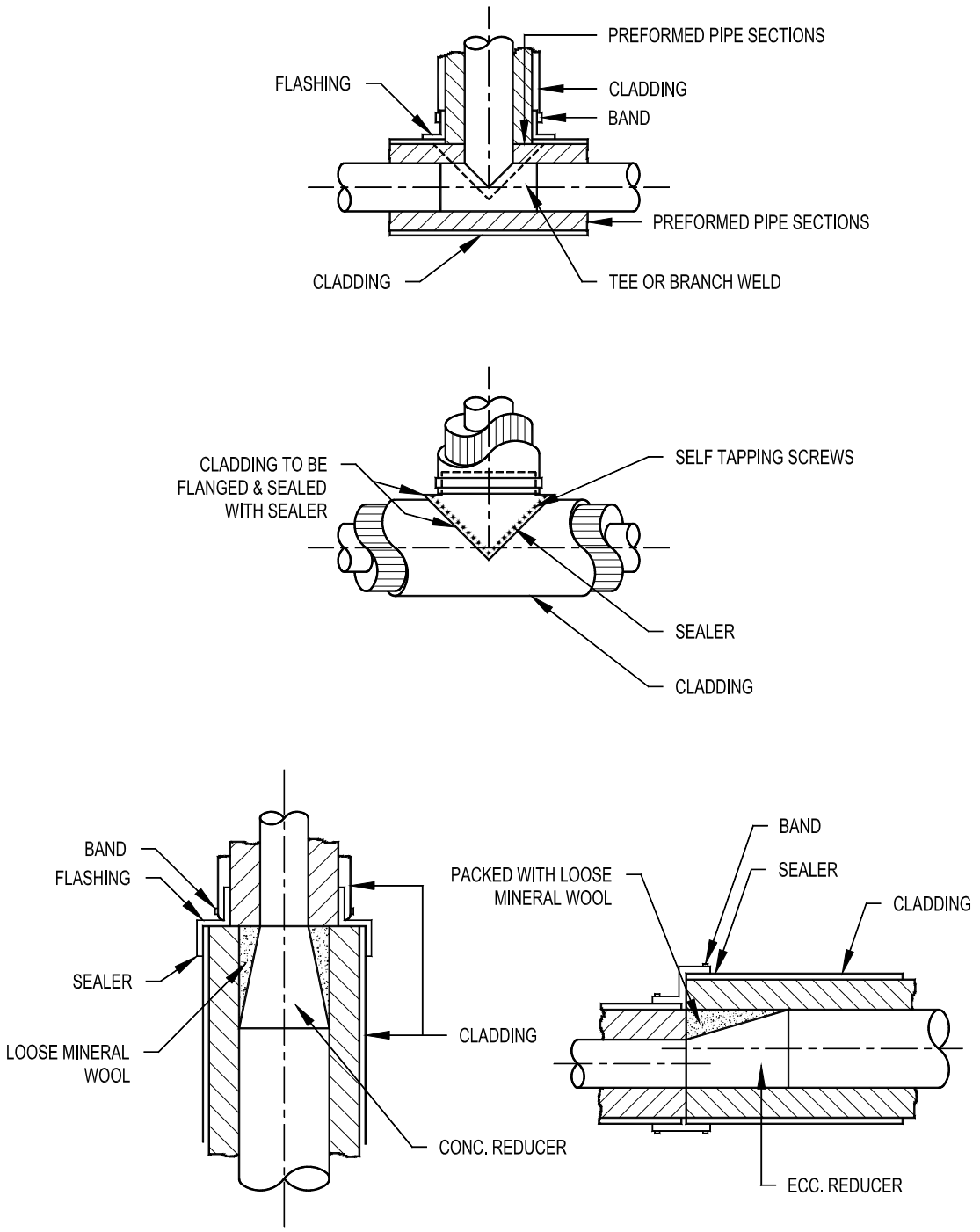

FIGURE – 08
INSULATION DETAILS: PIPE BRANCHED & REDUCER

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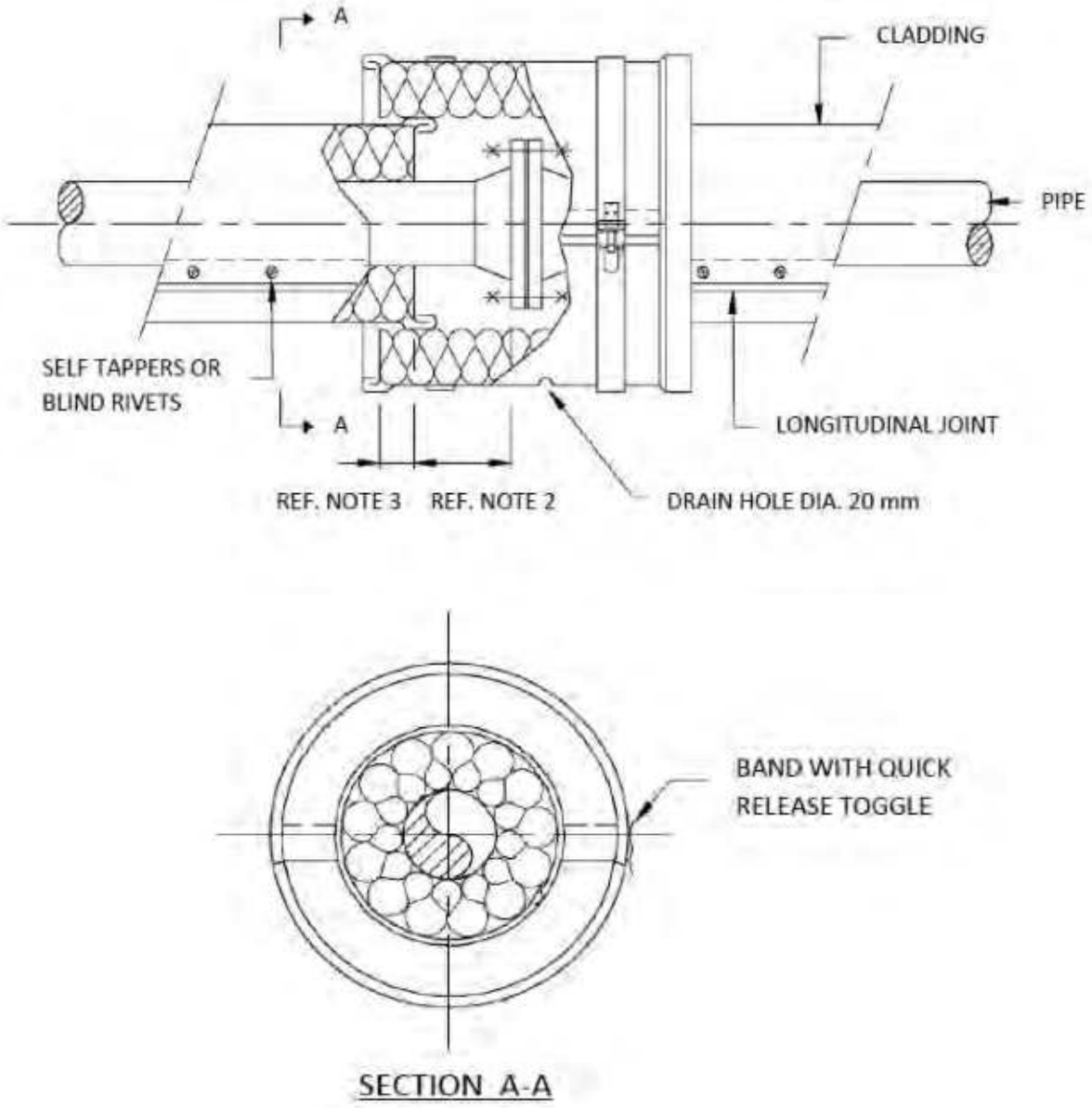

NOTE

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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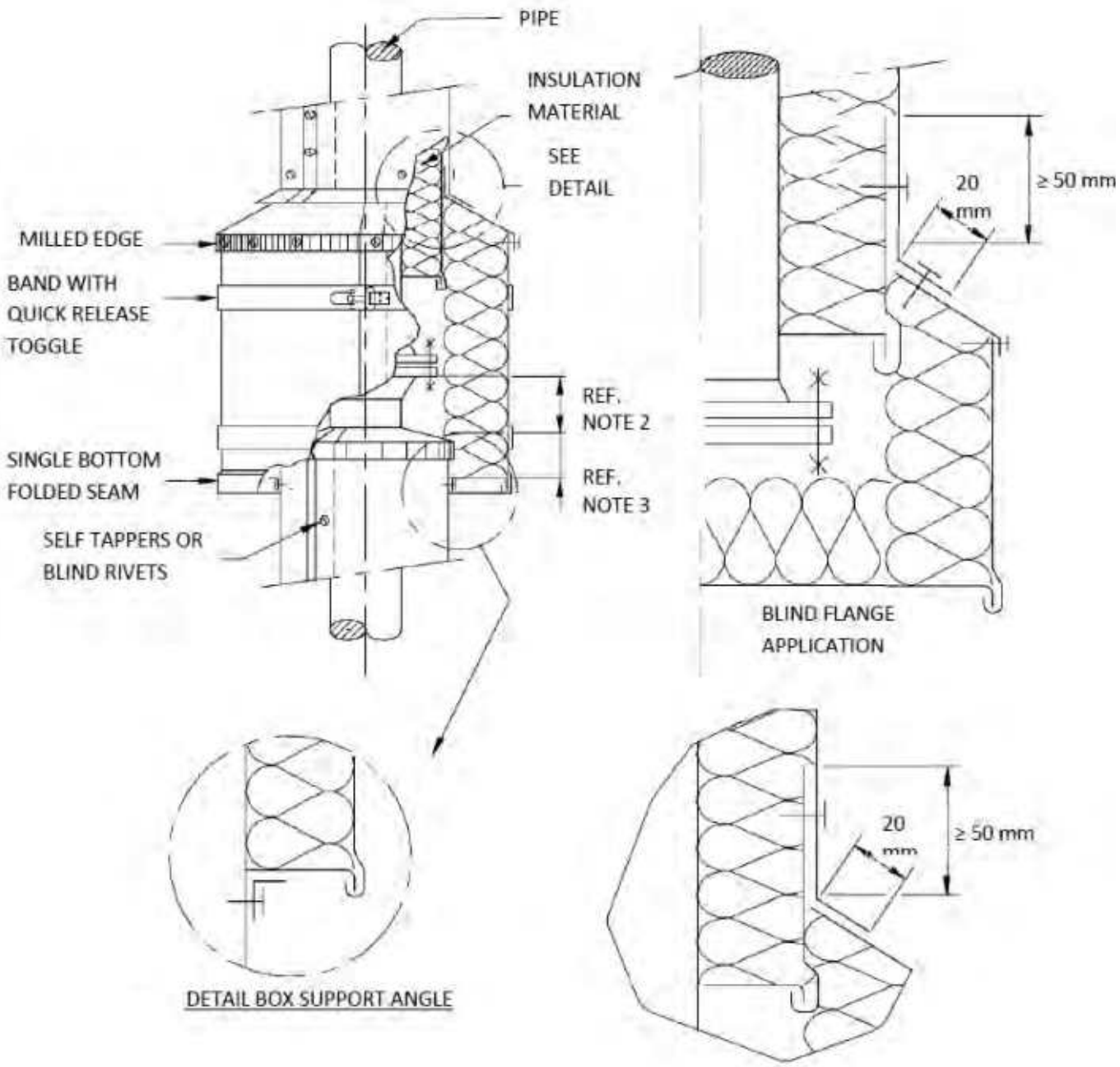

NOTE

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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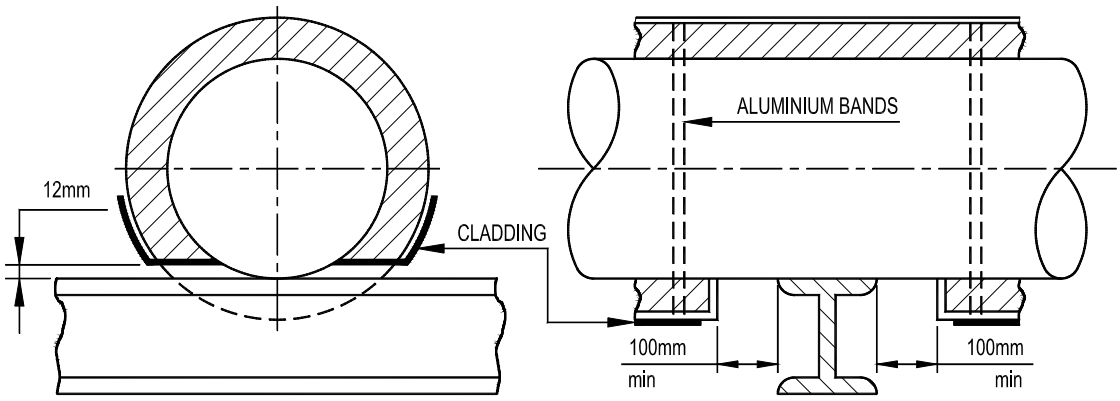
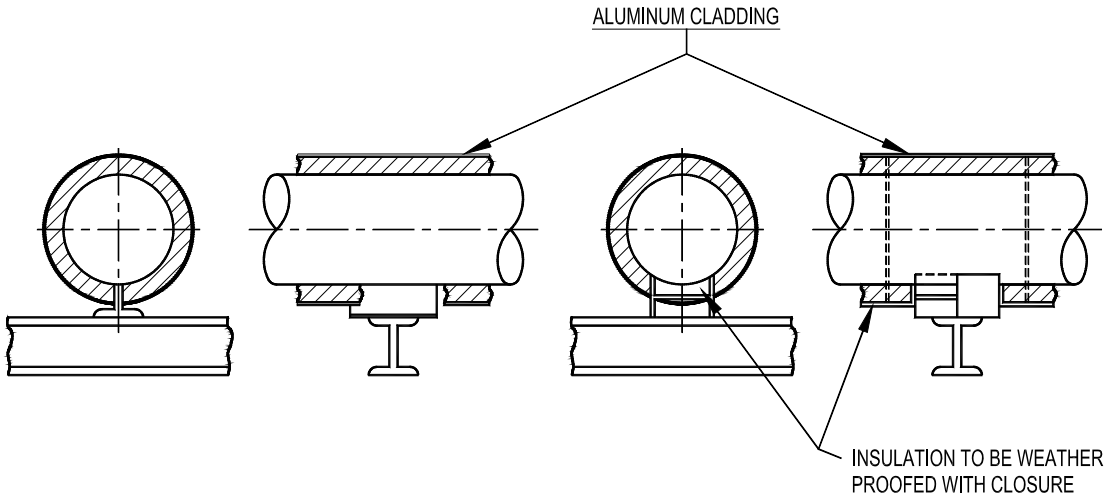


WHERE CLADDING IS TO BE CUT AWAY IT SHALL FIT CLOSELY TO
THE PIPE AND TO BE COMPLETELY WEATHERPROOF

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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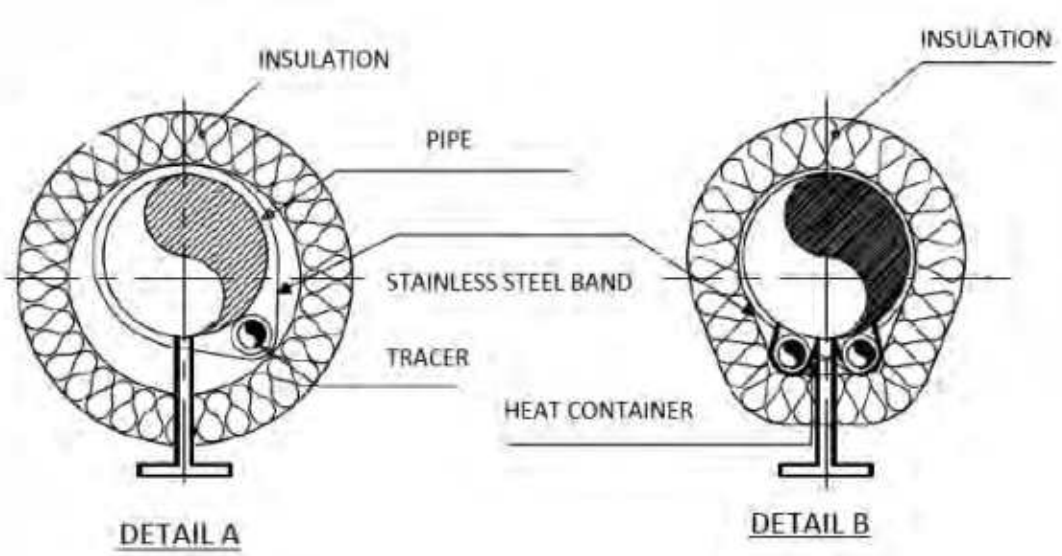

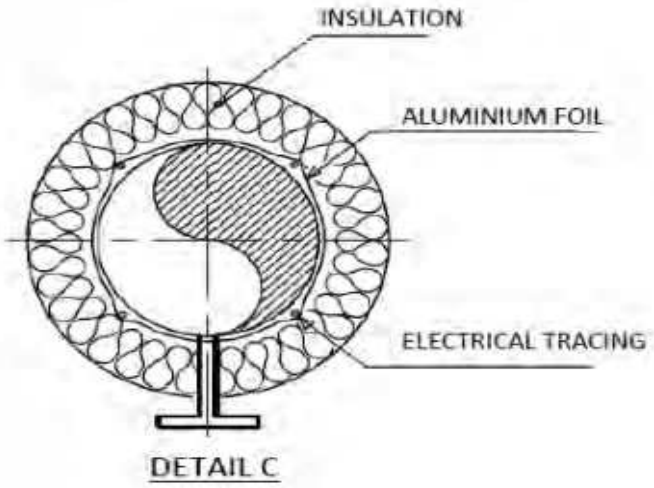

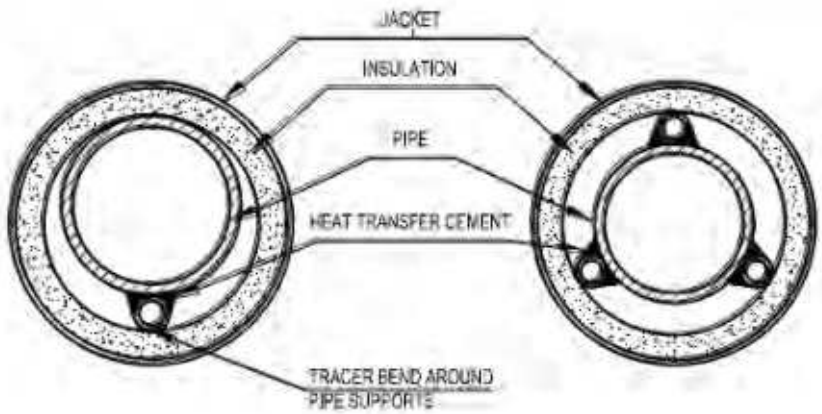

DETAIL D

FIGURE – 12
INSULATION OF TRACED PIPING

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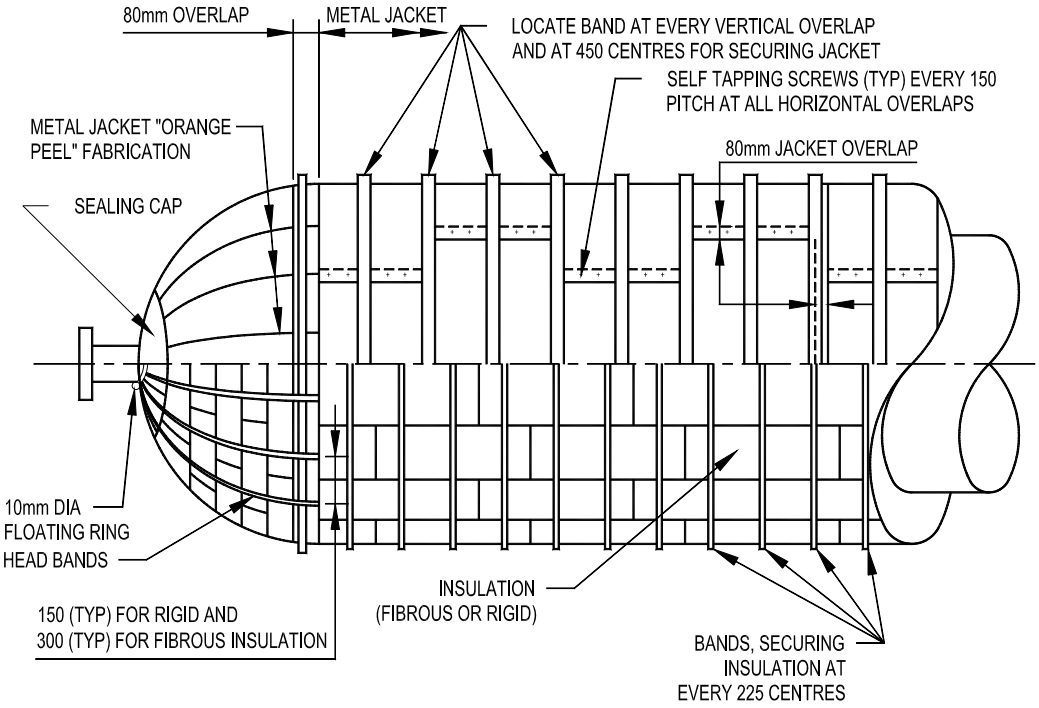

NOTES :-

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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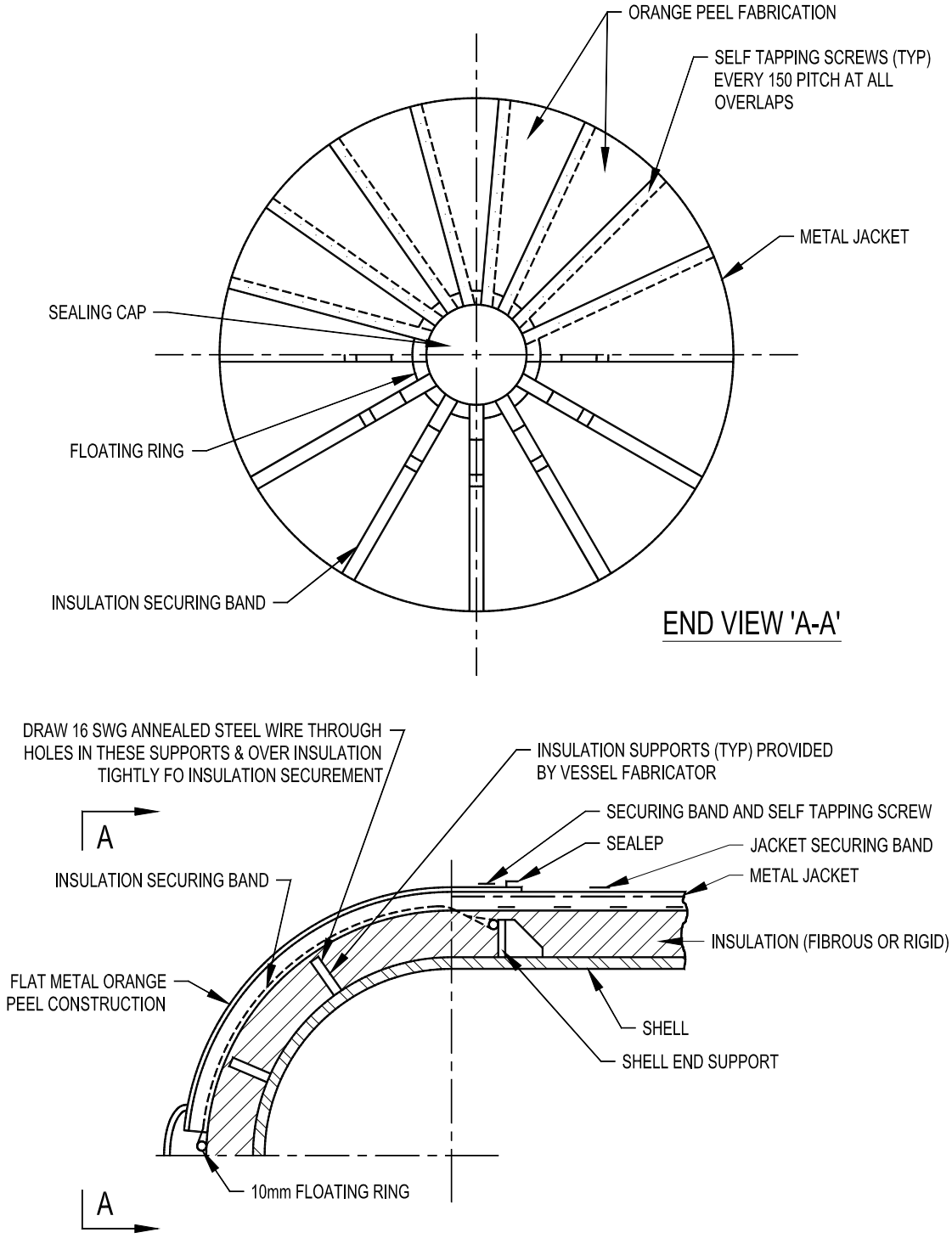

FIGURE – 14
HORIZONTAL EQUIPMENT HEADS

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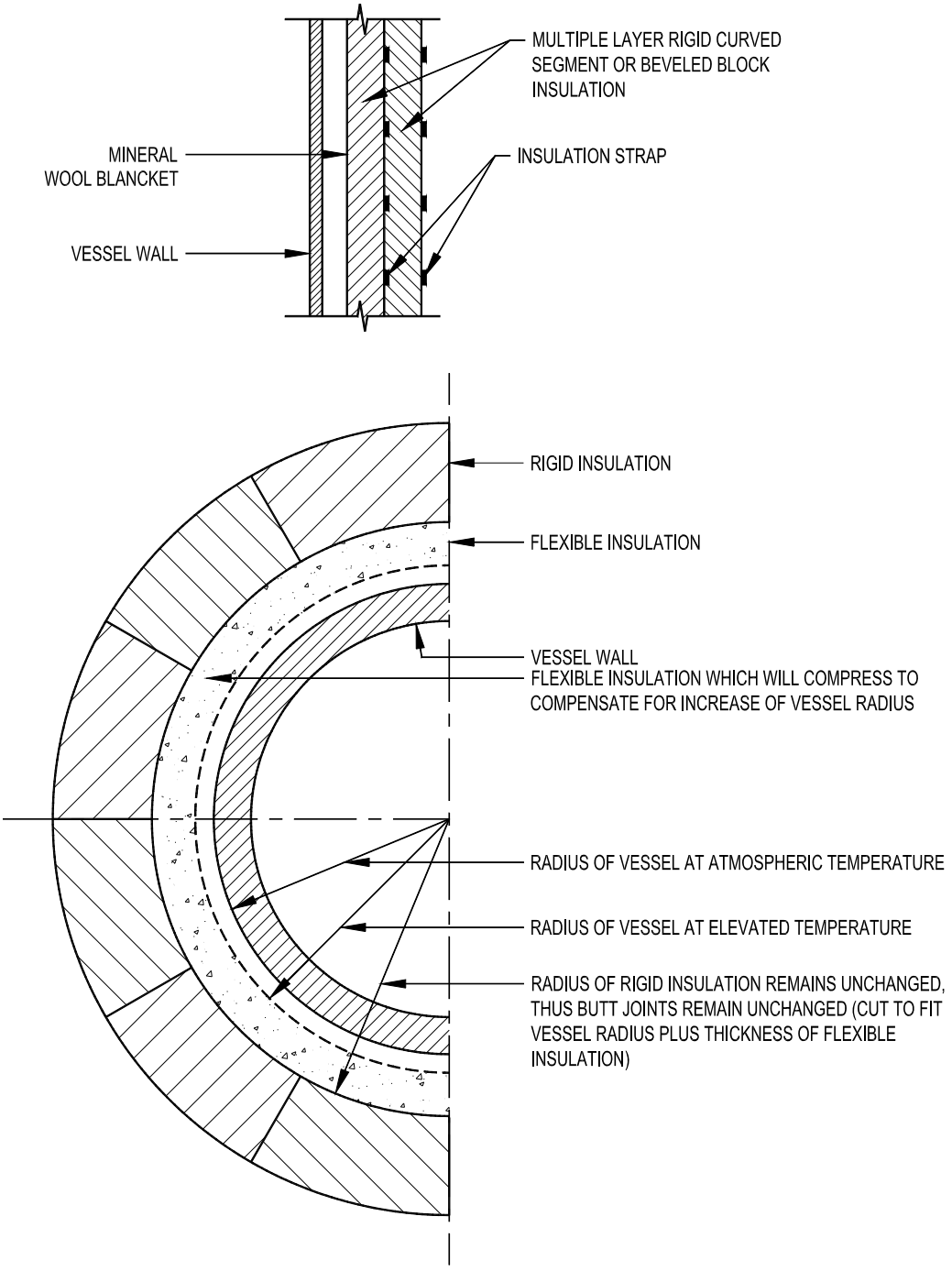

FIGURE – 15
USE OF FLEXIBLE INSULATION IN COMBINATION WITH RIGID INSULATION TO COMPENSATE FOR VESSEL EXPANSION

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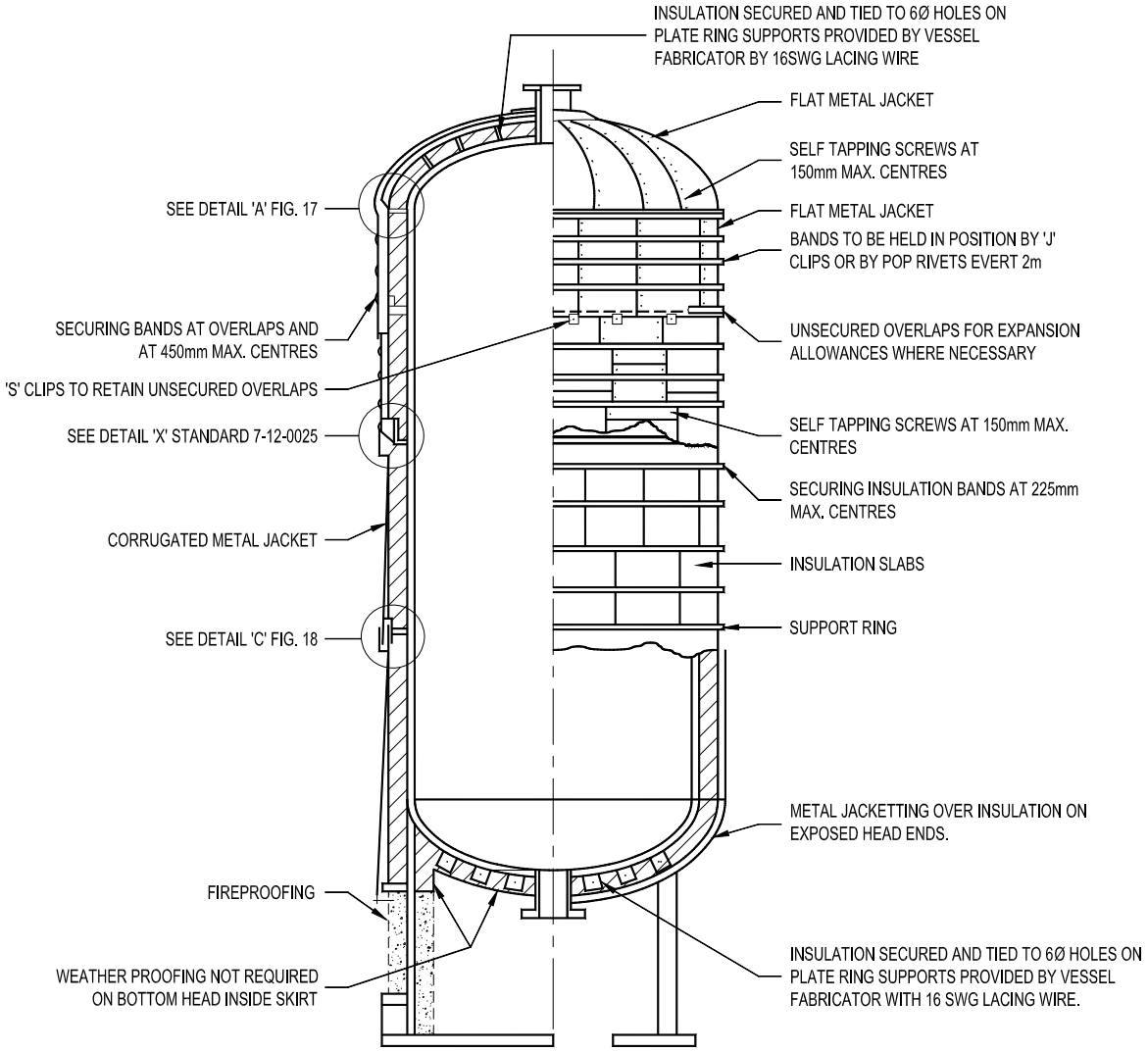

FIGURE – 16
INSULATION DETAILS : VERTICAL VESSEL

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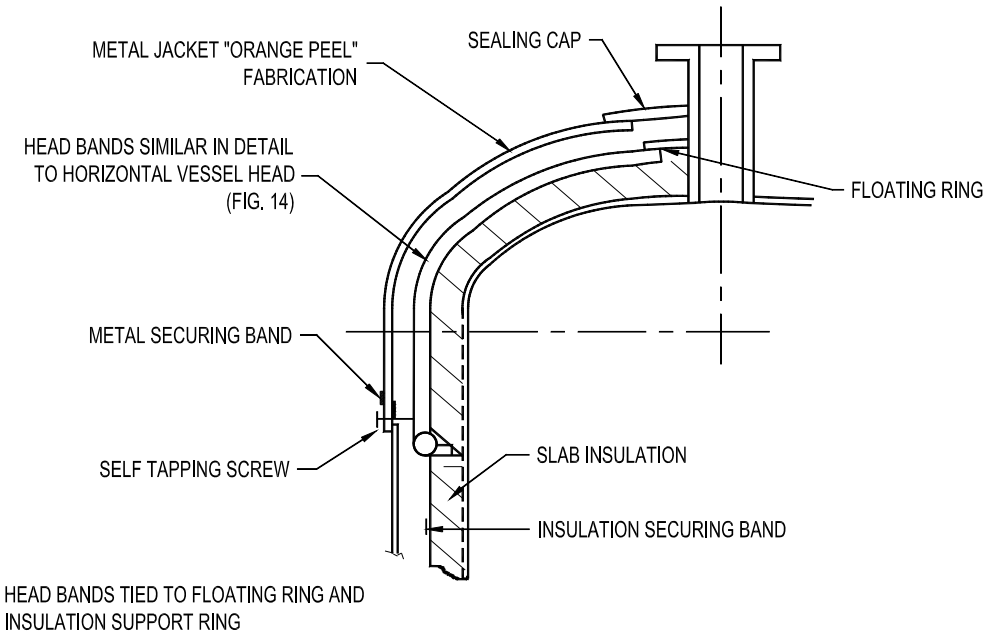

DETAIL 'A'

FIGURE – 17
INSULATION DETAILS VERTICAL VESSEL HEADS

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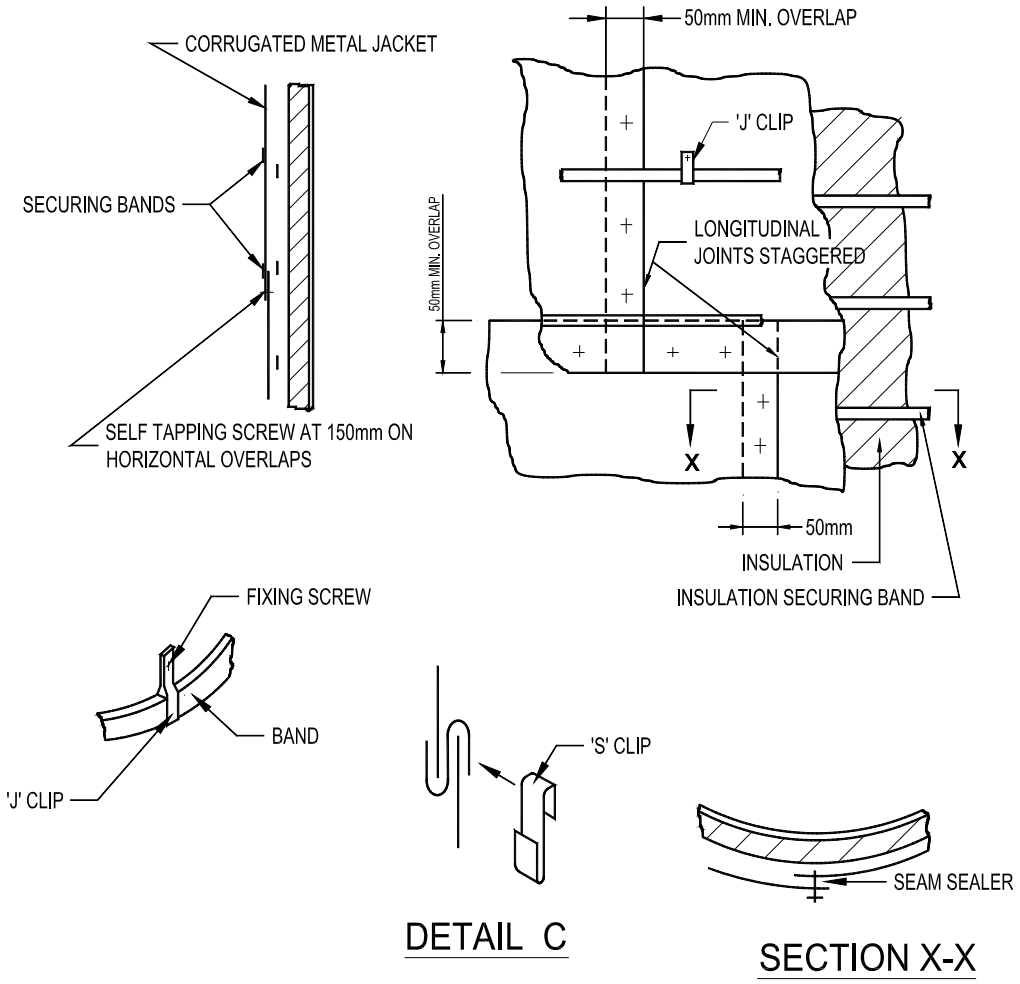

NOTE:

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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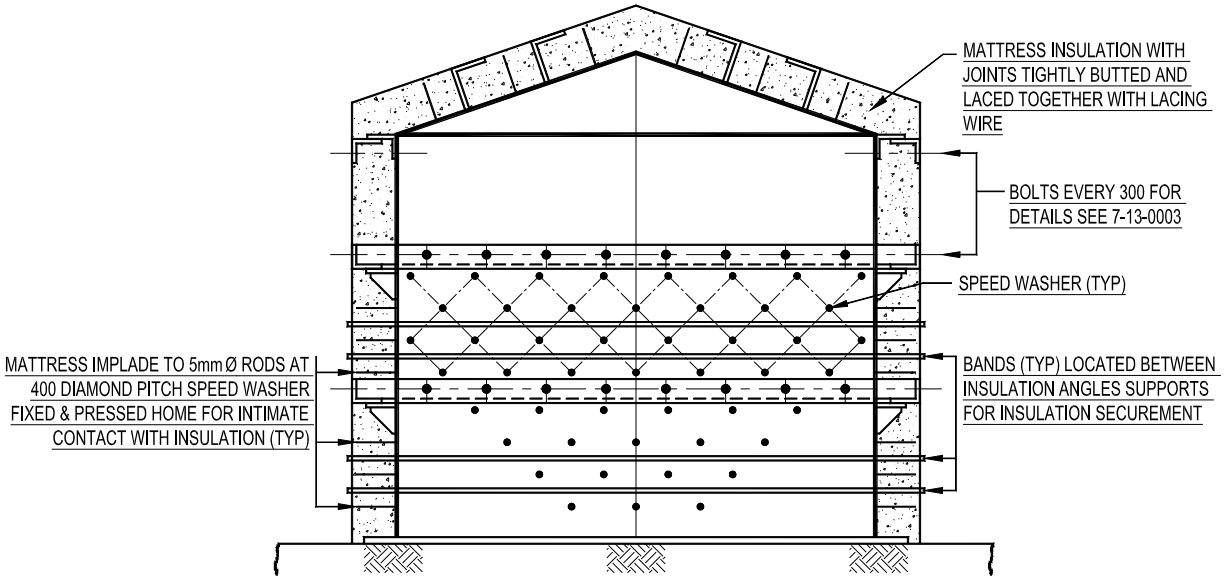
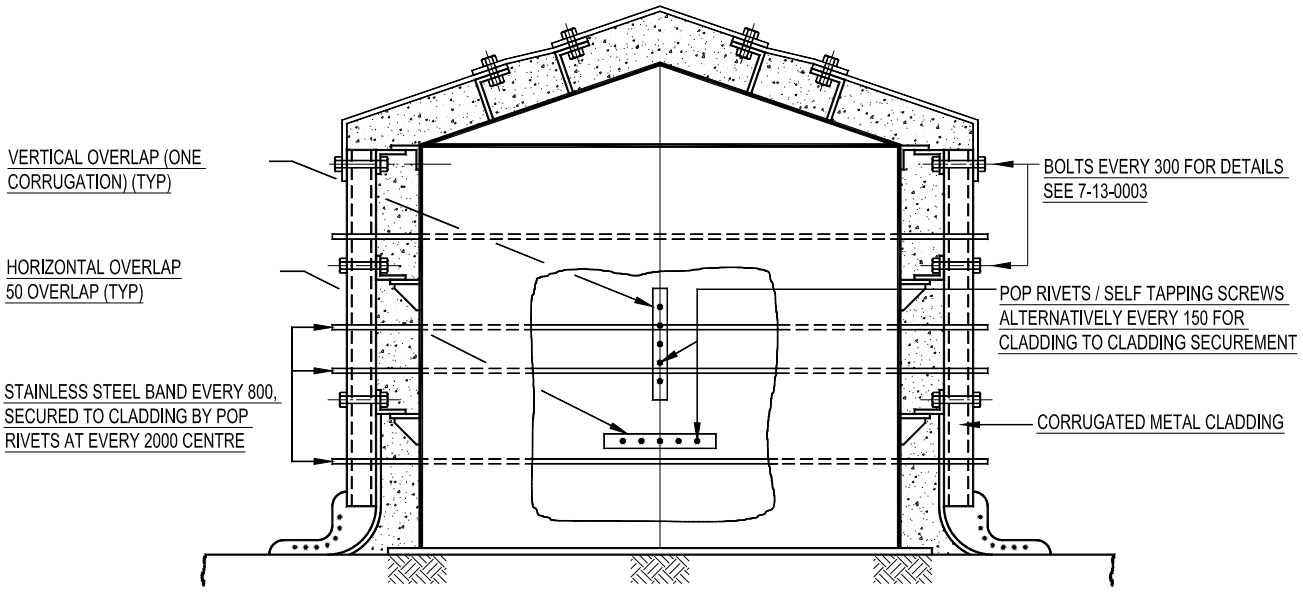


INSULATION SECUREMENT DETAIL



CLADDING SECUREMENT DETAIL

FIGURE – 19
INSULATION DETAILS : VERTICAL STORAGE TANK

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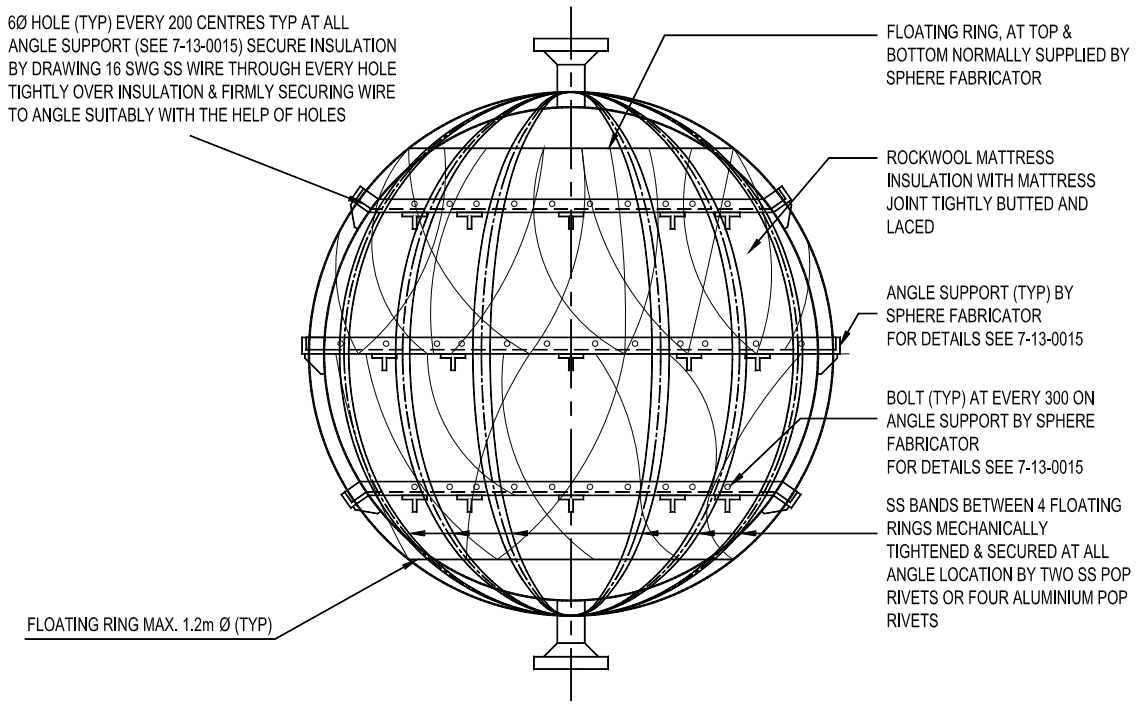
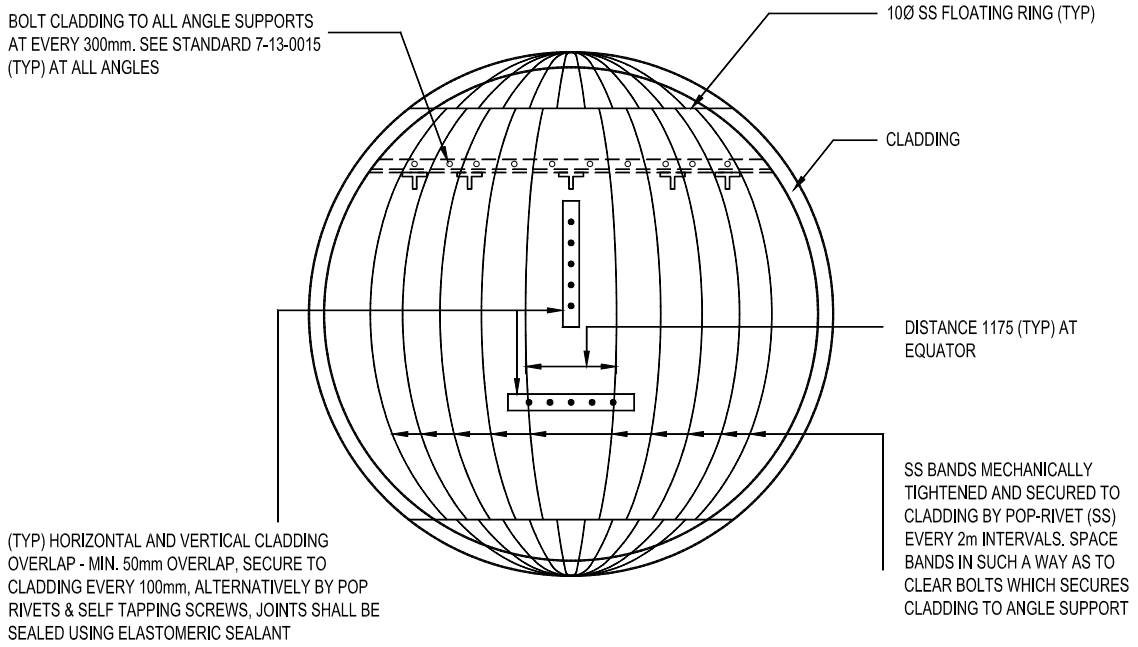


INSULATION SECUREMENT DETAILS



CLADDING SECUREMENT DETAILS

FIGURE – 20
INSULATION DETAILS : SPHERE

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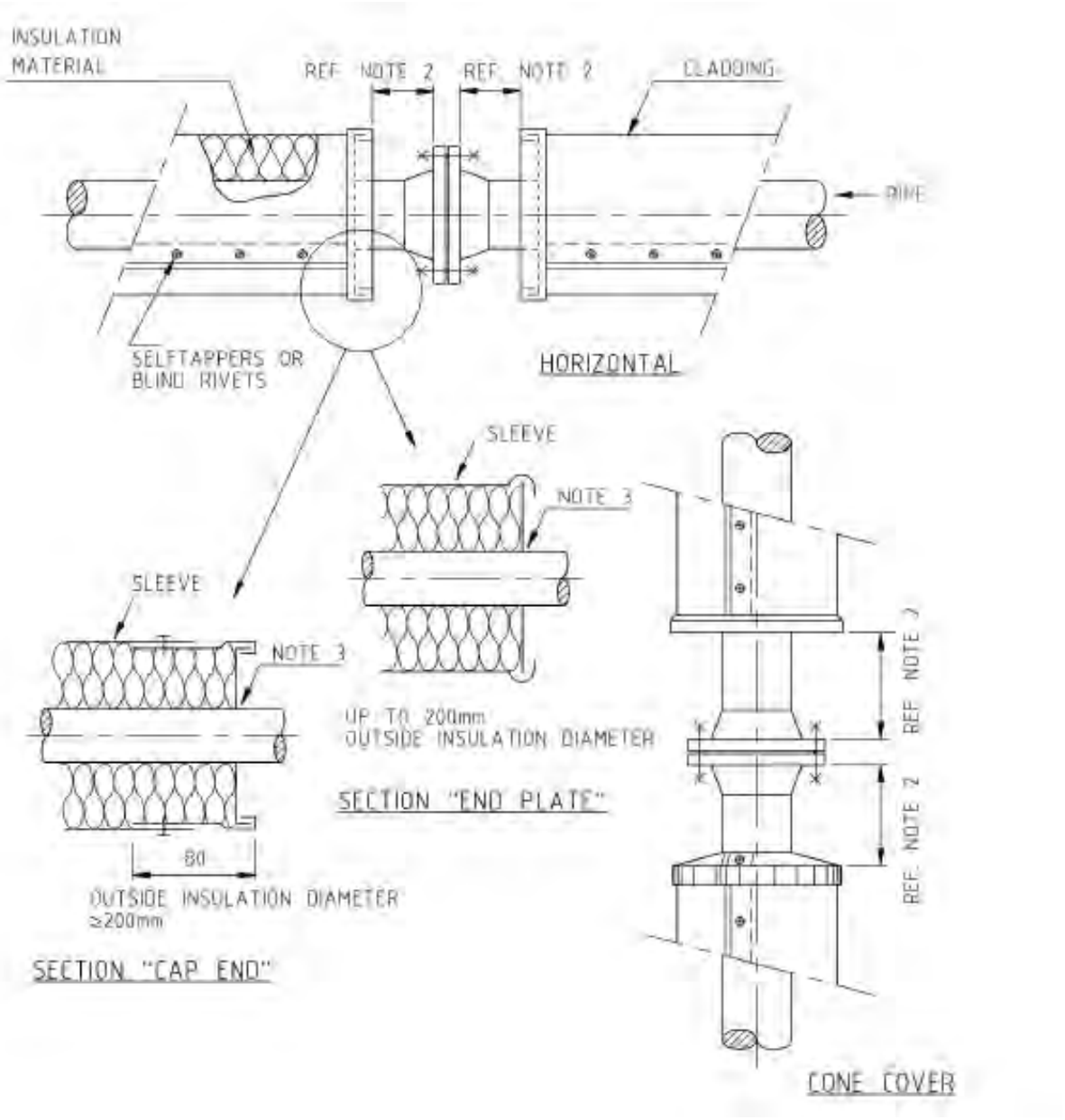

Note

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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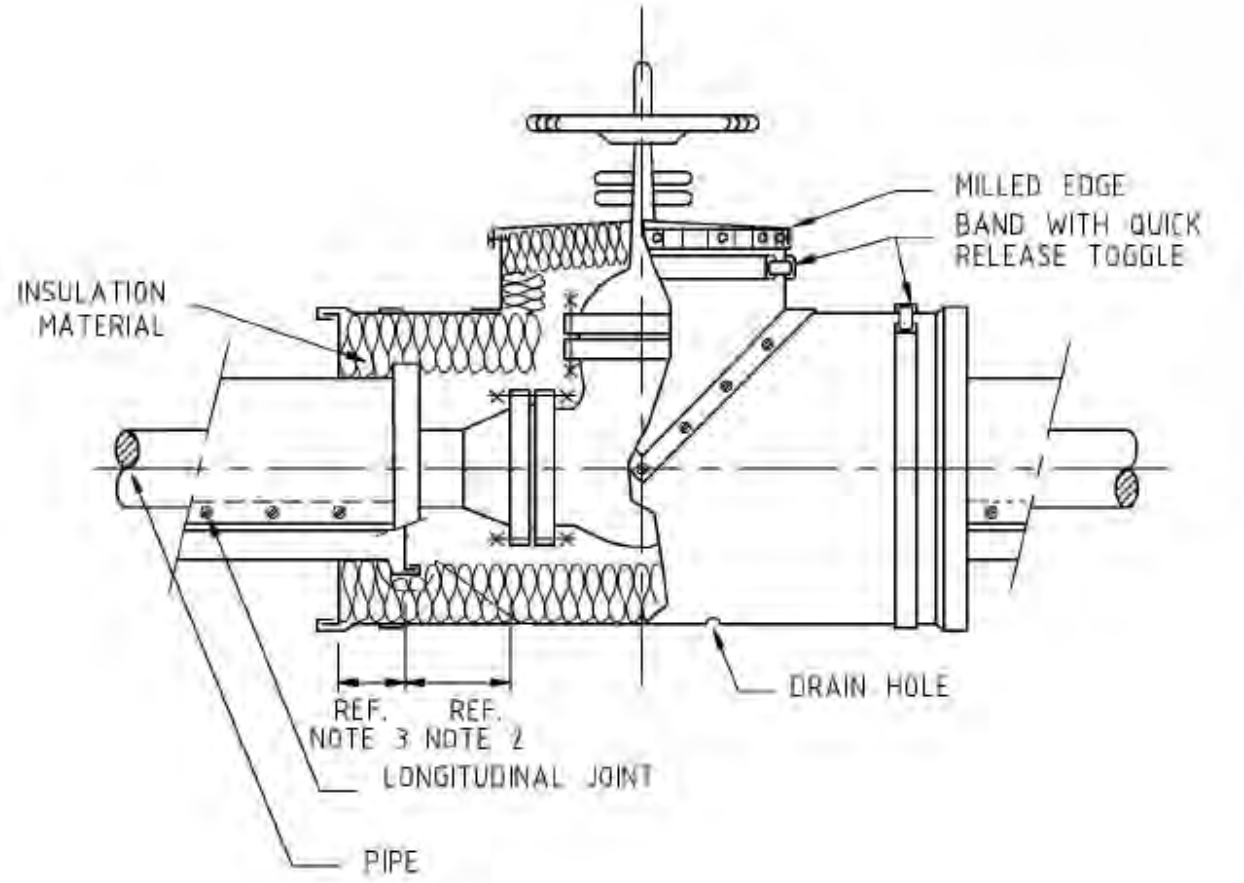

Note
1. Materials and Finishing in accordance with installation instructions and specification
2. Distance between insulation and flange to be bolt length + 30mm
3. Insulation Thickness

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

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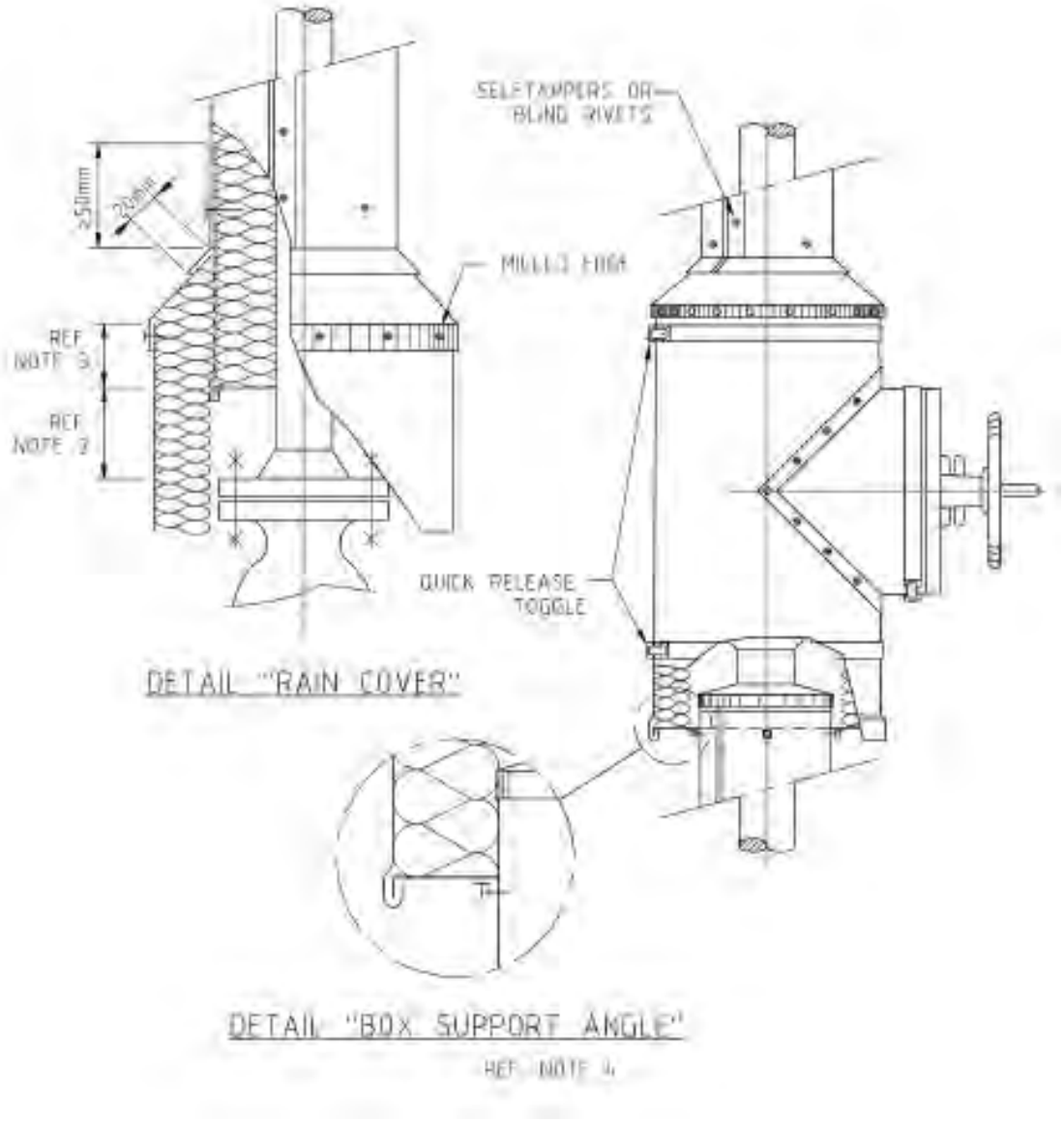

Note
1. Materials and Finishing in accordance with installation instructions and specification
2. Distance between insulation and flange to be bolt length + 30mm
3. Insulation Thickness
4. Per box minimal 4 support angles ≥ 30mm wide ≥ 0.8mm thick

FIGURE – 23
REMOVABLE VALVE BOX, "T" CONNECTION, VERTICAL
Applicable only valves which needs to be insulated as per applicable specification

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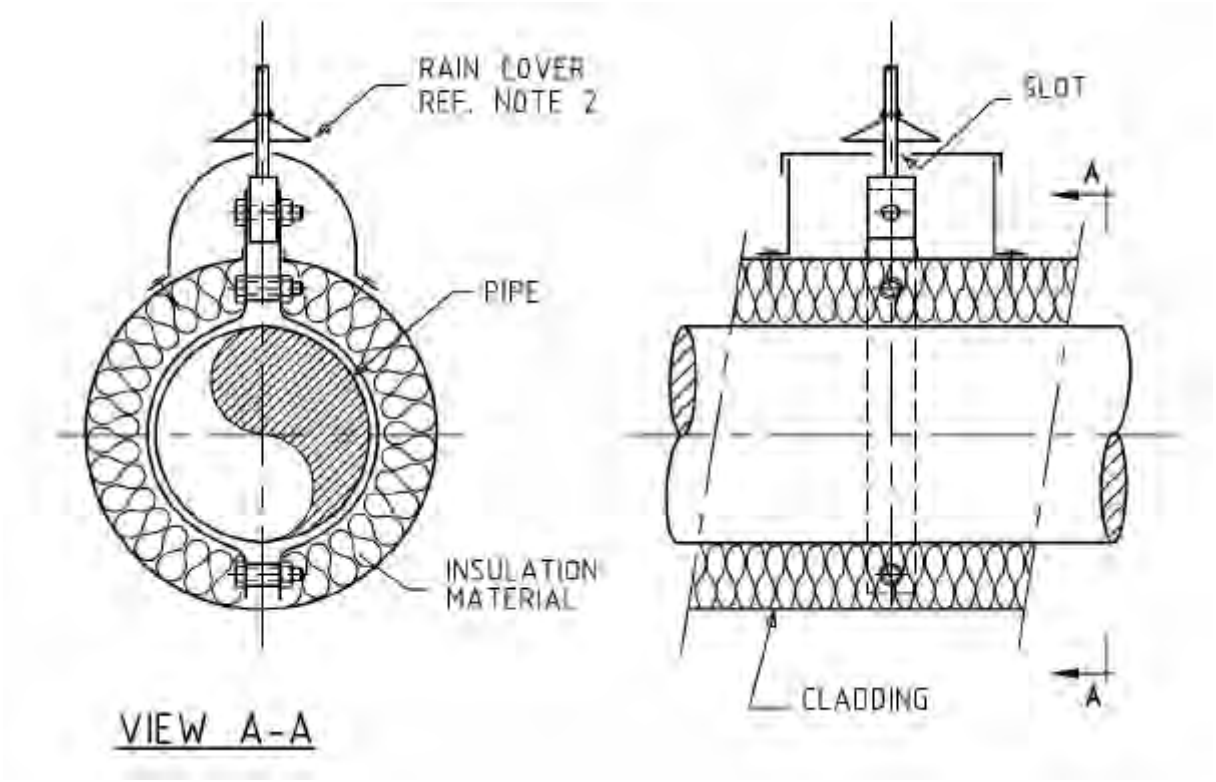

Note
1. Materials and finishing in accordance with installation instructions and specifications
2. Rain cover is a part of the bracket

FIGURE – 24
HANGER SUPPORT

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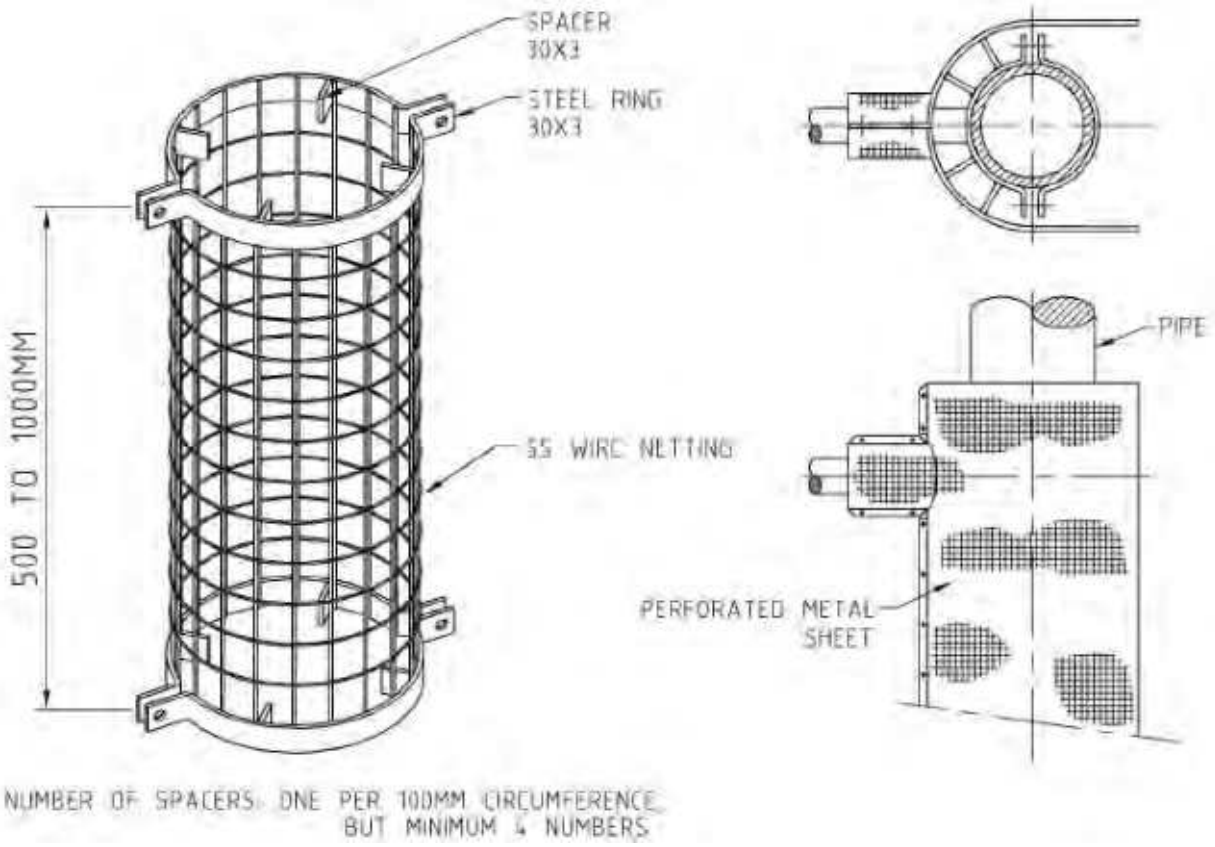

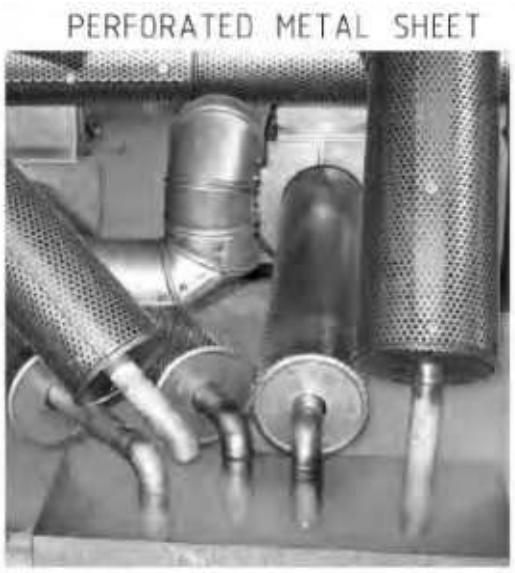

Note

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

FIGURE – 25
PERSONAL PROTECTION

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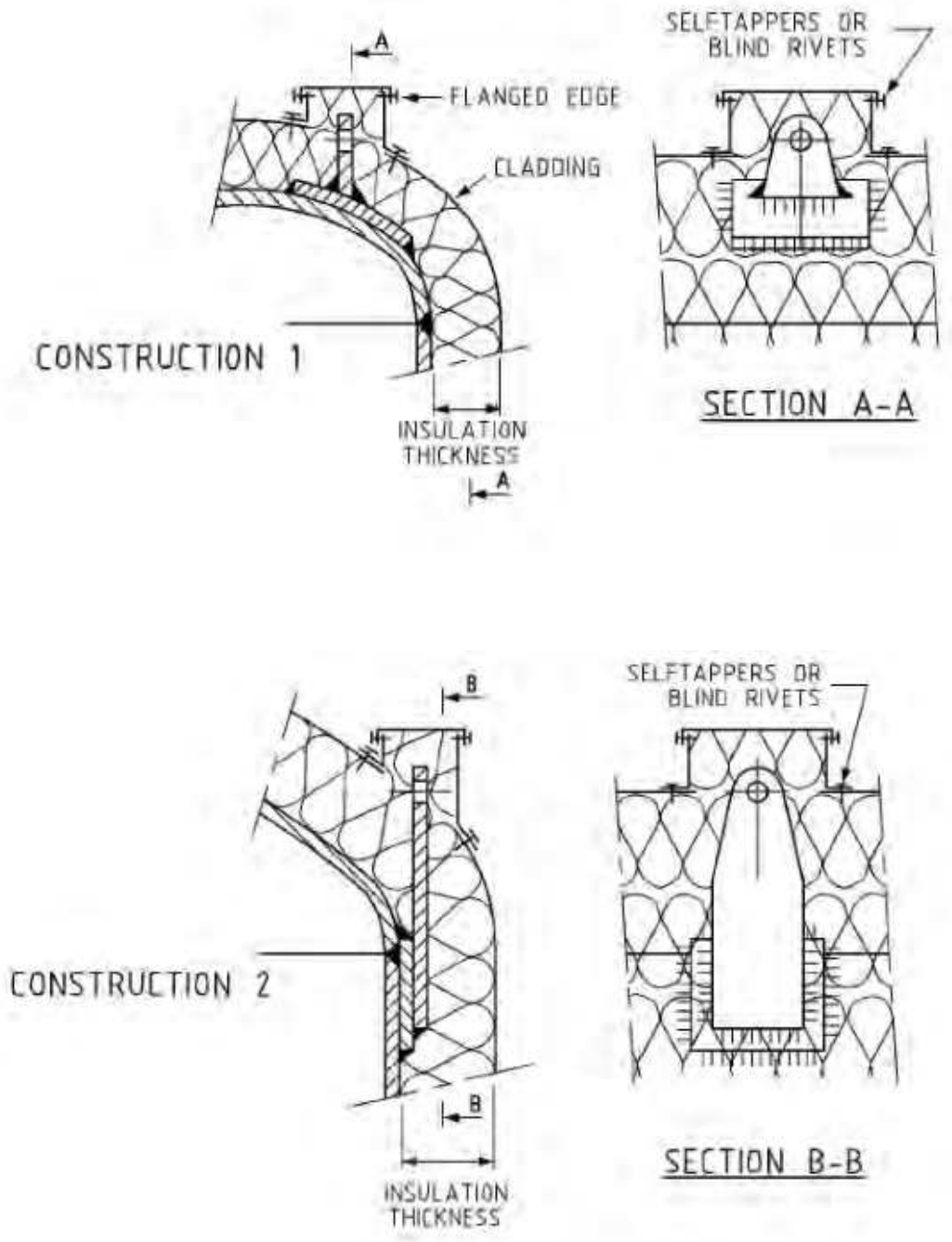

FIGURE – 26
DETAILS OF LIFTING LUGS

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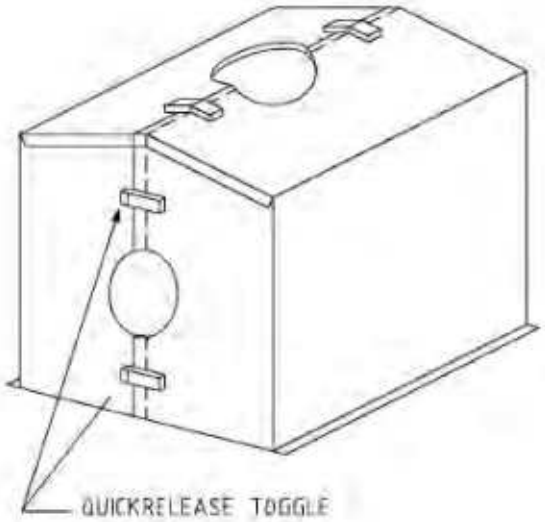

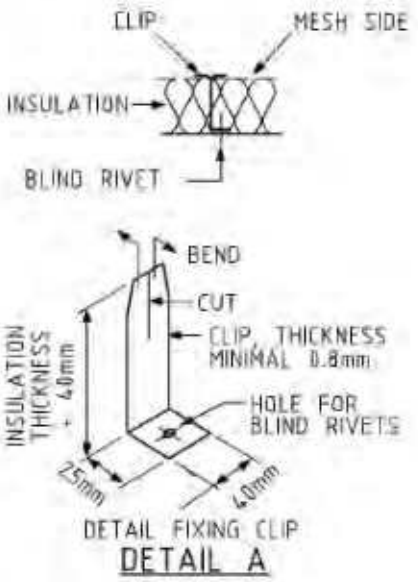

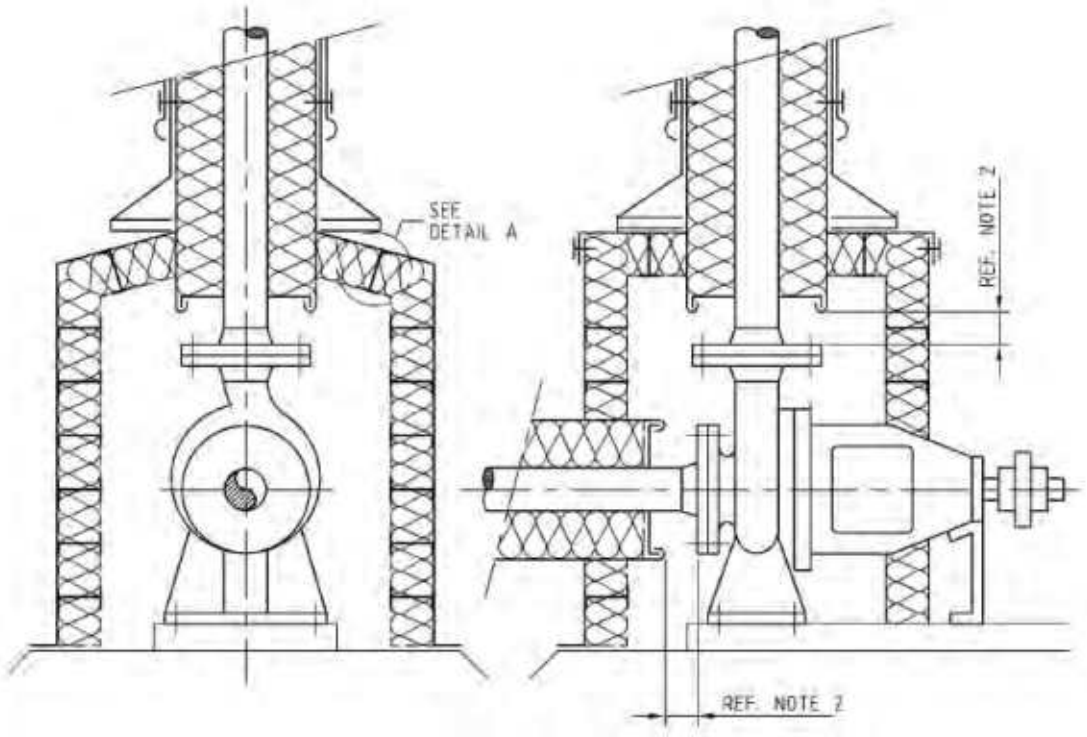

Note
1. Materials and Finishing in accordance with installation instructions and specification
2. Distance between insulation and flange to be bolt length + 30mm

FIGURE – 27
REMOVABLE BOX FOR PUMP

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विक्रेता कार्यशाला में सकारात्मक सामग्री पहचान के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR POSITIVE MATERIAL IDENTIFICATION (PMI) AT SUPPLIER'S WORKS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	23.12.21	REVISED AND RE-ISSUED	HKM	CS	RK	S Majumdar
3	19.09.16.	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
2	20.10.11	REVISED AND RE-ISSUED	RKS	SCG	AKC	DM
1	15.07.08	REVISED AND RE-ISSUED	NKR	SSL	SKP	VC
0	07.12.00	ISSUED AS STANDARD SPECIFICATION	AKC	AKB	AKB	MI

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Abbreviations:

API	:	American Petroleum Institute
AS	:	Alloy Steel
HIC	:	Hydrogen Induced Cracking
LSTK	:	Lump Sum Turn Key
NACE	:	National Association of Corrosion Engineers
PMI	:	Positive Material Identification
RTJ	:	Ring Type Joint
Sch	:	Schedule
SS	:	Stainless Steel
TPI or TPIA	:	Third Party Inspection Agency

Inspection Standards Committee

Convenor: Mr. Rajeev Kumar

Members:
Mr. Rajesh Sinha
Mr. Himangshu Pal
Mr. R. Muthuramalingam (RPO Representative)
Mr. Chandrashekhar
Mr. Avdhesh Agrawal
Mr. P V Satyanarayana (Engg. Representative)
Mr. Mahendra Mittal

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CONTENTS

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1.0 SCOPE

1.1 This specification applies to the requirements for Positive Material Identification (PMI) to be performed at the Supplier's works on Metallic Materials procured either directly by the Owner/EIL/ LSTK contractor or indirectly through the sub-Suppliers.

1.2 This specification covers the procedures and methodology to be adopted to assure that the chemical composition of the material is consistent with the material specifications as specified in purchase documents using 'Alloy Analyzer' at the time of final inspection before dispatch.

1.3 The scope of this specification shall include but shall not be limited to Positive Material Identification (PMI) to be performed on Materials listed below:

1.3.1 For alloy Steel materials as below:

- Alloy Steel Pipes including Clad Pipes
- Alloy Steel Flanges & Forgings
- Alloy Steel Fittings including Clad Fittings
- Alloy Steel Fasteners
- Alloy Cast & Forged steel valves
- Alloy Steel Instrumentation Items (Control Valves, Safety Valves etc.)
- Longitudinal Pipe & Fittings Welds.
- Gaskets (for Ring Type Joints)

1.3.2 For Carbon Steel materials as below:

- All Carbon Steel Piping items under NACE or HIC or H2 or Wet Hydrogen Sulfide (H_2S), Hydrofluoric acid (HF), Sulfuric acid (H_2SO_4) services etc.
- Carbon Steel flanges and valves (Rating 900# and above)
- LTCS items

Following items shall be excluded from scope of PMI examination.

- Gaskets other than for Ring Type Joints
- Internal Components of Valves

1.4 All grades of material supplies including Stainless Steels shall be liable for PMI test at site. In case of any defective materials being found at site, the Supplier shall be responsible to effect replacement of such defective materials at project site without any delays to the satisfaction of EIL site RCM (Resident Construction Manager).

2.0 REFERENCE DOCUMENTS

2.1 API Recommended Practice 578 (Third Edition, Feb 2018) - Material Verification Program for New and Existing Alloy Piping Systems.

3.0 DEFINITIONS

3.1 **Supplier:** Any Supplier or Manufacturer on whom an order is placed for the supply of referred items. This definition shall also include any sub-Supplier or manufacturer on whom a sub-order is placed by the Supplier.

3.2 **Inspection Lot:** A group of items offered for inspection covered under same size, Heat and Heat treatment lot.

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3.3 **Alloy Material:** Any metallic material (including welding filler materials) that contains alloying elements such as Chromium, Nickel, Molybdenum or Vanadium, which are intentionally added to enhance mechanical or physical properties and/or corrosion resistance.

4.0 PMI EXAMINATION

4.1 The Supplier shall submit a procedure of PMI to comply with the requirements of this Specification. Approval of PMI Procedure shall be obtained from Owner / EIL / TPIA prior to commencing manufacture / inspection of product.

4.2 PMI examination of materials is independent of any certification, markings or colour coding that may exist and is aimed at verifying that the alloy used are as per specified grades.

4.3 The Supplier shall identify all incoming alloy materials and maintain full traceability of all alloy
materials, including all off-cuts. Transfer of identification marks shall be undertaken prior to cutting to ensure maintenance of identification on off-cuts.

4.4 The Supplier shall ensure that all alloy materials are segregated and stored in separately identified locations to prevent the mix up of materials of different alloy specifications or alloy material with carbon steel. Non ferro-magnetic materials shall be segregated at all times from ferro-magnetic materials.

4.5 PMI examination is subject to surveillance inspection by Owner / EIL / TPIA.

5.0 ACCEPTABLE METHODS FOR PMI

5.1 The method used for PMI examination shall provide a quantitative determination of the alloying elements like Chromium, Nickel, Molybdenum or Vanadium in Alloy Steel items.

5.2 Instruments or methods used for PMI examination shall be able to provide quantitative, recordable, elemental composition results for positive identification of alloying elements present.

5.3 The acceptable instruments for alloy analyzer shall be either "Portable X-Ray fluorescence" or "Optical Emission" type each capable of verifying the percentage of alloy elements within specified range.

5.4 Chemical spot testing, magnets, alloy sorters and other methods using eddy current or triboelectric testing methods are not acceptable for PMI examination.

5.5 The PMI instrument used shall have the sensitivity to detect the alloying elements in the specified range.

5.6 All PMI instruments shall have been serviced within a 6 month period of the time of use to verify the suitability of batteries, sources etc., and the data of the last service shall be stated on the PMI Report Form (Sample enclosed).

5.7 Each analyzer must be calibrated according to the manufacturer's specification at the beginning and end of each shift. Instrument must be checked against known standard for each alloy type to be inspected during the shift.

5.8 Certified samples, with full traceability, of a known alloy materials shall be available for use as a random spot check on the instrument calibration.

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5.9 The surfaces to be examined shall be prepared by light grinding or abrasive paper and solvent cleaner. Evidence of Arc burn resulting from examination shall be removed by light grinding or abrasive paper. No permanent marks, which are injurious to the usage of product in service, are acceptable.

5.10 Alloy Steel ring type joint Gaskets shall be inspected by using portable X-Ray fluorescence instrument.

5.11 Testing shall be done as per the procedures outlined by the manufactures of alloy analyzer being used. Modification of these procedures if any must be approved by Owner/EIL.

5.12 The persons performing PMI shall demonstrate their capabilities to the satisfaction of Owner/EIL/TPIA visiting engineer. If the Supplier has qualified operator on their rolls, he may perform the examination. Otherwise PMI examination shall be sub-contracted to an independent testing agency approved by EIL.

5.13 Whenever material is identified as not meeting requirements by the visiting engineer a rejection note shall be issued.

6.0 EXTENT OF PMI EXAMINATION

Following sampling plans shall be applicable for PMI examination of various items.

A. Flanges, Fittings Valves, RTJ Gaskets - 100% by Supplier and 10% @ random witness by EIL/TPIA

B. Pipes - 100% (for pipes procured from traders)
2 random samples drawn from each Size/Heat/Lot (for pipes procured directly from mills)

C. Fasteners -

Lot Size	Sample Size for EIL/TPIA	Sample size for Supplier
Upto 100	2% (Min 2)	Min 10%
101 to 500	1% (Min 3)	Min 10%
501 and above	0.5% (Min 5)	Min 10%

Note:

a. For Welded Pipes and Fittings and flanges like Fig 8, Spacer and blinds etc. PMI shall be performed on Base Metal as well as weldments.

7.0 ACCEPTANCE CRITERIA

7.1 Base Metal

PMI test results showing presence of characteristic elements upto 10% less than the minimum specified value in the material specification and upto 10% more than the maximum specified value in the material specification shall be acceptable.

7.2 Deposited Weld Metal

For deposited weld metal using welding consumables matching with base metals, the recorded presence of characteristic elements upto 12.5% less than the minimum specified value in the

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welding consumable specification and upto 12.5% more than the maximum specified value in the welding consumable specification shall be acceptable.

8.0 REJECTION CRITERIA

8.1 If PMI test results fall outside the acceptable range as specified in 7.0 above, the supplier shall obtain a quantitative check analysis performed by a laboratory acceptable to Owner / EIL / TPIA for a complete chemical analysis. Alternatively, the item can be tested with a spark analyser for verification. Results of this analysis shall be submitted to Owner / EIL / TPIA for final decision.

Decision of Owner / EIL / TPIA shall be final in this regard.

8.2 If any sample drawn to PMI test on the basis of percentage selection as per 6.0 above, fails to meet specification requirements, 100% of items of lot shall be tested for PMI by supplier. Any failure thereafter during sample check shall mean rejection of whole lot.

9.0 RECORDING AND DOCUMENTATION

The results of PMI examination shall be recorded in a Report Format as enclosed with this specification.

10.0 MARKING

10.1 All alloy materials tested by PMI shall be identified using either of the following methods by indicating "PMI OK"

a) Bar Code/Hologram Sticker
b) A low stress stamp marking

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	POSITIVE MATERIAL IDENTIFICATION REPORT BULK MATERIALS							Page of
Project:		Client						Job No.
PMI Report No.		Supplier/Sub-Supplier						
Purchase Order No.		Testing Agency						
Purchase Requisition No:		PMI Location						
Bulk Item Type (as per Requisition)								
Material Specification/Grade Number of items in Lot								
Requisition Item No./ Description		Major content, Weight Percent						Remarks Accept/Reject
Element	Cr	Ni	Mo	V	Ti *	Cb/ Nb **	Mn ***	
Specified Range								
Actual observations 1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
Instrument Type / ID Last Service Date		Inspection Agency						Witnessed By

* To be reported in case of SS321 Material
** To be reported in case of SS347 Material
*** To be reported in case of LTCS Material

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वैल्डेड पाइपों के लिए
निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
WELDED PIPES

Rev. No.	Data	Purpose	Prepared By	Checked By	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.12.2021	REVISED AND RE-ISSUED	RKM	CS	RK	S Mazumdar
5	19.09.2016	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
4	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
3	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
2	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND

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Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. Rajeev Kumar

Members:

Mr. Rajesh Sinha	Mr. Himangshu Pal	Mr. R. Muthuramalingam (RPO Representative)
Mr. Chandrashekhar	Mr. Avdhesh Agrawal	Mr. P V Satyanarayana (Engg. Representative)
Mr. Mahendra Mittal		

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements for Welded Pipes.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedure**						
1.1	Hydrostatic Test, Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ (Approved under EIL/Reputed TPIA)	Welding Parameters & Qualification Record	100%	WPS,PQR &WPQ	-	H	W- New R- Existing (Qualified under reputed TPIA)
2.0	**Material Inspection**						
2.1	Raw Material Inspection	Review of MTC for Chemical & Mechanical Properties	100%	Test Certificates	-	H	R

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	**In Process Inspection**						
3.1	Welding	Welding Parameters as per WPS / PQR	100%	Inspection Reports	-	H	-
3.2	Heat Treatment	Stress Relieving, Normalizing, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart	-	H	R
3.3	Ferrite Check of SS Pipes (as Applicable) Before HT	% Ferrite Check	Random On Weld	Inspection Report	-	H	R
3.4	UT / RT As applicable	Surface & Internal Imperfections	PR / Purchase Specification	RT Films, Reports & UT Reports	-	H	R (Film review for RT)
3.5	TPM (Identification of Test Samples)	Product analysis, Tensile, Hardness, Impact, IGC and Other test as applicable	Lot as per specification.	Test Reports	-	H	H
3.6	Product Analysis	Chemical Composition	PR / Purchase Specification	Test Reports	-	H	R
3.7	Destructive Testing	Tensile (0.2 Offset/0.5% extension under load), Hardness, Impact, IGC and Other test as applicable	Lot as per specification.	Test Reports	-	H	H

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.8	Galvanizing (If Applicable)	Integrity Of Galvanized Coating	100%	Inspection Report	-	H	R
4.0	**Final Inspection**						
4.1	Hydrostatic Testing	Leak Check	100%	Test Report	-	H	RW (Min.5%)
4.2	Visual and Dimensional Inspection (VDI)	Surface Condition, Straightness, End Finish, Bevel Angle, Root Face, Outer Dia., Profile Thickness, Length, End Finish, Marking etc	100%	Inspection Report	-	H	RW (Min.5%)
4.3	Weight Checking as applicable	Weight	100%	Inspection Report	-	H	-
4.4	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.5	Final Stamping	Stamping of Accepted Pipes	Stamping of Pipes which are witnessed by EIL/TPIA.	Inspection Report	-	H	H

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.0	**Painting**						
5.1	Rust Preventive Coating & Color Coding (As applicable)	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Manufacturer TC & IC	-	H	H

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

NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable (Unless otherwise agreed upon).
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred therein /Job Specification /Approved Documents.
3. For orders placed on stockist, items shall be accepted based on manufacturer's TC with EN10204 type 3.2 certification from EIL approved suppliers.

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सीमलैस पाइपों के लिए
निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
SEAMLESS PIPES

Rev. No.	Date	Purpose	Prepared By	Checked By	Standards Committee Convenor	Standards Bureau Chairman
					Approved By	
6	23.12.2021	REVISED AND RE-ISSUED	HKM	CS	RK	S Majumdar
5	19.09..2016	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
4	17.06..2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
3	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
2	30.06.2010	REVISED AND RE-ISSUED	RK	VKJ	SKP	ND

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Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. Rajeev Kumar

Members:

Mr. Rajesh Sinha	Mr. Himangshu Pal	Mr. R. Muthuramalingam (RPO Representative)
Mr. Chandrashekhar	Mr. Avdhesh Agrawal	Mr. P V Satyanarayana (Engg. Representative)
Mr. Mahendra Mittal		

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Seamless Pipes.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/ TPIA
1.0	**Procedure**						
1.1	Hydrostatic Test, Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
2.0	**Material Inspection**						
2.1	Raw Material Inspection	Review of MTC for Chemical, Mechanical Properties, size & steel making process, etc.	100%	Test Certificates	-	H	R
3.0	**In Process Inspection**						

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SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/ TPIA
3.1	Heat Treatment	Normalizing, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart	-	H	R
3.2	NDT As applicable	Surface & Internal Imperfections	PR / Purchase Specification	NDT Reports	-	H	R
3.3	TPM (Identification of Test Samples)	Product analysis, Tensile ((0.2 Offset 0.5% extension under load),), Hardness, Impact, IGC and Other test as applicable	Lot as per specification	Test Reports	-	H	H (Note-1)
3.4	Product Analysis	Chemical Composition	Lot as per specification	Test Reports	-	H	R
3.5	Destructive Testing	Tensile, Hardness, Impact, IGC and Other test as applicable	Lot as per specification	Test Reports	-	H	H (Note-1)
3.6	Galvanizing (If Applicable)	Integrity of Galvanised Coating	100%	Inspection Report	-	H	R
4.0	**Final Inspection**						
4.1	Hydrostatic Testing	Leak Check	100%	Test Report	-	H	RW (Note 1)

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SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/ TPIA
4.2	Visual and Dimensional Inspection (VDI)	Surface Condition, Straightness, End Finish, Bevel Angle, Root Face, Outer Dia., Thickness, Length, End Finish, Marking, End Caps etc	100%	Inspection Report	-	H	RW (Note 1)
4.3	Weight Checking as applicable	Weight	100% By Supplier	Inspection Report	-	H	-
4.4	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.5	Final Stamping	Stamping of Accepted Pipes	Stamping of Pipes which are witnessed by EIL/TPIA..Other pipes to have suppliers identification	Inspection Report	-	H	H

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SL. NO.	STAGE/ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/ TPIA
5.0	**Painting**						
5.1	Rust Preventive Coating & Color Coding (As applicable)	Visual & Color Coding as applicable	100%	Inspection Report	-	W	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 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. Carbon Steel Pipes (Other than LTCS & Pipes for special services like NACE, H2, HIC, etc.) up to size 12" will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by EIL/TPIA.
2. 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).
3. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred therein /Job Specification /Approved Documents.
4. For orders placed on stockist, items shall be accepted based on manufacturer's TC with EN10204 type 3.2 certification from EIL approved suppliers.

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वाल्वों के लिए
निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
VALVES

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	08.05..2023	REVISED AND RE-ISSUED	NK	AK	RK	SM
6	14.11.2018	REVISED AND RE-ISSUED	KC	NM	RKS	RKT
5	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
4	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
3	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND
2	31.01.2008	REVISED AND RE-ISSUED	CS	SS	MVKK	VC

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Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. Rajeev Kumar

Members:

Mr. Rajesh Sinha	Mr. Himangshu Pal	Mr. Chandrashekhar	Mr. R Muthu Ramalingam (RPO Rep.)
Mr. Avdhesh Agrawal	Mr. Mahendra Mittal	Ms Sulakshna Hundekari (Piping)	

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Valves.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedure**						
1.1	Hydrostatic Test, Heat Treatment, NDT, Helium Leak Test, Fugitive Emission Test, Internal/ External Coating Procedures & Other Procedures (Wherever applicable as per MR/ PR)	NDT Level III Approved Documented Procedures	100%	NDT Level III Approved Procedure Documents	-	H	R
1.2	WPS, PQR & WPQ and NDT operator Qualification Record	Welding Parameters & Qualification Record	100%	WPS, PQR &WPQ	-	H	W- New R- Existing

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SL NO	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.3	Pre-Qualification Tests	Fire safe, Cryogenic, Fugitive Emission Test, Internal Epoxy Coating, Glass Lined Coating & Other Test as applicable	As per PR / Purchase Specification	Acceptance Report	-	H	H (If new)
2.0	**Material Inspection**						
2.1	Castings & Forgings (Body, Bonnet, Disc, Stem, Body ring)	Chemical, Mechanical (Tensile, Hardness, Impact Test etc.), Heat Treatment, NDT, IGC & Other Properties as applicable	100%	Test Certificates	H	R	R
2.2	Castings & Forgings (Body, Bonnet, Disc, Stem, Body ring)	Visual & Dimension	100%	Inspection Report	H	H	-
2.3	Body and Bonnet Castings	Radiography Examination after Heat Treatment	As per PR / Purchase Specification	RT Films and NDT reports	H	R	R
2.4	Bars for Trim material	Chemical Analysis	Each Heat	Test Certificates & Lab Report	H	R	-

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SL NO	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.5	Gaskets, Gear units, Fasteners, Gland, Packings, etc.	Physical / Chemical Properties	100%	Test Certificates & Lab Report	H	R	-
2.6	Actuators as applicable	Performance, Statutory Certificates etc. As per EIL ITP. 6-81-1091	100%	Test Certificates, Inspection report	H	H	R
3.0	**In Process Inspection**						
3.1	Welding, Weld Overlay, Stelliting, Hardfacing (As applicable)	Welding Parameters as per WPS / PQR	100%	Inspection Reports	-	H	-
3.2	Machining of components	Visual / Dimension	100%	Inspection Reports	-	H	-
3.3	DP Test for all weld joints, Bevel Ends & Bypass (as applicable)	Dye Penetrant Test	100%	NDT Report	-	H	RW
3.4	Hardness Check	Heat Treat Castings, Weld Joints, Grove Joints etc.	100%	Inspection Reports	-	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	a. Shell Hydrotest b. Seat Hydro Test (Both Sides) c. Backseat Hydrotest (Gate & Globe Valves) d. Seat Pneumatic/ Air Test	Leak Check	100%	Pressure Test Report, Water quality Report		H	RW (Note 1)
4.2	Helium Leak test / Vacuum Test (as applicable)	Leak Check	As per PR / Purchase Specification	Test Report	-	H	RW (Note 1)
4.3	Visual & Dimensional Check	Surface Verification & Dimension Measurement	100%	Test Report	-	H	RW (Note 1)
4.4	Functional Test for Motor/ Actuator Operated Valves	Satisfactory Performance	100%	Test Report	-	H	RW
4.5	Marking Verification	Verification of Marking, Valve Tagging & Name Plate Checking	100%	Marking & Tagging Report		H	RW (Note-1)
4.6	PMI Check	Chemical Check	As per EIL Spec. 6-81-0001	PMI Report	-	H	RW

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SL NO	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.7	Strip Check (As applicable)	Verify Components for wear, damage , harmful defects & Differential hardness as applicable	As per PR / Purchase Specification	Inspection Report	-	H	RW (Note-1)
4.8	Final Stamping	Stamping of Accepted Valves	Stamping of Valves which are witnessed by EIL/TPIA.	Inspection Report	-	H	H (Note-1)
5.0	**Painting**						
5.1	Painting/ Pickling & Passivation and Color coding as applicable	Visual / DFT Check	100%	Inspection Report	-	H	-
6.0	**PACKING & PROTECTION**						
6.1	Packing & Protection	Dispatch Instructions as per Technical Notes for Valves	100%	Compliance Report with photographs		H	RW
7.0	**Documentation & Inspection Certificate**						

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SL NO	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
7.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 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. Non NACE & Non Hydrogen service Carbon Steel Cast Valves up to size 12"-300ANSI Class and Carbon Steel Forged Valves up to size 1.5"- 800 ANSI Class will be accepted on review of Supplier Test Certificates.
   Supplier Test Certificate along with back up reports to be reviewed by EIL/TPIA.
2. 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)
3. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred therein /Job Specification /Approved Documents.

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फ़ोर्जड, सीमलेस और वेल्डेड फिटिंग
के लिए
निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
FORGED, SEAMLESS & WELDED FITTINGS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
					Approved by	
9	26.12.2024	REVISED AND RE-ISSUED	AA	CS	RK	MN
8.	01.06.2019	REVISED AND RE-ISSUED	AA	RS	RKS	RKT

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Abbreviations:

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

Inspection Standards Committee

Convener: Mr. Rajeev Kumar

Members:

Mr. Suresh G	Mr. Himangshu Pal	Mr. Chandrashekhar
Mr. Muthuramalingam	Mr. Avdhesh Agrawal	Mr. Anil Kumar
Mr. Mahendra Mittal	Ms. Sulakshana Hundeikari	

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Forged, Seamless & Welded Fittings.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedure**						
1.1	Heat Treatment / NDT	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS, PQR, WPQ	Welding Parameters & Welding &	100%	WPS, PQR &WPQ	-	H	W- New R- Existing
1.3	NDE Operator Qualification records & Calibration records of measuring instruments & testing equipment	NDE operator qualification certificates & calibration certificates	100%	NDE & Calibration summery	-	H	R
2.0	**Material Inspection**						

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.1	Raw Material Identification (Billets, Rounds, Pipes, Coil, Plates, etc.) (*For pipes, coils & plates of Alloy steels and Special services like NACE, H2, HIC, Wet H2S, LTCS, UOP, AXEN etc.)	Chemical and Mechanical Properties, Size & Steel making practice etc.	100%	Mill test certificate, Supplier's Inspection Report	-	H	W* / R
3.0	**In Process Inspection**						
3.1	Forming &Welding	Forming & Welding Parameters	100%	Supplier's records	-	H	-
3.2	Ferrite Check of SS Welds (If Applicable)	% Ferrite Check	100%	Inspection Report	-	H	R
3.3	Heat Treatment	Stress Reliving, Normalizing, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart / Report	-	H	R
3.4	NDT-RT As Applicable	Surface & Internal Imperfections	As per PR/Purchase Specification	RT Films & Reports	-	H	R (Films Review)

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.5	NDT – UT (as applicable)	Surface & Internal Imperfections	As per PR/Purchase Specification	UT Report	-	H	R
3.6	NDT – DPT/MPT on Bevel Ends (as applicable)	Surface & Internal Imperfections	100%	Test Report	-	H	RW
3.7	Identification of Test Samples	Product Chemical, Mechanical, Impact, IGC and another test as applicable	Per heat, per heat treatment lot (Note-4)	Test Reports	-	H	H
3.8	Product Analysis	Chemical Composition	As per PR/Purchase Specification	Test Reports	-	H	R
3.9	Destructive Testing	Mechanical, Impact, IGC, Hardness and Other test as applicable	100%	Test Reports	-	H	H
3.10	Galvanizing (If Applicable)	Integrity Of Galvanized Coating	100%	Inspection Report	-	H	R
4.0	**Final Inspection**						
4.1	Visual and Dimension	Size, Thickness / Schedule, Dimensions, Surface quality, Marking, etc.	100%	Inspection Report	-	H	RW

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.2	Hardness testing on finished fittings of Alloy steels and Special services (like NACE, H2, HIC, Wet H2S, UOP, AXEN etc.) & any other services as applicable.	Hardness value of Base metal & Welds/HAZ.	Random 10%	Test Report	-	H	RW
4.3	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.4	Final Stamping	Stamping Of Accepted Fittings	Stamping of Fittings which are witnessed by EIL/TPIA.	Inspection Report	-	H	H
5.0	**Painting**						
5.1	Rust Preventive Coating & Color Coding	Visual & Color Coding as applicable	100%	Inspection Report	-	W	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 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).

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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 orders placed on stockiest, items shall be accepted based on manufacturer's TC with EN10204 type 3.2 certification from EIL approved suppliers.
4. Test piece marking shall be carried out from the product for each heat of raw material and for each heat treatment batch at shop floor.

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फ्लैंजो, स्पैक्टेकल ब्लांइडों एवं ड्रिप रिंगों के लिये निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN FOR FLANGES, SPECTACLE BLINDS & DRIP RINGS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	22.02.2024	REVISED AND RE-ISSUED	BBK	PW	RK	MN
5	14.11.2018	REVISED AND RE-ISSUED	KC	NM	RKS	RKT
4	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
3	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM

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Abbreviations:

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

Inspection Standards Committee

Convenor: Mr. Rajeev Kumar

Members:

Mr. Chandrashekar	Mr. G Suresh	Mr. Himangshu Pal	Mr. R Muthu Ramalingam (RPO Rep.)
Mr. Avdhesh Agrawal	Mr. Mahendra Mittal	Ms. Sulakshna Hundekari (Engg.)	Mr. Anil Kumar

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1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Flanges, Spectacle Blinds & Drip Rings.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedure**						
1.1	Heat Treatment, NDT, PMI , IGC, Mechanical, Chemical testing and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS, PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS, PQR & WPQ	-	H	W- New R- Existing
2.0	**Material Inspection**						
2.1	Raw Material Inspection	Chemical & Mechanical Properties	100%	Test Certificates	-	H	R

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SL NO.	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	**In Process Inspection**						
3.1	Welding / Forging	Forging /Welding Parameters	100%	Inspection Reports	-	H	-
3.2	Heat Treatment	Stress Relieving, Normalising, Tempering, Solution Annealing, Stabilization Heat Treatment etc., as applicable	100%	HT chart	-	H	R
3.3	Identification of Test Samples	Product Chemical, Mechanical, Impact, IGC (Per heat/ Heat Treatment lot) and Other tests, as applicable	100%	Test Reports	-	H	H
3.4	Product Analysis (As applicable)	Chemical Composition	As per PR/Purchase Specification	Test Reports	-	H	R
3.5	Destructive Testing	Mechanical, Impact, IGC and Other tests, as applicable	100%	Test Reports	-	H	H
3.6	NDT as applicable	Surface & Internal Imperfections	As per PR/Purchase Specification	NDT Reports	-	H	R

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SL NO.	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.7	Galvanizing (If Applicable)	Integrity of Galvanised Coating	100%	Inspection Report	-	H	R
4.0	**Final Inspection**						
4.1	Final Inspection	1. Visual 2. Dimensions 3. Hardness 4. Marking etc.,	100%	Inspection Report	-	H	H (Note-1,2)
4.2	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.3	Review of Calibration Records	Summary of Calibration Reports of all Equipments, tools and instruments used during inspection and testing	100%	Calibration Reports	-	H	R
4.4	NDE Operator Qualification records	ASNT / ISNT Level I/II/III certifications	100%	Summery	H	H	R
4.5	Final Stamping	Stamping of Accepted Items	Stamping of Items which are witnessed by EIL/TPIA.	Inspection Report	-	H	H (Note-1,2)

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SL NO.	STAGE / ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
5.0	**Painting**						
5.1	Rust Preventive Coating & Color Coding	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	**Documentation & IC**						
6.1	Documentation & Inspection Certificate (IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 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. Non-NACE/HIC, Non-Hydrogen service & Non-LTCS, Carbon Steel (CS) Flanges, Spectacle Blinds and drip Rings up to size 24"-300 ANSI Class will be accepted based on the review of the Manufacturer's Test Certificates. Manufacturer's Test Certificate shall be as per EN 10204 Type 3.1. MTC along with backup reports to be reviewed by EIL/TPIA.

2. For cases apart from Note-1, Manufacturer's Test Certificate shall be as per EN 10204 Type 3.2 Certification, unless otherwise specified.

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