

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
RCC :	Reinforced Cement Concrete
VOC :	Volatile Organic Compounds
ISO :	International Organization for Standardization
NFPA :	National Fire Protection Association

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1.0 GENERAL

This standard specification lays down the requirements of steel/ aluminium door, window and ventilator and rolling shutter assemblies for buildings.

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:

Sl.no:	Standards	Document Title
1.	IS 5	Colour for ready mixed paints and enamels.
2.	IS 325	Three phase induction motors
3.	IS 617	Specifications for aluminium and aluminium alloy ingots & castings for general engineering purposes.
4.	IS 733	Specifications for wrought aluminium and aluminium alloy bars, rods & sections for general engineering purposes.
5.	IS 737	Specifications for wrought aluminium and aluminium alloy sheet & strip for general engineering purposes.
6.	IS 1038	Specifications for steel doors, windows and ventilators.
7.	IS 1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
8.	IS 1161	Steel Tubes For Structural Purposes - Specification
9.	IS: 1239	Steel tubes, tubulars and other wrought steel fittings — Specification
10.	IS 1285	Specifications for wrought aluminium and aluminium alloy extruded round tube & hollow sections for general engineering purposes.
11.	IS 1361	Specifications for steel windows for Industrial buildings.
12.	IS 1477 Part-2	Code of practice for painting of ferrous metals in buildings
13.	IS 1948	Specifications for Aluminium doors, windows and ventilators.
14.	IS 2062	Standard for hot rolled medium and high tensile structural steel
15.	IS 2074	Specifications for Ready mixed paint, air drying, red oxide zinc chrome, priming specification
16.	IS 2223	Dimensions of flange-mounted AC Induction motors
17.	IS 2253	Designation for types of construction and mounting arrangements of rotating electrical machines
18.	IS 2385	Designation for types of construction and mounting arrangements of rotating electrical machines
19.	IS 2553 Part-1	Safety glass – specification Part 1: General purposes
20.	IS 2835	Flat transparent sheet glass
21.	IS - 2968	Dimensions of slide rails for electrical motors
22.	IS 3548	Code of practice for glazing building

23.	IS 3564	Specification for hydraulically regulated door closer
24.	IS 3614 Part-1	Specification for fire check doors. Part-1: Plate metal cover and rolling type
25.	IS 3614 Part-2	Specification for metallic and non metallic fire check doors. Part-2: Resistance test & performance criteria
26.	IS 4029	Guide for testing of three phase induction motors
27.	IS 4351	Specifications for steel door frames.
28.	IS 4454-part I	Steel wire for mechanical springs — specification
29.	IS 4691	Degree of protection provided by enclosure for rotating electrical machinery
30.	IS 4722	Rotating electrical machines
31.	IS 4889	Method of determination of efficiency of rotating electrical machines
32.	IS 5437	Figured rolled and wired glass
33.	IS 6248	Specifications for metal rolling shutters and rolling grill
34.	IS 6315	Specification for Floor springs (hydraulically regulated) for heavy doors.
35.	IS 6362	Designation of methods of cooling of rotating electrical machines
36.	IS: 7088	Recommended practice for anodizing aluminum and its alloys.
37.	IS 7452	Specification for hot rolled steel sections for doors, windows and ventilators.
38.	IS 12436 (1998)	Specifications for preformed rigid polyurethane (PUR) and polyisocyanurate (PIR) foams for thermal insulation..

3.0 DOOR,WINDOW AND VENTILATORS

- 3.1 Door, window and ventilator assemblies shall be complete with frames, shutters and required, hardware ensuring stability, safety and smooth operation.
- 3.2 Type of Door, window and ventilator assemblies shall be as mentioned in job specifications or construction drawings.

4.0 STEEL DOORS

- 4.1 Steel door assemblies shall have following components. For further details reference shall be made to EIL Standard Nos.7-75-0070, 7-75-0071 and 7-75-0074

Component	Specification
Door frame	<p>Made of 16 SWG galvanized steel pressed and profiled to required size with 3mm thick MS flat spacers welded towards jamb size, 3mm thick MS pad plate and 18 SWG galvanized steel mortar guard welded at all hinge & lock locations.</p> <p>The vertical members shall be provided with 20mm x 20mm x 3mm welded MS angle threshold which shall be embedded in flooring.</p> <p>The hollow frame shall be filled up with concrete or any other approved suitable material.</p>

	Continuous "D" profile EPDM gasket shall be provided in the rebate of the frame in case of air-tight doors.
Door Shutter	Made of 18 SWG galvanized steel pressed and profiled to required size and thickness (minimum thickness – 40mm) with 3mm thick MS flat welded continuously along the perimeter of the shutter, profiled vertical stiffeners made of 18 SWG galvanized steel. The shutter shall be filled up with mineral wool (density – 48 Kg/ cum). Other approved filler material is permissible for large doors/shutters. In case of double shutters, suitable profiling/ rebating shall be done at the junction of meeting shutters for proper closure of the shutters.
Vision Panel	Vision panels shall be provided in the shutters as per project drawings. Glass shall be as mentioned in the drawings. Glass pane shall be fixed by means of 18 SWG galvanized steel "Z" angle welded to the shutter along the periphery of the opening and continuous EPDM gasket. If nothing is specified 350mm x 450mm sized vision panel with 5mm thick toughened glass shall be provided.
Louvers	Louvers shall be provided in the shutters if specified or mentioned in the project drawings. Louvers shall be made of 18 SWG galvanized steel "Z" profiled blades welded to the shutter. Louvers shall not be provided in air conditioned and pressurized area.

4.2 Hardware

Following hardware shall be provided in the steel door assemblies

Hardware	Specification
Hydraulic door closer	1 no. heavy duty hydraulic door closer confirming to IS 3564 for each shutter .
Tower/ Flush bolt	1 no. 10mm dia stainless steel Tower/ Flush Bolt (SS 304 grade, 250mm long upto 2100mm high door and 600mm long upto 2500 mm high door) for each shutter on both sides. For large size door (width- above 2000mm to 3000mm, height- above 2500mm to 3000mm), tower/ flush bolt shall be upto 1400mm long and shall be surface mounted or concealed type.
Aldrop	1 no. 16mm dia stainless steel Aldrop (SS 304 grade, 300mm long) for each shutter on both sides. For large size door (width- above 2000mm to 3000mm, height- above 2500mm to 3000mm), Aldrop shall be 400mm long.
Door Handle	1 no. 18mm dia stainless steel door handle (SS 304 grade, 200mm long) for each shutter on both sides. For large size door (width- above 2000mm to 3000mm, height- above 2500mm to 3000mm), door handles shall be 300mm long.
Door Stopper	1 no. spring loaded heavy duty door stopper for each shutter.
Hinges for shutters	100mm long stainless (SS 304 grade) steel heavy duty ball bearing hinge. Number of hinges shall be : 3 (for upto 2100mm high door)

	4 (for upto 2400mm high door)
	5 (for upto 2700mm high door)
	6 (for upto 3000mm high door)

4.3 Fabrication & Installation

- 4.3.1 Doors shall be true to the plumb, size and design and smooth operation shall be ensured.
- 4.3.2 All metallic components shall be shall be welded or rigidly fixed together by mechanical means. Joints between horizontal and vertical frame members shall be mitred. All welding shall be finished smooth.
- 4.3.3 The frames shall be fixed to the masonry by means of 200 mm x 25 mm x 6 mm MS hold fast welded to the spacers and grouted with M-20 grade concrete in minimum 250 mm x 100 mm x 100 mm sized hole in the masonry.
- 4.3.4 In case of concrete, the frames shall be fixed by minimum 100 mm long, 12 mm dia metallic counter sunk type anchor fasteners through the frame and spacers.
- 4.3.5 Vertical frame member shall be tied together below floor finish by mean of 20mmx20mmx3mm MS Angle welded to both faces of frame.
- 4.3.6 40mmx150mmx3mm thick MS pad shall be welded to frame at all hinges and lock locations. 18 SWG GI mortar guard shall be provided at the back of hinges and lock.
- 4.3.7 The metallic surfaces shall be thoroughly cleaned of rust, mill scale, dirt, oil etc. and then finished with painting or powder coating as specified. If not specifically mentioned elsewhere, Finishing of the door assemblies shall be minimum 40 micron powder coating in desired colour. The thickness of powder coating shall be subjected to verification at site (on random basis) as directed by Engineer- in- Charge with appropriate measuring instruments supplied by contractor.

5.0 STEEL WINDOW & VENTILATORS

- 5.1 Steel window and ventilator assemblies shall have steel frames and shutters (glazed/with wire mesh/ with louvers as specified) with required hardware. For further details reference shall be made to EIL Standard Nos.7-75-0025, 7-75-0027 to 7-75-0032.
- 5.2 Steel windows and ventilators shall in general conform to IS 1038 and IS 1361.
- 5.3 **Materials/ Assembly components**
- 5.3.1 Frame and shutter shall be made of rolled steel sections conforming to IS: 7452.
- 5.3.2 Glass for glazed shutters shall be as specified. If nothing is mentioned specifically, minimum 5 mm thick toughened glass shall be provided.
- 5.3.3 Louvers shall be made of 18 SWG MS steel profiled sheets.
- 5.3.4 Wire mesh shall be of stainless steel (SS-304 grade) or wire of galvanized steel as specified. If nothing is mentioned specifically, stainless steel wire mesh shall be provided.

5.4 Hardware

5.4.1 All hardware required for smooth operation, durability and safety such as handles, Peg-stays, hinges, closure of shutters etc. shall be provided.

5.5 Fabrication & Installation

5.5.1 Steel window and ventilator assemblies shall be true to the plumb, size and design and smooth operation shall be ensured.

5.5.2 All metallic components shall be shall be welded together. Joints between horizontal and vertical frame members shall be mitred. All welding shall be finished smooth.

5.5.3 Frames shall be fixed in the opening by means of 100mm x 15mm x 6 mm thick MS lugs @ grouted with M-20 grade concrete or with minimum 100 mm long, 12 mm dia metallic counter sunk type anchor fasteners. when fixing to steel work, mastic shall be applied to the sill of the opening and the unit shall be placed on it with the jambs and head buttered with mastic and the unit shall be fixed with special fixing dips or with nuts and bolts.

5.5.4 Where larger units are to be formed by coupling individual units, the mullions, transoms shall be bedded in mastic to ensure weather tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembly, and the two units being coupled shall be drawn together tight with clamps, the mastic being squeezed out and cut off neatly when the units shall be screwed together tight.

5.5.5 Where fixed glazing units are placed over openable units, a push fit weather bar shall be provided.

5.5.6 Before glazing, all opening parts shall be checked for their operational smoothness. The frame shall be completely cleaned and bedding putty shall be placed in the rebate before glazing. Glass then shall be cushioned into the bedding and shall be fronted with front putty in a manner so as to enable the painting to be done up to the sight line. The back putty oozing out over the glazing rebate shall be cut off square and smoothed down.

5.5.7 For panels exceeding 600 x 300 mm in size, glass shall be secured by special glazing clips inserted in holes already provided in the steel sections, before applying the front putty.

5.5.8 For glazing of very large areas, rust proof steel beading with mitred corners shall be provided with screws @ 10 cm. from each corner and @ 20 cm. apart from each other. Putty shall be provided to the face of the bead in contact with glass, in addition to back putty.

5.5.9 Side hung shutters shall be connected to the frame by means of friction hinges. The handle for side hung shutters shall be of pressed brass mounted on a steel handle plate welded to the opening shutter frame and shall not be removable easily after glazing. The handle shall have a two point nose which shall engage with a brass striking plate on the fixed frame in a slightly open as well as in a fixed position.

5.5.10 Top hung shutters shall be provided with steel butt hinges welded to the fixed frame after cutting a slot in it. Top hung casements shall be provided with peg stay of 3 holes of pressed brass; 300 mm long which when closed shall be held tightly by the locking bracket fitted to the fixed frame or to the window.

5.5.11 All the steel surfaces shall be thoroughly cleaned free of rust, mill scale, dirt, oil etc. by sand and shot blasting and then finished with painting by priming with red oxide zinc chromate primer conforming to IS:2074 and minimum two coats of synthetic enamel paint conforming to IS:1477 (Part II). Putty shall also be provided with painting in a manner so as to seal the putty glass junction. Surfaces not meant for painting shall be cleaned of any strains of paint.

6.0 ALUMINIUM DOORS, WINDOWS AND VENTILATORS

6.1 Aluminium door, window and ventilator assemblies (glazed/with wire mesh/ with louvers as specified) shall have frames and shutters made of extruded profiled tubular Aluminium sections with required hardware. Aluminium window shutters shall be side hung or sliding type as mentioned in the design basis, job specifications or construction drawings. For further details reference shall be made to EIL Standard Nos. 7-75-0014, 7-75-0015, 7-75-0016, 7-75-0017 etc.

6.2 Materials/ Assembly components

6.2.1 Aluminium sections shall be extruded profiled tubular sections of approved Manufacturers having aluminium alloy as per IS: 733 and IS: 1285.

6.2.2 Aluminium sections shall be anodised as per IS: 7088 or electrostatically powder coated to as specified. The thickness of anodizing/ powder coating shall be subjected to verification at site (on random basis) as directed by Engineer- in- Charge with appropriate measuring instruments supplied by contractor.

6.2.3 If not mentioned specifically, the finishing of Aluminium sections shall be of powder coating in approved colour.

6.2.4 Thickness of powder coating shall be as specified. If not specified the minimum thickness shall be 50 micron.

6.2.5 Glass used for glazing shall be as specified. If not mentioned specifically minimum 5 mm thick toughened glass conforming to IS: 2835 shall be provided.

6.2.6 Louvers shall be made of 2 mm thick bend and profiled Aluminium sheets framed suitably and shall be fixed to the door/ window/ ventilator frame. The profiles and spacing of louver blades/ sheets shall ensure prevention of water ingress.

6.2.7 Wire mesh shall be of stainless steel (SS-304 grade) or wire of galvanized steel as specified. If nothing is mentioned specifically, stainless steel wire mesh shall be provided.

6.3 Hardware

6.3.1 If not specifically mentioned, following hardware shall be provided in the Aluminium door assemblies.

Hardware	Specification
Hydraulic door closer	1 no. heavy duty hydraulic door closer confirming to IS 3564 for each shutter .
Tower/ Flush bolt	1 no. 10mm dia aluminium or stainless steel (SS-304 grade), 250mm long upto 2100mm high door and 600mm long upto 2500 mm high door) for each shutter on both sides.

	For large size door (width- above 2000mm to 3000mm, height- above 2500mm to 3000mm), tower/ flush bolt shall be upto 1400mm long and shall be surface mounted or concealed type. Finishing of Aluminium tower/ flush bolts shall be similar to aluminum profiled sections of the door assembly.
Door Handle	1 no. 10mm dia aluminium or stainless steel (SS-304 grade), minimum 250mm long for each shutter on both sides. For large doors, longer door handles shall be provided as mentioned in design basis, job specification or construction drawings. Finishing of Aluminium handles shall be similar to aluminum profiled sections of the door assembly.
Door Stopper	1 no. spring loaded heavy duty door stopper for each shutter.
Double action hydraulic floor spring	1 no for each shutter conforming to IS 6315 with double spring mechanism and pivot.
Lock	Brass body, minimum 4 lever

Note: In case of Aluminum doors, either Double action hydraulic floor spring as per IS 6315 or Hydraulic door closer as per IS 3564 will be applicable.

6.3.2 If not mentioned elsewhere, window/ ventilator assemblies shall be provided with hardware such as hinges, handles, peg-stays, tower/flush bolts, sliding mechanism etc. as required for safety, operation and durability.

6.3.3 If not mentioned elsewhere, visible hardware shall be of Aluminium having finishing similar to aluminum profiled sections of the window/ ventilator assembly.

6.4 Fabrication & Installation

6.4.1 Frames and shutters shall be square and flat, the corner of the frame being fabricated to true right angles. Aluminium sections of frames, shutters etc. shall be mitred and jointed rigidly. Details of construction of frames, shutters etc. shall be as per construction drawings and EIL standards.

6.4.2 In case of composite Door/window/ventilator units, the units shall be coupled as per drawing. Weather bar shall be provided whenever a coupling member is fitted over an external opening shutter.

6.4.3 The Aluminium frames shall be fixed in the openings by means of aluminium lugs fixed to the frame (by counter sunk brass machine screws) and grouted with concrete or by means of anchor fasteners.

6.4.4 Glazing shall be fixed to the extruded sections by means of extruded Aluminium beading. Glass panes shall be provided with EPDM gasket/rubber lining before fixing.

6.4.5 Side hung window shutters shall be fixed to the frame with pivots or hinges.

6.4.6 Gaps at the junction of opening and frame shall be filled up with weather silicon sealant.

7.0 STEEL, ALUMINIUM ROLLING SHUTTERS

7.1 Rolling shutters shall be of steel or Aluminium as specified and shall conform to IS 6248.

7.2 Rolling shutters shall be push or pull type or operated by mechanical means or by electrical motors as specified. However, rolling shutter beyond 10 square metre in area shall not be push and pull type. If nothing is mentioned specifically, rolling shutters shall be electrical motor operated type.

7.4 Steel Rolling Shutters

7.4.1 Rolling shutter components

Components of steel rolling shutters shall have following specification.

1. Shutter

Shutter shall be built-up of inter locking lath section formed from cold rolled steel strips.

The thickness of the steel strips shall not be less than 0.90 mm for shutters upto 3.5 m width.

The lath sections shall have interlocking curls at both the edges and deep corrugation at the centre with a bridge depth of minimum 12 mm.

Each lath section shall be a continuous single piece without any welded joint.

When interlocked, the lath sections shall have a distance of 75mm rolling centers.

Each alternate lath sections shall be fitted with MS clips securely riveted at either ends to prevent lateral movement of the individual lath sections.

2. Guide channels

Guide channels shall be of mild steel . Width shall be minimum 25mm. Minimum depth (shutter clear width wise) shall be as below :

Upto 3.5 metre wide shutter – 65mm

3.5 metre to 8 metres – 75mm

8 metre and above – 100mm

The gap between the two legs of the guide channels shall be sufficient to allow free movement of the shutter and at the same time close enough to prevent rattling of the shutter.

3. Roller and brackets

The suspension shaft of the roller shall be heavy duty steel pipe conforming to IS 1161.

For shutter upto 6 metre width and height not exceeding 5 metre, steel pipe of minimum 50 mm nominal bore shall be used. The shaft shall be supported on MS brackets.

Size of the brackets shall be minimum 375mm x 375mm x 3.15 for shutters upto clear height of 3.5 metre, minimum 500mm x 500mm x 10mm for clear height above 3.5 metre and upto 6.5 metre.

The suspension shaft shall be fitted with rotatable cast iron pulleys to which the shutter is attached. The pulleys and the pipe shaft shall be connected by means of pretensioned helical

springs to counter balance the weight of the shutter and to keep the shutter in equilibrium in any partly open position.

When the width of the opening is greater than 3.5 metre, the pullies shall be interconnected with a cage formed out of MS flats and dummy rings to distribute the torque uniformly. Self aligning two row ball bearing with cast iron casing shall be provided at the extreme pulley.

4. Spring

The spring shall be built of coiled type manufactured from high tensile spring steel wire or strips of adequate strength conforming to IS 4454-part I

5. Cover

Top cover shall be of mild steel sheets not less than 0.90mm thick and shall be stiffened with MS angle or flat stiffeners.

6. Hardware

Lock plates with sliding bolts, handles and anchoring rods conforming to IS 6248 shall be provided.

7. Grills

If specifically mentioned, rolling grills shall be provided in the shutter. In general, height of grill portion shall not exceed 500mm. In case of grills at multiple locations, cumulative height of the grill portions shall not exceed 1000mm. Grills shall be made of 8 mm dia MS round bars.

8. Finishing

All metallic parts shall be painted with minimum 2 coats of red oxide zinc chromate primer conforming to IS 2075. Visible parts shall be further painted with minimum two coats of synthetic enamel paint conforming to IS 2933.

7.4.2 Sizes and dimensions of various components mentioned in above clause are for normal conditions. For larger sizes and windy locations, the sizes and dimensions shall be suitably modified as directed by the Engineer-In-Chief.

7.4.3 Mechanically operated rolling shutters shall have suitable gear mechanism for smooth operation.

7.4.4 Motor operated rolling shutters shall be provided with necessary and suitable electrical fittings like motors, switch panel, switches, wires, cables etc. all complete and conforming to India standards.

7.4.5 Installation

Rolling shutters shall be installed true to the plane and fixed in the opening ensuring smooth operation as per IS 6248.

7.5 ALUMINIUM ROLLING SHUTTER

7.5.1 Aluminium Rolling Shutters shall be motorized gear operated and either double walled Insulated type or non- insulated type as specified complete with all accessories.

The Brackets and hood cover shall conform to IS: 6248. The clear opening dimensions shall not exceed 5000 mm x 5000 mm.

The motorised rolling shutters shall be suitable for electrical motor operation (automatic) as well as manual operation with chain-wheel & hand chain. The rolling shutters shall be provided with mechanical reduction / bevel gear box for operation either mechanically or with electrical device.

7.5.2 Rolling shutter components

Components of Aluminium rolling shutters shall have following specification.

1. Shutter curtain

The shutter curtain shall be fabricated using aluminium alloy profiled slats. Aluminium alloy shall have composition of Magnesium 0.4-0.9 %, Silicon 0.3-0.7 %, Manganese 0.3% (maximum) and remaining Aluminium. Aluminium Alloy shall have UTS (Ultimate tensile strength) – 19 Kg/mm² and Elongation – Min 7%.

The surface of these aluminium alloy shall be micro ribbed with the ends of alternate profiles fitted with end locks to prevent lateral movements of the laths.

The shutter curtains shall have interlocking aluminium alloy slats with integral bottom lock plate.

The non-insulated shutter curtains shall generally be of 80mm x 18mm (minimum size) double-walled /skinned slats and the insulated shutter curtains shall be 80mm x 18mm double-walled / skinned slats (minimum size) with thermal PUF (Polyurethane Foam) insulation packing (within the walls).

The PUF packing shall be tight enough so as to fill all irregular voids and at joints. The PUF shall be non-toxic and fire retardant / self-extinguishing. The PUF density shall not be less than 40 kg / cu. meter and its thermal properties & characteristics shall be in accordance with IS-12436

2. Bracket

The bracket shall be made of mild steel conforming to relevant IS having minimum size of 350 mm x 350 mm x 3 mm thick for clear opening dimensions up to 4000 mm x 4000 mm & 350 mm x 350 mm x 4 mm thick for clear opening dimensions beyond 4000 mm x 4000 mm and up to 5000 mm x 5000 mm.

3. Shaft

MS Pipes used for the suspension shaft of the roller shall be heavy duty pipe suitable for mechanical purposes and shall conform to IS: 1239. Minimum diameter shall be 100mm.

4. Side Guides/ Channels

The side guides/ channels shall be joint less (single piece construction) made of aluminium alloy of minimum 3mm thickness. The guide rails shall be provided with PVC / Rubber / Brush seals to ensure silent shutter travel & effective sealing. Size shall be 105mm x 42mm or as required.

5. Bottom Profile

Aluminium Bottom bar / locking plate shall be minimum 100mm high having a special non-degradable neoprene / rubber profile for providing a complete sealing upon closure.

6. Hood & Side-Motor Cover

The covers shall be made of painted GI sheets not less than 0.8 mm thick. They shall be of rectangular or cylindrical contour depending on the contour of the bracket / end plate. The hood cover shall be stiffened with angle or flat stiffeners at top and bottom edges to retain shape. The hood cover shall be fixed to the bracket plate by means of angle cleats and supported at the top at suitable intervals for preventing sagging. The hood & motor/actuator assembly - covering shall be a water-tight arrangement for ensuring no water seeps through to the internal mechanical & electrical components. Adequate slopes & guide-ways are to be provided to avoid any water accumulation on the hood-covers.

7.5.3 Finishing

All components of rolling shutter except springs and inside of guide channel shall be thoroughly cleaned with a mild non-corrosive chemical to free the substrate of rust, mill-scale, dirt, oil, etc.

Aluminium sections and other visible metallic surfaces shall be electrostatically powder coated (approved colour) to minimum 50 microns. The thickness of powder coating shall be subjected to verification at site (on random basis) as directed by Engineer-in-Charge with appropriate measuring instruments supplied by contractor.

All coated surfaces shall be free from flaking / peeling. Each shutter shall be clearly and legibly marked with the Manufacturer's Name or Trade Mark / Shutter Size / Year of Manufacture.

7.5.4 Electrical Operation of Rolling shutter

The rolling shutters shall be operated by electric motor actuators - operating on 415 Volts, 3-phase or 240 Volts, 1-phase - 50 Hz. AC supply.

All associated electrical components for motor control shall be compatible for working at the above mentioned voltage profile. The motor shall be of side-mounted type installed in alignment with the roller shaft inside the shaft-hood or adjacent to the rolling-shutter box. In either case, the rolling shutter motor & actuator assembly enclosure shall have IP-55 (or better) ingress protection against water & dust. The rolling shutter motor shall be rated for intermittent periodic duty (Duty Type – S3) or intermittent periodic duty with starting (Duty Type – S4). Arrangements shall also be made for emergency manual operation of the rolling shutter with mechanical reduction-gear, wheel & hand-chain override assembly - in the event of failure of the electric equipment or electricity.

For buildings in safe area, all electrical equipment's shall be in weatherproof executive with IP-54 protection for direct drive and IP 44 Protection for indirect drive ingress protection.

For buildings in hazardous are, if specified in Tender/MR, following shall be ensured:

1. For hazardous area buildings, all electrical equipment's such as motor, actuators, push button control stations, PDB/Local panels etc. shall be flameproof type Exd suitable for applicable Gas Group and Temperature Class.
2. All hazardous area equipment shall have test certificates issued by recognised independent test house (CIMFR/ERTL/BASEEFA/LCEI/UL/FM/KLP or equivalent). All indigenous equipment shall conform to Indian standards and shall be certified by recognised testing agencies. All equipment (indigenous & imported) shall have valid statutory approval (e.g. PESO/DGMS etc.) as applicable for the specified location. All indigenous flameproof equipment shall have valid BIS license and marking as required by statutory authorities.

Make of all hazardous area equipment (for hazardous area building) and weatherproof equipment (for safe area building) shall be approved by owner / Engineer-In-Charge before selection & order placement. The motor shall be heavy duty type & sturdy - suitable for lifting shutters weighing up to 600 kilograms. The motors shall have BIS or equivalent approvals & relevant performance guarantee track records. The motor drive unit for the rolling shutter shall be complete with Drive-Chain / Gear, Plate-Wheel, Bush, Drive-Sprockets, mounting base-plates, integrated safety brakes & limit-switches, etc. Ideally all metallic components of the drive system shall be constructed out of non-corrosive high-grade stainless steel. The motor speed shall be regulated with gear drives such that the speed of the shutter (during up & down movement) for indirect drive shall be up to 0.05 m/s. The motor operating time within the intermittent duty cycle shall be long enough to ensure that the motor does not get heated up excessively, thereby resulting in tripping and / or damaging of motor windings for up to three continuous up & down (full height traverse) operation of the rolling shutter.

The motor shall be automatically protected from thermal overload by internal thermal probes / overload relays. The motor shall be compact and motor operation shall be with minimum of noise & vibration. Ideally, the motor controls (including motor-starter / over-load protections / contactors / etc) shall be placed within the motor-actuator enclosure.

The automation of the shutter shall have local control with a directional push button control station flush-mounted with the wall-surface, with 3 buttons marked UP; DOWN and STOP. The STOP Button must be of Mushroom-head type with lockable arrangement & push to release type. All the push-buttons shall be of latching type (single press & release) – without the need to continuously press the buttons during the traverse time of the shutter. The shutter traversing shall be prohibited if the STOP button is pressed & locked. The push-button unit shall have an enclosure with a minimum degree of IP-44 dust & water protection

7.5.5 Installation

Rolling shutters shall be installed true to the plane and fixed in the opening ensuring smooth operation as per IS 6248.

All fixing / mounting accessories shall be made of stainless steel only.

All necessary control wiring / cabling for the side-motor with the limit switches / controller panel shall be done with 3 / 5 core X 2.5 sq. mm. PVC insulated multi-stranded Copper Conductor armoured and flame retardant Low Smoke (FRLS) cables. All power cabling from PDB to the side motor shall be with 3 core X 4 sq. mm (minimum) Cu conductor, FRLS cable. Only fire rated & PVC insulated cables / wires with multi-stranded copper conductors shall be used for internal wiring of the motor / actuator / push-button. All cabling & wiring shall be concealed type with heavy-duty PVC conduits. Works include termination of the incoming power cable from the owner's Main Power Distribution Board to the motor / actuator /

controller unit & all outgoing power & control cables from the controller panel to individual electrical components with supply & installation of cable glands & copper lugs of adequate sizes.

7.5.6 Mandatory & commissioning spares

The entire consignment of motorized rolling shutters for the shed / buildings shall be supplied with the following mandatory spares for each rolling shutter.

1. One set of the complete motor / actuator drive unit (of each rating) – duly assembled with limit switches, drive-chain / worm-gear, plate-wheels / bush / sprockets & mounting base-plates.
2. One set of motor controller (PCB / Controlling Unit).





8.0 MEASUREMENT

Doors, windows, ventilators and rolling shutters shall be measured in the following manner.

Pressed steel frames for doors	Length (vertical and horizontal members) in Running metres (RM)
Pressed steel door shutter	Actual shutter area in square metre (SqM)
Steel Windows/ ventilators with MS sections	Actual area of window/ ventilator in square metre (SqM)
Aluminium Doors/windows/ventilators	Aluminium sections by weight (Kg) Glazing - Actual area in square metre (SqM)
Rolling shutters	Actual area of Rolling shutter in square metre (SqM)
Loose hardware	In numbers

पलस्तर एवं पॉइन्टिंग का मानक विनिर्देशन

STANDARD SPECIFICATION FOR PLASTERING & POINTING

7	31.05.23	REVISED & ISSUED AS STANDARD SPECIFICATION	 SANDEEP SHARMA	 GURSHARAN JEET KAUR	 SAMIR DAS	 SANJAY MAZUMDAR
6	31.05.17	REAFFIRMED & ISSUED AS STANDARD SPECIFICATION	AM	JS/ JKB	R. SRIVASTAVA	R. NANDA
5	05.04.12	REVISED & ISSUED AS STANDARD SPECIFICATION	AM	SM	JKB	D. MALHOTRA
4	21.03.07	REVISED & ISSUED AS STANDARD SPECIFICATION	SD	JKB	ARVIND KUMAR	V. CHATURVEDI
3	10.03.99	REAFFIRMED AS STANDARD SPECIFICATION	SD	MLB	SCJ	AS
2	16.03.94	REVISED & ISSUED STANDARD SPECIFICATION	JS	JS	AKG	AS
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
Approved by						



Abbreviations:

ASTM :	American Standards of Testing of Materials
BS :	British Standards
EN :	European Standards
IS :	Indian Standards
ISO :	International Organization for Standardization
NBC :	National Building Code of India

Architecture Standards Committee

Convener : Mr. Samir Das

Members : Mr. Rajesh Gujral
Mr. Anish Kundu
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Ms. Maitrayee Majumdar (Strl)
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1.0 GENERAL

- 1.1 This specification covers requirements of plastering and pointing in civil work, on building or Architectural or structural elements and as interior or exterior finishing or decorations etc.
- 1.2 Unless otherwise specifically mentioned in design basis, job specification, drawings, item descriptions etc. all masonry, block work, RCC surfaces shall be plastered.

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, NBC etc. conformity with any of the similar codes is acceptable.
- 2.2 Reference codes and standards:

Standards	Document Title
IS: 1542	Sand for Plaster - Specification
IS: 1661	Code of Practice for application of cement and cement- lime plaster finishes
IS: 2114	Code of practice for laying in-situ terrazzo floor finish
IS: 2250	Code of Practice for Preparation and Use of Masonry Mortars
IS: 2386 (Part 2)	Methods of test for aggregates for Concrete Part II: Estimation of Deleterious materials and organic impurities
IS: 2402	Code of Practice for External Rendered Finishes
IS: 2542 (Part 1)	Methods of test for Gypsum plaster, Concrete and products, Part I - Plaster and Concrete
IS: 2547 (Part 2)	Specification for Gypsum building plasters, Part II - Premixed lightweight plasters.
IS: 2645	Integral waterproofing compounds for Cement Mortar and Concrete – Specification.
IS: 4031 (Part 1)	Methods of physical tests for hydraulic cement.

3.0 TYPE AND THICKNESS OF PLASTERING

- 3.1 Plastering shall be of plain cement plastering or plain cement plastering with waterproofing compound or Gypsum plastering or ready-mix plastering as mentioned in design basis, job specification, drawings, item descriptions etc.

- 3.2 Unless otherwise specified in design basis, drawings, item descriptions, job specifications etc, the external surfaces shall be plastered with or plain cement plastering with waterproofing compound and internal surfaces shall be plastered with plain cement plastering.
- 3.3 Unless otherwise specified in design basis, drawings, item descriptions, job specifications etc, thickness of plastering shall be as per following table.

Type of plaster	Surface	Average thickness
Plain cement Plaster	Plumb surface of the internal masonry/ all block work walls & RCC Columns coming in line (flush) with this side of wall.	12 mm
Plain cement Plaster	Rough side of the internal masonry/ all block work walls & RCC Columns coming in line (flush) with this side of wall.	15mm
Plain cement Plaster with waterproofing compound	External surface	18 mm
Plain cement Plaster	Internal RCC surface	06 mm
Gypsum Plaster	Plumb surface of the internal masonry/ all block work walls & RCC Columns coming in line (flush) with this side of wall.	12 mm
Gypsum Plaster	Rough side of the internal masonry/ all block work walls & RCC Columns coming in line (flush) with this side of wall	12 -15 mm
Gypsum Plaster	Internal RCC surface	06 mm
Ready mix plaster	Similar to Plain cement plaster	Similar to plain cement plaster

Note:

However, if the undulation in the surface is beyond proper finishing with specified thickness of plaster, extra thickness of plaster shall be applied as required for proper finish without any extra cost.

4.0 MATERIALS

4.1 Cement

Cement shall conform to 'Standard Specification for Civil and Structural Works- Materials' (Structural Specification no. 6-68-0002)

4.2 Sand

Sand for plaster and pointing shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these and shall conform to IS: 1542. Sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain any appreciable amount of silt, day bails or pellets. Sand shall not contain harmful impurities such as iron pyrites, coal particles, lignite, mica shale etc in such form or in quantities as to affect adversely the hardening, strength or durability of the mortar.

The maximum quantities of clay, fine silt, fine dust and organic impurities in the sand shall not exceed the following limits:

Clay, fine silt and fine dust when determined in accordance with IS 2386 (Part 2):

- a. In natural sand or crushed gravel sand & crushed stone sand: Not more than 5% by mass
- b. Organic impurities when determined in accordance with IS 2386 (Part 2): Color of the liquid shall be lighter than that indicated by standard specified in IS 2386 (Part-2)

Grading of sand for use in Plaster shall conform to IS 1542 (as below)

IS sieve designation	Percentage passing
10mm	100
4.75mm	95 to 100
2.36mm	95 to 100
1.18mm	90 to 100
600 micron	80 to 100
300 micron	20 to 65
150 micron	0 to 15

4.3 Water

Water for plastering and pointing shall conform to 'Standard Specification for Civil and Structural Works- Materials' (Structural Specification no. 6-68-0002)

4.4 Cement Mortar

Cement mortar shall conform to 'Standard Specification for Civil and Structural Works- Brick Masonry' (Structural Specification no. 6-68-0009) unless otherwise mentioned.

4.5 Cement Mortar with Waterproofing Compound

Waterproofing compound shall conform to IS: 2645 of approved make.

4.6 Gypsum Plaster

Gypsum plaster shall conform to IS 2542 (Part I) and IS 2547 (Part II). The plaster shall consist of retarded hemihydrate gypsum plaster and light weight aggregate. Other additions may be incorporated to impart desired properties.

4.7 Ready Mix Plaster

Ready Mix Plaster shall be ready mix cement plaster rendered with polymer additives, well graded sand and fillers. Compressive strength of the material shall be minimum 7.5 Mpa in 28 days as per IS: 2250.

Ready Mix Plaster shall be pre packed material requiring only water addition at site.

5.0 PLAIN CEMENT PLASTER

- 5.1 The mortars of specified mix as per the specifications of 'Cement Mortar' (Refer clause 4.4) shall be used for plain cement plaster. Proportions of ingredients of cement mortar for various thicknesses of plaster shall be as per following table:

20mm thick plaster	1 cement: 6 sand (by volume), in two layers
18mm thick plaster	1 cement: 6 sand (by volume), in two layers
15mm thick plaster	1 cement: 4 sand (by volume)
12mm thick plaster	1 cement: 4 sand (by volume)
06mm thick plaster	1 cement: 4 sand (by volume)

6.0 CEMENT PLASTER WITH WATERPROOFING COMPOUND

- 6.1 The mortars of specified mix as per the specifications of 'Cement Mortar' (Refer clause 4.4) shall be used. Proportions of ingredients of cement mortar for various thicknesses of plaster shall be as per clause no 5.1
- 6.2 Waterproofing compound shall be mixed to cement mortar as recommended by the approved Manufacturer but @ 3% by weight as minimum.

7.0 SAND FACE PLASTER

- 7.1 Sand face plaster shall be 20mm thick consisting of 13 mm thick under layer and 7 mm thick top layer.
- 7.2 Under layer shall be 13 mm thick (1 cement: 4 sand, by volume) plain cement plaster.
- 7.3 Top layer shall be 7 mm thick (1 cement: 2 sand, by volume, granule size 2 to 2.5mm) plain cement plaster.
- 7.4 The mortars of specified mix as per the specifications of 'Cement Mortar' (Refer clause 4.4) shall be used for plain cement plaster.
- 7.2 Application of sand face plaster shall be as described in 'two-layer plaster work' in clause no. 9.7. The surface of the sand face plaster shall be finished rough with sponge or as directed by the Engineer-in-charge.

8.0 EXPOSED AGGREGATE FINISH

- 8.1 Exposed aggregate finish plaster shall consist of 12 mm thick under layer and 20 mm thick top layer.
- 8.2 Under layer shall be 12 mm thick plain cement plaster (1 cement: 4 coarse sand, by volume) finished rough. The mortars of specified mix as per the specifications of 'Cement Mortar' (Refer clause 4.4) shall be used for plain cement plaster. The under layer shall be applied in accordance with 'One layer plaster work' described in clause no. 9.6.
- 8.3 Top layer shall be 20 mm thick admixture of white cement and grey cement (mix. ratio 1:1 by volume) mixed with white/colored marble chips/pebbles (as required for desired shade/ colour

of the finished surface) of 6mm to 12mm nominal size. Mix ratio shall be 1 cement: 1 marble chips/pebbles by volume. Marble dust @ 15% by volume with pigment (conforming to IS:2114, as required for obtaining desired colour/ shade of the finished surface) shall be added to the admixture.

The pebbles to be used shall be well washed and drained. The admixture shall be thrown wet on to the under layer while it is still plastic using strong whipping motion at right angles to the face of the wall.

One coat of neat cement slurry @ 2.75 kg cement per square meter of area shall be applied on to the under layer to receive the top layer.

The whole plastering shall be laid in panels of maximum 1200mm x 1200mm size or as per drawing with 12mm x 20mm grooves in between formed by holding removable wooden batons over the under layer.

Loose mortar etc. on the top surface shall be cleaned/removed by brushing/washing/spraying with water jet after initial setting of mortar.

9.0 APPLICATION OF PLASTER

9.1 Finishing

Plastered surface shall be plumb, without any undulations and defects such as cracks etc. Patterns/ grooves etc. shown in the drawing shall be provided. Any cracks, damages, any part of work which sound hollow when tapped or found damaged or defective otherwise shall be cut out in rectangular shape and redone as directed by Engineer-in-charge

9.2 Preparation of Background Surface

- 9.2.1 The background surface shall be cleaned of all dust, loose mortar droppings, traces of algae, efflorescence and other foreign matter by water or by brushing.
- 9.2.2 Smooth surfaces shall be roughened by wire brushing or hacking for non-hard and hard surfaces respectively.
- 9.2.3 Projections on surfaces shall be trimmed wherever necessary to get even surfaces. In case of brick/stone masonry, raking of joints shall be carried out wherever necessary.
- 9.2.4 The background surface shall be allowed to dry out for sufficient period before carrying out the plaster work. The background surface shall not be soaked but only damped evenly thereafter before applying the plaster.
- 9.2.5 In case of concrete work, projecting blurs of mortar formed due to the gaps of joints in shuttering shall be removed. Such surface shall be scrubbed clean with wire brushes. The surface shall be pock marked with a pointed tool at spacing of not more than 50 mm centers, the pocks being made not less than 3 mm deep to ensure a proper key for the plaster. The surface shall be washed off and cleaned of all oil, grease etc. and well wetted before the plaster is applied.

9.3 Sequence of Operations

- 9.3.1 The surfaces to be plastered, shall first be prepared as described in 'Preparation of background surface' in clause no 9.2
- 9.3.2 For external plaster, the plastering operations shall be started from the top floor and carried downwards.
- 9.3.3 The first under layer shall then be applied to ceilings. After the ceiling plaster is complete and scaffolding for the same removed, plastering on wall shall be started.
- 9.3.4 After a suitable time interval, the secondary layers if required shall be applied. After a further suitable time interval, the finishing coat shall be applied first to the ceiling and then to the walls.
- 9.3.5 Plastering of cornices, decorative features, etc. shall be completed before the finishing coat is applied.

9.4 Scaffolding/Staging

Scaffolding/staging for plastering/pointing shall be as per 'Standard Specification for Civil and Structural Works- Brick Masonry' (Structural Specification no. 6-68-0009)

9.5 Chicken Wire Mesh

150mm wide, closely knit, 20-gauge chicken wire mesh stretched tight and fixed with G.I. "U" type nails shall be provided at all the masonry/ block work and RCC joints.

9.6 One Layer Plaster Work

- 9.6.1 To ensure even, specified thickness, plaster of 150 mm x 150 mm shall be first applied horizontally and vertically at not more than 2-meter interval over the entire surface to serve as gauges.
- 9.6.2 The surface of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall be brought to true surface by working with a wooden straight edge reaching across the gauges with small upward and sideways movements at a time.
- 9.6.3 Finally the surface shall be finished off true with a trowel or wooden float to obtain a smooth texture. Excessive trowelling or overworking the float shall be avoided.
- 9.6.4 All corners, arises. angles and junctions shall be truly vertical/ horizontal and shall be carefully finished. Rounding or chamfering of corners, arises, junctions etc. shall be carried out with proper templates to the size required.
- 9.6.5 In suspending the work, the plaster shall be left cut clean to line, both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped clean and wetted before plastering the adjoining area.

9.6.6 Plastering work shall be closed on the border of the wall and nearer than 150 mm to any corners or arises and shall not be closed on the body of the features such as plaster bands, cornices nor at the corners or arises.

9.7 Two Layer Plaster Work

9.7.1 The first or under layer of the specified thickness shall be applied as described in clause no. 9.6.

9.7.2 Before the first coat hardens, surface of it shall be beaten up by edges of wooden tapers and close dents shall be made on the surface. The subsequent coat shall be applied after this coat has been allowed to set for 3 to 5 days depending upon weather conditions. The surface shall not be allowed to dry during this period.

9.7.2 The second layer shall be complete to the specified thickness in the same manner as for first layer.

9.8 Curing of plaster

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of 7 days. During this period the plaster shall be suitably protected from all damages at the contractor's expense by such means as approved by the Engineer-in-charge. The date of execution of plastering shall be marked on the plastering to ensure the proper duration of curing.

10.0 GYPSUM PLASTER

10.1 Gypsum plastering shall be done using premixed gypsum plaster and aggregates as mentioned in clause no. 4.6

10.2 Preparation of Gypsum plaster shall be in accordance with approved Manufacturer's standard and recommended practice. The powder (gypsum plaster) shall be mixed with clean water in clean plastic buckets to avoid mixing with impurities, ensuring thorough mixing by help of mixing rod so as to avoid formation of lumps and unmixed residues. The water to plaster ratio should be maintained as per approved manufacturer's specification.

10.3 Application of Gypsum plaster shall be in accordance with clause nos. 9.1 to 9.7

10.4 Curing

There is no requirement of curing. Gypsum plaster dries in 3 days, after which painting can be done directly over the finished surface.

11.0 READY MIX PLASTER

11.1 Ready-mix plastering shall be done using pre packed plaster ingredients as mentioned in clause 4.7

11.2 The powder (ready mix) shall be mixed with clean water, preferably in clean plastic buckets to avoid mixing with impurities, ensuring thorough mixing by help of mixing rod or mechanical

stirring for 2-3 minutes as to avoid formation of lumps and unmixed residues. The water to plaster ratio shall be maintained as per approved manufacturer's specification.

- 11.3** Application of ready-mix plaster shall be in accordance with clause nos. 9.1 to 9.7. The plaster mix shall be applied within the time (after preparation of the mix) recommended by the approved Manufacturer. Curing shall be done in accordance with clause no 9.8 or as recommended by the approved Manufacturer as approved by the Engineer-In-Charge.

11.4 Curing

Curing shall be done in accordance with clause no 9.8 or as recommended by the approved Manufacturer and as approved by the Engineer-In-Charge.

12.0 POINTING

Pointing shall be of the type specified such as flush, cut or weather struck, raised and cut etc.

12.1 Preparation of Base Surface

The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunk surface of the finished pointing or from the edge of the brick shall be less than 20 mm.

12.2 Cement Mortar

Cement Mortar shall be in accordance with the specifications of cement mortar described in clause no. 4.4.

12.3 Application of Mortar and Finishing

The cement mortar (1 cement: 4 sand, by volume) shall be pressed into the raked out joints with a pointing trowel according to the type of pointing specified. The mortar shall be spread over the corner edges or surfaces of the masonry. The pointing shall then be finished with the pointed tool. The superfluous mortar shall be cut off from the edges.

12.4 Flush Pointing

The cement mortar shall be pressed into joints and shall be finished off flush and leveled. The edges shall be neatly trimmed with trowel and straight edges.

12.5 Cut or Weather Struck Pointing

The mortar shall first be pressed into joints. The top of the horizontal joints shall then be neatly pressed back by about 15 mm with the pointing tool so that the joint is sloping from top to bottom. The vertical joint shall also be similarly pointed. The junctions of vertical joints with the horizontal joints shall be at true right angles in case of brick & coursed rubble masonry.

12.6 Raised and Cut Pointing

This type of pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm and width 10 mm more as directed. The pointing shall be finished to a smooth but hard surface.

12.7 Curing

Curing shall be as described in clause no. 9.8





13.0 MEASUREMENT

13.1 Plastering shall be measured by the area of actual plastered surface.

13.2 Pointing shall be measured by the actual area of the surface on which pointing is done.

पुताई, रंगीन पुताई, डिस्टेम्परिंग, पैन्टिंग
और पालिशिंग का मानक विनिर्देश

STANDARD SPECIFICATION
FOR
WHITE/ COLOUR WASHING,
DISTEMPERING, PAINTING AND
POLISHING

7	11.05.23	REAFFIRMED AND ISSUED AS STANDARD SPECIFICATION	 TUSHAR SRIVASTAVA	 ATUL GUPTA	 SAMIR DAS	 SANJAY MAJUMDAR
6	25.08.17	REVISED & ISSUED AS STANDARD SPECIFICATION	AM	JS/ JKB	RAJAN SRIVASTAVA	R. NANDA
5	09.04.12	REVISED & ISSUED AS STANDARD SPECIFICATION	TS	JS	JKB	D MALHOTRA
4	21.03.07	REVISED & ISSUED AS STANDARD SPECIFICATION	SD	JKB	ARVIND KUMAR	V. CHATURVEDI
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

ASTM :	American Society for Testing and Materials
BS :	British Standards
IS :	Indian Standards
NBC :	National Building Code of India
BIS :	Bureau of Indian Standards
EN :	European Standards
RCC :	Reinforced Cement Concrete
VOC :	Volatile Organic Compounds
ISO :	International Organization for Standardization
NFPA :	National Fire Protection Association
POP :	Plaster Of Paris

Architecture Standards Committee

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Members : Mr. Rajesh Gujral
Mr. Anish Kundu
Mr. Sandeep Sharma
Mr. Maitrayee Majumdar (Strl)
Mr. Charanjeet Singh (Proj.)
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1.0 GENERAL

- 1.1 This Specification covers requirements of White/ Colour Washing, Distempering, Painting & Polishing on building works as interior or exterior finishing or decorations etc.
- 1.2 Unless otherwise specifically mentioned in design basis, job specification, drawings, item descriptions etc. all plastered, wooden and bare metal surfaces shall be painted.
- 1.3 For energy efficient and green or sustainable buildings job specification, item descriptions specific to these buildings shall be referred.

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
IS 2395	Code of practice for painting concrete, masonry and plaster surfaces.
IS 6278	Code of practice for white washing and colour washing.
IS 712	Specification for building limes
IS 55	Specification for Ultramarine blue for paints.
IS 63	Specification for whiting for paint and putty.
IS 427	Distemper (dry), colour as required.
IS 428	Washable Distemper
IS 15489	Paint, Plastic Emulsion- Specification
IS 2338 Part-1	Code of practice for finishing of wood, and wood based materials. Part-1 : Operations & workmanship
IS 2338 Part-2	Code of practice for finishing of wood, and wood based materials. Part-2 : Schedule
IS 5410	Cement paint, colour as required.
IS 2524 Part-1	Code of practice for painting non-ferrous metals in buildings. Part-1 : Pre-treatment
IS 2524 Part-2	Code of practice for painting non-ferrous metals in buildings. Part-2 : Painting
IS 1477 Part-1	Code of practice for painting ferrous metals in buildings. Part-1 : Pre-treatment
IS 1477 Part-2	Code of practice for painting ferrous metals in buildings. Part-1 : Painting
IS 384	Brushes, paints and varnishes, flat.
IS 486	Brushes, sash, tool, for paints and varnishes.
IS 110	Ready mixed paint, brushing, grey filler enamels for use over primers
IS 3585	Ready mixed paint, aluminium brushing priming water resistant for wood work.
IS 110	Ready mixed paint, brushing, grey filler for enamels for use over primers
IS 2395 Part-1	Painting of concrete, masonry & plastered surface, code of practice. Part-1 : Operations and workmanship
IS 2395 Part-2	Painting of concrete, masonry & plastered surface, code of practice

	Part-2 : Schedule
IS 3536	Ready mixed paint, brushing, wood primer - Specification
IS 109	Specification for ready mixed paint, finishing, priming, plaster, to indian standard colour no. 361 light stone and no. 631 light grey, white and off - White
IS 2074	Ready mixed paint air drying red oxide zinc chrome priming specification

3.0 TYPES OF PAINTS /POLISHING

- 3.1 Type of Painting/ polishing shall be as mentioned in design basis, job specification, drawings, item descriptions etc.
- 3.2 Unless otherwise specified in design basis, drawings, item descriptions, job specifications etc, Type of Painting/ polishing shall be as per following table.

Surface	Paint/ polishing type
Internal Masonry/ Block work/ RCC wall and ceiling surface	Interior grade Acrylic Emulsion paint
External Masonry/ block work/ RCC/ plastered surface	Exterior grade Acrylic Emulsion paint
Local/ Hard wood, engineered wood and bare metal surface	Synthetic Emulsion paint
Teak or superior wood surface	French polishing

Note :

For energy efficient and green or sustainable buildings job specification, item descriptions specific to these buildings shall be referred.

4.0 MATERIALS

- 4.1 All materials required for the execution of painting work shall be obtained direct from approved manufacturers and shall be brought to the site in makers drums, bags etc. with seals unbroken.
- 4.2 In case of ready mixed paints, thinning if necessary, the brand of thinner shall be as per recommendations of the manufacturer.
- 4.3 Wall putty shall be minimum 2 mm thick and white cement and polymer based wall putty type.
- 4.4 Primer shall be compatible with the finishing paint.
- 4.5 The allowable limits of quantity of VOC (Volatile Organic Compounds) in different types of paints and primer shall be as defined in the following parameters:

A. Primer

Type of Primer		Allowable VOC Content
Pink & Grey primer on wood	:	< 50 gms/ltr
Ready mix red oxide zinc chromate primer	:	< 250 gms/ltr

Water thinnable cement primer on wall	:	<50 gms/ltr
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B. Paints

Type of Paint	:	Allowable VOC Content
Acrylic Emulsion	:	<50 gms/ltr
Plastic Emulsion	:	<50 gms/ltr
Acrylic Distemper	:	<50 gms/ltr
Synthetic Enamel	:	<150 gms/ltr

5.0 WORKMANSHIP

- 5.1 Colour/ texture of the wash/ distemper/paint/ polishing shall be as approved by the Engineer-in-charge. Sample painting shall be done as directed by the Engineer-In- charge for approval/ selection of the colour/ texture.
- 5.2 Washed/ distempered/ Painted/ polished surface shall be even and uniform without patches, marks, without any defect and of finish as desired by the Engineer-In-Charge. Any defect or shortcomings in the finishing shall be rectified to the satisfaction of the Engineer –In- Charge.
- 5.3 Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface which is being white washed.

For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

Where ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls.

For ceiling, proper stage scaffolding shall be erected.

- 5.4 Surface preparation shall be done as mentioned for various type of wash/ distemper/paint/ polishing. The surface affected by moss, fungus, algae, efflorescence shall be treated in accordance with IS: 2395.
- 5.5 Preparation and application of wash/ distemper/paint/ polishing shall be done as mentioned for various types. However, in case of excessive un-even surfaces, punning with Plaster of Paris shall be done on the surface if and as directed by the Engineer-In-Charge.
- 5.6 Paint shall be applied by brushing or spraying or by using rollers as directed by the Engineer-In-Charge. The brushing operations are to be adjusted to the spreading capacity advised by the manufacturer. During painting, every time after the paint has been worked out of the brush bristles, the bristles shall be opened up by striking the brush suitably.

Spray machine used may be of high pressure type or low pressure depending on the nature and location of work. After work, the brushes shall be completely cleaned of paint and shall be hung in a thinner if intended to be used afterwards. The spray guns shall be cleaned thoroughly after every break in work. The paint/ polish containers, when not used shall be kept close and free from air.

- 5.7 After the finishing of work, the adjacent surfaces not intended to be washed/ distempered/painted/polished shall be thoroughly cleaned of all paint patches and shall be

finished in accordance with surface finishing of such surfaces. Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed, shall be protected from being splashed upon. Splashing and droppings, if any shall be removed by the contractor at his own cost and the surfaces cleaned.

- 5.8 Number of coats of paint as mentioned is the minimum number of coats. Additional coats shall be provided as required for obtaining desired colour and finishing.
- 5.9 The operation for each coat shall consist of stroke of the brush/ roller 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.
- 5.10 The painting on ceiling should be done prior to that on walls.

6.0 WHITE WASHING

White washing in general shall conform to IS 6278.

6.1 Preparation of Surface

The surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied. Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of lime wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 sq. m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS: 2395.

6.2 Preparation of White Wash

The fat lime conforming to IS: 712 shall be slaked at site and shall be mixed and stirred with about 5 litres of water for 1 kg. of unslaked lime to make thin cream. This shall be allowed to stand for a period of 24 hours and then shall be screened through a clean coarse cloth. 4 kg of gum dissolved in hot water shall be added to each cubic metre of lime cream. Approved quality ultramarine blue conforming to IS 55 @ 3 gram per kg. of lime shall also be added to the solution. The whole solution shall be stirred thoroughly before use.

6.3 Application

White wash shall be applied with "MOONJ" brush to the specified number of coats. Minimum number of coats shall be three. 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.

7.0 COLOUR WASHING

- 7.1 Preparation of Surface shall be similar to clause no 6.1

7.2 Preparation of colour wash

Sufficient quantity of colour wash enough for the complete job shall be prepared in one operation to avoid any difference in colour. The basic white wash solution shall be prepared in accordance with clause no 6.2. Mineral colours of approved shade and quality not affected by lime shall be added to the white wash solution in proportions as directed by Engg.in-charge. Solid lumps etc. in the colour powder shall be ground to fine powder, sieved and mixed evenly and thoroughly to the white wash solution. No colour wash shall be done until a sample of the colour wash of the required tint or shade has been got approved from the Engineer-in-Charge. The colour shall be of even tint or shade over the whole surface.

7.3 Application

Colour wash shall be applied with "MOONJ" brush to the specified number of coats. Minimum number of coats shall be three. 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.

For new work, a priming coat of white wash with lime or with whiting shall be provided. Three or more coats of colour wash shall then be applied on the entire surface till it represents a smooth and uniform finish.

For old work, after the surface preparation, a coat of colour wash shall be applied over the patches and repairs. Then coats of colour wash shall be applied over the entire surface. The colour washed surface shall present a uniform finish.

The finished dry surface shall not be powdery and shall not readily come off on the hand when rubbed.

8.0 ACRYLIC DISTEMPER

8.1 Preparation of Surface

The surface shall be thoroughly cleaned of dust, old finish by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of Plaster of Paris (POP) mixed with water on the entire surface including filling up the undulations and then sand papering the same after it is dry.

In case of distempering over existing distempered surface, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc.

Pitting in plaster shall be made good with plaster-of-paris mixed with the colour to be used. The surface then shall be rubbed down again with a fine grade sand paper and made smooth. A coat of distemper shall be applied over the patches. The surface shall be allowed to dry thoroughly before the regular coat of distemper is allowed.

8.2 Priming Coat

The priming coat shall be with distemper primer or cement primer, as required. If the wall surface plaster has not dried completely, cement primer shall be applied before distempering the walls. But if distempering is done after the wall surface is dried completely, distemper primer shall be applied. For old work no primer coat is necessary.

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.

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

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.

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 grinding 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.

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 smoothed with abrasive paper.

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.

Where two coats of varnish are applied, the first coat shall be a hard drying under coating or flattening varnish which shall be allowed to dry hard and then be flattened 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 flattening 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.



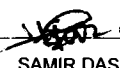

A pad of woollen cloth covered by a fine cloth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may 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 dampened 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

7	04.03.22	REVISED & ISSUED AS STANDARD SPECIFICATION	 ANISH MAHALA	 ANISH KUNDU	 SAMIR DAS	 SANJAY MAZUMDAR	
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						Approved by	

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

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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.

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.

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 purlins 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.

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

Eaves piece	0.71 mm thick, minimum 150 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)

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

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.

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) / Zinalume 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)

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.

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	<p>The sheets shall be asbestos free and reinforced by organic and /or inorganic synthetic fibres.</p> <p>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</p>
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	<p>siliceous (includes ground silica, pulverized fuel ash and amorphous silica) and calcareous material reinforced by organic and /or inorganic synthetic fibres.</p> <p>Pozzolanic materials process aids, fillers and pigments which are compatible with the fibre reinforced cement may be added.</p> <p>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.</p>
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	<p>The sheets shall be free from cracks, chipped edges or corners and other damages.</p> <p>Top exposed surface shall have pre-painted finish with minimum 30 micron thick exterior grade premium quality acrylic emulsion paint.</p> <p>Bottom surface shall have factory finish.</p>

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

- 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.

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

प्री-इंजीनियर्ड भवन
का मानक विनिर्देशन
(वास्तुकला)

STANDARD SPECIFICATION
FOR
PRE-ENGINEERED BUILDING
(ARCHITECTURAL)

1	09.03.26	REVISED & ISSUED AS STANDARD SPECIFICATION	PIYALEE DAS	ATUL GUPTA	ANISH KUNDU	NALIN KUMAR
0	01.06.20	ISSUED AS STANDARD SPECIFICATION	ATUL GUPTA	SAMIR DAS	RAJANJI SRIVASTAVA	SUNIL KUMAR SAXENA
Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

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

Architecture Standards Committee

Convenor: Mr. Anish Kundu

Members: Mr. Sandeep Sharma
Ms. Maitrayee Majumder (Strl)
Mr. Charanjeet Singh (Projects)
Mr. Indrajit Neog (Construction)
Ms Gursharan Jeet Kaur
Mr. Atul Gupta
Mr. Anish Mahala

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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, fascia 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.

- 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/ paneling for balance height. Low height masonry wall/ block 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 (aerial and eye-level views showing roof and all sides). The approved design shall be adopted for

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 fascia 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, fascias, 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 & material of these shall be similar to the top sheet of roofing/ side sheeting/ cladding/ panelling.

3.12 Maintenance Philosophy

- 3.12.1 Roof access and maintenance philosophy shall clearly incorporate provisions for safe and regular inspection, maintenance, and cleaning of the roof.
- 3.12.2 Detailed arrangements for permanent access systems such as cat ladders, walkways, maintenance hooks, lifeline systems, and safety nets shall be provided.
- 3.12.3 All necessary fall-protection measures and safety arrangements shall be designed and detailed to ensure safe access to all serviceable roof areas, in compliance with applicable statutory requirements and relevant latest standards including the National Building Code of India and standards issued by the Bureau of Indian Standards.

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, fascias, 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 : <ul style="list-style-type: none"> - Floor plans, Roof Plan - Site Plan - Sections - Elevations - 3D rendered views
2	Architectural construction drawings including: <ul style="list-style-type: none"> - 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
8	Drawings and documents for roof access and maintenance philosophy shall include provisions for regular maintenance and cleaning, along with details of safety nets, maintenance hooks, cat ladders, and other necessary safety arrangements.

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 coated Zinc aluminum 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 metal sheet similar to the top sheet of roofing/side sheeting/cladding/paneling 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 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.

8.4.3 If not mentioned otherwise, louvers in the sheeting/ cladding/ paneling shall be of similar to the top sheet of sheeting/ cladding/ paneling

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.

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

उपस्कर एवं यंत्रों की स्थापना हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR ERECTION OF EQUIPMENT & MACHINERY

4	30.03.2019	Reaffirmed & Reissued	RJ	MI	RP	RKT
3	21.01.2013	Revised & Reissued	MA	RS	VK	DM
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Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
Approved by						

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

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Mr RB Bhutda (EWS)
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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.

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.

- 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.

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 coal tar 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.

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. In case 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.

- 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.

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.

- 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

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.

- 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.

4.3 Hydrotesting of Shell and Tube Exchangers including Condensers

- 4.3.1 These shall be 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.

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

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.

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 provided 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 outlined 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.

- 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 manufacturer's 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.

- 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, diaphragm, screw, gear type etc.). Induced draft fan, forced draft fan, air blowers, pumps (centrifugal, reciprocating, diaphragm, 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.

6.1 Grout (Material)

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

6.1.1 Non-Shrink Grout

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

It shall have the following features:

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

It should have the following physical properties:

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

6.1.2 Epoxy Grout

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

It should have the following physical properties :

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

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.

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

पाइपिंग के निर्माण के लिए वेल्डिंग विनिर्देश

WELDING SPECIFICATION FOR FABRICATION OF PIPING

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

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)
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Dr. Arijit Roy (SMMS)
Mr. Prabhakar Chowdhary (SMMS)
Mr. Lokesh Singh Jangpangi (Piping)

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1.0 GENERAL

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

The welded pipe joints shall include the following:

- a) All pipe joints, longitudinal butt welds, circumferential butt welds and socket welds.
- b) Attachments of forgings, flanges and other supports to pipes.
- c) Welded manifold headers and other sub-assemblies.
- d) Welded branch connections with or without reinforcing pads.
- e) Joints in welded/fabricated piping components.
- f) The attachments of smaller connections for vents, drain drips and other instrument tapings.

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.

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.

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.

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.

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.

- (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

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.

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.

- 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.

- (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.

- (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^o to 50^oC.

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.

- (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.

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 :

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						Average	Remarks
				As per code, max./avg.	1	2	3	4	5		

D. Chemical Analysis Results

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

E. Fillet Weld Test Results :

Base Materials :

Sl. No.	Batch no./ identification no.	Size of electrode	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 :

	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
(CONTRACTOR)

REVIEWED BY
(CONTRACTOR)

APPROVED BY
(EIL/OWNER)

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. <u>General Details</u>	<u>Other Details</u>
Name of the Equipment : _____	Type of Heating : Elec. Res./ Induction (Tick mark applicable method)
	Maximum Permissible Temp at Uncovered Parent Metal _____
	Width of heated band _____
	Width of Insulation _____
Material : _____	No. of Thermo 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 _____

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 spacing 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 _____

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. _____

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

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 _____

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.

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)

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

SHEET 1 OF 3

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 _____

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).

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

<u>Variable</u>	<u>Record Actual Values Used in Qualification</u>	<u>Qualification Range</u>
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	_____	_____

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.

**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)

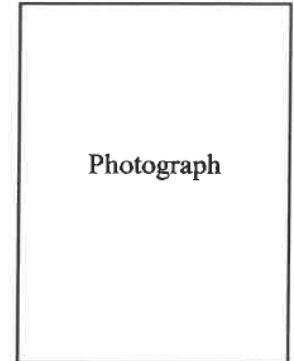
Signature of LSTK CONTRACTOR/Agency with Seal

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.

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)



Approved by:

Employer's Signature with Seal

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

EXHIBIT – I: ULTRASONIC TESTING (UT)

- 1.0 INTRODUCTION
- 2.0 REFERENCE DOCUMENTS
- 3.0 AUT SYSTEM
- 4.0 COUPLANTS
- 5.0 CALIBRATION/DEMONSTRATION BLOCK
- 6.0 CALIBRATIONS
- 7.0 PROCEDURE
- 8.0 TRAINING AND QUALIFICATION
- 9.0 EVALUATION AND ACCEPTANCE CRITERIA

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 ≥ 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.

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.

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.

- (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 $\pm 5\%$ 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

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 sensitivity 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

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 are 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 beam 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 μ Sec 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 \geq 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.

- 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.

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.

EXHIBIT – J: COMPUTED RADIOGRAPHY

- 1.0 DIGITAL RADIOGRAPHY- INTRODUCTION
- 2.0 REFERENCE DOCUMENTS
- 3.0 DIGITAL RADIOGRAPHY SYSTEM
- 4.0 SYSTEM CHARACTERIZATION
- 5.0 QUALIFICATION PLANS⁴⁴
- 6.0 TECHNIQUES
- 7.0 FILE FORMAT AND STORAGE
- 8.0 PERSONNEL REQUIREMENTS

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.

- 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.

- 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


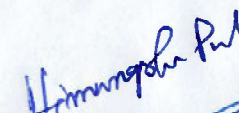
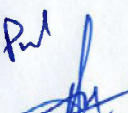

- 7.4 Data Archival - Data should be archived in a secure location for the minimum duration specified in the contract.
- 7.5 Digital Annotation - If digital labeling is used, it should not permanently alter the nature of the image or hinder interpretation of an area within the image.

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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प्रणाली अपेक्षाओं हेतु विनिर्देश

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

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

Abbreviations:

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

QMS Standards Committee

Convener: Mr. Anil Kumar

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

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1.0 SCOPE

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

- QMS requirements to be met by suppliers/contractors after award of work/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 “Bidder” is considered synonymous to supplier, contractor or vendor.

2.2 Project Quality Plan (PQP)

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

2.3 Owner

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

3.0 REFERENCE DOCUMENTS

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

4.0 QUALITY MANAGEMENT SYSTEM – GENERAL

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

5.0 QUALITY SYSTEM REQUIREMENTS

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

- 5.2 BIDDER shall identify all specified or implied statutory and regulatory requirements and communicate the same to all concerned in his organization and his sub contractor's organization for compliance.
- 5.3 BIDDER shall deploy competent and trained personnel for various activities for fulfilment of PO / contract. BIDDER shall arrange adequate infrastructure and work environment to ensure that the specification and quality of the deliverable are maintained.
- 5.4 BIDDER shall do the quality planning for all activities involved in delivery of order. The quality planning shall cover as minimum the following:
- Resources
 - Product / deliverable characteristics to be controlled.
 - Process characteristics to ensure the identified product characteristics are realized
 - Identification of any measurement requirements, acceptance criteria
 - Records to be generated
 - Need for any documented procedure
- The quality planning shall result into the quality assurance plan, inspection and test plans (ITPs) and job procedures for the project activities in the scope of bidder. These documents shall be submitted to EIL/Owner for review/approval, before commencement of work.
- 5.5 Requirements for sub-ordering of outsourced items /sub-contracting / purchasing of services specified in MR/ contract / tender shall be adhered to. In general all outsourced items will be from approved vendors of EIL. Wherever requirements are not specified, or approved sub vendors do not exist, the sub-contractor shall establish and maintain a system for purchasing / sub-contracting to ensure that purchased product / service conforms to specified requirements in concurrence with EIL / Owner. Criteria for selection of sub-contractor, evaluation, re-evaluation, maintenance of purchasing data and verification of purchased product (sub-contractor services), constitute important components of this requirement.
- 5.6 BIDDER shall plan and carry production and service provision under controlled conditions. Controlled conditions shall include, as applicable
- a) the availability of information that describes the characteristics of the product
 - b) the availability of work instructions
 - c) the use of suitable equipment
 - d) the availability and use of monitoring and measuring devices
 - e) the implementation of monitoring and measurement
 - f) the implementation of release, delivery and post-delivery activities
- 5.7 BIDDER shall validate any processes for production and service provision where resulting output cannot be verified by subsequent monitoring and measurement. This includes any process where deficiencies become apparent only after the product is in use or service has been delivered.
- 5.8 BIDDER shall establish a system for identification and traceability of product / deliverable throughout product realization. Product status with respect to inspection and testing requirements shall be identified.
- 5.9 BIDDER shall identify, verify, protect and safeguard EIL / Owner property (material / document) provided for use or incorporation into the product. If any Owner / EIL property is lost, damaged or otherwise found to be unsuitable for use, this shall be reported to the EIL / Owner.

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

- 5.10 BIDDER shall establish system to ensure that inspection and testing activities are carried out in line with requirements. Where necessary, measuring equipment shall be calibrated at specified frequency, against national or international measurement standards; where no such standard exists, the basis used for calibration shall be recorded. The measuring equipment shall be protected from damage during handling, maintenance and storage.
- 5.11 BIDDER shall ensure effective monitoring, using suitable methods, of the processes involved in production and other related processes for delivery of the scope of contract.
- 5.12 BIDDER shall monitor and measure the characteristics of the product/deliverable to verify that product requirement has been met. The inspection (stage as well as final) by BIDDER and EIL / Owner personnel shall be carried out strictly as per the approved ITPs or ITPs forming part of the contract. Product release or service delivery shall not proceed until the planned arrangements have been satisfactorily completed, unless otherwise approved by relevant authority and where applicable by Owner / EIL.
- 5.13 BIDDER shall establish and maintain a documented procedure to ensure that the product which does not conform to requirements is identified and controlled to prevent its unintended use or delivery
- 5.14 All non-conformities (NCs) / deficiencies found by the BIDDER'S inspection / surveillance staff shall be duly recorded, including their disposal action shall be recorded and resolved suitably. Effective corrective actions shall be implemented by the BIDDER so that similar NCs including deficiencies do not recur. The BIDDER shall take appropriate actions to address the Risks and Opportunities in the project.
- 5.15 All deficiencies noticed and reported by EIL / Owner shall be analysed by the BIDDER and appropriate corrective actions shall be implemented. BIDDER shall intimate EIL / Owner of all such corrective action implemented by him.
- 5.16 BIDDER should follow the standards, specifications and approved drawings. Concessions/Deviations shall be allowed only in case of unavoidable circumstances. In such situations Concession/deviation request must be made by the BIDDER through online system of EIL vendor portal for document exchange. URL of EIL vendor portal for document exchange is <http://edocx.eil.co.in/vportal>. BIDDER shall have documented procedure for control of documents.
- 5.17 All project records shall be carefully kept, maintained and protected for any damage or loss until the project completion, then handed over to EIL / Owner as per contract requirement (Refer Specification Nos. 6-78-0002 - Specification for Documentation Requirements from Contractors and 6-78-0003 - Specification for Documentation Requirements from Suppliers), or disposed as per relevant project procedure.

6.0 AUDITS

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

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

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

7.0 DOCUMENTATION REQUIREMENTS

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

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

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

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

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

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SPECIFICATION FOR DOCUMENTATION REQUIREMENTS FROM CONTRACTORS

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

Abbreviations:

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

QMS Standards Committee

Convener: Mr. Anil Kumar

Members: Mr. Himangshu Pal (SCM-Inspection)
Mr. Ravindra Kumar (Const.)
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Annexures:

S. No.	Title	Doc. No.
1.	Format for completeness of Final Documentation	Format No. 3-78-0004

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

- Specification for Quality Management System Requirements from Bidders (Doc. No. 6-78-0001)

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 through online portal and provide requisite details. Project Manager details shall include e-mail address, mailing address, mobile/telephone nos., fax nos. and name of Project Manager. All the system generated emails pertaining to that order shall be sent to the assigned Project Manager.

4.2 Documents/Data to be submitted by the Contractor

4.2.1 The contractor shall submit the documents and data against the Tender/Contract as per the list specified in respective Tender/Contract.

4.2.2 Review of the contractor drawings / Documents by EIL would be only to review the compatibility with basic designs and concepts and in no way absolve the contractor of his responsibility/contractual obligation to comply with Tender/Contract requirements, applicable codes, specifications and statutory rules/regulations. Any error/deficiency noticed during any stage of manufacturing/execution/ inspection / installation shall be promptly corrected by the contractor without any extra cost or time, whether or not comments on the same were received from EIL during the drawing review / inspection stage.

4.2.3 Unless otherwise specified, submission of documents for Review/Records shall commence as follows from the date of Fax of Intent /Letter of Intent/ Fax of Acceptance (FOA)/ Letter of Acceptance (LOA):

QMS	-	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 obtain the title block from EIL and ensure that the following information are properly entered in each drawing:

- Tender Number
- Name of Equipment / Package
- Equipment / Package Tag No.
- Name of Project
- Owner
- Main Contractor (if work is sub-contracted)
- Drawing / Document Title
- Drawing / Document No.
- Drawing / Document Revision No. and Date

4.4 Review and Approval of Documents by Contractor

4.4.1 All the Drawing/Documents shall be reviewed, checked, approved and duly signed/stamped by contractor before submission. Revision number shall be changed during submission of the revised contractor documents and all revisions shall be highlighted by clouds. Whenever there is a requirement of any sub-contractor/DEC drawings to be reviewed by EIL, the same shall be submitted by the contractor duly reviewed, approved and stamped by the sub-contractor/DEC and the contractor. Direct submission of sub-contractor's drawings without contractor's approval shall not be entertained.

4.5 Transportation Plan

Transportation Plan for Over Dimensional Consignments (ODC), if any, shall be submitted within 2 weeks of receiving FOA / LOA, for approval. Unless otherwise mentioned, consignments with parameters greater than following shall be considered as over dimensional.

Dimensions : 4 meters width x 4 meters height x 20 meters length

Weight : 32 MT (Metric Ton)

Dimensions and weight provided above are inclusive of all nozzles, attachments, transportation saddles etc.

Physical Route survey for ODC movement shall be submitted to EIL within 8 weeks of receiving FOA / LOA.

4.6 Document Category

Following review codes shall be used for review of contractor Drawings/Documents:

Code 1 - No comments. Proceed with Manufacture/ Fabrication/ Construction as per the document.

Code 2 - Proceed with Manufacture/Fabrication/Construction as per commented document. Revised document required.

- Code 3** - Document does not conform to basic requirements as marked. Resubmit for review.
- Code R** - Document is retained for Records. Proceed with Manufacturing/ fabrication as per Tender/ Contract Requirement.
- Code V** - Void, Document is returned as invalid.

Document is marked as Void under following conditions:

- a) Wrong item drawing uploaded.
- b) Superseded or obsolete submission.
- c) Duplicate submission.
- d) Out of sequence submission.
- e) Mismatch in document name and title under which document uploaded.
- f) Document not legible.
- g) For PMC projects, document not signed and stamped by contractor and DEC

4.7 Methodology for Submission of Documents to EIL/Owner

4.7.1 Document Control Index (DCI)

Contractor shall create and submit Document Control Index (DCI) for review based on PO/PR/MR along with schedule date of submission of each drawing/document on EIL Vendor Portal. The DCI shall be specific with regard to drawing/document no. and the exact title. Proper sequencing of the drawings/documents should be ensured in schedule date of submission.

4.7.2 Submission of Drawings/Documents / Data

Drawings/documents, data and DCI shall be uploaded on the EIL Vendor Portal. The detail guidelines for uploading documents on EIL Vendor Portal are available on following URL:

<http://edocx.eil.co.in/vportal>

4.7.3 Statutory Approvals

Wherever approval by any statutory body is required to be taken by Contractor, the Contractor shall submit copy of approval by the authority to EIL.

4.7.4 Schedule and Progress Reporting

Contractor shall submit monthly progress report (MPR) and updated procurement, engineering and manufacturing status (schedule vs. actual) and highlight constraints, if any, along with action plan for mitigation, to the EIL / Owner by 1st week of every month. One month Look-ahead schedule including the mobilization plan shall be submitted within 2 weeks from FOA / LOA. In case of exigencies, EIL/Owner can ask for report submission as required on weekly/fortnightly/ad-hoc basis depending upon supply status and contractor shall furnish such reports promptly without any price implication. Format for progress report shall be submitted by the contractor during kick off meeting or within one week of receiving FOA/LOA, whichever is earlier.

Contractor shall submit progress reports including Daily Progress Reports (DPR) through planning portal. "EIL CP Contractor Daily Update System" available in following url: <https://www6.eil.co.in/CDUS/>

4.7.5 Quality Assurance Plan/Inspection and Test Plan

Inspection and test plans attached if any, to the tender are generic and indicative only. Immediately after receipt of the order, contractor shall submit within one week of receiving FOA/LOA, job specific ITPs based on the indicative ITPs. Further, contractor shall also submit Quality Assurance Plan for project activities in the scope of contract, starting from manufacturing to handing over/ commissioning, these plans shall cover/identify the activities, relevant procedure, if any, code of conformance, resources for performance and checking/monitoring, approval requirements and authority, records to be generated and audit scope by EIL/Owner.

For EPCC/LSTK/Package contracts, the contractor shall prepare a list of items/ equipment and their inspection categorization plans for all items included in the scope of supply immediately after receipt of order and obtain approval for the same from EIL. The items shall be categorized into different categories depending upon their criticality for the scope of inspection of TPIA and/or EIL.

4.7.6 Inspection Release Note (IRN)/ Inspection Certificate (IC)

Contractor shall ensure that all documents viz. documents reviewed, manufacture's test certificate etc., mentioned in Inspection Release Note(IRN), issued by EIL/third party against the materials supplied by contractor, are sent to EIL along with the IRN.

IRN/ IC shall be issued by EIL Inspector/ third party inspection agency only after all the drawings/documents as per DCI are submitted and are accepted under review code-1 & code R. Material/Equipment dispatch from contractor's/sub vendor's works shall not commence till above condition is met.

Note 1: Nonfulfilling above requirement shall result into appropriate penalty or with- holding of payment as per conditions of Tender/Contract.

Note 2: For items where IRN/IC is issued by TPIA, supplier to ensure that following as a minimum must be mentioned by TPIA in IRN/IC

- a) Tender document number
- b) List of drawings / documents with EIL approval code
- c) Tests witnessed, documents reviewed
- d) Compliance statement by TPIA that product meets the requirement as specified in EIL standard specifications, Inspection Test Plan / Quality Assurance Plan (QAP) and approved documents.

4.7.7 Pre-Commissioning& Commissioning Activities Management System (PCAMS)

Pre-Commissioning& Commissioning activities management system software shall be followed for Mechanical completion, check listing of loops, punch points, hydro test and issue of Formats during the Pre-Commissioning and Commissioning activities and the same can be accessed on following URL

<https://pcams.eil.co.in/>

4.8 Final Documentation

4.8.1 As built Drawings

Minor Shop/Site changes made by contractor after approval of drawings under 'Code 1' by EIL and deviations granted through online system, if any, shall be marked in hard copies of drawings which shall then be stamped 'As-built' by the contractor. These 'As-built' drawings shall be reviewed and stamped by EIL Inspector/Site engineer/TPIA also, as the case may be. Format for completeness of final documents (Format No. 3-78-0004) is attached with this specification. Contractor shall prepare scanned images files of all marked – up 'As – built' drawings. Simultaneously contractor shall incorporate the shop/site changes in the native soft files of the drawings also.

4.8.2 As built Final Documents

As built final documents shall be submitted as listed in Tender/Contract

4.8.3 Packing/Presentation of Final Documents

Final Documents shall be legible photocopies in A4, A3 size only. Drawings will be inserted in plastic pockets (both sides transparent, sheet thickness minimum 0.1 mm) with an extra strip of 12 mm wide for punching so that drawings are well placed.

Final Documentation shall be bound in hard board plastic folder(s) of size 265 mm x 315 mm (10½-inch x 12½-inch) and shall not be more than 75 mm thick. It may be of several volumes and each volume shall have a volume number, index of volumes and index of contents of that particular volume. Where numbers of volumes are more, 90mm thickness can be used. Each volume shall have top Poly Vinyl Chloride (PVC) sheet of minimum 0.15 mm thick duly fixed and pressed on folder cover and will have 2 lever clips. In case of imported items documents, 4 lever clip shall also be accepted. All four corners of folders shall be properly metal clamped. Indexing of contents with page numbering must be incorporated by contractor. Spiral/Spico bound documents shall not be acceptable. As mentioned above, books should be in hard board plastic folders with sheets punched and having 2/4 lever clips arrangement.

Each volume shall contain on cover a title block indicating Tender No., name of project, name of customer, package equipment tag no. & name (if applicable). Each volume will have hard front cover and a reinforced spine to fit thickness of book. These spines will also have the title printed on them. Title shall include also volume number (say 11 of 15) etc.

4.8.4 Submission of Soft copies

Contractor shall submit to EIL, the scanned images files as well as the native files of drawings/documents, along with proper index.

In addition to hard copies, contractor shall submit soft copies of all the final drawings and documents in pen drive or any other specified medium with proper identification tag, all text documents prepared on computer, scanned images of all important documents (not available as soft files), all relevant catalogues, manuals available as soft files (editable copies of drawings/text documents, while for catalogues/manuals/proprietary information and data PDF files can be furnished). All soft files shall be appropriately named, systematically indexed, and duly bookmarked in PDF format to facilitate ease of reference and access.

All the above documents shall also be uploaded on the EIL Vendor Portal and if applicable on Client Server also.

4.8.5 Completeness of Final Documentation

Contractor shall get the completeness of final documentation verified by EIL/TPIA and attach the Format for Completeness of Final Documentation (Format No. 3-78-0004) duly signed by EIL or TPIA as applicable to the final document folder.

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