Volume Solids % Minimum.	67	67	50	98	98
DFT per coat in microns	100-125	75-100	100-125	300-450	500-600
Theoretical covering capacity in M^2/coat/ litre	5.4-6.7	6.7-8.9	4-5	2.2-3.3	1.6-2
Weight per liter in Kg/litre (min.)	1.45	1.65	>1.3	1.7	>1.2
Touch dry at 30°C (max)	4 hrs.	3 hrs.	1 hrs.	2 hrs.	2 hrs.
Hard dry at 30°C (max).	24 hrs.	24 hrs.	16 hrs.	24 hrs.	4 hrs.
Full cure 30°C (for immersion / high temp service)	168 hrs (7 days)	168 hrs (7 days)	NA	168 hrs (7 days)	96 hrs (4 days)
Over-coating interval	Min. 6 hrs Max.5 days	Min. 36 hrs Max.21 days	Min.6 hrs Max. Not applicable	Min. 16 hrs Max.21 days	Min. 4 hrs Max.3 days
Pot life at 30ºC, hrs (for two component paints)	4	4-6	1	1	50 min-1 hr.
Adhesion, MPa (ASTM D 4541)	>6	>7	NA	>8	>7, Tensile strength >20N/mm2 (ASTM D 638)
Temperature resistance (min.) º C (ASTM D 2485) *Note 8 & 9	125 (Method A)	150 (Method A)	650 (Method B)	200 (Method A)	90 (Method A)

General notes for TABLE-2:

1. Covering capacity and DFT achieved per coat depends on method of application. Covering capacity specified above is theoretical. For estimation of actual quantity of paints required, include the losses during application. Minimum specified DFT should be maintained in any case.

2. All primers and finish coats should be ambient temperature curing and air drying unless otherwise specified.

3. All paints shall be applied in accordance with manufacturer's instructions for surface preparation, intervals, curing and application. Wherever a deviation is noticed from the specification in manufacturer data sheet, more stringent one between the data sheet and the specification shall

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prevail e.g. if this specification recommends Sa 2 ½ and the manufacturer data sheet requires Sa3, the surface preparation shall be done as per Sa 3. However, in another case if this specification requires the surface preparation of Sa 2 ½ and the manufacturer data sheet recommends only Sa 2 as minimum, the surface preparation shall be done as per Sa 2 ½.

4. Technical data sheets for all paints shall be supplied at the time of submission of quotations.

5. Internationally recognized & acceptable testing method shall be used for lab testing wherever testing standards are not mentioned.

6. Touch dry, hard dry, pot life, full cure period, & over coating interval shall be as per manufacturer's data sheets and no testing is required. Slight variation in the values of these parameters along with weight per liter may be permissible with the discretion of engineer-in-charge in consultation with SMMS.

7. Temperature resistance tests (ASTM D2485) shall be carried out for minimum required temperature resistance indicated.
8. Wherever ASTM D 2485 method B is applicable, test results of the panels subjected to salt spray (ASTM B 117) after muffle furnace exposure shall be submitted for pre-qualification purpose.

9. F6-C shall be suitable for drinking water service and should have certification from competent authority.

7.0 SELECTION OF COATING SYSTEMS

The external coating system for EIL projects should be selected based on the C5 environment (very high durability) as per ISO12944-2, design temperature, involved services of the steel substrate and plant location.
The paint system to be applied for a specific job shall be arrived at sequentially as given below:

a. Identify the environment from area classification details and choose the appropriate table.
b. Identify the design temperature from the technical documents.
c. Identify the specific field paint system and surface preparation requirement from the above identified table and temperature range.
d. Identify the shop priming requirement from based on compatibility of the above paint system.
e. Identify the need of repair of shop primer and execute as per Table-3.

TABLE-3: REPAIR OF PRE-ERECTION/PRE-FABRICATION OR SHOP PRIMER AFTER ERECTION/WELDING

(For all un-insulated CS, LTCS & alloy steel items in all environments)

Sl. No.	Design Temp. in ºC	Surface Preparation	Coating System	Total DFT in Microns (min.)	Remarks
3.1	-45 to 80	SSPC-SP-3	1 coat of F-8 @ 125 µ DFT/coat	125	See Note-1 below and clause 5.11
3.2	81 to 400	SSPC-SP-3	1 coat of F-9 @ 65-75 µ DFT/coat	65-75	
3.3	401 to 550	SSPC-SP-3	1 coat of F-16 @ 125 µ DFT/coat	125	

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Note for Table-3:

1. The application and repair of pre-erection/pre-fabrication and shop primer given in above tables shall be done for all the items to be painted. In case the damages of primer are severe and spread over large area, entire primer shall be removed by blasting to achieve SSPC-SP-10 and surfaces to be primed again with F-8/ F-9/F-16, as applicable. After the repairs of the primer, suitable intermediate and final coats shall be applied as per applicable coating systems mentioned in Table 5.0 to Table 11.0.

TABLE-4: COATING SYSTEM FOR GALVANIZED ITEMS (Refer clause 2.2.7)

Sl. No.	Design Temp. in °C	Coating System	Total DFT in Microns (min.)	Remarks
4.1	Up to 60	Hot Dip Galvanizing with thickness as per ISO 1461, Surface preparation over galvanization as per SSPC SP 16 & ISO 12944-4; 1 coat of F-6B @ 100µ DFT/coat + 1 coat of F-2 @ 40 microns DFT/coat	140µ of finish coat (excluding the thickness of galvanizing)	Special primers like etch primer may also be considered for coating on galvanized surfaces

Notes for Table-4:

1. F-6B shall be modified type and suitable for coating over galvanization.
2. Repair of the damaged areas of galvanized coatings due to welding during erection shall be carried out as per recommended practice ISO 1461, using cold galvanizing spray process. Organic paint systems are not acceptable for the repair.
3. After repair of damaged galvanized coating by cold galvanization (P-7), the repaired area shall be top coated with paint system as given in table-4 above (i.e. 1 coat of F-6B @ 100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat).
4. Galvanized gratings don't require painting in general until otherwise specified elsewhere or as per the requirement of the OWNER. Galvanized items may require painting to meet the colour coding requirement of the OWNER. Contractor has to ensure the applicable colour coding prior to application of coating as per this clause.

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TABLE-5: COATING SYSTEM FOR CORROSIVE AREAS

(For all un-insulated above ground CS, LTCS & Alloy steel piping, equipment, structures, valves, vessels & columns, furnace stacks etc.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
5.1	-45 to -15	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/	-	-	65-75	a) No over coating on F-9 is allowed b) F-12 shall be ambient temperature curing type c) Surface profile for F-9 shall be 30-40 µm
5.2	-16 to 80	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/ coat	1 coat of P-6 @ 40 µ DFT/ coat	2 coats of F-6B @ 100 µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat (2x100 + 40= 240)	345-355	
5.3	81 to 400	SSPC-SP-10; 1coat of F-9 @ 65-75µ DFT/ coat	-	2 coats of F-12 @ 20µ DFT/coat 2x20=40	105-115	
5.4	401-650	SSPC-SP-10; 1 coat of F-16 @ 125 µ	-	1 coat of F-16 @ 125 µ	250-300	-

NOTES for TABLE-5:

1. The list of items given in the heading of the above table is not exhaustive. There may be more items for a particular contract where these specifications are used. The CONTRACTOR is fully responsible for completing painting including prefabrication primer for all the items supplied and fabricated as per contract document and scope of work.

2. If the application of pre-erection/pre-fabrication/shop primer has already been completed, the same shall not be repeated in the field. In case the damages to the primer coat are severe and spread over large areas, the Engineer-In-Charge may decide & advise re-blasting and re-application of the primer coat. Repair of pre-fabrication/pre-erection primer, if required, shall be done as per Table-3.

3. Flare line within unit or offsite areas shall be coated as per clause 5.3 of Table-5.

4. For external surface of RCC Chimney, 2 coats of F-6 B@ 100µ DFT/coat to obtain a total DFT of 200 µ shall be applied after proper surface preparation as per guidelines in clause 4.6.

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TABLE-6: COATING SYSTEMS FOR EFFLUENT TREATMENT PLANT (ETP)

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
6.1	For external surfaces of steel items: screens, walk way bridges, clarifier/thickener scrapping mechanism, baffles, Media filters/vessels (PSF, DMF, MMF, & ACF etc.), vertical pumps, CS/MS tanks/ vessels and structures.					
	-14 to 80	SSPS-SP-10	1 coat of F-9 @ 65-75µ DFT/coat	2 coats of F-6B @100µ DFT/coat + 1 coat of F-2 @ 40µ DFT/coat (2x100+40= 240)	305	-
6.2	For internal surfaces of steel items: all effluent handling units such as TPI, DAF, tube settlers, clarifiers, tanks, sludge tanks and sewage tank, wet slop oil tanks etc., scrapping mechanism in clarifier etc.					
	-14 to 80	SSPS-SP-10	1 coat of F-15 @ 80µ DFT/coat.	2 coats of F-15 @180µ DFT/coat (2x80=160)	240	-
6.3	All R.C.C./concrete surfaces exposed to effluent water / liquid such as tanks, structures, drains etc., all effluent handling units such as API, TPI, DAF, tube settlers, clarifiers, tanks, sumps, sludge sumps/tanks and sewage sumps/tank, wet slop oil sump/tanks etc.					
	-14 to 80	As per clause 4.6 of this specification	Epoxy screed lining		3000	Note 1
6.4	Internal surface of equipment like Media filters/vessels (PSF, DMF, MMF, & ACF etc.), activated carbon filters, alkaline, acids & other high corrosive service					
	Up to 90	SSPC-SP-10	1 coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat + 2 coats of F-20 @ 500µ DFT/ Coat		1100	Note-2

NOTES for TABLE-6:

1. Contractor shall follow manufacturer recommendations to develop epoxy screed lining procedure for EIL review and approval.
2. This coating system is applicable in conjunction with relevant PDS of the equipment.

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TABLE-7: EXTERNAL COATING SYSTEMS FOR CARBON STEEL AND LOW ALLOY STEEL STORAGE TANKS

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system (Note-1)		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
7.1	All external surfaces of shell, wind girders, appurtenances, roof tops of all above ground tank including top side of external and internal floating roof and associated external structural works.					
7.1.1	-14 to 80	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat + 1coat of P-6 @ 40µ DFT/ coat	2 coats of F-6B @ 100µ DFT /coat + 1 coat of F-2 @ 40µ DFT/ coat	345-355	-
7.1.2	81 to 450	SSPC-SP-10	1coat of F-9 @ 65-75µ DFT/coat	1 coat of F-16 @ 125 µ DFT / coat	190-200	
7.2	External surfaces of bottom plate (in contact with soil) for all storage tanks.					
7.2.1	-14 to 80	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	3 coats of F-7@ 150µ DFT/coat (3x150=450)	515-525	-
7.2.2	81 to 200	SSPC-SP-10	1 coat of F-17 primer @ 400µ DFT/ coat	1 coat of F-17 finish coat @ 400µ DFT/ coat	800-825	Note-4
7.3	For underside of the bottom plate (not in contact with soil)(in case tank is not lifted during PWHT) (Note- 2)					
7.3.1	-29 to 400	SSPC SP-10	1 coat of F-16 @ 125 µ	1 coat of F-16 @ 125 µ	250-300	Note-3

Notes for TABLE-7:

1. All paint coating application including primer for tanks shall be carried out at field after erection and completion of entire welding.

2. For underside of bottom plate as per clause no.7.3.1:

a) Painting shall be carried out before laying the bottom plate for tanks with non-Post Weld Heat Treatment (PWHT).

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b) For tanks with PWHT, painting shall be carried out after PWHT.

c) In case tank is not lifted during PWHT then painting shall be applied before laying the bottom plate.

3. This coating system (7.3.1) is also applicable for temperature ranges not covered in 7.2 above.

4. This coating system (7.2.2) is also applicable for bottom plates having MOC as Stainless Steel.

TABLE-8: INTERNAL COATING SYSTEMS FOR CARBON STEEL AND ALLOY STORAGE TANKS

Sl. No.	Design Temp. in °C	Surface Preparation	Coating system		Total DFT in Microns (min.)	Remarks
			Primer	Finish Coat		
8.1	Internal side of bottom plate and first shell course of Crude oil tanks					
8.1.1	-14 to 90	SSPC-SP-10	1 Coat of F-6A @ 100 µ DFT/coat	1 Coat of F-6C @ 400 µ DFT/coat	500	-
8.2	Underside of floating roof, internal surfaces of shell for full height above first course, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures, roof legs, drain pipes and ladders etc. of crude oil tanks					
8.2.1	-14 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-
8.3	All internal surfaces of hydrocarbon, slops, amine solutions, sour water and other hydrocarbon-water solutions tanks but not limited to: Underside of floating roofs, internal surface of cone roof, inside of bottom plate, internal surfaces of shell for full height, underside of floating roof, oil side surfaces of deck plates, oil side surfaces of pontoons, support structures, roof legs, drain pipes and ladders etc.					
8.3.1	-14 to 45	SSPC-SP-10	1 coat of F-9 @ 65-75 µ DFT/coat	-	65-75	-
8.3.2	46 to 90	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat	240	-
8.3.3	91 to 200	SSPC-SP-10	-	1 coat of F-17 @ 400µ DFT/coat	400	-

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8.4	Potable, Raw & Fire water, De-mineralized (DM) water & Condensates etc. All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.4.1	-14 to 60	SSPC-SP-10	1 Coat of F-6A @ 100µ DFT/coat	1 coat of F-6C @ 300-350 µ DFT/ coat	400-450	-
8.4.2	61 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat (80+80=160)	240	-
8.5	Hydrochloric acid (HCl) 10 %: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.5.1	-14 to 60	SSPC-SP-10	1 Coat of clear two component solvent free vinyl ester primer @ 100µ DFT/ Coat	2 Coats of F-20 @ 500µ DFT/ Coat	1100	-
8.6	Aggressive solvents like hexane, hexene, benzene, xylene and toluene etc.: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.6.1	-14 to 65	SSPC-SP-10	1 coat of F-9 @ 65-75µ DFT/ coat	-	65-75	-
8.7	Ethylene glycol tanks: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.7.1	All	SSPC-SP-10	-	3 coats of vinyl chloride co-polymer @ 75µ /Coat; (3x75=225)	225	-
8.8	Inside pontoon and inside of double deck of all floating roofs					
8.8.1	-14 to 80	SSPC-SP-3	1 coat of F-8 @ 100µ DFT/coat	1 coat of F-8 @ 100µ DFT/coat	200	-
8.8.2	81 to150	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	1 coat of F-15 intermediate coat @ 80µ DFT/coat + 1 coat of F-15 finish coat @ 80µ DFT/ coat (80+80=160)	240	-
8.8.3	151 to 200	SSPC-SP-10	-	1 coat of F-17 @ 400µ DFT/coat	400	-

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8.9	Alkalis up to 50 % concentration: All internal surfaces but not limited to internal surfaces of shell for full height, bottom plate, accessories, roof and roof structures of cone and dome roof tanks etc.					
8.9.1	Up to 60°C	SSPC-SP-10	1 coat of F-15 primer @ 80µ DFT/ coat	2 Coats of F-6 A @ 100µ DFT/coat (2x100=200)	280	-

General Note for Table-8: The list of surfaces to be painted are not exhaustive. All internal surfaces of all type of tanks including structural items shall be coated as per the above table. No CS surface shall be kept un-painted.

TABLE-9: COATING SYSTEMS FOR EXTERNAL SIDE OF UNDERGROUND CARBON STEEL PLANT PIPING AND VESSELS

Sl. No.	Design Temp. in °C	Surface Preparation & Shop Primer	Coating system		Total DFT in Microns (min.)	Remarks
			Surface Preparation & Primer	Finish Coat		
9.1	Underground carbon steel plant piping.					
9.1.1	25 to 80	-	As per document B862-000-06-42-PLS-04	3layer polyethylene (3LPE) coating as per document B862-000-06-42- PLS-04	3.5 mm	--
9.1.2	81 to 200	-	SSPC-SP-10; 1 coat of F-17 primer @400 µ DFT/ coat	1 coat of F-17 @ 400 DFT/coat	800	-
9.2	External side of underground storage vessels					
9.2.1	-45 to 80	SSPC-SP -10; 1 coat of F-9 @ 65-75µ DFT/ coat	-	3 coats of F-7 @ 100µ DFT/coat	365-375	-
9.2.2	81 to 200	SSPC-SP -10	1 coat of F-17 primer @400 µ DFT/ coat	1 coat of F-17 @400µ DFT/ coat	800	-

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TABLE-10: COATING SYSTEMS FOR UNDER INSULATION (ALL UNIT AREAS & OFFSITES)
(For insulated piping, equipment, storage vessels, tanks, columns etc. of CS, LTCS, Alloy steel, SS, DSS and SDSS in all environments.)

Sl. No.	Design Temp. °C	Surface Preparation & Pre-erection/Shop Primer	Coating system		Total DFT Microns (min.)	Remarks
			Primer	Finish paint		
10.1	Carbon steel, LTCS and Alloy steel Piping, Storage tanks, Vessels, Equipment etc.					
10.1.1	-45 to 125	SSPC-SP-10; 1coat of F-15 @ 75µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note 1
10.1.2	126 to 450	SSPC-SP-10; 1 coat of F-16 @ 125µ DFT/coat	None	1 coat F-16 @ 125µ DFT/coat	250	
10.2	Stainless Steel, Duplex Stainless steel, Super Duplex stainless steel & Piping, Tanks, Vessels & Equipment etc.					
10.2.1	-45 to 125	SSPC-SP-16; (15-25µ surface profile) 1 coat of F-15 @75 µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note 1
10.2.2	126 to 650	SSPC-SP-16; (15-25µ surface profile) 1 coat of F-16 @125µ DFT/coat	None	1 coat of F-16 @125µ DFT/coat	250	
10.3	Cyclic service of CS, LTCS, SS, DSS, SDSS & Alloy Steels (Note-1)					
10.3.1	-45 to 150 (Note-1)	SSPC-SP-10 For CS, LTCS & Alloy steel. SSPC-SP-16 for SS; (15-25µ surface profile) 1 coat of F-15 @75 µ DFT/coat	None	2 coats of F-15 @75µ DFT/coat	225	Note-2&3

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10.3.2	-180 to 650	SSPC-SP-10 for CS, LTCS & Alloy steel. SSPC-SP-16 for SS (15-25µ surface profile) 1 coat of F-16 @ 125µ DFT/coat	None	1 coat of F-16 @ 125µ DFT/coat	250	-

Notes

1. Coating system for any other design temperature range not covered in Sr. No. 10.1 & Sr. No. 10.2 shall be as per Sr. No. 10.3.2.
2. In case of overlapping of cyclic temperature ranges as mentioned in 10.3.1 and 10.3.2 then clause 10.3.1 shall be followed.
3. Alternatively, for this temperature range, 1 coat of F-17 @ 400 µ is also acceptable.

General notes for TABLE-10:

1. "Cyclic Service" is characterized by rapid or periodical temperature fluctuation or temperature cycles or as defined in the process datasheet.
2. The blasting abrasives for SS and alloy steels shall be aluminum oxide or garnet only.
3. The coating system applicable for any other temperature range shall be reviewed if it is encountered.

TABLE-11: INTERNAL COATING SYSTEMS FOR WATER SIDE COMPONENTS OF CS, SS, DSS & NON-FERROUS HEAT EXCHANGERS

Sl. No.	Design Temp. in °C	Surface Preparation & Pre-erection/Shop Primer	Coating System		Total Final DFT in Microns (min.)	Remarks
			Primer	Finish paint		
11.1	Up to 80	SSPC-SP-10 for CS and SSPC-SP-16 for SS	1 coat of F-15 @ 80 µ DFT/coat	2 coats of F-15 @ 80 80 µ DFT/coat	240	-
11.2	81 to 200	SSPC-SP-10 for CS and SSPC-SP-16 for SS	-	2 coats of F-17@ 400µ/coat	800	-

Note for Table-11:

1. Coating systems are applicable as per requirement specified in the data sheets of the respective exchangers or equipment.

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GENERAL NOTES FOR TABLE: 5 TO 11

1. For uninsulated or insulated items, scope of surface preparation, application of primers to finish coat including repair shall be as per applicable contractual documents like SOR, MR, and PR etc. The list of items is not exhaustive.

8.0 GUIDELINES FOR STORAGE & HANDLING

8.1 All paints and painting materials shall be stored in rooms only which are to be arranged by CONTRACTOR and approved by Engineer-In-Charge for the purpose. All necessary precautions shall be taken to prevent fire. The storage building shall preferably be separate from adjacent building. A signboard bearing the word “PAINT STORAGE- NO NAKED LIGHT-HIGHLY INFLAMMABLE” shall be clearly displayed outside. Manufacturers’ recommendation /Materials safety datasheet shall be followed for storage and handling of paint materials.

Note: This specification doesn’t address all the safety concerns if any, associated with its use. It is responsibility of the user of this specification to establish appropriate safety and health practice and determine the applicability of regulatory limitations prior to use.

9.0 COLOUR CODE

The colour coding system as per Annexure-1 of this specification shall be followed.

9.1 Identification

The system of colour coding consists of a ground colour and secondary colour bands superimposed over the ground colour. The ground colour identifies the basic nature of the service and secondary colour band over the ground colour distinguishes the particular service. The ground colour shall be applied over the entire length of the un-insulated pipes. For insulated lines, ground colour shall be provided as per specified length and interval to identify the basic nature of service and secondary colour bands to be painted on this specified length to identify the particular service. Above colour code is applicable for both unit and offsite pipelines.

9.2 Ground colour

On un-insulated pipes, the entire pipe has to be painted in ground colour. On metal cladded insulated lines, minimum 2 m long portion should be painted.

9.3 Colour bands

9.3.1. Location of colour bands:

a. At battery limits.
b. Intersection points & change of direction points in piping.
c. Midway of piping section, near valves, across culverts.
d. At 50 m interval on long stretch pipes.
e. At starting and termination points.

9.3.2. Minimum width:

NB	Width
3” and below	75 mm
Above 3” to 6”	NB X 25 mm

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Above 6" to 12"	NB X 18 mm
Above 12"	NB X 15 mm

For insulated pipes, NB indicates OD of the insulation.

Sequence: Colour bands shall be arranged in sequence as shown above and the sequence follows the direction of flow. The width of the 1st Band to 2nd band is 4:1.
Wherever deemed required by process department or safety, pipes handling hazardous substances will be given hazard marking of 30 mm wide diagonal stripes of black and golden yellow.

9.4 Identification markings on equipment/piping

Equipment tag numbers shall be stenciled/neatly painted using normal 'Arial' lettering style on all equipment and piping (both insulated & un-insulated) after completion of all paint works. Lettering colour shall be either black or white, depending upon the background, so as to obtain good contrast.

Operations group shall specify the location of the marking.

Size of the making shall be as follows:

Columns, vessels, heaters	: 150 mm
Pumps and other machinery	: 50 mm
Piping	: OD / 2 with maximum 100 mm
Storage tanks	: (as per drawings)

9.5 Colour coding for control valve

a)

Carbon steel body	:	Signal grey (RAL7004)
Alloy steel body	:	Golden yellow (RAL1004)
Stainless steel body	:	Natural

b) The actuator of the control valve shall be painted as:

Direct action (open on-air failure) valves : Traffic Green (RAL 6024)
Reverse acting (close on-air failure) valves: Traffic Red (RAL 3020)

The painting status shall be comprehensively updated every 6 months for compliance.

10.0 IDENTIFICATION OF VESSELS, PIPING ETC.

10.1 Equipment number shall be stenciled in black or white on each vessel, column, equipment & machinery (insulated or un-insulated) after painting. Line number in black or white shall be stenciled on all the piping of more than one location as directed by Engineer-In-Charge. Size of letter printed shall be as below:

Column & vessels	:	150 mm (high)
Pump, compressor & other machinery:		50 mm (high)
Piping	:	40-150 mm

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10.2 Identification of storage tanks

The storage tanks shall be marked as detailed in the drawing.

11.0 PAINTING FOR CIVIL DEFENCE REQUIREMENTS

Painting for civil defense is a specific requirement and should be applicable as per instructions of OWNER and competent government authorities.

11.1 The following items shall be painted for camouflaging, if required by the client:

a. All columns
b. All tanks in offsite
c. Large vessels
d. Spheres

11.2 Two coats of selected finishing paint as per defense requirement shall be applied in a particular pattern as per clause 11.3 and as per the instructions of Engineer-In-Charge.

11.3 Method of camouflaging

a. Disruptive painting for camouflaging shall be done in three colours in the ratio of 5:3:2 (all matte finish).

Dark Green		Light Green		Dark Medium Brown
5	:	3	:	2

b. The patches should be asymmetrical and irregular.
c. The patches should be inclined at 30º to 60º to the horizontal.
d. The patches should be continuous where two surfaces meet at an angle.
e. The patches should not coincide with the corners.
f. Slits and holes shall be painted in dark shades.
g. Width of patches should be 1 to 2 m.

12.0 QUALITY CONTROL, INSPECTION AND TESTING

12.1 All painting materials including primers and thinners brought to site by CONTRACTOR for application shall be procured directly from manufactures as per specifications and shall be accompanied by manufacturers' test certificates. Paint formulations without certificates are not acceptable (see section 14.0 & 15.0).

12.2 The CONTRACTOR must produce test certificate from pre-qualified paint manufacturer for various tests as detailed out in section 15.0 of this document. The Engineer-In-Charge, in consultation with SMMS, shall have the right to test wet samples of paint at random for verifying quality of paint supplied. CONTRACTOR shall arrange to have such tests, as instructed, performed at his cost at any one of the NABL accredited laboratories under a TPI agency.

Samples for the test will be drawn at random in presence Engineer-In-Charge or his representations. Following tests to be carried out if called:

a. Specific Gravity
b. % solids by weight (% zinc content in case of inorganic or organic zinc primer)

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c. Drying time (touch dry & full curing)
d. Adhesion test on a test panel prepared at the site (ASTM D 6677).

Test methods for above tests shall be as per relevant ASTM or ISO Standard.

12.3 The painting work shall be subject to inspection by Engineer-In-Charge at all times. In particular, following stage-wise inspection will be performed and CONTRACTOR shall offer the work for inspection and approval of every stage before proceeding with the next stage. The record of inspection shall be maintained in the registers. Stages of inspection are as follows:

a. Surface preparation
b. Primer application
c. Each coat of paint

12.3.1 Following tests are to be carried out during surface preparation:

a. Test for presence of oil/grease and contamination

The steel substrate after degreasing as per SSPC-SP-1 shall be tested as per following procedure to validate absence of oil and grease contamination:

- Visual inspection - continue degreasing until all visible signs of contamination are removed.
- Conduct a solvent evaporation test by applying several drops or a small splash of residue-free tri-chloromethane on the suspect area especially pitting, crevice corrosion areas or depressed areas. An evaporation ring formation is indicative of oil and grease contamination. Continue degreasing and inspection till test is passed.

b. **Tests for surface finish of blasted surface** shall be done by visual inspection using SSPC-VIS1. Clear cellophane tape test as per ISO 8502-3 shall be used to confirm absence of dust on blasted surface. Checks shall be done on each component at least once per 200 m^2 of blasted surface and a minimum of 3 checks per shift.

c. **Test for presence of soluble salt** as per method ISO 8502-9. Maximum allowable salt content shall be considered 20 mg/m^2.Checks shall be done on each component at least once per 200 m^2 of blasted surface and minimum of 3 checks per shift. In case salt exceeds specified limit, the contaminated surface shall be cleaned by method as per Annexure-C of ISO 12944-4 (water cleaning). After cleaning, surface shall be retested for salt after drying.

d. **Blast Profile Measurement**: (In-Process testing during actual production before application coating). The angular profile depth measurement shall be done by profile tape as per method ASTM D 4417 method B (Profile depth gauge micrometer)/ calibrated Digital gauge meter. Spot measurement shall be carried out every 15m^2 of blasted surface. At each spot three measurements shall be taken over an area of 10 cm^2 and average of measurements to be recorded and reported. If profile is less than specified range, blasting shall continue till greater specified depth profile is achieved.

e. **Tests for blasting media:** Blasting Media (For every fresh batch of media and one random test during blasting)**.** Blasting Media shall be visually inspected for absence of contamination and debris using 10 X magnification.

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- Inspection for the absence of oil contamination shall be conducted using following procedure :
  - Fill a small clean 200 ml bottle half full of abrasive.
  - Fill the bottle with potable water, cap and shake the bottle.
  - Inspect water for oil film/slick. If present, the blasting media is not to be used.

- Soluble salt contamination if suspected shall be verified by method ASTM D 4940. If present, media to be replaced.

- Clean blasting equipment, especially pot and hoses, and then replace blasting media and retest.

f. **Test for Blasting Air** (Once Daily before start of blasting and once at random during Blasting). The air for blasting shall be free from moisture and oil. The compressor air shall be checked for oil and water contamination per ASTM D 4285.

In addition to above, record should include type of shop primer already applied on equipment e.g. zinc silicate or zinc rich epoxy or zinc phosphate. Any defect noticed during the various stages of inspection shall be rectified by the CONTRACTOR to the entire satisfaction of Engineer-In-Charge before proceeding further. Irrespective of the inspection, repair and approval at intermediate stages of work, CONTRACTOR shall be responsible for rectifying any defects found during final inspection/guarantee period/defect liability period as defined in general conditions of the contract. Dry film thickness (DFT) shall be checked and recorded after application of each coat and extra coat of paint should be applied to make-up the DFT specified without any extra cost to OWNER, the extra coat should have prior approval of Engineer-in-charge.

12.4 Final inspection of finished coating shall consist of the following:

a. Coating DFT & WFT check: DFT measurement shall be as per ISO 2808. Type-II electronic gauge shall be used as described in ASTM D7091. DFT gauge calibration, adjustment of gauge coating thickness, frequency and number of coating thickness measurement shall be as per ASTM D7091 and SSPC-PA2. Measured DFT shall have a tolerance as per SSPC-PA-2 level-3 of the dry film thickness, specified in this specification. Once in every layer of coating application, spot checks of WFT shall be carried out during the coating application according to ISO 2808, Method No. 1A- comb gauge. This is to ensure that film thickness is being achieved as per the specification.

b. Adhesion testing: Adhesion of the primer to the steel substrate and inter-coat adhesion of the subsequent coat(s) after curing for at least a week after application of the topcoat shall be examined by a knife test in accordance with ASTM D6677. For the knife test, if the rating is better than 8, the adhesion is considered acceptable. The adhesion is destructive and tested areas shall be repaired afterward using the spot repair procedure. Alternatively, the applicator may perform the adhesion test on a steel panel coated using the same surface preparation and coating application procedure as the work piece. Adhesion testing shall be carried out for each component at least once per 200 m^2 of coated surface.

c. Holiday detection check: Holiday testing of non-conductive coatings shall be carried out in accordance with NACE SP0188. For immersion, buried & under insulation services, 100% of coated area shall be inspected for holidays. For atmospheric exposure, 10% of coated area which must include weld seams, corners and edges to be holiday tested. Voltage at which test is to be carried out will depend upon DFT of coating being tested and shall be as per NACE SP0188. Any holiday is unacceptable and should be marked and repaired immediately**.**

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The CONTRACTOR shall arrange for spot checking of paint materials for specific gravity, glow time (ford cup) and spreading rate.

13.0 PAINT MATERIAL GUARANTEE CERTIFICATE

The CONTRACTOR shall guarantee that the chemical and physical properties of paint materials used are in accordance with the specifications contained herein/to be provided during execution of work and shall submit necessary certificate of the paint material.

14.0 QUALIFICATION CRITERIA OF PAINTING CONTRACTOR/SUB-CONTRACTOR

Painting CONTRACTOR who is awarded any job for EIL, Projects under this specification must have necessary equipment, machinery, tools and tackles for surface preparation, paint application and inspection. The CONTRACTOR must have qualified, trained and experienced surface preparator, paint applicator, inspector and supervisors. The CONTRACTOR supervisor, inspector, surface preparator and paint applicator must be conversant with the standards referred in this specification.

15.0 PRE-QUALIFICATION/ACCEPTANCE CRITERIA FOR PAINT COATING SYSTEM

15.1 Pre-qualification of paint coating manufacturer and their products

Paint manufacturer meeting the following requirements shall be considered by the CONTRACTOR for supply of the paint products.

a) Manufacturer should have been in continuous business of paint coating formulation and manufacturer for at least past 5 years.

b) Manufacturer should possess past experience of supplying his products to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms in the past 5 years.

c) Coating manufacturer should have supplied at least 10000 litre of an individual product to hydrocarbon, petrochemical, fertilizer. Chemical processing industry or offshore platforms.

d) The manufacturer's manufacturing procedure & QA/QC system shall meet ISO 9001 requirements and preferably should possess ISO 14000 certificate.

e) The Quality control set up should be manned by qualified paint technologists whose biodata should be sent along with quality control organization chart.
The Past Track record of the manufacturers as mentioned above shall be substantiated by providing relevant documents to EIL-SMMS for their review and acceptance. This shall include Work Orders, Purchase orders and ISO 9001 certification covering all the requirements mentioned from bullets a) to e) above.
CONTRACTOR shall procure the paint materials from the qualified manufacturer meeting above requirements and after obtaining prequalification testing approval as per requirements mentioned in clause 15.2 below.

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15.2 Pre-Qualification Testing procedure:

The paint manufacturer engaged by the mechanical contractor shall carry out the tests in NABL accredited government laboratories or in suggested list of laboratories below, as a part of qualification. Paint manufacturer shall provide the paint samples to laboratory for testing of the parameters mentioned in Table-2 (typical characteristics) and Table-13 (tests on coating systems) of this specification. The testing laboratory will confirm the compliance of the paint material with respect to the acceptance criteria mentioned in the respective tables. Colored photographs of coated test panels should be taken before and after the test and should be enclosed along with test report. Contractor shall furnish these test certificates along with all necessary supporting documents/information to EIL-SMMS for approval/ acceptance. The paint manufacturer will be qualified and approved by EIL-SMMS for supply of paints after review/assessment of the submissions made by the contractor. Test certificates which are more than 3 years old will not be considered. Paint manufacturers are advised to carryout pre-qualification testing accordingly for paints supply to EIL projects.

List of suggested laboratories:

1. National Test house – Kolkata
2. National Test house-Mumbai
3. HBTU- Kanpur
4. GIRDA (Gujarat Industrial Research & Development Agency)- Vadodara
5. Indian institute of chemical technology – Hyderabad
6. RITES – Kolkata
7. ICT- Mumbai

TABLE-13: PRE-QUALIFICATION TESTING

SYSTEM No.	COATING SYSTEM	REFERENCE CLAUSE (from table-3 to 12)	TOTAL DFT µ (min)
1.	F-9+P6+F6B+F2	5.2	345
2.	F9+F12+F12	5.3	105
3.	F15+F15+F15	8.2.1	240
4.	F16+F16	7.3.1	250
5.	F17	8.3.3	400
6.	F8	3.1	125
7.	F20+F20	8.5.1	1100
8.	F6A+F6C	8.1.1	500
9.	F9+F7+F7+F7	9.2.1	365
10.	F15+F6A+F6A	8.9.1	280

S. No.	TEST	FOR SYSTEM NUMBER	DURATION	ACCEPTANCE CRITERIA
1.	Cyclic Test Salt Spray : 72 hrs. Drying in air: 16 hrs. UV-A340 nm weather meter: 80 hrs. One cycle: 168 hrs.	1	4200 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling shall be observed.

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	(25 cycles at 168 hrs. each cycle) (ASTM D5894)			
2.	Chemical Resistance Test **(**ASTM D543)			
2a.	10% & 40% NaOH	3, 5, 7, 9 & 10	1000 hrs.	Shall pass. No cracking, discoloration, blistering, peeling or softening of film shall be observed.
2b.	5% H2SO4		168 hrs.	
2c.	Xylene		4 weeks	
2d.	Acetone		4 weeks	
2e.	Ethanol		4 weeks	
2f.	Kerosene		4 weeks	
2g.	Sea water		2000 hrs.	
3.	Immersion in DM/DI water @90^0 (ASTM C868)	3, 5, 7, 9 & 10	30 days	No softening, blistering or film damage.
4.	Resistance to DM water using water immersion. (ASTM D870)	8	2000 hrs.	Shall pass. No chalking, cracking, flaking, blistering or peeling.
5.	100% Humidity Test (ASTM D2247)	1 to 10 (except system-2)	1440 hrs.	Shall pass
6.	Thermal Shock Resistance Test; 5 cycles @ 30 minutes in furnace at 120 º C and 15 minutes in water after quenching in water for each cycle. (ASTM D2485 method A)	2, 3, 4, & 10 (For system-2, testing to be done after heating the panels at 400°C for 2 hrs.)	-	Shall pass
7.	Cathodic Disbondment Test (ASTM G42 @80°C)	3, 5, 9, & 10	-	Diameter of cathodic Disbondment < 10 mm with 6 mm diameter artificial holiday.
8.	Assessment of Adhesion and artificial ageing as per ISO 19277	3, 4, 5, 9 & 10	-	Shall Pass

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Each coating product to be qualified shall be identified by the Specific gravity of base and curing agent (ISO 2811). The identification shall be carried out on the batch, which is used for the pre-qualification testing.

15.3 Information to be furnished during delivery of paint materials:

CONTRACTOR along with delivery of paint material has to furnish following information from paint manufacturer to EIL for acceptance/approval of products:

a) Batch test certificates:

Along with paint products delivery to site from the pre-qualified coating manufacturer, CONTRACTOR has to produce test certificate (from paint manufacturer) for each category of product for the following test items. All test results must mention clearly the batch no. and category of product tested. Tests to be conducted for following properties:

- Specific Gravity
- % solids by weight (% zinc content in case of inorganic or organic zinc primer) ~ ASTM D521.

b) Product information sheet/ technical data sheet for each category of product.
The contractor shall be fully responsible for the quality of the paints products as per prequalification testing. After the paint materials are supplied to site, the supplier shall organize random sampling and testing in a NABL laboratory as per discretion of the Engineer-in-charge in consultation with SMMS. Failing to meet the specified quality requirements may cause rejection of the paint products.

16.0 METHOD OF SAMPLING & DISPATCH FOR LABORATORY TESTING

(Pre-Qualification tests (sec. 15.2), Batch testing (sec. 15.3) and Inspection testing (sec. 12.0))

16.1 Samples of coating materials should be submitted to the laboratory in sealed containers with batch no. and test certificate on regular format of manufacturer's testing laboratory.

16.2 All test panels should be prepared by testing laboratory. Surface preparation for a system shall be done in accordance with this specification. For individual products testing, minimum shall be Sa 2.5. Colour photographs of test panels should be taken before and after the test and should be enclosed along with test report. Sample batch no. and manufacturer's test certificate should be enclosed along with the report. Test report must contain details of observation and rusting if any, as per the testing code.

16.3 Manufacturers should intimate EIL, details of sample submitted for testing, name of testing agency, date, and contact personnel of the testing agency.

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ANNEXURE-1: COLOUR CODE

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SR. No.	SERVICE	RECOMMENDED COLOUR FOR PAINT SYSTEM	RAL COLOUR CODE	
			BASE COLOUR	BAND COLOUR
		HYDROCARBON LINES (UNINSULATED)		
1	CRUDE SOUR	Basalt Grey with 1 deep orange band	7012	2011
2	CRUDE SWEET	Basalt Grey with 1 signal red band	7012	3001
3	LUBE OILS	Basalt Grey with 1 grass green band	7012	6010
4	FLARE LINES	White Aluminum	9006	
5	LPG	Deep Orange with 1 oxide red band	2011	3009
6	PROPYLENE	Deep Orange with 2 Cobalt blue bands	2011	5013
7	NAPTHA	Deep Orange with 1 grass green band	2011	6010
8	M.S.	Deep Orange with 1 Basalt Grey band	2011	7012
9	AV.GASOLINE (96 RON)	Deep Orange with 1 band each of grass green, white and signal red bands	2011 / 6010	9010 / 3001
10	GASOLINE (regular, leaded)	Deep Orange with 1 Jet black band	2011	9005
11	GASOLINE (premium, leaded)	Deep Orange with 1 Cobalt blue band	2011	5013
12	GASOLINE (white)	Deep Orange with 1 white band	2011	9010
13	GASOLINE (Aviation 100/130)	Deep Orange with 1 signal red band	2011	3001
14	GASOLINE (Aviation 115/145)	Deep Orange with 1 traffic purple band	2011	4006
15	N-PENTANE	Deep Orange with 2 Cobalt blue bands	2011	5013
16	DIESEL OIL (White)	Oxide red with 1 white band	3009	9010
17	DIESEL OIL (Black)	Oxide red with 1 traffic yellow band	3009	1023
18	KEROSENE	Oxide red with 1 grass green band	3009	6010
19	HY.KEROSENE	Oxide red with 2 grass green bands	3009	6010
20	DISUFIDE OIL (EX-MEROX)	Oxide red with 1 jet black band	3009	9005
21	M.T.O	Oxide red with 3 grass green bands	3009	6010
22	DHPPA	Oxide red with 2 white bands	3009	9010
23	FLUSHING OIL	Oxide red with 2 jet black bands	3009	9005
24	LAB FS	Oxide red with 2 Basalt Grey bands	3009	7012
25	LAB RS	Oxide red with 3 Basalt Grey bands	3009	7012
26	LAB (Off. Spec)	Oxide red with 1 light grey band	3009	7035

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27	N-PARAFFIN	Oxide red with 1 Cobalt blue band	3009	5013
28	HEAVY ALKYLATE	Oxide red with signal red band	3009	3001
29	BLOW DOWN, VAPOR LINE	Off white / Aluminum with 1-Brown band	9006	8004
30	BLOWDOWN	Off white / Aluminum with 2 copper brown bands	9006	8004
31	A.T.F.	Clay Brown with 1 white band	8003	9010
32	TOULENE	Clay Brown with 1 traffic yellow band	8003	1023
33	BENZENE	Clay Brown with 1 grass green band	8003	6010
34	LAB PRODUCT	Clay Brown with 1 Cobalt blue band	8003	5013
35	FUEL OIL	Jet Black with 1 traffic yellow band	9005	1023
36	FULE OIL (Aromatic rich)	Jet Black with 2 traffic yellow bands	9005	1023
37	ASPHALT	Jet Black with 1 white band	9005	9010
38	SLOP AND WASTE OILS	Jet Black with 1 deep orange band	9005	2011
39	SLOP AROMATICS	Jet Black with 2 deep orange bands	9005	2011
		CHEMICAL LINES		
40	TRI-SODIUM PHOSPHATE	Lemon Yellow with 1 violet blue band	1012	5000
41	CAUSTIC SODA	Lemon Yellow with 1 jet black band	1012	9005
42	SODIUM CHLORIDE	Lemon Yellow with 1 white band	1012	9010
43	AMMONIA	Lemon Yellow with 1 Cobalt blue band	1012	5013
44	CORROSION INHIBITOR	Lemon Yellow with 1 Aluminum band	1012	9006
45	HEXAMETA PHOSPHATE	Lemon Yellow with 2 jet black bands	1012	9005
46	ACID LINES	Golden Yellow with 1 signal red band	1004	3001
47	RICH AMINE	Lemon Yellow with 2 Cobalt blue bands	1012	5013
48	LEAN AMINE	Lemon Yellow with 3 Cobalt blue bands	1012	5013
49	SOLVENT	Lemon Yellow with 1 grass green band	1012	6010
50	LCS	Lemon Yellow with 1 Blue Grey	1012	7031
		WATER LINES		
51	RAW WATER	Sky blue with 1 jet black band	5015	9005
52	INDUSTRIAL WATER	Sky blue with 2 signal red band	5015	3001
53	TREATED WATER	Sky blue with 1 oxide red band	5015	3009
54	DRINKING WATER	Sky blue with 1 grass green band	5015	6010

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55	COOLING WATER	Sky blue with 1 light brown band	5015	1011
56	SERVICE WATER	Sky blue with 1 signal red brown	5015	3001
57	TEMPERED WATER	Sky blue with 2 grass green bands	5015	6010
58	DM WATER	Sky blue with 1 aluminum band	5015	9006
59	DM WATER ABOVE 150°F	Sky blue with 2 jet black bands	5015	9005
60	SOUR WATER	Sky blue with 2 traffic yellow bands	5015	1023
61	STRIPPED WATER	Sky blue with 2 Cobalt blue bands	5015	5013
62	ETP TREATED WATER	Sky blue with 2 oxide red bands	5015	3009
FIRE PROTECTION SYSTEM (ABOVE GROUND)				
63	FIRE WATER FOAM & EXTINGUISHERS	Carmine Red	3002	
AIR & OTHER GAS LINES (UNINSULATED)				
64	SERVICE AIR	Yellow green with 1 signal red band	6018	3001
65	INSTRUMENT AIR	Yellow green with 1 jet black band	6018	9005
66	NITROGEN	Yellow green with 1 deep orange band	6018	2011
67	FREON	Yellow green with 1 traffic yellow band	6018	1023
68	CHLORINE	Lemon Yellow with 1 oxide red band	1012	3009
69	SO_2	Lemon Yellow with 2 white bands	1012	9010
70	H_2S	Deep Orange with 2 oxide red bands	2011	3009
71	GAS (Fuel)	Deep Orange with 1 aluminum band	2011	9006
72	GAS (Sour)	Deep Orange with 2 aluminum bands	2011	9006
73	GAS (Sweet)	Deep Orange with 2 signal red band	2011	3001
74	HYDROGEN	Deep Orange with 1 Pale green band	2011	6021
STEAM AND CONDENSATE LINES (UNINSULATED)				
75	HP STEAM	White Aluminum with 1 traffic yellow band	9006	1023
76	MP STEAM	White Aluminum with 1 signal red band	9006	3001
77	MLP STEAM	White Aluminum with 1 orange band	9006	2011
78	LP STEAM	White Aluminum with 1 light green band	9006	6021
79	CONDENSATE	Sky blue with 1 white band	5015	9010

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80	CONDENSATE ABOVE 150°F	Sky blue with 3 oxide red band	5015	3009
81	BFW	Sky blue with 2 signal red bands	5015	3001
Note: For all insulated steam lines, the colour coding shall be followed as given for un-insulated lines with the specified length of colour bands.				
INSULATED HYDROCARBON PIPING				
82	IFO SUPPLY	Jet Black ground colour with 1 traffic yellow band in centre	9005	1023
83	IFO RETURN	Jet Black ground colour with 1 grass green band in centre	9005	6010
84	HPS	Jet Black ground colour with 1 signal red band in centre	9005	3001
85	BITUMEN	Jet Black ground colour with 2 signal red bands in centre	9005	3001
86	CLO	Jet Black ground colour with 1 brown band in centre	9005	8004
87	VB TAR	Black ground colour with 2 copper brown bands in centre	9005	8004
88	VR AM (BITUMEN / VBU FEED)	Jet Black ground colour with 1 Cobalt blue band in centre	9005	5013
89	VR BH	Black ground colour with 2 Cobalt blue bands in centre	9005	5013
90	VAC. SLOP	Black ground colour with 1 white band in centre	9005	9010
91	SLOP	Black ground colour with 1 deep orange band in centre	9005	2011
92	CRUDE SWEET	Basalt Grey ground colour with 1 signal red band in centre	7012	3001
93	CRUDE OUR	Basalt Grey ground colour with 1 deep orange band in centre	7012	2011
94	VGO / HCU	Oxide red ground colour with 2 iron grey bands in centre	3009	7011
95	OHCU BOTOM / FCCU FEED	Oxide red ground colour with 2 iron grey bands in centre	3009	7011
UNINSULATED EQUIPMENT, TANKS AND STRUCTURES				
96	HEATER STRUCTURE	Iron grey	7011	
97	HEATER CASING	White Aluminum	9006	
98	VESSELS & COLUMNS	White Aluminum	9006	
99	HYDROGEN BULLETS	Antique Pink	3014	
100	LPG VESSELS	Oxide red	3009	
101	SO_2 VESSEL	Lemon Yellow	1012	
102	HEAT EXCHANGER	White Aluminum	9006	
103	FO TANK AND HOT TANKS	Jet Black	9005	

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104	ALL OTHER TANKS	White Aluminum	9006	
105	CAUSTIC / AMINE / ACID TANKS	Golden yellow	1004	
106	SOUR WATER	Sky Blue	5015	
107	OUTER SURFACE IN BOILER HOUSE	Aluminum	9006	
108	COMPRESSORS AND BLOWERS	Basalt Grey	7012	
109	PUMPS	Pigeon Blue	5014	
110	MOTORS & SWITCH GEAR	Pastel Blue	5024	
111	HAND RAILING	Signal red	3001	
112	STAIRCASE, LADDER AND WALKWAYS	Jet Black	9005	
113	LOAD LIFTING EQUIPMENT AND MONORAILS ETC	Clay Brown	8003	
114	GENERAL STRUCTURE	Steel blue (equivalent to British Airways Blue as per British Standard)	5011	
115	FLUE GAS STACK	Jet Black	9005	
PIPES AND FITTINGS OF ALLOY STEEL AND SS MATERIAL IN STORE				
115	IBR	Signal red	3001	
116	9Cr-1Mo	Pale Green	6021	
117	5Cr-0.5Mo	Light Blue	5012	
118	$2_{1/4}$Cr-1 Mo	Luminous Yellow	1026	
119	$1_{1/4}$Cr-½ Mo	Traffic Yellow	1023	
120	SS-304	Grey Blue	5008	
121	SS-316	Blue Lilac	4005	
122	SS-321	Pigeon Blue	5014	
SAFETY COLOUR SCHEMES				
123	DANGEROUS OBSTRUCTION	Jet Black and Bright Red Orange band	9005	2008
124	DANGEROUS OR EXPOSED PARTS OF MACHINERY	Bright Red Orange	2008	

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बायलर क्वालिटी कार्बन स्टील प्लेटों का मानक विनिर्देश

STANDARD SPECIFICATION FOR BOILER QUALITY CARBON STEEL PLATES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
9	08.02.2022	REVISED AND REISSUED AS STD. SPEC.	JK	KA	NK	SM
8	19.01.2017	REVISED & REISSUED AS STD. SPEC.	RNK	SK/KJH	RKT	RN
7	30.06.2010	REVISED & REISSUED AS STD. SPEC.	KA	RKT	AKM/DM	N.DUARI
6	10.09.09	REVISED & REISSUED AS STD. SPEC.	VB	RKG	AKM	N.DUARI
5	16.04.04	REVISED & REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG

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Abbreviations:

ASME	American Society of Mechanical Engineers
EN	European Norm
HIC	Hydrogen Induced Cracking
IBR	Indian Boiler Regulations
SSC	Sulphide Stress Cracking

STANDARDS COMMITTEE

SMED-I (Static Equipment) (Group code 12,13,15,26)

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CONTENTS

1.0	SCOPE	4
2.0	GENERAL	4
3.0	SUPPLEMENTARY TECHNICAL REQUIREMENTS	4
4.0	CERTIFIED DOCUMENTS	6
5 .0	PAINTING AND COATING	6
6.0	INSPECTION AUTHORITY	7

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1.0 SCOPE

1.1 This specification covers requirements for carbon steel plates intended primarily for pressure vessels/heat exchangers. The steel plates shall meet the requirements of ASME Boiler and Pressure Vessel Code Section II (latest). This is intended to supplement the minimum applicable requirements of the material specification indicated in the material requisition.

1.2 Following codes, standards etc shall be followed in their latest edition and addenda, errata, amendments unless specified otherwise:

1.2.1 ASME Sec VIII Div 1

1.2.2 ASME Sec II part A

1.2.3 EN 10163: Delivery Requirements for Surface Conditions.

1.2.4 EN 10204: metallic products – Types of Inspection Documents.

2.0 GENERAL

2.1 Plates supplied to this specification shall conform to specification SA-20 of ASME sec II part A with additional requirements mentioned herein.

2.2 The tolerance on thickness of steel plates shall be positive only.

2.3 Final Rolling shall be lengthwise.

2.4 The plates shall be free from injurious defects and shall have workmanlike finish. Reconditioning/repair of plates by welding shall not be permitted. Surface conditions shall meet requirements of EN 10163 Class A Subclass 3.

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS

3.1 All plates shall be supplied in normalised condition except when the applicable material specifications require supply of plates in quenched and tempered condition.

3.2 a. One product analysis of each heat shall be carried out and reported. Chemical analysis shall be as per applicable specification.

b. The carbon content for plates shall not exceed 0.23%.

Additionally, one of the following requirements for carbon equivalent based on heat analysis, shall be also satisfied:

$$Ceq = C + \frac{Mn}{6} \leq 0.42 \quad \text{.....} \quad \text{(Eqn. - 1)}$$

$$Ceq = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15} \leq 0.43 \quad \text{.....} \quad \text{(Eqn. - 2)}$$

Equation-1 shall be used when applicable material specification specifies C and Mn only.

Equation-2 shall be used when applicable material specifies the above elements or restricted chemical requirements are specified or supplementary requirements S19 and S21 of SA-20 are specified in material requisition.

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For HIC services, these requirements shall be as listed separately.

3.3 Ultrasonic Examination of Plates

a. Plates having thickness 16 mm to 50 mm (both inclusive) shall be examined ultrasonically as per SA-435.

b. For thicknesses above 50mm ultrasonic examination shall be carried out as per SA-578 and shall have acceptance standard of level-B.

c. For quenched and tempered steel plates, ultrasonic examination shall be done after the heat treatment of plates.

3.4 Simulated Heat Treatment of Test Coupons

The following heat treatment shall be conducted on the test coupons representative of heat treated plates before the specified mechanical testing like tensile, bend, impact tests, etc. to meet minimum ASME Sec. II Part - A requirements and these details shall also be recorded on the test certificates.

a. All plates supplied in Normalised condition and intended for hot rolling / hot forming:

Heat Treatment Cycle

One normalising* + One stress relieving as per UCS-56 of ASME Sec. VIII Div.1 complying with UCS-85 of ASME Section VIII Div. 1.

Note: Any other special requirement shall be specified in MR.

b. All plates supplied in Quenched & Tempered condition and intended for hot rolling/ hot forming:

Heat Treatment Cycle

One normalising* + quenched & tempering + One stress relieving as per UCS-56 ASME Section VIII Div.1 complying with UCS-85 of ASME Section VIII Div.1.

Note : Tempering temperature shall be at least 20° C above highest stress relieving temperature.

* Normalising cycle shall be as per Material Test Certificate (MTC).

c. All plates supplied in Quenched & Tempered condition and intended for cold forming:

Heat Treatment Cycle

One stress relieving as per UCS-56 ASME Section VIII Div.1 complying with UCS-85 of ASME Section VIII Div.1.

3.5 Impact test requirements shall be ascertained as per ASME Sec VIII Div.1 or Div.2 as applicable. When required, Impact testing shall be performed as per supplementary requirement of S5 of specification SA-20 and acceptance criteria for energy absorption shall be as per table A2.15 of SA-20.

3.6 If specified in the material requisition, plates shall meet the requirements of Indian Boiler Regulations (IBR).

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3.7 Additional Requirements for High Thickness Plates

Plates above 50mm thickness shall meet following additional requirements:

a. Vacuum Degassing treatment as per the supplementary requirement S1 of specification SA-20. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

b. Charpy V-notch impact test as per the supplementary requirement S5 of specification SA-20.

Material meant to be used for design temperature warmer than 0°C, impact test shall be carried out at 0°C or MDMT whichever is lower and acceptance criteria for energy absorption shall be as per Table A2.15 of SA-20. Incase the acceptance criteria is not available in SA-20, then applicable design code shall be referred unless otherwise specified in material requisition.

c. Simulated heat treatment of test coupons for all plates as per Clause 3.4 mentioned above.

4.0 CERTIFIED DOCUMENTS

The supplier shall furnish certificates/documents (number of copies as specified in requisition) inclusive of all the following tests required as per specification duly certified by the Inspecting Authority before shipment of plates. The actual values obtained shall be recorded in the test certificates/documents. Material certificates shall conform to EN 10204 Type 3.1/3.2 as specified.

a. Chemical Analysis

b. Mechanical Tests

c. Data of heat treatment i.e. initial temperature, heating rate, soaking temperature, cooling rate, etc.

d. Simulated Heat Treatment of Mechanical Test coupons (S3 of SA-20) at indicated Heat Treatment Cycle (if specified in the requisition or whenever applicable)

e. Ultrasonic Examination (S8 or S12 of SA-20)

f. Charpy V-notch impact tests (S5 of SA-20 if specified in the requisition or whenever applicable)

g. Certification as per IBR (if specified in the requisition)

h. SSC and/or HIC tests (if specified in material requisition)

i Additional tests (if specified in requisition).

5.0 PAINTING AND COATING

No painting/coating of any kind is permitted on the steel plates, except stencil marking. However steel plates shall be carefully protected and packed against any damage during transit and shall be of sea worthy condition.

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6.0 INSPECTION AUTHORITY

Material test certificates, duly certified by Mill's Quality Assurance Department are acceptable i.e. 3.1 certification as per EN 10204. However, if third party inspection is required specifically for plates in material requisition, all test certificates and documents shall be duly certified by the third party. i.e. 3.2 certification as per EN 10204.

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भंडारण टैंक एवं वैसल के लिये वेल्डिंग योग्य स्ट्रक्चरल क्वालिटी स्टील प्लेटों का मानक विनिर्देश

STANDARD SPECIFICATION FOR WELDABLE STRUCTURAL QUALITY STEEL PLATES FOR STORAGE TANKS AND VESSELS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
7	27.03.2023	REVISED AND REISSUED AS STD. SPEC.	NSK 27/03/23	TK 27/03/23	NK	SM
6	22.09.2017	REVISED AND REISSUED AS STD. SPEC.	SK	KJH	RKT	RN
5	30.06.2010	REVISED AND REISSUED AS STD. SPEC.	KA	RKT	AKM/DM	N.DUARI
4	15.09.09	REVISED & REISSUED AS STD. SPEC.	VB	RKG	AKM,	N.DUARI
3	08.04.04	REVISED & REISSUED AS STD. SPEC.	DNN	AKM	SSA	SKG

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Abbreviations:

EN	:	European Norm
IS	:	Indian Standard

Static Equipment Standards Committee

Convenor : Mr. Nalin Kumar

Members :

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Mr. Tarun Kumar (Emp. No. A328)
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Mr. Anish Trehan
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Mr. Avdhesh Agarwal (SCM-Inspection)

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CONTENTS

1.0 SCOPE 4

2.0 GENERAL 4

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS 4

4.0 CERTIFIED DOCUMENTS 4

5.0 PAINTING AND COATING 5

6.0 INSPECTION AUTHORITY 5

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1.0 SCOPE

1.1 This specification covers additional and supplementary requirements for weldable structural quality Steel Plates to IS: 2062 (latest), intended primarily for storage tanks and vessels.

1.2 Following Codes, standards etc. shall be followed in their latest edition and addenda, errata, amendments unless specified otherwise:

1.3 IS:2062, IS:1852, IS:10842 (All Parts)

1.4 EN 10163 (All Parts): Delivery for Surface Condition.

1.5 EN 10204: Metallic products – Types of Inspection Documents.

2.0 GENERAL

2.1 The maximum under tolerance permissible on the thickness of plate shall be 0.25 mm. Tolerances on other dimensions of plates shall be as per IS: 1852.

2.2 Direction of final rolling shall be lengthwise.

2.3 Reconditioning/Repair of plates by welding shall not be permitted. Surface finish shall be ground/flush smooth and shall be free from any surface imperfection.

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS

3.1 Heat analysis and product analysis shall be carried out for each heat and chemical composition shall meet the limits as specified in IS: 2062.

3.2 Y-groove weld crackability test as per IS: 10842 shall be carried out for plates conforming to Gr. E250 C having thickness 12mm and above.

3.3 Charpy impact test shall be carried out on the plates having thickness greater than 12 mm conforming to Grade E250 BR, E250 B0 & E250 C. Test temperature and acceptance criteria for energy absorption shall be as mentioned in Table-2 of the specification IS: 2062.
For Thickness less than 12 mm (for materials E250 Gr.B0 & E250 Gr.C), if required, the minimum impact energy values of reduced sizes shall be as per Fig. 2 of the specification IS: 2062.

4.0 CERTIFIED DOCUMENTS

The supplier shall furnish certificates/documents (number of copies as specified in requisition) inclusive of all the following tests required as per specification, duly certified by the Inspecting Authority before shipment of plates. The actual values obtained during tests shall be recorded in the test certificates/documents. Material certificates shall conform to EN 10204 Type 3.1/3.2 as required.

a. Chemical Analysis
b. Mechanical Tests
c. Data of heat treatment
d. Charpy V-notch impact tests
e. Y- groove crackability test

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5.0 PAINTING AND COATING

No painting/coating of any kind is permitted on the steel plates except stencil marking. However steel plates shall be carefully protected and packed against any damage during transit and shall be of sea worthy conditions.

6.0 INSPECTION AUTHORITY

Material test certificates, duly certified by Mill's Quality Assurance Department are acceptable i.e. 3.1 certification as per EN 10204. However, if third party inspection is required specially for plates in requisition, all test certificates and documents shall be duly certified by the third party. i.e. 3.2 certification as per EN 10204.

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स्टेनलैस स्टील प्लेटों का मानक विनिर्देश

STANDARD SPECIFICATION FOR STAINLESS STEEL PLATES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
9	29.05.2023	REVISED AND REISSUED AS STD. SPEC.	NSK	TK	NK	SM
8	22.09.2017	REVISED AND REISSUED AS STD. SPEC.	RNK	SK/KJH	RKT	RN
7	30.06.2010	REVISED AND REISSUED AS STD. SPEC.	KA	RKT	AKM/DM	N.DUARI
6	25.09.09	REVISED AND REISSED AS STD. SPEC	VB	RKG	AKM	N.DUARI
5	16.04.04	REVISED AND REISSED AS STD. SPEC	DNN	AKM	SSA	SKG

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Abbreviations:

ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing & Materials
EN	European Standard
BHN	Brinell Hardness Number
SS	Stainless Steel

Static Equipment Standards Committee

Convenor : Mr. Nalin Kumar
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Mr. Avdhesh Agrawal (SCM-Inspection)

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CONTENTS

1.0 SCOPE 4

2.0 GENERAL 4

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS 4

4.0 CERTIFIED DOCUMENTS 5

5.0 PAINTING AND COATING 5

6.0 INSPECTION AUTHORITY 5

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1.0 SCOPE

1.1 This specification covers requirements for chromium, chromium-nickel and chromium-manganese-nickel stainless and heat resisting steel plates intended primarily for pressure vessels/heat exchangers. The steel plates shall meet the requirements of ASME Boiler and Pressure Vessel Code Section II (latest). This is intended to supplement the minimum applicable requirements of the material specification indicated in the material requisition.

1.2 Following codes, standards etc. shall be followed in their latest edition and addenda, errata, amendments unless specified otherwise:

1.2.1 ASME Sec II Part A.

1.2.2 EN10163 (All parts): Delivery Requirements for Surface Conditions.

1.2.3 EN 10204: Metallic products- Types of Inspection Documents.

2.0 GENERAL

2.1 Plates supplied to this specification shall conform to specification SA-480 with additional requirements mentioned herein.

2.2 Adequate tolerance shall be considered on Plate length and width for shear and plasma cutting. The tolerance on thickness of plates shall be positive only.

2.3 Final Rolling shall be lengthwise.

2.4 Plates shall have no. 1 finish on both sides with reference to SA-480. Cold Rolled plates, if permitted by Requisition, shall have no. 2B finish. Repair/reconditioning of plates shall not be permitted.

3.0 SUPPLEMENTARY TECHNICAL REQUIREMENTS

3.1 All plates shall be supplied in hot-rolled, fully annealed and pickled condition. All stabilized grades of Stainless Steel (SS 321, SS 347etc.) shall be given stabilization heat treatment in addition to solution annealing. The soaking temperatures for stabilization heat treatment shall be 915°C ± 10°C and soaking period shall be minimum of 4 hours (2 hours for thickness $\leq$ 3.5mm).

3.2 Unless specified otherwise in material requisition, plate representative of each heat shall be subjected to intergranular corrosion tests as per ASTM A-262 Practice E for all the 300 series materials. The bend test specimen shall be examined at a magnification of 200 x; and bent specimen shall be free of any cracks or grain dropping.

3.3 For straight chrome (13% Cr) material, maximum carbon content shall not exceed 0.06%. Hardness of UNS no.S41000, S41008 and S40500 shall be less than 241 BHN unless otherwise specified in the ASME BPV Section II, material specification.

3.4 a. Plate having thickness 16 mm to 50 mm (both inclusive) shall be examined ultrasonically as per SA-435.

b. For thickness above 50mm ultrasonic examination shall be carried out as per SA-578 and shall have acceptance standard of level-B.

3.5 All mandatory tests as per material specification shall be carried out. However tension test specimen shall be from finished material and shall be selected in transverse direction.

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4.0 CERTIFIED DOCUMENTS

The supplier shall furnish certificates/documents (number of copies as specified in requisition) inclusive of all the following tests required as per specification duly certified by the Inspecting Authority before shipment of plates. The actual values obtained shall be recorded in the test certificates/documents. Material certificates shall conform to EN 10204 Type3.1/3.2 as required.

a. Chemical Analysis

b. Mechanical Tests

c. Data of heat treatment i.e. initial temperature, heating rate, soaking temperature, cooling rate, etc.

d. Ultrasonic Examination

e. Intergranular corrosion test for 300 series

f. Intergranular corrosion test for series other than 300 (whenever specified in the requisition)

g. Type of finish for plate surfaces

5.0 PAINTING AND COATING

Plates are not to be painted/coated but shall be covered with plastic foils or paper or by other means for careful protection and shall be packed against any damage during transit and sea-weather conditions.

6.0 INSPECTION AUTHORITY

Material test certificates, duly certified by Mill's Quality Assurance Department are acceptable i.e. 3.1 certification as per EN 10204. However, as specified, if third party inspection is required specifically for plates, all test certificates and documents shall be duly certified by the third party. i.e. 3.2 certification as per EN 10204.

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सामान्य विनिर्देश

GENERAL SPECIFICATION
FOR
HEAT EXCHANGERS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	26-04-2024	REVISED & REISSUED AS SPECIFICATION	MKP	TKh	KA/NK	MN
5	19-09-2018	REVISED & REISSUED AS SPECIFICATION	SK	KA	KJH	RKT
4	11-08-2010	REVISED & REISSUED AS SPECIFICATION	KA	RKT	AKM/DM	ND
3	12-01-2006	REVISED & REISSUED AS SPECIFICATION	KA	PK	AKM	VJN
2	10-12-1999	REVISED & REISSUED AS SPECIFICATION	HN	PK	RKA	AS

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Abbreviations:

ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
BHN	Brinell Hardness Number
BTD	Bolt Tensioning Device
BV	Bureau Veritas
CIB	Chief Inspector of Boilers
CS	Carbon Steel
DIA	Designated Inspection Agency
DNV	Det Norske Veritas
DP	Dye Penetrant
FPW	Full Penetration Weld
GPC	General Purchase Condition
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
IBR	Indian Boiler Regulation
ID	Inside Diameter
IGC	Inter Granular Cracking
IS	Indian Standards
LAS	Low Alloy Steel
LTCS	Low Temperature Carbon Steel
MDMT	Minimum Design Metal Temperature
MP	Magnetic Particle
NB	Nominal Bore
NDT	Non-Destructive Testing
PO	Purchase Order
ppm	parts per million
PTC	Production Test Coupons
PWHT	Post Weld Heat Treatment
QAP	Quality Assurance Plan
SS	Stainless Steel
TEMA	Tubular Exchangers Manufacturers' Association
UT	Ultrasonically Tested
UTS	Ultimate Tensile Strength

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar
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1.0 GENERAL

1.1 Scope

This specification covers the requirements for residual design, engineering, materials, fabrication, workmanship, inspection and testing of shell and tube heat exchangers and is intended to supplement the requirements of the applicable Codes. EIL specifications and standards wherever indicated in the requisition shall be followed unless stated otherwise.

This specification shall not be considered limiting and it shall be Supplier's responsibility to comply with all requirements of requisition or bid documents to which it is annexed.

1.2 References

1.2.1 CODES AND REGULATIONS

The following Codes in their edition referenced in drawings or data sheets or design basis along with the other specifications enclosed with the requisition shall form the basis for design, materials, fabrication, inspection, testing and acceptance of the equipment:

(a) ASME Boiler and Pressure Vessel Code Section VIII Division 1 (Code), ASME Section II Part A, B, C and D, ASME Section V, ASME Section IX.

(b) TEMA (Class as specified on the drawings or data sheets or design basis).

(c) IBR, if applicable (latest edition with amendments up to date).

(d) National and local laws or regulations, as applicable.

1.2.2 FOR HEAT EXCHANGERS UNDER THE PURVIEW OF IBR:

(a) Supplier shall carry out design calculations as per IBR and only in case of any doubt refer the same to Owner and EIL for clarifications. All materials, fabrication, welding, testing etc. shall meet the requirements of IBR.

(b) In case the equipment is manufactured in India, the design calculations and fabrication drawings after preliminary review of Owner and EIL shall be got approved by Supplier from CIB of the State where Supplier's shop is located, prior to start of fabrication. Supplier shall also provide the necessary assistance to Owner for obtaining approval from CIB of State of installation, such as providing additional copies of calculations and drawings etc. as required by CIB of that State.

(c) In case the equipment is manufactured outside India, the design calculations and fabrication drawings after preliminary review by Owner and EIL shall be got approved by Supplier from the agency authorised by IBR in the country of fabrication and the CIB of the State where the equipment is to be installed, before the start of fabrication.

(d) It shall be the responsibility of Supplier to incorporate modifications or additions required by CIB or its authorised agency and obtain the final approval. Owner and EIL shall be kept informed about these. All costs towards approval from CIB shall be borne by Supplier. All IBR approved design calculations and drawings shall be furnished to EIL for final review of fabrication drawings and in equipment dossier.

1.3 Deviations

In general, no deviations from datasheets, drawings, standards, specifications and requisition shall be permitted.

Generally, no deviations shall be entertained after the Supplier has accepted the order unless it is to comply with statutory or Code requirements. All waivers and deviations after order shall be routed through the Regional Procurement or Inspection Office In charge in the prescribed format. Delay in supply of the equipment because of such deviations being not entertained or approved by Owner or EIL or any delay in processing the same by Owner or EIL shall be to Supplier's account. Any additional design work in support of such a deviation shall be performed by the Supplier and submitted along with the deviation.

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1.4 Contradictory Requirements

In case of any contradiction between the requirements of the requisition, drawings and other documents forming part of the requisition, Supplier shall resolve the matter in consultation with Owner or EIL. Decision of Owner or EIL shall be binding and without any implication of cost and time, if not resolved at bidding stage.

2.0 MATERIAL SPECIFICATION

2.1 General

2.1.1 All materials used for fabrication shall be new and of first quality. All materials and accessories required for the fabrication, inspection, testing etc. of the heat exchanger shall be supplied by the Supplier unless otherwise stated. Whenever some material is to be supplied by the Owner, this shall be so indicated as Free Issue Material and the supplementary specifications in this regard shall be complied with.

2.1.2 In addition to the requirements of materials as per material specifications, materials shall also meet the requirements mentioned in this specification and other specifications enclosed with the requisition. All materials shall be certified for compliance with IBR requirements for the item(s) so specified. While procuring materials, Supplier shall stipulate additional requirements such as limits on hardness, UTS, yield strength, chemical composition, heat treatment and any other specific requirements to ensure that final requirement as per specification and Code are met with.

All materials for pressure parts and parts welded to pressure parts including materials in the scope of sub-suppliers, shall be accompanied with mill test certificates duly certified by a reputed third-party inspection agency. In the absence of mill test certificate the material shall be got tested from a reputed third-party inspection agency like CEIL, Lloyds, BV, DNV etc. and test results shall be submitted in lieu of mill test certificate. All cost towards such testing and inspection shall be borne by the Supplier. All materials shall be inspected at Supplier and sub-supplier's shop for verification prior to use on the job. The decision of DIA to accept or reject materials on the basis of such testing shall be final.

2.1.3 Wherever simulated heat treatment of test specimens is required as per Code or specification, the simulation cycle shall include one extra cycle of stress relieving for any eventuality of repair at site by Owner during the life of the equipment.

2.1.4 MDMT shall be taken as 0 °C or the design temperature specified in drawing or datasheet whichever is lower, unless specified otherwise in design basis or datasheets or drawings. For low temperature service (0°C and colder), unless exempted by ASME Section VIII, Div. 1, Paragraph UG-20 (f) and Paragraph UCS-66, all Carbon & Low Alloy Steel materials (for pressure parts and attachments to pressure parts) shall be impact tested at the MDMT or colder and meet requirements of ASME, Section VIII, Division 1, Paragraph UG-84.

2.1.5 PLATES

2.1.5.1 Pressure parts having thickness 16 to 50 mm (both inclusive) shall be UT as per SA-435.

2.1.5.2 Pressure parts having thickness >50 mm shall be UT as per ASME SA-578 Level B.

2.1.5.3 Reconditioning, repair of plates by welding shall not be permitted. Surface conditions shall meet requirements of EN 10163 (Part: 2) Class A Subclass 3.

2.1.6 TUBES

2.1.6.1 All the tubes shall be seamless and cold drawn.

2.1.6.2 Product analysis of tubes shall be carried out and reported in the material test certificates.

2.1.6.3 Tubes shall be in fully heat-treated condition as received from the mill. CS tubes shall be in annealed condition and copper alloy tubes shall be in annealed temper condition. LAS tubes shall be supplied in normalized and tempered condition.

2.1.6.4 All unstabilized SS tubes shall be supplied in the solution annealed condition and all stabilised grades of SS such as SS 321 and SS 347 shall be supplied in stabilization heat treated condition, in addition to solution annealing.

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2.1.6.5 It is preferable while ordering tubes the maximum yield strength and hardness of tubes are specified such as to be lower than those of tube sheet, in order to achieve a sound expanded tube to tube sheet joint, complying with Code requirements.

2.1.6.6 "Air under water" testing shall be carried out for all tubes except non-ferrous tubes. As an alternative, tubes can be hydro tested. In case the tubes are hydro tested, hydro test pressure of tubes shall be higher of tube side test pressure or as required by Code. Water quality shall be as per Para 7.2.1 of this specification.

2.1.6.7 For requirements of U tubes refer EIL specification 6-15-0006.

2.1.7 FORGINGS

Forgings manufactured to SA-105 and SA-266 above 75 mm thickness (thickness as defined in para 3.2.9 of ASME Sec. VIII Division 2), all tube sheet forgings and all forgings of other materials, except for the standard nozzle flanges up to 8" NB and small forgings (of couplings, plugs and eye bolts) shall be 100% UT as per SA-388. Acceptance criteria shall be as per para 3.3.4 of ASME Section VIII Division 2.

2.1.8 PIPES

Dimensions and tolerances shall be in accordance with ASME 36.10 or ASME 36.19, as applicable, as per material specification.

2.2 Specific material requirements (Pressure parts and parts welded to pressure parts)

2.2.1 CS AND LTCS MATERIALS

(a) Carbon content shall not exceed 0.23%.

(b) All plates shall be in normalized condition.

(c) Use of SA 515 of any grade is not permitted.

(d) Plates > 50mm thickness shall meet following additional requirements of SA-20:

(i) Vacuum treatment as per the supplementary requirement S1. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

(ii) Charpy V-notch test as per supplementary requirement S5 of specification SA-20. Material meant to be used for design temperatures warmer than 0°C, impact test shall be carried out at 0°C or MDMT whichever is lower and acceptance criteria for energy absorption shall be as per Table A2.15 of SA-20. Incase acceptance criteria is not available in SA-20, then applicable design code shall be referred unless otherwise specified in requisition. Orientation of test bar shall be transverse to rolling direction.

e) Unless specified otherwise in requisition or bid document, all CS materials specified as HIC tested shall meet the requirements of specification: 6-79-0012 or 6-79-0013 (as applicable).

(f) All LTCS and CS charpy plate material shall be made to fine grain practice and the primary austenitic grain size shall be measured and reported in mill test certificates.

(g) CS pipes shall be SA-106 Gr. B for MDMT greater than – 29 °C, unless otherwise specified. For MDMT less than and equal to – 29 °C, CS pipes shall be SA 333 Gr. 1 or 6.

(h) Non-standard forgings (SA 266, SA 350 etc.) shall be normalized and tempered.

2.2.2 LAS MATERIALS

a) All LAS plates, pipes, forgings and fittings shall be in normalised and tempered condition. Use of C-½ Mo material is prohibited. All LAS materials shall be charpy V-notch impact tested. Test temperatures shall be lowest of minimum ambient temperature, design temperature, MDMT and –18°C (0 °C instead of –18 °C for 5Cr-1/2Mo materials). Impact energy values as per UG-84 or applicable specification, whichever is higher.

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b) Accelerated cooling from an austenitizing temperature by liquid quenching followed by tempering (N + ACC. + T) is also acceptable for plates. Irrespective of thickness, LAS plates shall meet the requirements of API RP 934 (part as applicable).

c) In the case of 1¼ Cr-½ Mo and 2¼ Cr- 1 Mo materials and weldments, the maximum room temperature tensile strength for all pressure containing components, materials and welds shall be 100000 psi.

d) For LAS tubes (SA 209 and 213) hardness test shall be performed on outside of the tubes as per SA-450.

e) For LAS plates > 50 mm thickness, vacuum treatment as per supplementary requirement S1 of SA 20. If vacuum degassing is not reported in the test certificates, then through thickness tests as per SA 770 shall be conducted and minimum reduction in area of 35% shall be ensured.

2.2.3 SS AND OTHER HIGH ALLOY MATERIAL

a) All SS material (300 series) shall be in the solution heat-treated (fully annealed) and pickled condition. All stabilised grades of SS (SS 321, SS 347 etc.) shall be given stabilisation heat treatment, in addition to solution annealing. For all stabilized grades of stainless-steel materials soaking temperatures for stabilization heat treatment shall be 915°C ± 10°C and soaking period shall be minimum of 4 hours (2 hours for thickness ≤ 3.5mm).

b) SS (300 series) plates shall be hot rolled and shall have No.1 finish on both sides. Cold rolled plates, if permitted by requisition, shall have No. 2B finish.

c) SS (300 series) materials for all components including non-pressure parts like baffles, tie rods, etc. shall be procured with the IGC test as per ASTM A-262 (test shall be carried out, after the specified heat treatment and sensitisation per specification) with acceptable corrosion rate and practices as under:

i) For all services except nitric acid service, Practice E shall be followed. Specimen after exposure shall be bent as per requirements mentioned in A262 Practice E and shall be inspected under magnification of 200X. The bent specimen shall be free of any cracks or grain dropping. The microstructure shall be submitted to DIA for approval.

ii) Nitric acid service - Practice C corrosion rate <635 micro-m per annum.

(d) For straight chrome (13% Cr.) material, maximum carbon content shall be < 0.06%. Hardness of UNS no. S41000, S41008 and S40500 shall be ≤241 BHN.

2.2.4 NON-FERROUS MATERIALS

(a) All copper based non-ferrous plates shall be procured in annealed condition.

(b) Plates for pressure parts shall be 100% UT. Supplier shall submit the procedure for UT to DIA for approval.

(c) In addition to hydro test, all tubes shall be eddy current tested in their final annealed condition.

(d) All pipe bends shall be stress relief annealed after bending.

(e) The paragraphs NF7 and NF14 in part UNF of Code are mandatory. This applies to non-ferrous cladding and weld overlay also.

2.2.5 CLAD MATERIALS

(a) Cladding shall be integrally and continuously bonded to the base metal. All clad plates shall be rolled-on or explosion bonded type.

(b) Clad plates shall be UT from the cladding surface as per SA-578. Scanning shall be 100% of the plate surface. Acceptance standard shall be level B. Clad plates shall meet the supplementary requirements of S1 of SA-578 and Integrity of clad plate shall be ensured Quality level: class-1 as per SA 263 or SA 264 or SA 265. All UT shall be undertaken after specified heat treatment of clad plates.

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(c) Both base material and clad material shall meet the specification of the respective materials as stipulated in this specification.

(d) Alloy clad steel plates shall be as per SA 263 or SA 264 or SA 265. Bond between cladding and the base metal shall be checked for a minimum strength of 14 kg/mm^2 in shear for alloy clad steel plates, by conducting shear test as per applicable material specification.

(e) For copper alloy clad plates, the bond between cladding and base metal shall be checked for a minimum strength of 10 kg/mm^2 in shear by conducting shear test.

(f) During tension test of clad plates, the cladding shall be removed and the tensile properties of the base material shall meet the Code material requirements.

(g) For austenitic SS clad plates, the SS surface shall be acid pickled as per ASTM A-380. For chromium steel clad surfaces, the pickling shall be as per Supplier's established procedure. The same shall be submitted to Owner or EIL for approval.

(h) For clad components, Supplier to ensure that plate thickness after bonding and machining shall not be less than the thickness specified in drawings. Supplier to consider sufficient margin on clad and base materials so that thickness after machining and complete fabrication shall be as per the drawings. For nozzle necks with weld deposit, sufficient margin on ID shall be taken to allow for shrinkage

2.3 Non pressure parts

2.3.1 CS plates shall be minimum IS-2062 or SA 283 Gr. C or equivalent. Pipes shall be to IS 1239 or SA 53 or equivalent.

2.3.2 Saddle material shall be same as that of shell for shell design temperature > 350°C and for shell design temperature less than 0°C.

2.4 Equivalent materials

The materials for various components in a heat exchanger shall be as per Owner or EIL's requirement. This does not preclude use of equivalent or better materials. However, these deviations should be clearly indicated in the prescribed format. If an equivalent material sought by the Supplier is to a specification, other than IS or ASTM or ASME, it is necessary for the Supplier to submit the specifications of the equivalent material with complete details in English for approval.

3.0 SUPPLY

Supply shall be in accordance with requisition or bid document to which this specification is attached. It shall, however, include the following also:

3.1 Test Ring Assembly, Dummy Shell and Test Flange

a. Test ring assemblies, dummy shells and test flanges wherever required shall be designed and supplied by the Supplier. The stresses shall not exceed 90% of the minimum yield stress of the material as stipulated in material specification. Material used for fabricating these shall be of tested quality. For removable bundle with tube side test pressure higher than shell side, the bundle shall be tested outside the shell, with tube side pressurised for tube side test pressure to check tube to tube sheet joint leakage from the back of tube sheet. Test flange shall be designed accordingly.

b. Test ring assembly construction shall be stuffing box type as per fig. E-4.1.3-2 of TEMA. It is preferred that the test ring flange thickness not exceed the shell cover flange thickness, Otherwise, Supplier to provide separate bolting for assembling test ring flange to shell. Similarly, Supplier to check that the studs for stationary tube sheet bolting can be used with test flange. Else separate bolting shall be provided for assembling test flange.

c. For "T" type of floating head exchanger necessary washers, bolts and nuts for sealing of bolt holes in tube sheet to be provided during hydro test.

3.2 Accessories for Testing

All necessary accessories such as supports, blind flanges, test gaskets, bolts, nuts etc. shall be provided and supplied by the Supplier for testing of heat exchangers, in Supplier's shop and for subsequent testing

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by Owner at site, whenever required.

3.3 Other Accessories

3.3.1 Supplier shall also supply tie bolts, leveling shims or intermediate supports for stacked units. In case the stacked units are transported separately, the leveling shims required for matching the nozzles shall be tack welded to the saddles and shall not be supplied loose to avoid misplacement during transit and at site. Gaskets, nuts and bolts for interconnecting nozzles (both tube and shell side) along with spares shall be supplied by Supplier. All these components shall be despatched separately with due care having been taken regarding identification of these for ease of installation.

3.3.2 Earthing lugs shall be provided on each heat exchanger and shall be located in such a way as to avoid any fouling with the exchanger foundation bolts at site.

3.3.3 Supplier to supply one set of torque wrenches for bolt size M45 (1¾") to M56 (2¼") and one BTD for bolt sizes greater than M56 (2¼"), in case these bolt sizes are being used in exchangers covered in the requisition. BTD capacity shall be 40% more than the maximum load required for hydro test condition. BTD pump shall be pneumatically and manually driven. Supplier shall supply one pump unit, required load cells, 4 heads of each size, one set of flexible high pressure main hose to connect the pump unit to loading cells, hoses common for all bolt sizes and spares as recommended by the BTD supplier. Torque values for tightening the bolts shall be mentioned in the fabrication drawings. For all studs requiring tightening by bolt tensioner, length of studs shall be longer by "one diameter / as recommended by BTD Supplier". All bolt tensioners must be satisfactorily used/demonstrated during assembly/disassembly and hydrotest at shop before dispatch.

3.3.4 Davits, if required as per design basis or drawings, shall be provided.

3.3.5 Additions like cleats for piping, ladder, platform, insulation etc. that may be required at a later stage shall be provided.

3.4 Cathodic Protection

Whenever cathodic protection is specified both sacrificial anodes and internal painting shall be provided. Separate specifications shall be provided in the requisition.

3.5 Spares to be supplied by Supplier

Following spares shall be supplied by Supplier unless otherwise specified in the Requisition:

3.5.1 BOLTING: 20% studs and nuts but not less than 4 studs with 8 nuts for each joint.

3.5.2 GASKET: 400% gaskets other than those used for hydro testing and despatch for each joint.

3.5.3 Spare bolting and gaskets shall be provided for all joints of girth flanges, floating head, channel cover, tube sheet, interconnecting nozzles, nozzles with blind flange etc.

4.0 FABRICATION

4.1 Edge Preparation

4.1.1 For CS, the edges for welding shall be made by machining, chipping, cold shearing, oxy-acetylene flame cutting or a combination of these. Chipping or cold shearing shall be followed by grinding to a smooth and regular surface. Oxy-acetylene flame cutting shall be followed by machining or grinding to eliminate any discoloration of material affected.

4.1.2 For LAS, the edges for welding shall be made by oxy-acetylene flame cutting or by machining. Cold shearing may be used for cutting thickness up to 10 mm. Oxy-acetylene flame cutting shall be used with preheat and shall be followed by machining or grinding to eliminate any discoloration of material affected.

4.1.3 For austenitic SS, the edges for welding shall be made by plasma arc, however, cold shearing may be adopted for thickness up to 15 mm. In all cases the cut edges shall be ground back or machined back by 2 to 3 mm.

4.1.4 All welding edges after cutting shall be DP or MP examined for laminations, cracks or segregation. Additionally, UT shall be carried out within, two times the material thickness of edge for LAS materials

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or five times the material thickness of edge for materials when the service is low temperature or hydrogen or HIC.

4.1.5 The paragraphs NF7 and NF14 in part UNF of Code are mandatory. This applies to non-ferrous cladding and weld overlay also.

4.2 Rolling and Dishing of Plates

4.2.1 ROLLING

Rolling for bending and forming of plates shall be in the longitudinal direction of the plates. This direction shall be clearly marked on the plates.

Rerolling after welding is not normally recommended. However, if for large diameter shells, rerolling of welded shell course is inevitable, procedure for rerolling along with extent of NDT shall be submitted for approval of the DIA. All welds on the section to be rerolled must be ground flush. After rerolling all the welds on the re-rolled section must be DP checked. Such welds shall then be subjected to radiography as required by drawings and Code.

4.2.2 DISHING

All dished heads shall preferably be of single piece construction. However dished ends with one chordal seam are acceptable for shells with diameter greater than 1 m. In such cases, the chordal seam shall preferably be in the middle one-third of the blank. Dished ends shall be torispherical (knuckle radius 15% of outside diameter and crown radius 80% of outside diameter) or 2:1 ellipsoidal. Dished heads shall be subjected to DP test on knuckle portions (both inside and outside) and weld edges after heat treatment. Supplier to ensure adequacy of indicated thinning allowance for dished head. If nominal thickness indicated is not adequate then the nominal thickness should be increased accordingly, keeping minimum thickness as per item drawing. A straight face of 38 mm or 3 times the nominal thickness of dished head, whichever is more, shall be provided, but maximum straight face shall be limited to 50 mm.

4.3 Welding

4.3.1 All welding and weld overlays shall be done with electrodes, fillers and fluxes of reputed make with proven reproducibility of results. DIA shall specifically approve brand names. For CS pressure parts, the electrodes shall be of low hydrogen type. IGC test as per ASTM A262 Practice E shall be done for austenitic SS consumables, which are to be used in application involving solution annealing. Austenitic SS consumables of low carbon and stabilised grade shall also be IGC tested as per ASTM A262 Practice E. Straight chrome materials shall be welded with electrode that produces an austenitic chromium nickel weld deposit or a non air hardening nickel-chromium-iron weld deposit for both the barrier layer & final layer. Alternatively, welds that produces the same composition as Straight Chrome materials are also acceptable.

4.3.2 All welding procedures shall be submitted for approval by DIA giving all relevant details. Welding qualification records shall indicate hardness values of weld metal, HAZ and parent metal and also results of impact tests when design temperature is below 0 °C or when specifically indicated for materials being welded. No welding shall be undertaken until DIA has approved the welding procedure and welder's qualification. All welding procedures and welders shall be qualified for the particular type of welding and material in accordance with the ASME Section IX. Supplier shall be responsible for the quality of the welds performed.

4.3.3 Pressure holding joints shall be FPW. Root pass of single side welded joints shall be done with GTAW process. Backing strip for single side welded joints is not permitted. For LTCS materials, both inside and outside of welds shall be ground flush or dressed smooth. All internal welds in the shell shall be ground flush in order to insert and remove tube bundle. Also, all internal welds shall be ground flush to the extent of facilitating draining of complete equipment. All other weld may be left in the descaled condition only.

4.3.4 Longitudinal seams shall be staggered with the circumferential distance between the centres of welds being at least 5 times the thickness of the thicker-plate. Weld seams shall be located so as to avoid interference with weld seam of nozzles and external attachments.

4.3.5 Attachment to pressure part shall be of same quality as the pressure part. All LAS weld attachments to pressure retaining component shall be FPW and ground to a smooth concave contour. External

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attachments like lugs, supports etc. of CS shall not be welded directly to high alloy or austenitic SS heat exchanger components. These attachments should be of the same material as the heat exchanger component. If this is not so, intermediate pad plate of the same material type as the heat exchanger component may be used. These pads shall be at least 100mm wider and longer than the attachment and shall be at least 5 mm thick. Welding of CS or LAS to austenitic SS shall be done with austenitic SS electrodes or filler wire (AWS-ASTM-E 309L or E-309 Mo L only).

Wrapper plates, reinforcing pads, saddle plates or stiffeners of higher thickness than specified can be used provided there is no change in basic dimensions and with the approval from DIA. No separate deviation permit is required for the same.

4.3.6 Partition plates of CS and 300 series SS except for low temperature service, shall be welded to channels etc. by continuous fillet welds with minimum size of 6 mm on both sides. For all other materials and for hydrogen and low temperature services, all welds involving partition plates shall be FPW. However, all pass partition plates shall be FPW up to a distance of 2" (50mm) from the gasket contact surface. Partition plates thicker than 10 mm shall be tapered to 10 mm at partition groove end except when mentioned otherwise on drawings. One weep hole of 6 mm diameter shall be provided at the center of each horizontal pass partition plate and a 5 mm radius notch on top and bottom point of each vertical pass partition plate for all multipass exchangers for effective venting and draining.

4.3.7 Welding of shell to unhubbed tube sheet shall meet the requirements of Code considering that the tube sheet is unsupported.

4.3.8 When impact tests are required on material as per Code or specification the welds shall also be qualified for impact test. In such case following special requirement shall apply to the welding procedure qualification:

i) Qualification tests shall be made on plates of the ASME specification as specified for the exchanger using welding electrodes of AWS or SFA specification and wire & flux of the specification and brand as are to be used on the job.

ii) Welding current and travel speed shall be considered essential variables in order to ensure that production welding is substantially equivalent to the procedure qualification.

iii) Welded test plates shall be subjected to a total thermal cycle sequence similar to the finished equipment. Specifically, test plates shall be held at intermediate and final stress relief temperatures for approximately the same length of time as the finished exchanger. Final cooling rate shall be approximate to that expected for the finished exchanger.

iv) Charpy V-notch impact tests shall be made on the weld and HAZ of the test plate for each welding procedure to be qualified. Test procedure shall be as per UG 84 of Code. Test temperature shall not be higher than MDMT. Impact energy requirements shall be as per Table 2.15 of SA 20 of ASME Section II Part A or UG 84 of Code whichever is higher.

4.3.9 WELD OVERLAY

4.3.9.1 Wherever cladding is specified in datasheets or drawings, weld overlays are not acceptable. However, wherever cladding is specified in the Tube sheet/ channel cover, weld overlay can also be acceptable in place of cladding.

4.3.9.2 Weld deposit overlay shall be done by a qualified welding procedure and surface shall be properly machined or ground flush after overlay. Minimum thickness of finished weld deposit shall be as indicated in the drawings or specifications. In case a higher deposition thickness and multiple weld layers are required to achieve the minimum specified undiluted deposit metal, the same shall be done only after taking prior approval from EIL. Minimum thickness of undiluted finished weld overlay from top shall be 2 mm or as specified in the drawings. For non-ferrous weld deposit, the iron dilution should be restricted to 2.5% (maximum) in the finished undiluted layer (thickness defined above). Supplier must ensure minimum thickness of undiluted finished weld overlay as per above and shall take special precautions to ensure the same. Undercutting of base material shall not be done while ensuring the minimum undiluted chemistry. Supplier to take suitable allowance on machining in this regard so that minimum undiluted thickness is guaranteed after machining. Supplier to qualify WPS/PQR and submit documents to DIA for approvals before proceeding with fabrication.

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4.3.9.3 The weld overlay procedure shall be qualified on base metal of the same composition as the exchanger component and meeting the requirements of ASME Section IX.

4.3.9.4 The weld overlay shall be relatively smooth with no notches and undercuts that would act as stress raisers. All cracks, fissures and circular defects greater than 1/16 inch diameter shall be removed. Repaired areas shall be DP checked. Weld overlay shall be applied to base metal, which has been grit blasted and is smooth and clean so as to ensure full bonding. Welding overlay cladding shall be applied after any normalising but before PWHT. The weld overlay shall consist of at least 2 layers.

4.3.9.5 The alloy cladding shall be cut back at all seams to permit back welding of the base metal. Weld metal shall be ground flush and fully covered with the applicable weld deposit. The weld joint in base plate shall be 100% DP tested for detection of cracks and flaws before welding from clad side. The weld deposit shall be at least as thick as the cladding.

4.3.9.6 Shells, cones, dished heads and nozzles formed from clad plates shall be subject to UT after forming, for a minimum of 10% of the clad surface, but no less than one square feet in each 10 square feet or fraction thereof. Unbonded areas that cannot be encompassed by a 3 inch diameter circle shall be repaired by weld overlay. When repairs in excess of 5 % of the total examined area are required, the complete component shall be subject to 100% UT. Repaired areas and weld deposit overlay at weld seams shall be DP examined. UT shall be repeated for dished heads after heat treatment. UT procedures shall be in accordance with SA 578 S6 for spot examination and SA 578 S7 for 100% examination.

4.3.9.7 All weld overlays shall be 100% DP examined in accordance with the method described in ASTM-E-165. The barrier layer shall be 100% examined. When the overlay involves multiple passes (layers) and the procedure uses an intermediate heat treatment with cooling to room temperature prior to applying the subsequent layer, each layer shall be examined by DP. Where overlay is to be machined such as for flange facing, machined surface shall be 100 % examined after final PWHT. If 100% of overlay is examined prior to the final PWHT, overlay shall be spot examined (not less than 10% of the surface) after heat treatment.

4.3.9.8 Samples of the weld overlay shall be taken to perform chemical analysis to the specified depth. The number and location of samples and method of taking samples shall be approved by DIA. However, they shall be representative of each exchanger component for each type of welding process. Report of chemical analysis shall be submitted to DIA for approval.

4.3.9.9 For all weld overlays used in hydrogen or H_2S service with design temperature greater than 350°C, Hydrogen disbonding test shall be carried out. The test condition shall be representative of the actual design conditions and the procedure shall be submitted to DIA for approval. Rate of cooling shall be 100°C/hr (min.) unless specified otherwise in datasheets. Holding time shall be 48 hours unless specified otherwise in datasheets

4.3.9.10 PTCs are required for CS welds above 50 mm thickness and for LAS welds above 25 mm or when required by the Code or when specified in the requisition. The following shall apply: -

a) Two PTCs representative of one longitudinal and another circumferential seam shall be provided for each procedure, position and thickness.

b) PTC shall be from material of the same heat and thickness as that of parent metal. During and after production welding PTC shall be subjected to same heat treatment as and together with the course they represent. Extra PTC shall be preserved to take care of eventuality of retests.

c) The tests mentioned below shall be carried out as per methods of testing in Code:

i) One transverse tension test.

ii) Two side bend tests with weld located in the center of bend.

iii) One hardness test on PTC weld and HAZ. The acceptable limits are 200 BHN for CS, 225 BHN for P3 and P4 materials and 235 BHN for P5 as per EIL specification no. 6-15-0091.

iv) Micro and macro structural examination of welds.

v) For CS, charpy V notch tests on weld and HAZ shall be carried out. For MDMT < 0°C, impact test temperature shall be MDMT. For MDMT > or equal to 0°C, the test

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temperature shall be 0°C. The acceptance criteria for impact energy shall be as per table a 2.15 of SA 20 of ASME Section II part A or UG-84 of Code whichever is higher.

vi) For LAS, charpy V notch test on weld and HAZ shall be carried out. Test temperature and acceptance criteria shall be as per clause 2.2.2 (d) (ii).

4.4 Tube to Tube Sheet Joints

Requirements of EIL specification no. 6-15-0003 shall be complied with for welded tube-to-tube sheet joints and that of EIL specification no. 6-15-0004 shall be complied with for expanded tube-to-tube sheet joints.

Wherever expanded tube to tube sheet joint are specified and Supplier is not able to meet the Fr value in mock up, EIL reserves a right to ask supplier to provide strength welded tube to tube sheet joint without any cost & delivery implication.

4.5 Hardness Limitations

Hardness limitation for CS materials, welds and HAZ wherever specified on drawings or datasheets shall be ensured as per Specification 6-15-0091. Hardness limitation for LAS materials, welds and HAZ shall always be ensured as per Specification 6-15-0091. Hardness limitation compliance for tube-to-tube sheet welded joints shall be established/verified on a mock-up with simulation heat treatment

4.6 Nozzle flanges, Nozzles and Reinforcing Pads

4.6.1 FLANGES

Unless otherwise indicated, dimensions, drilling, facing and tolerances for nozzle flanges (and blind covers if required) shall be as per ASME B 16.5 (for size up to 24" NB) and ASME B 16.47 series B (for sizes above 24" NB) for the respective class. Weld overlays, wherever specified or required, shall be in addition to the thickness as per these standards. Boltholes on these nozzle flanges shall straddle principal vertical and horizontal centerlines of equipment. If the component to which nozzles are attached is subsequently stress relieved, it shall be Supplier's responsibility to maintain true gasket faces by machining or otherwise. If distortion is expected, final machining operation should be done after stress relieving; sufficient machining allowance for this purpose should be available. All flange faces shall be suitably protected against oxidation during post weld heat treatment. Gaskets, for flanges to ASME B 16.5 and B16.47, shall be as per ASME B16.20.

4.6.2 NOZZLES

4.6.2.1 Nozzle pipes shall be attached to the heat exchanger components by FPW. Attachment welds using only inner and outer fillet welds are not permitted. Unless otherwise indicated on the datasheets or drawings, necks of all nozzles shall be flush with the inside of the heat exchanger component. Inside corners of nozzle pipes at shell and channel inside diameter shall be radiused. All nozzles 2" NB and below, except long weld neck, shall have two stiffeners (40 mm x 6 mm) at right angles.

4.6.2.2 Whenever nozzle inside is required to be overlaid, these shall be done by weld overlay or cladding. Minimum nozzle ID before weld depositing to be 50 mm in such cases. Liners are not acceptable.

4.6.3 REINFORCING PADS AND TESTING

Reinforcing pads whenever required as per drawings or Code shall be of the same material or equivalent as the heat exchanger component to which it is welded. All reinforcing pads shall be provided with two 1/8" (3 mm) NPT tapped holes located 180 apart for air soap solution test with a pressure of 1.25 kg/cm^2 (g). This test shall also be required to be carried out for slip on flanges. Higher test pressures are not recommended because of accompanying risks and also because the soap bubbles have a chance to blow off. Tell-tale holes in the reinforcing pads shall be plugged with hard grease after the hydro test of the exchanger. No grub screws to be provided.

4.7 Bolts, Studs etc. and Tapped Holes

4.7.1 Metric threads shall be used for all non-standard flanges. However, ASME flanges may have threads as per American standards. All inch bolting and threading shall conform to ASME B 1.1 except for size 1"

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and above where it shall be 8 threads per inch. Metric bolting and threading shall conform ISO-R261 shall be followed except for size M24 and above, where it shall have 3 mm pitch.

4.7.2 Studs shall extend beyond the nut by about 10 mm and shall be threaded full length except when square ends are required for use with BTD, in which case the extension shall be as per BTD manufacturer's recommendation. The studs for extended tube sheets and the studs for use with connecting piece shall also have square ends.

4.7.3 All nuts shall be of heavy series only and nut seating faces shall be machined or spot faced.

4.7.4 Threads on external bolting, plugs etc. shall be lubricated with graphite grease for working temperature up to 200°C and with Molybdenum Disulphide for higher temperatures.

4.7.5 Tapped holes on the channel side face of clad tube sheet for removable bundles shall be fitted with plugs of a material similar to channel side material in contact with tube side fluid.

4.7.6 For extended tube sheets, tapped holes shall be provided for girth bolting.

4.7.7 All floating head bolting to have 2 mm wide and 0.5 mm deep groove at both ends to prevent mix up with other bolts.

4.7.8 In addition to stamping, the specifications and manufacturers symbol as specified in ASME material specifications, on one of the ends the size of the studs shall be clearly punch marked. Similarly, the nuts shall have the size punch marked on one of the faces. In case of tapped hole, the size shall be punch marked near the hole without disturbing the gasket seating area. Further for all alloy/SS metallurgy bolts & nuts shall also be identified by distinct colour marking at the stud end/bolt side face

4.8 Assembly and Handling

4.8.1 Supplier shall be responsible for taking adequate preventive measures to ensure the quality and finish of materials and to avoid any rusting.

4.8.2 Suitable method of alignment like dowels etc. shall be provided for proper assembly of channel, channel covers, stationary tube sheet etc.

4.8.3 Stacked exchangers shall be assembled in the shop for a trial fit. Special care shall be exercised in truing up connecting nozzle flanges.

4.8.4 'T' wherever indicated on drawings, denotes match mark for assembly and shall be punched on all mating parts.

4.8.5 Lifting lugs shall be provided as per standard for lifting of channels, channel covers, floating heads, shell covers, test rings, test flanges etc.

4.8.6 In case of removable bundles the following are required: -

(a) Stationary tube sheets shall be drilled and tapped at vertical (0°) position for attaching eyebolts; or a lifting lug of adequate thickness shall be welded with 25 mm (minimum) diameter hole.

(b) Drilling and tapping as above shall be carried out on floating tube sheet.

(c) Last support plate shall be drilled (25 mm diameter hole) for lifting the assembled bundle. Local stiffening may be necessary to withstand the bundle load., which shall be designed by the Supplier.

4.8.7 Pulling eyebolts made from forged CS shall be provided for all removable bundles. These shall be sent loose along with the spares. Insert piece shall be provided for all clad tube sheets. Material of insert piece shall be same as that of cladding material.

4.8.8 Stationary tube sheet shall be drilled and tapped for tie rods. Care should be taken to ensure that holes are not drilled through.

4.8.9 Interchangeable and 180° rotatable bundles shall have common pass-partition groove arrangement in the respective tube sheet. For exchangers where bundles are specified to be interchangeable, the same shall be ensured at the Supplier's shop by actually inserting the bundles or using a template consisting of 4 full diameter baffles, each spaced at a distance equal to the baffle pitch.

4.8.10 Jackscrews shall be provided on all girth flanges.

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4.9 Descaling, pickling and passivation shall be done for all SS parts in accordance with ASTM A-380. The Supplier shall furnish details of the procedure for approval to DIA.

4.10 No distortion whatsoever shall be permitted on the gasket seating surfaces due to tube-to-tube sheet welding, shell to tube sheet welding, PWHT etc. If distorted, the same shall be machined subsequently.

4.11 Fabrication Tolerances and Finish

4.11.1 The dimensional tolerances shall be within the limits indicated on EIL drawings and standards. Where tolerances are not specified, these shall be in accordance with the requirements of TEMA and Code.

4.11.2 All edges and corners including baffle holes shall be deburred (or rounded, if shown).

4.11.3 Finish of all machined components shall be minimum 12 microns (500 RMS) unless otherwise indicated. Parts subjected to UT shall have minimum finish of 6 microns.

4.11.4 Tube sheet face shall be flat within +/- 1.5 mm (camber).

5.0 NON-DESTRUCTIVE TESTS

5.1 All the NDT procedures shall be submitted to DIA for approval. For all NDT activities, only qualified NDT technicians shall be deployed with the approval of DIA.

5.2 The extent of radiography shall be as specified in datasheets or drawings or job specification. Radiography shall be performed after PWHT. In case radiography is carried out before PWHT, then UT shall be carried out on the welds after PWHT.

5.3 Minimum extent of radiography shall be spot, unless full radiography is specified in the drawings or required as per specification or Code.

Each category A or B pressure containing weld shall be spot radiographed in accordance with ASME Section-VIII Division-I, paragraph UW-52 as a minimum requirement. Each Spot radiograph shall be a minimum of six inches (150mm) in length and minimum one spot shall be selected in each circumferential & longitudinal seam. Additionally, at least one T-joint in each circumferential seam shall also be selected. Welds from each welding procedure, welded/welding operator shall be examined. DIA shall be consulted in marking the areas to be radiographed.

5.4 Full radiography when specified shall imply 100% radiography of all butt welds including nozzle flange to nozzle neck, pipe to pipe and pipe to fitting.

5.5 All welds of nozzle necks fabricated from plate, irrespective of diameter, thickness of plate and radiography specified, shall be 100% radiographed.

5.6 Weld seams of formed heads shall be 100% radiographed after forming and heat treatment.

5.7 All nozzle to shell welds and unhubbed tube sheet to shell welds shall be DP or MP checked at the root run and final weld.

5.8 All welds, which cannot be fully radiographed such as nozzle to shell, shell to unhubbed tube sheet, unhubbed floating head to cover etc., shall be 100% UT after final PWHT. Fillet welds and welds which cannot be radiographed or UT (i.e. pass partition plate to channel and floating head etc.), the root run shall be DP checked and the welds shall be finally MP checked after PWHT.

5.9 All attachment welds shall be either DP or MP tested.

5.10 If vendor intends to carry out radiography by Computed Radiography technique, then demo should be carried out under AI to prove vendor's capability to produce acceptable images meeting the Code requirements.

5.11 If radiography is being substituted by UT for the final closing seam as permitted by Code, MP shall be carried out in addition to UT.

5.12 In case Supplier want to perform UT in lieu of RT based on Code paragraph UW 51 (a) (4), the same is acceptable subject to the following:

a) Material of construction is either CS or LAS.

b) The thickness of weld is greater than 13 mm.

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c) The joint is either Category A or Category B joint except shell to hemispherical dished end joint. (Category of joint as defined by Code).

d) Automated UT incorporating TOFD and pulse echo probes or TOFD and Phased Array mounted on the same chassis that automatically traverses along the joints to be inspected and displaying both results simultaneously on a single screen may be considered in lieu of RT.

e) Calibration block of similar material/thickness shall be used. Calibration block shall have suitable notches to simulate longitudinal as well as transverse cracks on outside and inside surface. Setup should be capable of detecting defects on outside as well as inside while scanning from one surface only.

f) The system that is proposed to be deployed in lieu of radiography shall be submitted along with the track record prior to use for EIL review. The Supplier shall demonstrate successfully the capability of AUT machine and the defects evaluation in the same screen during the site visit of EIL representative. Based on which, the approval of the parties and their AUT system shall be given.

g) Qualified NDT persons shall be deployed to perform UT.

h) Acceptance criteria shall be as per Code paragraph UW 51.

6.0 HEAT TREATMENT

6.1 PWHT shall be done if required by datasheets, drawings, specifications, Code etc. PWHT when mentioned on the drawings shall be over and above the requirements of specifications or Code. No welding or heating is permitted after PWHT. All machining operations shall preferably be carried out after PWHT (also refer clause 4.6.1). It shall be the responsibility of the Supplier to leave sufficient allowance for this purpose. Supplier shall submit all the procedures for PWHT to DIA for review.

6.2 During PWHT of assemblies of fixed tube sheet exchangers, care shall be taken to ensure that differential stresses are not caused between tubes, shell and tube sheet. The temperature differential between shell and tubes during PWHT to be minimised (not to exceed 25°C) and the rate of heating and cooling shall not exceed 25-30°C per hour. For this purpose, thermocouples shall be installed on various components and compliance assured.

6.3 Heat treatment of SS clad assemblies shall be at reduced temperature to avoid sensitisation of SS materials. The soaking time shall be increased accordingly as per Code.

6.4 Heat treatment of non-ferrous clad assemblies, if required, shall be performed with extra care, at reduced temperatures to avoid differential thermal expansion. The soaking time in such a case shall be increased accordingly as per Code.

6.5 Heat treatment of CS and LAS dished heads shall be as follows:

a) Stress Relieving for:

(i) Cold formed dish heads up to 16 mm thick.

(ii) Cold formed floating head cover up to 16 mm thick if fiber stretch exceeds 5%.

b) Normalizing for CS and normalising and tempering for LAS:

(i) Hot formed dish head and floating head dish if not formed in normalising range.

(ii) Cold formed dish heads for thickness greater than 16 mm.

(iii) Cold formed floating head dish above 16 mm thick.

This heat treatment need not be given if same heat treatment is given subsequently on sub-assembly. Thicknesses specified above are nominal.

In case of LAS plates, it shall be fabricator's responsibility to ensure that mechanical properties of material are not impaired during any cold / hot forming process and subsequent stress relieving heat treatment. Tests to demonstrate suitability of process shall be carried out by fabricator.

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6.6 SS components shall be solution annealed in the following cases.

i) Cold formed dished heads with nominal thickness of 16 mm or above.

ii) Hardness value of dished heads after cold forming exceeds 235 BHN.

iii) Hot formed shells, cones, dished heads.

After any heat treatment on austenitic SS, IGC test shall be carried out as per clause 2.2.3 (c)

6.7 All LAS welds shall be PWHT.

6.8 If stress relieving is indicated on shell side or tube side and the service on either side is lethal or low temperature or if specifically indicated in the datasheet or drawings, the welded tube-to-tube sheet joints of CS or LTCS material shall be stress relieved.

6.9 For LAS materials, preheating procedure shall be established in the welding procedure and got approved by DIA. Preheating by resistance or induction-heating method is preferred. Preheating shall extend uniformly to at least three times the thickness of joint but not less than 50 mm on both sides of the weld. Temperature indicating crayons shall be used for assessment of correct pre heat temperature.

7.0 INSPECTION AND TESTING

7.1 Inspection

7.1.1 The inspection shall be carried out by DIA. The materials, fabrication and testing of exchangers shall be open to inspection by DIA in addition to any inspection required by the specified Code or local authorities having jurisdiction over the installation.

7.1.2 Inspection shall be carried out both during fabrication and before delivery and also for sub ordered materials. In addition to final inspection and certification by DIA during the course of manufacture, DIA's written approval shall be obtained by the Supplier at various stages of fabrication. For this purpose, Supplier shall prepare his QAP, defining the stages of fabrication, hold points for his own inspection and that by the DIA or Code or Statutory Authorities etc. The QAP shall be discussed with DIA before start of job and mutually agreed. The various stages of fabrication to be inspected (either by Supplier or DIA or both) shall include but not limited to the following:

(a) raw material identification and verification of mill test certificate.

(b) edge preparation for welding, including visual check for laminations.

(c) alignment of longitudinal and circumferential seams.

(d) rolling tolerances on individual section.

(e) alignment and fit up of sections and components.

(f) root pass clearance before further welding and cleaning.

(g) profile and thinning of dished ends and toriconical pieces after forming.

(h) checking of tube sheet after drilling including checking of tube layout patterns, tube holes, pass partition locations, visual check for laminations.

(i) tube sheet to shell set up for fixed tube sheet exchangers, prior to welding.

(j) tube to tube sheet joint expansion or welding.

(k) visual check of shell inside and tube bundle insertion.

(l) welding of expansion bellows or joints, if required.

(m) review of NDT reports and heat treatment charts.

(o) final visual and dimensional inspection.

(p) witnessing of hydro test.

7.1.3 The presence of DIA shall not modify or reduce the obligation of the Supplier to carry out his own tests and control. If any material and/or equipment are not found in compliance with the specified

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requirements, DIA or his delegate shall be entitled to irrevocably reject them, even if such non-compliance has not been evidenced in the course of inspection and/or tests.

7.1.4 DIA will, at the time of his initial visit, set up with the Supplier actual details of inspection stages to be witnessed or carried out; the schedule of future visits and subsequent inspection notices can be arranged between DIA and the Supplier.

7.1.5 The Supplier shall notify DIA sufficiently in advance of any fabrication operations to permit arrival at the Supplier's shop in time to witness these.

7.1.6 The Supplier shall provide to DIA, free access to his shops at all times. He shall also supply all tools and tackles to DIA for carrying out the inspection. The Supplier shall also arrange for similar facilities at his sub-contractor's shops.

7.1.7 The Supplier must satisfy DIA that the welding procedures, welders, electrodes, fluxes, welding wires etc. are in accordance with the requirements of the Code and specifications. Further the welder's qualification test must be carried out in the presence of DIA.

7.1.8 Prior to final inspection, all slag, weld spatter loose scale, dirt, grit, paint, grease, oil and other foreign matter shall be removed in order to facilitate inspection. All reinforcing pads and slip on type flange welds shall be pressure tested with air and soap solution before and after heat treatment (if any) and before final hydrostatic test.

7.1.9 A dimensional check of equipment shall be carried out taking into account the tolerances shown on drawings, standards, specifications or Code, the more stringent values shall govern. Dimensional checks are to be taken of the internal measurements of equipment together with external ones and these are to be recorded on the drawings as being the "As Built" dimensions.

7.2 Hydrostatic Tests

7.2.1 Hydrostatic tests shall be witnessed by DIA. When hydrostatic tests are performed the indicating gauge shall be connected to the upper most part of the equipment. Testing water shall be clean potable water. Seawater shall not be used. For SS equipment, water used for these tests shall not contain more than 25 ppm chlorides. Minimum metal temperature during hydrostatic tests shall be as per Code. Test pressures shall be maintained for at least one hour. Shell and tube sides shall be tested separately, unless otherwise mentioned on the drawing. For tube sheets designed for differential pressure, special care shall be taken during testing. Equipment drawings shall clearly indicate if tube sheets have been designed for differential pressure. Drying out as per clause 9.1 shall be carried out immediately after hydro test.

7.2.2 All vertical exchangers shall be tested in vertical position. Alternatively, exchanger may be tested in horizontal position with test pressure modified with prior approval of Designer.

7.2.3 Stacked exchangers with nozzles interconnected shall be hydro tested in stacked condition except when the hydro test pressure of the individual exchanger is different.

7.2.4 Actual torque values applied for tightening of bolts during hydro test to be recorded/indicated in hydro test reports

8.0 STAMPING, NAME PLATES AND WARNING PLATES

8.1 Each exchanger shell shall be fitted with an SS nameplate.

8.2 Warning plates, if required, shall be provided.

8.3 The following exchanger parts shall have the item number stamped except for heat exchangers in low temperature service in which case the item number shall be marked with non-removable ink:

Shell girth flanges, shell cover flange, channel girth flanges, flat channel cover, stationary and floating tube sheets, floating head cover flange, floating head backing ring, connecting pieces, test rings, test flanges and other main removable parts.

9.0 PROTECTION AND DESPATCH

9.1 After completion of all testing and inspection, the inside of complete equipment shall be thoroughly drained and dried out. Equipment shall be completely dried by passing hot air for sufficient time until no further increase in relative humidity of outgoing air is observed. Dry out shall be done simultaneously on

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both shell and tube sides. Alternatively, vacuum drying is also acceptable. After drying, the equipment shall be purged and filled with dry N_2 at 0.25 kg/cm^2. The equipment shall be provided with pressure gauge to monitor N_2 pressure, and ½" non-return valve. All threaded holes, other than tell tale holes for testing, shall be suitably protected with steel bar plugs. All nozzles not provided with blind flange shall be provided with steel covers, temporary gaskets and bolts.

9.2 Shop Painting

Surface preparation, Primer application and finish paint shall be required as per applicable specification enclosed elsewhere in the requisition. In absence of any requirements in the requisition following shall be complied:

All CS and LAS external surfaces, except gasket faces and machined surfaces, shall be primer painted. Surfaces to be painted shall be prepared for painting by removing loose mill scale, rust, oil, grease and other films or substances harmful to the adhesion of paint by an approved method such as shot blast cleaning. The surface shall be prepared to near white finish as per SSPC-SP-10 [SA 2 ½ Swedish standard (SIS-05-5900)]. The primer shall be inorganic zinc silicate (65-75 microns dry film thickness) for design temperatures up to 400°C and Heat Resistant Silicone Aluminium Paint (20 microns dry film thickness) for design temperatures between 400 °C and 540 °C, unless stated otherwise.

9.3 The equipment item number, PO number and Owner name and address shall be painted in bold white paint letters written with stencil, on the heat exchanger.

Sliding end of exchangers shall be painted as "CAUTION-SLIDING END" in black on the primer coating in the shop.

9.4 Dispatch of Equipment

No heat exchanger shall be released for shipment until it has been approved by DIA. Heat exchangers shall be despatched after the operations as required by clauses 9.1, 9.2 and 9.3 have been carried out and shall be despatched in as-tested condition. In case stacked exchanger shells are despatched separately the Supplier shall provide additional set of gaskets for interconnected nozzles other than the gaskets included in spares. Heat exchangers shall be securely anchored for despatch in order to prevent any shifting and damage during transportation. Expansion joints and bellows shall be suitably protected against any possible damage by providing tie bars before boxing up. Packaging shall be suitable for rail or road transport and also sea worthy if transported by sea. Spares shall be despatched separately in a box and marked with PO number, item number and Owner's name and address.

Supplier shall provide sling mark identification on all heat exchangers with respect to center of gravity of the equipment.

No equipment shall be despatched until a written clearance is obtained from Owner or EIL regarding Piping Clips and Structural Cleats on individual equipment.

10.0 SUPPLIER'S GUARANTEES

The Supplier shall be completely responsible for the compliance to Code requirements, residual design, detailing, fabrication, materials and workmanship of the exchangers as per the stipulations of the requisition and its attachments. In this regard, it may be noted that review by Owner or EIL shall not relieve the Supplier of his responsibility of meeting all requirements and ensuring satisfactory performance of the equipment. Guarantee period shall be as per GPC of Owner.

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वेल्डेड ट्यूब से ट्यूबशीट जोडों के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR WELDED TUBE TO TUBESHEET JOINTS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	22.01.25	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKP	TKh	KA/NK	MN
5	20.05.19	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	NK	KA	KJH	RKT
4	07.06.13	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	TK	KA	RKT/SC	DM
3	28.01.08	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	KA	PK	AKM	VC
2	01.09.99	REVISED AND REISSUED AS STANDARD SPECIFICATION	HN	PK	RKA	AS
1	04.05.89	ISSUED AS STANDARD SPECIFICATION	RKA	BSG	VKM	RNS

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Abbreviations:

API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
OD	Outside diameter
TEMA	Tubular Exchangers Manufacturers' Association
TIG	Tungsten inert gas shielded arc

Static Equipment Standards Committee

Convenor: Mr. Nalin Kumar
Co-Convenor: Mr. K. Anjaneyulu

Members:

Mr. Tarun Kumar (Emp. No. A328)
Mr. Tarun Khurana (Coordinator)
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Mr. Anish Trehan
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CONTENTS

1.0	SCOPE	4
2.0	APPLICABLE CODES AND STANDARDS	4
3.0	WELDING PROCESS AND JOINT DETAIL	4
4.0	WELDING PROCEDURE QUALIFICATION	4
5.0	WELDERS QUALIFICATION	6
6.0	PREPARATION OF TUBES AND TUBESHEET	6
7.0	WELDING	6
8.0	EXAMINATION OF JOINTS	7
9.0	TUBE EXPANDING	7
10.0	REPAIRS	7
11.0	TEST AND REPAIR REPORTS	7

APPENDIX-1 - JOINT DETAILS

APPENDIX-2 - DETAILS OF TEST SPECIMENS

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1.0 SCOPE

1.1 This specification covers minimum requirements for the welding and testing of tube to tubesheet joints of shell and tube heat exchangers and air coolers. It is the Fabricator's responsibility to furnish sound, leak free joints. For the purpose of this specification, the terms "joints" shall be construed to mean "tube-to-tube sheet joints".

2.0 APPLICABLE CODES AND STANDARDS

The latest edition of the following codes and standards shall be complied with:

a) ASME Section VIII Division I
b) ASME Section V
c) ASME Section IX
d) TEMA for tubular exchangers
e) API 661 for air coolers
f) AWS

3.0 WELDING PROCESS AND JOINT DETAIL

3.1 Manual or automatic Tungsten Inert Gas shielded Arc (TIG) welding shall be used. All joints shall be made by using minimum two weld passes. The first pass should be preferably made without filler wire to ensure root fusion. The second or final pass shall be with filler wire. Any other welding process can be used only after obtaining written approval from the Authorized Inspector.

3.2 Joint detail shall be as indicated on the Purchaser drawings by giving reference to figure numbers in Appendix-1 of this specification. In absence of any Purchaser drawings or indication regarding type of joint, Figure 2 or Figure 3 shall be used depending upon whether tube thickness is $\geq$ 2 mm or < 2 mm respectively.

4.0 WELDING PROCEDURE QUALIFICATION

4.1 Welding Procedure Specification shall be compiled by the Fabricator and submitted to the Authorized Inspector for approval before the qualification tests are performed. Mock up test shall commence only after approval is obtained from the Authorized Inspector.

4.2 Welding procedure qualification test is required to be carried out if:

a) Authorized Inspector requires the test to be carried out.

b) There exist no previous qualification tests within last three years for the proposed combination of tube and tubesheet P number and group number (as per ASME Section IX), tube outside diameter (OD), tube thickness, tubesheet thickness, tube pitch, tube pitch pattern, welding procedure and joint detail. All other factors remaining same, the procedure test need not be repeated if the job tubesheet thickness exceeds 40 mm and qualification exists for 40 mm or higher tubesheet thickness.

For plug type air coolers additional procedure qualification test is required to be performed for any of the following conditions:

i) The job has lower clearances between tube and any of the header plates like top/bottom/end/stiffener/pass partition plate compared to earlier tests.

ii) The job has lower plug size for the same tube size compared to earlier tests.

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iii) The job has higher plugsheet thickness compared to earlier tests.

c) Code or requisition or bid document requires the test to be carried out.

4.3 If required as per 4.2 above, the Fabricator shall perform a procedure qualification test, at least two weeks before the scheduled beginning of production. Procedure shall be qualified for the same hand position as is being proposed for production. Procedure test shall consist of the welding of nine tubes for square pitch and eight tubes, (three, two and three tubes per row arrangement) if on a triangular pitch. This shall be done for each set of combination of tube and tubesheet P number and group number, welding procedure, joint detail, tube OD, tube thickness, tube pitch, tube pitch pattern, tubesheet thickness. Additionally for air cooler, tests shall be done for each tube size with lowest plug size, lowest clearance between tube and any of the header plates, and the lowest plugsheet thickness to be used on the job. Thickness of the tubesheet used for procedure testing shall be same as used for job, except that for carbon steel and austenitic stainless steel materials, it need not exceed 40 mm, unless otherwise indicated. Refer Appendix-2 of this specification for test specimen details.

4.4 The following data report (six copies) shall be furnished for review to Authorized Inspector with the weld samples as outlined below.

a) Complete details of welding procedure employed indicating various machine settings, welding rods, inert gas composition & purities, flow rate, weld sequence etc.

b) Mechanical properties and chemical composition of tubesheet, tubes and filler metal.

c) The hardness of the weld, the tube, the tubesheet heat affected zone and the tubesheet base metal after each pass.

d) The complete test sample shall be cut (by sawing) as per Appendix 2 of this specification. These shall then be subjected to various tests etc. as outlined below:

i) Section 1 shall be polished, etched and microphotographed for examination of depth of weld, penetration and definition of boundaries. The minimum leak path of each weld shall be not less than the nominal thickness of the tube. The weld leg shall also be measured and shall be minimum 1.4 times the nominal thickness of the tube.

ii) Section 2 (two specimens) shall be subjected to tear test. These specimens shall be tongue bent to show the extent of weld penetration. The underside of the weld shall show evidence of adequate & uniform weld penetration.

iii) A section 10 mm thick containing the tube end welds shall be sawed from section 3 and radiographed for weld quality. The radiograph shall be submitted to Authorized Inspector. No cracks or crack like or visual defects are acceptable. Acceptance shall be as per Appendix 4 of ASME Section VIII Division 1. In case the radiograph is not acceptable, welding procedures shall be suitably modified so that proper weld and acceptable radiographs are obtained. These shall be proved by retests.

iv) Section 4 shall be etched and polished and given to Authorized Inspector.

e) A tension strength test shall be carried out as per clause 4.21 of ASME Sec VIII Div-2. This strength test shall be performed at room temperature for each combination set of tube and tubesheet P number and group number, tube OD, tube thickness and joint detail. The breaking loads shall be at least equal to the load required for breaking the tube using the minimum specified ultimate tensile strength of tube as indicated in

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certificates issued by the tube supplier. When tube material is to a specification which does not call for mechanical tests to be performed, ultimate tensile strength of the tube material shall be considered as four times the allowable stress at room temperature as indicated by the ASME Section II Part D, or other relevant code. Failure of the test piece at the weld shall not be a cause for rejection in case the minimum strength is attained, but the fracture should be examined for any evidence of faulty workmanship.

4.5 Fabricator is advised to satisfy himself that the procedures employed are the best for the job and would enable him to give workmanship guarantee for the equipment. Authorized Inspector's approval shall in no way relieve the Fabricator of his responsibility and guarantee to supply the equipment as per the conditions of the purchase order.

5.0 WELDERS QUALIFICATION

The purpose of this operator qualification test is to demonstrate that both the welding operator and the welding machines are capable of producing satisfactory joints. Once welding procedures have been qualified as above, welding operators employed on welding shall be required to prove their ability by making test samples similar to that prescribed above for welding procedure qualification. Welding operators may be qualified based on para 4.4 d (i), 4.4 d (ii), and 4.4 d (iii) above only, provided same welding machines & welding procedures are used. This welding operator qualification test should also be carried out if the welding operator has not executed similar welding six months prior to production. Repeat tests may be called for in the course of manufacture to determine the consistency of operator or machine to produce sound welds.

6.0 PREPARATION OF TUBES AND TUBESHEET

6.1 Tube holes shall be to special close fit tolerance as per TEMA for shell and tube exchangers and as per API 661 for air coolers. Tube holes shall be free from any burns and the bundle side edge of tube holes shall be chamfered or radiused. Tube holes shall have smooth finish to 63 AARH.

6.2 Prior to assembly, the tubesheet and tube ends (inside and outside for a distance equal to the tubesheet thickness + 30 mm) shall be cleaned and degreased to free from dirt, grease etc. It is essential that the solvent used for degreasing be chloride free and sulfide free and non residue forming. The solvent should not lead to any possible fire hazard.

6.3 The tubes shall be positioned in the tubesheets by 30° tapered drift pin.

6.4 Before welding tube to tubesheet, the tubesheets shall be heated to a temperature as required to remove any last traces of moisture or solvent which may remain after the cleaning operation. Any specific requirement for application of preheat shall be established as a part of the welding procedure qualification test and should account for increased restraint offered by the larger assembly during production.

7.0 WELDING

Tubes shall be individually welded, using the procedure approved by the Authorized Inspector. Systematic welding procedure shall be adopted so as to result in minimum tubesheet distortion. All tubes are to have initial pass completely cleaned as necessary, visually examined and tested as per para 8.1 below, if required, before subsequent layers are applied. Welds shall be suitably finished and any spillage or spatter on tubesheet removed. Spillage of weld metal into the bores of tube is not permitted.

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8.0 EXAMINATION OF JOINTS

8.1 Joints shall be subjected to air-soap solution test after first weld pass with air at 1.25 kg/cm^2 (g). Procedures outlined in ASME Section V, Article 10 shall be followed.

8.2 After completion of welding, the tubesheet face, the welds and internal tube surfaces to a distance of 25 mm beyond the fusion line must be cleaned thoroughly by wire brushing and examined carefully for surface defects. Defects such as cracks, surface breaking porosity, slag inclusions and lack of fusion are not acceptable.

8.3 After the visual inspection, a liquid penetrant examination in accordance with ASME Section VIII Division I, Appendix-8 & Section V, Article 6 shall be done. Before conducting this test, the faces of the carbon steel tubesheets shall be cleaned thoroughly by wire brush and solvents to remove all weld slag, rust and scale.

8.4 When specified on the drawings or requisition, a halide test shall be performed after the tests as per para 8.1, 8.2, and 8.3 above have been successfully completed. Procedures for halide test shall be as per ASME Section V, Article 10, Appendix - III Halogen diode detector probe test.

8.5 After the final tube expanding (refer para 9.0) has been completed, the liquid penetrant examination as outlined in para 8.3 above shall be repeated.

8.6 Whenever a halide test has been specified, an envelope test shall also be done as a further test for leaks after final tube expanding. For this test, tubesheets shall be securely wrapped in plastic sheets and the shell allowed to remain under test pressure with halogen tracer, for a period of 10 to 12 hours. Then with the detection set at a maximum sensitivity, the probe shall be inserted through the plastic cover at the bottom of the tubesheets and readings taken to observe if any leakage has occurred.

8.7 Final acceptance hydraulic pressure test shall be conducted after tube expansion at hydrotest pressure for at least one hour.

9.0 TUBE EXPANDING

After the tests outlined in 8.1, 8.2, 8.3, and 8.4 have been successfully completed and all leaking welds repaired, the tubes shall be "contact expanded" with a PARALLEL type expander. Contact expanding is intended to bring the tube OD into contact with the tube hole. Contact expanding shall begin 12 mm from the tubesheet face and extend to 3 mm from the back face. The contact expansion shall have thinning of 3-5% which shall be ensured by measuring the inside diameter of tubes.

10.0 REPAIRS

If leaks are found during any of the above testing procedures these shall be reported to the Authorized Inspector and after obtaining his approval, repairs shall be made by removing the defects down to sound parent metal and repeating the qualified weld procedures. All weld repairs shall be retested in accordance with procedures outlined in para 8.0 above.

11.0 TEST AND REPAIR REPORTS

Test and repair reports shall be included in the Data Folder. These reports shall also indicate the number of leaks discovered on each test and the extent of the repair done.

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APPENDIX 1 - JOINT DETAILS

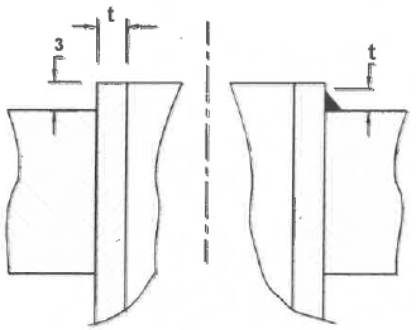


FIG-1

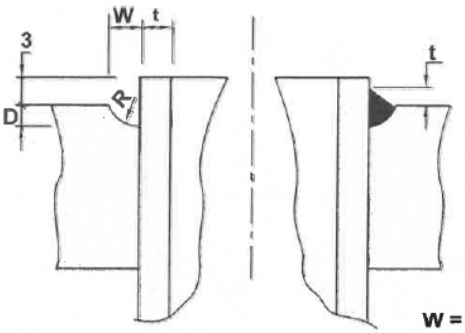


FIG-2

W = t
R = t
D = t FOR t ≤ 3
AND
= 0.6t FOR t > 3

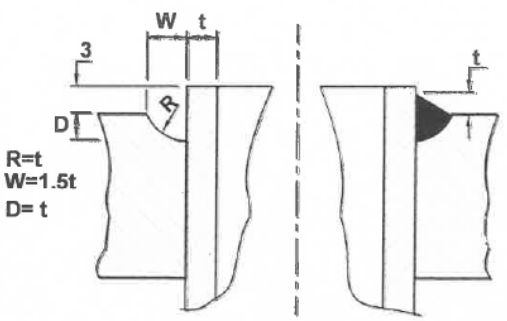


FIG-3

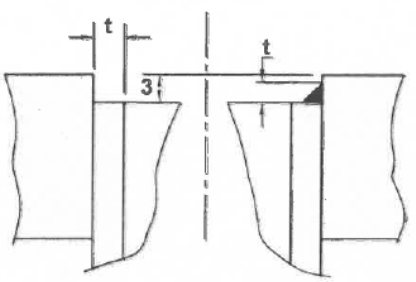


FIG-4

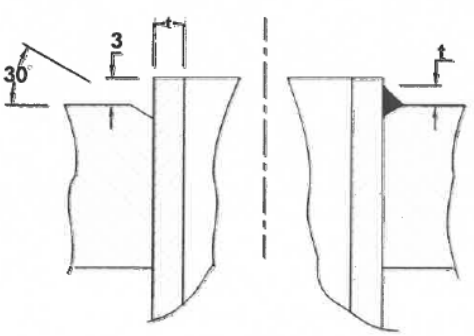
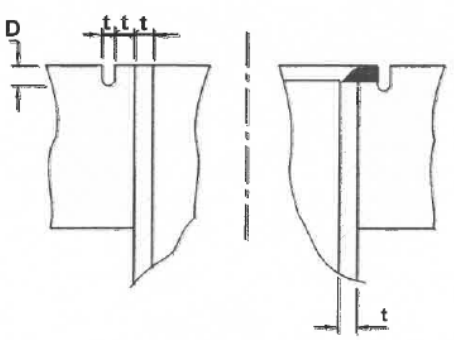


FIG-5



D = 1.5t TO 2t

FIG-6

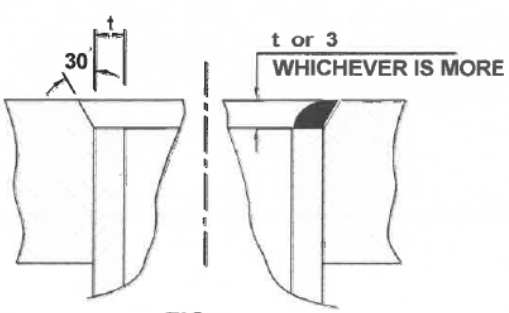


FIG-7

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APPENDIX 2 - DETAILS OF TEST SPECIMENS

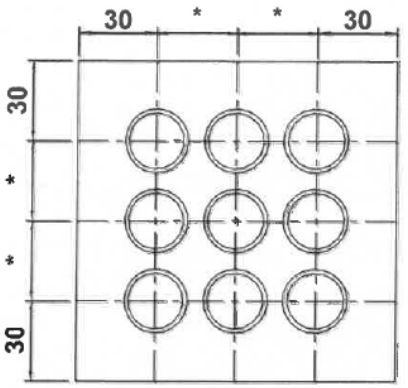


FIG-11

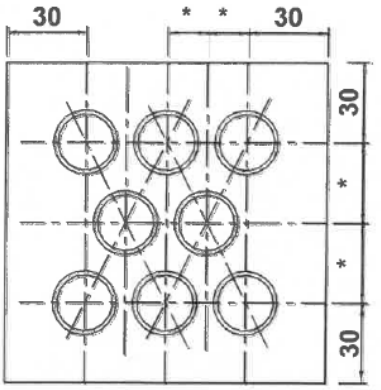
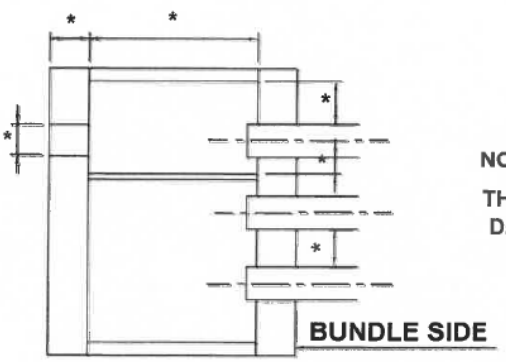


FIG-12



NOTE:-

THE MOCKUP ASSEMBLY SHOULD HAVE THE DIMENSIONS/THICKNESS MARKED '*' AS PER JOB

FIG-13 FOR PLUG TYPE AIRCOOLERS

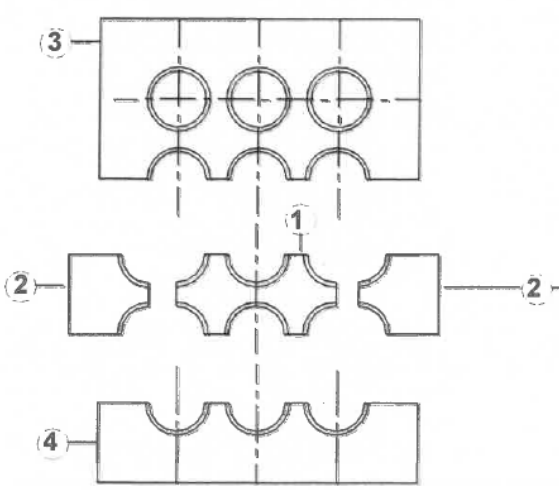


FIG-14

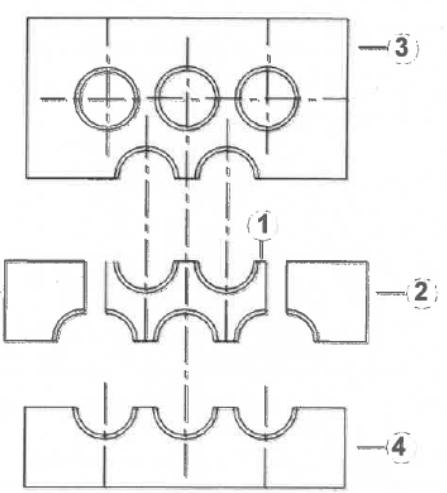


FIG-15

LEGEND

1. FOR MICROPHOTOGRAPHIC EXAMINATION
2. FOR TEAR TEST
3. FOR RADIOGRAPHIC EXAMINATION

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एक्सपान्डेड् ट्यूब से ट्यूबशीट जोडों के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR EXPANDED TUBE TO TUBESHEET JOINTS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	05-12-24	REVISED AND REISSUED AS STANDARD SPECIFICATION	MKP	TKh	KA/NK	MN
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Abbreviations:

ASME	American Society of Mechanical Engineers
API	American Petroleum Institute
ID	Inside diameter
OD	Outside diameter
SS	Stainless steel
TEMA	Tubular Exchangers Manufacturers Association

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CONTENTS

1.0	SCOPE	4
2.0	APPLICABLE CODES	4
3.0	JOINT CONFIGURATION	4
4.0	PROCEDURE TESTING	4
5.0	CARE OF TUBE	5
6.0	TUBE HOLES IN TUBESHEET	6
7.0	ASSEMBLY AND EXPANSION	6
8.0	TESTING	6
9.0	INSPECTION	7

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1.0 SCOPE

This specification covers the minimum requirements of expanded tube-to-tubesheet joints for shell & tube heat exchangers and air coolers. It is the fabricator's responsibility to furnish sound, leak free joints. For the purpose of this specification, the term "joints" shall be construed to mean "tube-to-tube sheet joints".

2.0 APPLICABLE CODES

The latest edition of the following Codes and Standards shall be complied with:

a) ASME Sec. VIII Div. 1 (Code)
b) TEMA for tubular exchangers
c) API 661 for air coolers.

3.0 JOINT CONFIGURATION

Joint with two grooves as per 7-15-0006 shall be used unless specified otherwise.

4.0 PROCEDURE TESTING

4.1 Procedure testing is required to be carried out in any of the following cases:

a) Authorized Inspector of Purchaser or EIL requires it to be carried out.

b) There are no previously established procedures for Fr values (Factor of Reliability) in the last five years with the same combination of tube and tubesheet material, outside diameter (OD) and thickness of tubes, tube hole groove detail and length of expansion (excluding contact expansion).

c) Code or specification or the equipment drawing requires it to be carried out.

d) The length of expansion in the job is less than existing qualification length of expansion of same materials, tube size, tube hole groove detail. However, if qualification exists for length of expansion of 51 mm or more for the same combination of materials, size of tubes, tube hole grooving details, and the length of expansion for the job is 51 mm or more, the procedure testing need not be repeated. The length of expansion to be considered excludes any contact expansion.

e) If previously established procedure of the fabricator is to be used, Authorized Inspector has the option of asking for a demonstration of the procedure to satisfy himself of its accuracy or to confirm the suitability of the expanding equipment or control unit. With time, the equipment used for expansion may change its characteristics and Authorized Inspector may like to check this by actual procedure tests.

4.2 Procedure test shall demonstrate % thinning vs machine setting and shear load test as per the requirements given below.

4.2.1 A sample tubesheet of same material and thickness as required for the job shall be drilled and/or reamed to achieve the required surface finish as per clause 6.0 and grooved as per 7-15-0006. Tube hole dimensions shall be as specified in clause 6.0 and as far as possible tube holes shall be prepared to cover the complete range of tolerance allowed. Tubesheet thickness used for procedural testing shall be as per item drawing or specification except that it need not exceed 55 mm. Diameter of tube holes drilled in the sample tubesheet shall be measured accurately. Hardness of tubesheet shall be measured and reported.

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4.2.2 At least eight tubes from the same heat shall be selected with extreme tolerances as far as obtainable from the given lot of tubes to the satisfaction of the Authorized Inspector. The OD, inside diameter (ID) & hardness of these selected tubes shall be measured and reported.

4.2.3 One of these tubes shall be selected and positioned in the tube hole and assembly held in the same position as shall be adopted for production. Tube expander to be used for production shall be set at an estimated low value and tube shall be expanded inside the tube hole. Expander setting shall be increased until the thinning is in the range of 8-10% for all materials, except for non-ferrous and stainless steel, in which case it shall be 6-8%. In no case shall the % thinning exceeds the values given in clause 8.1. The thinning figures are to finally such that these can result in achieving the required Fr value. It shall be the fabricator's responsibility to ensure the same.

Percentage thinning is defined as follows:

$\%\ \text{thinning} = [1-(D_h - ID_f)/(OD-ID_i)] * 100$

Where

D_h = Tube hole diameter in tubesheet

ID_f = ID of tube after complete expansion

OD = OD of tube before expansion

ID_i = ID of tube before expansion.

4.2.4 Expander setting thus found shall be tested on the remaining tubes and thinning shall be checked to be within the range specified above. Results of these tests (reporting combination number and % thinning achieved and various diameters used for calculation of thinning) shall be reported to the Authorized Inspector.

4.2.5 Samples prepared above, shall be cut in two halves along the axis of the tubes to show the flow of metal into the grooves. These cut-sections shall be presented to the Authorized Inspector who shall check the samples for flow of metal into the grooves and also check the expansion length. Authorized Inspector's approval shall be obtained on the same.

4.2.6 Fabricator is advised to satisfy himself that settings reported and to be used in the production shall be the best for the job, will enable him to achieve the required Fr value and give workmanship guarantee for the equipment. Authorized Inspector's approval shall in no way relieve the fabricator of his responsibility and guarantee to supply the equipment as per the conditions of the purchase order.

4.2.7 Shear load tests shall be carried out as per clause 4.21 of ASME Sec VIII Div-2. Fr value of the joint shall be established and shall be demonstrated to be greater than or equal to Fr (test) required as per clause 4.21 of ASME Sec VIII Div-2. For nonferrous and stainless steel combination of tubes & tubesheet a minimum Fr value of 0.7 shall be achieved. Actual value shall be reported in the test reports.

5.0 CARE OF TUBES

5.1 Ends of the tubes (tubesheet thickness + 100 mm) shall be subjected to careful visual inspection. These shall be cleaned to remove scales, rust, grease and dirt and should subsequently be cleaned by using a suitable sulfide free and chloride free solvent to get rid of oil and grease. The solvent should be non-residue forming and should not lead to any possible fire hazard. The area should be defect free and should have no scoring marks, rough surface etc. No repair is permitted on defective tubes unless approved by Authorized Inspector. In case a repair is done using an approved procedure, the tube dimensions after repair shall be within limits laid down by the tube material specification, otherwise the tube shall be discarded.

5.2 At least 10% tubes (subject to a minimum of 20 tubes per shell) shall be tested for hardness at the tube manufacturer's shop (This shall be taken care during sub-ordering). The hardness

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measured should not be greater than the maximum hardness reported in the mockup. Tubes with greater hardness shall be rejected. Further hardness testing shall be done, if required by Authorized Inspector.

6.0 TUBE HOLES IN TUBESHEETS

Tube holes in tubesheets shall be drilled as per TEMA special close fit for shell and tube exchangers and as per API 661 special close fit for air coolers. For example, metric tube of size 20 mm OD, the nominal size of tube holes shall be 20.20 mm with tolerances as $\pm$ 0.05 mm, for 25 mm OD tubes, nominal size of holes shall be 25.25 mm with tolerances as $\pm$ 0.05 mm and so on.

Tube holes in tubesheets shall be drilled or drilled and reamed to final size and surface finish. Grooves shall be machined in the tube holes as per 7-15-0006. Tube holes shall have no burrs or scoring marks and shall be circular with parallel sides and normal to the tubesheet surface. Longitudinal and spiral scratches are not permitted. Edges of the tube holes shall be deburred and chamfered as per the figure in 7-15-0006. Tube holes shall have surface finish to 63 AARH or better & shall be cleaned prior to assembly.

7.0 ASSEMBLY AND EXPANSION

7.1 Care shall be taken during assembly to avoid scoring of tube holes in tubesheet or outer surface of the tubes. The tubes shall be positioned so that their projection from the tubesheet is as per 7-15-0006. For vertical shell & tube exchangers, the tubes are required to be flush with top tubesheet unless specified otherwise.

7.2 Tube expanders used by the fabricator shall be electronically or pneumatically or hydraulically controlled type and shall be in good condition and shall have the Authorized Inspector's approval. The tube expanders shall have `stops' to prevent the rollers approaching nearer than 3 mm to the back of the tube sheet.

7.3 Expansion of tube into tubesheet shall be done as per the established procedure.

7.4 Tubes shall be expanded for the full thickness of the tubesheet leaving 3 mm (minimum) at the backside face of the tubesheet. However, for tubesheet thickness more than 55 mm, the expansion may be limited to 51 mm from the tube side face and remaining portion to be contact expanded leaving 3 mm (minimum) to 6 mm (maximum) at the back of tubesheet. Contact expansion shall have thinning of 3 - 5% which shall be ensured by measuring the ID of tubes.

7.5 Care shall be taken to avoid any distortion of the tubesheet or gross deformation of the ligaments. It is suggested that tubes be expanded systematically in small, diametrically opposite groups. The tube expansion shall be uniform on the whole expanded length. There shall be no abrupt transition at junction with unexpanded zone.

7.6 A check shall be made of the percentage thinning on tubes selected by Authorized Inspector and the results recorded and compared against percentage thinning figures of the procedure test.

8.0 TESTING

8.1 After expansion of all joints is completed on the job tubesheet, tubesheet face and the internal surfaces of the tubes to a length of about 15 mm shall be thoroughly cleaned. Any grease or oil shall be suitably removed using proper solvent or steam jets. These joints shall then be subjected to pneumatic air-soap solution test of 1.25 kg/cm^2 (g). Leaking tubes shall be further expanded, in the presence of Authorized Inspector after the reasons for the leakage are

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ascertained and accepted by the Authorized Inspector. If the % thinning is greater than 15% for carbon steel and low alloy steel combinations and 12% for non ferrous and stainless steel combinations, then the defective tube shall be replaced and re-expanded.

8.2 Joints shall also be subjected to hydrostatic leakage test at a test pressure indicated in the drawings or requisition for at least one hour. Leaking tube, if any, may be further expanded keeping the guide lines given above in view.

9.0 INSPECTION

Inspection of the equipment shall be carried out as per the purchase order by the Authorized Inspector. For expanded tube to tubesheet joints, following stages of inspection shall be observed and reported:

a) Agreement regarding expansion procedure. If procedure testing is to be carried out, then all preparations, cut samples, test results etc. shall be inspected by the Authorized Inspector.

b) Inspection of tube ends. Special attention shall be paid to tube dimensions & hardness. These shall be within the specified tolerances.

c) Approve any repair procedure to rectify defective tube end.

d) After tube holes in the tubesheet have been drilled, and / or reamed and grooved, all tube holes shall be given a careful check for:

   i) Tube layout pattern and locations.

   ii) Tube holes meeting requirements of clause 6.0 above. Also, it is to be checked that grooves in tube holes are located properly and of required dimensions.

   iii) Minimum ligament width as per TEMA or API as applicable.

e) Check the tube projection before expansion is to be started.

f) Agree to the sequence of expanding tubes into the tubesheet holes.

g) Check for distortion of tubesheet and thinning of tubes after expansion is complete.

h) Witness pneumatic & hydrostatic testing.

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STANDARD SPECIFICATION

FOR U-TUBES

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
6	23.11.23	REVISED AND REISSUED AS STD. SPEC.	MKP	TK	KA/NK	MN
5	22.09.17	REVISED & REISSUED AS STD. SPECN.	SK	KJH	RKT	RN
4	15.11.11	REVISED AND REISSUED AS STD. SPECN.	KA	RKT	AKM/SC	DM
3	17.02.06	REVISED & REISSUED AS STD. SPECN.	AKM	PK	AKM	VJN
2	01.09.99	REVISED & REISSUED AS STD. SPECN.	AKM	PK	RKA	AS

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Abbreviations:

AI	:	Authorized Inspector
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing and Materials
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
MD	:	Maximum or minimum outside dimension at bent portion
OD	:	Outside Diameter
TEMA	:	Tubular Exchangers' Manufacturers Association

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CONTENTS

1.0 SCOPE.....4

2.0 CODES.....4

3.0 MATERIAL.....4

4.0 MANUFACTURE.....4

5.0 HEAT TREATMENT.....5

6.0 INSPECTION & TESTING.....6

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1.0 SCOPE

This specification covers the minimum requirements for materials, manufacture, inspection and testing of U-tubes required for installation in shell and tube heat exchangers.

2.0 CODES AND SPECIFICATION

The following standards/ specifications with latest edition shall be used :

ASME Section II Part A & B
ASME Section VIII Division 1
TEMA
IBR, if applicable
EIL Specification No. 6-15-0001

3.0 MATERIAL

3.1 Tubes required for the manufacture of the U-bends shall meet all the requirements of EIL Specification No. 6-15-0001 and the Codes mentioned above.

3.2 Tube thickness specified in the datasheets and/or drawings are minimum before forming.

3.3 Low carbon austenitic Stainless steel type 304L, 316L in solution annealed condition or stabilized austenitic stainless steel grades 321, 347, 316 Ti in solution annealed followed by thermal stabilization heat treatment condition shall be used. The other austenitic stainless steel type may be used with the restriction of Carbon content similar to its equivalent Low Carbon grade.

4.0 MANUFACTURE

4.1 All U-tubes shall be formed from a continuous length of tubing, free of girth welds.

4.2 The minimum mean radius of U-bends of tubes shall be 2 times the OD of the tube, unless specified otherwise.

4.3 U-tubes shall be manufactured only from seamless tubes. Welded tubes shall not be used.

4.4 All U-bends shall be cold formed.

4.5 Thinning

Thinning of tubes after bending shall be as per TEMA. One tube for each material and size shall be bent to the specified minimum radius and cross sectional thickness measured at 4 points i.e. 0°, 30°, 60° & 90° from tangent line of U-bend.

4.6 Flattening

4.6.1 Flattening after bending shall be within the range given below unless approved otherwise:

Minimum radius of bend	Flattening
Up to 2 x OD	± 10%
Greater than 2 x OD	± 5%

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4.6.2 Flattening shall be calculated as below:

$$\% \text{ Flattening} = \frac{MD - OD}{OD} \times 100$$

4.7 Centre to Centre Distance

Centre to centre distance shall be measured at the tangent line of the U bend and shall have the following tolerances:

Bend Radius	**Tolerance (mm)**
R < 5 x OD	± 1.0
R ≥ 5 x OD	± 1.5

4.8 The bent portion shall be substantially uniform in curvature and shall not exceed ± 1.5 mm of nominal centre line radius.

4.9 Permissible deviation from the plane of bend shall not exceed 1.5 mm as measured from the point of tangency.

5.0 HEAT TREATMENT

5.1 Killed Carbon Steel, Low Temperature Carbon Steel, 3½% Ni, Low Alloy Steel U-tubes up to 5 times tube OD bend radius shall be stress relieved after bending over U-tube plus 300 mm (min) beyond the point of tangency.

5.2 U tubes up to 5 times tube OD bend radius shall be subjected to solution annealing heat treatment after bending over U- tube plus 300 mm (min.) beyond the point of tangency for low carbon austenitic stainless steel types 304L, 316L or stabilized grades austenitic stainless steel type 321, 347, 316Ti.

5.3 For copper and copper alloys, U-tubes shall be stress-relief annealed after bending over U bend plus 300 mm on each straight length beyond the point of tangency, irrespective of bend radii.

5.4 For nickel and nickel alloys and titanium and titanium alloys, U- tubes shall be heat treated if it is specified in the datasheets/ drawings. The heat treatment procedure for U-tubes shall be agreed with the consultant/owner.

5.5 For duplex stainless steel and super duplex stainless steel tubes heat treatment shall be done only if specified in the data sheets/drawings.

5.6 For ferritic stainless steel and martensitic stainless steel, U-tubes shall be stress relieved only if specified in datasheet/drawings. Stress relieving, if applicable shall be carried out, on the U-bend plus 300 mm (minimum) beyond the point of tangency.

5.7 Tube bending lubricants, oil, grease, etc., shall be removed from U-bends before stress relieving. Internal surfaces of austenitic stainless steel tubes above mentioned shall be checked for cleanliness by blowing close fitting acetone soaked felt plugs. Dry, oil free air or nitrogen shall be used for blowing the plugs. If plugs show more than a light gray discoloration, the tubes shall be recleaned and retested.

5.8 Temperature during heat treatment shall be controlled through the use of optical pyrometers or emission pyrometers or both. Temperature indicating crayons, lacquers or pellets shall not be used.

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5.9 Methods for Heat Treatment

5.9.1 **Electric Resistance Heat Treatment**

5.9.1.1 Heat treatment by electric resistance heat treatment is acceptable for most materials except ferritic and martensitic SS and chrome-moly steels, and is always recommended for austenitic stainless steel.

5.9.1.2 The close control of tube temperature during heat treatment shall be monitored with the use of thermocouples or calibrated optical pyrometer on the straight tangent near a U- bend. The heat treatment temperatures among the readings shall not be deviated by ±15°C as specified in the Code.

5.9.2 **Furnace Heat Treatment**

5.9.2.1 U-Tubes shall be properly supported above the furnace floor.

5.9.2.2 Establish a procedure on lines similar to Cl. 5.9.1.2. Proposed procedure shall be submitted to the AI and approval obtained prior to actual heat treatment.

5.10 Heat treatment temperatures by furnace and/or electric resistance methods shall be as given in the respective product specification or in the Code, subject to a maximum variation of ±15°C. The stress relief heat treatment temperature shall be at least 25°C below the minimum tempering temperature used for the original material.

In the case of duplex stainless steel, cooling after the solution annealing shall be carried out by using forced air, inert gas blast or water quenching.

5.11 The applicable stainless steels U-tubes as mentioned above in this specification shall be pickled and passivated as per ASTM A380 after heat treatment, employing a previously qualified procedure acceptable to Purchaser/ EIL.

6.0 INSPECTION & TESTING

6.1 All U-bends shall be visually inspected to detect any harmful effect.

6.2 All U-bends with bend radii less than 5 times the tube OD shall be inspected for thinning, flattening, centre to centre distance, bend curvature and for the deviation from the plane of bend, to ensure conformance to the limits specified. U-bends with bend radii greater than 5 times the tube OD shall be inspected randomly at the discretion of the AI, subject to a minimum 1 tube per one bend radius batch.

6.3 For austenitic stainless steels above mentioned, IGC corrosion test shall be carried out as per ASTM A262 practice-E after final heat treatment unless stated otherwise. Specimen after exposure to the IGC environment shall be bent as per A262 practice-E and shall be examined with minimum magnification of 200x. The acceptance criterion is that the bent specimen shall be free of any cracks or grain dropping. The microstructure shall be submitted to Purchaser/EIL or AI for approval.

6.4 After heat treatment and final cleaning of U-bend tubes, the same shall be subjected to hydro-testing at a pressure of 70 kg/cm^{2}g or tube side test pressure (whichever is greater) prior to assembling the tube bundle. Minimum holding time shall be 2 minutes. Hydrotest reports shall be submitted to Purchaser/EIL or AI for approval.

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स्टैटिक ईक्विपमेंट (प्रैशर वैसल्स हीट एक्सचेन्जर्स) के आवश्यक कठोरता के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR HARDNESS REQUIREMENT OF STATIC EQUIPMENT

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
5	24.03.25	REVISED & REISSUED AS STD. SPEC.	BVK	TKh	KA/NK	MN
4	27.12.19	REAFFIRMED & REISSUED AS STD. SPEC.	PKP	NSK	KJH	RKT
3	05.11.14	REVISED & REISSUED AS STD. SPEC.	TK	KA	RKT	SC
2	29.06.09	REAFFIRMED & REISSUED AS STD. SPEC.	VB	RKG	AKM	N.DUARI
1	26.03.04	REAFFIRMED AND REISSUED AS STANDARD SPECIFICATION	NSK	PK	SSA	SKG
0	15.03.96	ISSUED AS STANDARD SPECIFICATION	RV	SSA	RKA	AS

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Abbreviations:

ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
HAZ	:	Heat Affected Zone
PWHT	:	Post Weld Heat Treatment

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CONTENTS

1.0 SCOPE 4

2.0 HARDNESS REQUIREMENTS 4

3.0 WELDING QUALIFICATION TEST 4

4.0 PRODUCTION TEST 4

5.0 APPROVAL 5

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1.0 SCOPE

This specification covers general requirement of hardness of base metal, weld and heat-affected-zone (HAZ) and is applicable to all C-½ Mo, Cr-Mo steels and other materials whenever asked for in drawings/ specifications/standards. All testing shall be done after PWHT.

2.0 HARDNESS REQUIREMENTS

Hardness in base metals, weld and heat affected zone as per ASTM E10 shall not exceed the following:

For P1 materials	- 200 BHN
For P3 & P4 materials	- 225 BHN
For P5 & P6 materials	- 235 BHN

3.0 WELDING QUALIFICATION TEST

3.1. For each welding procedure qualification nine tests shall be made, three in base metal, three in weld metal and three in HAZ. Hardness requirements shall be as per cl. 2.0 above.

3.2. In addition to the requirement of 3.1 above, Vickers Micro hardness test shall be made on a full cross-section at 25 mm intervals beginning at 3 mm from the top surface with 5 kg load or with a load approved by the authorized inspector. Tests shall be made at each level for each of the following locations as per ASTM E 92:

Three tests shall be made in the weld metals, two tests in HAZ and one test in the base metal in accordance with Fig.1 and the hardness shall not exceed the following in base metal, weld metal and HAZ.

For P1 materials	- 210 VHN
For P3 & P4 materials	- 237 VHN
For P5 & P6 materials	- 247 VHN

4.0 PRODUCTION TEST

4.1 All pressure containing weld metals are to be checked for hardness of weld and HAZ after PWHT but before hydro-test. The hardness shall not exceed the value stipulated.

4.2 Each longitudinal seam shall be checked both internally and externally near the center and at one end.

4.3 Each circumferential weld shall be checked at four locations approximately 90°apart, both internally and externally.

4.4 Each nozzle weldments shall be checked at two locations, 180° apart, both internally and externally.

4.5 Above hardness readings shall be taken at minimum 3-4 locations inside as well as outside covering the entire seam, to the satisfaction of inspector.

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5.0 APPROVAL

In case the hardness as obtained on production test is more than the limit specified in 2.0 above, the vendor shall submit the corrective procedure to lower the hardness in writing to EIL and/or authorized inspection agency for review/approval.

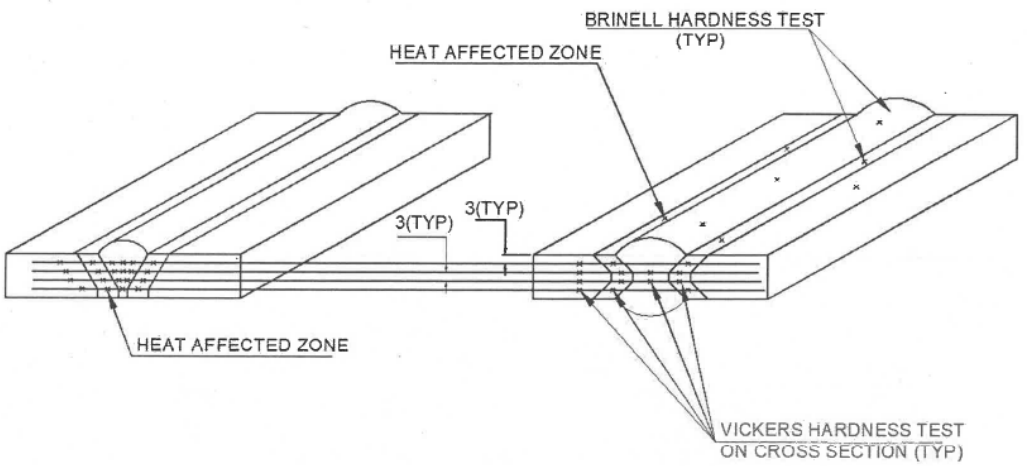

FIG.1- HARDNESS REQUIREMENT ON TEST COUPONS

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फ्लैंज जोड़ों के लिए बल-आघूर्ण (टॉर्क) तथा हाइड्रोलिक बोल्ट टेंशन के अनुप्रयोग हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR APPLICATION OF TORQUE AND HYDRAULIC BOLT TENSION FOR FLANGE JOINTS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
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2	04-05-2016	Issued for Implementation	PG	SVRS	RP	RN
1	26-05-2008	Issued for Implementation	PG	KPS	AA	VC
0	15-05-2003	Issued for Implementation	PG	KPS	VC	SKG

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Abbreviations:

ASME	American Society of Mechanical Engineers
PMS	Piping Material Specification

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CONTENTS

1.0	PURPOSE	4
2.0	SCOPE	4
3.0	REFERENCES	4
4.0	DEFINITIONS	4
5.0	METHODOLOGY AND CONTROL	4
6.0	RESPONSIBILITIES / APPROVALS	11
7.0	DOCUMENTATION	11
	ANNEXURE-I	34
	ANNEXURE-II	35

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1.0 PURPOSE

The purpose of this specification is to describe the methodology for preparation of bolted flange joints by controlled bolt tightening during construction and commissioning stage of process plant piping. This specification shall be used in conjunction with the other process/project specific requirements and the licensor/vendor recommendations.

2.0 SCOPE

This specification covers ASME B16.5 and ASME B16.47 Series B bolted flanged joints, involving identical pair of flanges, which are tightened by means of either hydraulic bolt tensioning or calibrated torque wrenches.

3.0 REFERENCES

EIL Spec no. 6-44-0005 Rev 7	-	Standard Piping Material Specification
ASME B16.5	-	Pipe Flanges and Flanged Fittings (1/2" to 24" NPS)
ASME B16.47 Series B	-	Pipe Flanges and Flanged Fittings (26" to 60" NPS)
ASME B31.3	-	Process Piping
BP RP 42-2	-	British Petroleum Recommended Practice: Bolting for flange joints
ASME Section VIII Division 1 and Division 2	-	Boiler and Pressure Vessel Code

4.0 DEFINITIONS

None.

5.0 METHODOLOGIES AND CONTROL

5.1 Identification of joints for controlled bolt tightening

Controlled bolt tightening can be done either by application of calculated bolt tension with hydraulic tensioner or by application of calculated bolt torque with calibrated torque wrenches. The criteria for selection of joints for these two application procedure are given below.

5.1.1 Hydraulic Bolt tensioning

Hydraulic bolt tensioning shall be applied for all joints where the bolt sizes match the criteria outlined in Table 1, except those in the category 'D' services. Category 'D' service is defined in ASME B31.3.

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**Table 1: Criteria for Bolt Tensioning –
Not applicable for flange joints in category 'D' services**

Nominal Bolt diameter	Condition	Remarks
All	When specified by the Process licensor/ vendor / project specifications	
50 mm and above	All joints	
38 mm and above, but less than 50 mm	Class 600 and above	
	Hydrogen service	(See Note-1 below)
	Category 'M' fluid services	Refer ASME B31.3
	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)
25 mm and above, but less than 38 mm	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)

Note-1: Hydrogen Service

In absence of project specific definition, Hydrogen service may be defined as service in contact with Hydrogen or gaseous mixtures containing Hydrogen in which the partial pressure of Hydrogen is 7 bar (100 psi) abs. or more.

Note-2: Joints with leakage potential shall include

a) Joints involving tapped holes.
b) Joints not subjected to hydro test e.g. joints for equipment manholes, equipment mounted temperature, pressure and level instruments, line mounted temperature connections, on line instrument joints like control valves and safety valves, compressor volume bottles.
c) Items involving two sets of gaskets with one set of bolt e.g. orifice flange joint, joints with spectacle blind, spacer, flangeless wafer check valve, wafer type butterfly valves.
d) Tie-in joints with other contractors and package vendors.
e) High temperature (above 371°C) joints in hydrocarbon services.

Note-3: Critical joints with the equipments shall include the inlet and the outlet flanges of pumps, compressors and turbines.

5.1.2 Application of torque

Controlled bolt torque, with calculated torque values, shall be applied using calibrated torque wrench. Joints those qualify for hydraulic bolt tensioning per 5.1.1 shall not be considered for torque application. Controlled bolt torque should be applied for the joints meeting the criteria given in Table 2. Joints fulfilling the criteria for Hydraulic bolt tensioning need not be checked for these criteria

Table 2: Criteria for Bolt Torque application

Service	Joints
Hydrogen service	All joints (Note-1)
Category 'M' services	All joints (Note-1)
Other services	Class 600 and above

Note-1: Joints, those qualify for hydraulic bolt tensioning as per cl. 5.1.1, shall not be considered for torque application.

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5.2 Pre-bolting Operations

5.2.1 Design

a) Flange connection with bolting of nominal diameter 25 mm and above shall have sufficient clearances and access to allow the use of hydraulic tensioning equipment (wherever hydraulic bolt tensioning is being used).

b) Stud bolts shall be longer by one diameter to suit the bolt tensioners for hydraulic bolt tensioning. Excess threads shall be protected by using nut, threaded cap etc. On bolts at ambient temperature duty the cap should have a grease nipple.

c) All flanges on hydrogen service must be left exposed unless otherwise agreed.

d) Interface joints shall be system pressure tested as per the relevant code to ensure their integrity.

5.2.2 General

a) Use of right type of gasket, fasteners etc. conforming to the specifications as per design and drawings should be ensured.

b) The Vickers hardness number of ring joint gaskets should be 30 to 40 less than that of the mating face of the flange.

c) All non-ring joint gaskets shall be replaced with the new ones whenever an opened joint is to be re-closed during construction and commissioning stage. Ring joint gaskets normally can be re-used provided they are inspected and are free from any damage

d) Shop tested flange joints should not be disturbed at site. In case the joint is opened, the Contractor shall be responsible for final hook-up joints including bolt tensioning if applicable.

5.2.3 Visual inspection

a) Condition of flange faces should be checked. Those shall be free from dirt, scale, remnant gasket, and protrusions. Faces with pitting, indentations or radial tool marks, or scratches are not desirable. Surface finish should conform to specifications.

b) Flanges should be aligned properly. Flange faces shall be parallel and boltholes shall match so that the studs can be inserted freely.

c) Visual examination of gaskets should be carried out prior to installation to ensure that these are free of any defects such as bends, crease or loose spiral windings etc.

d) Gasket position should be checked.

e) Studs and nuts shall be free from dirt, nicks, burrs and chips. Studs shall be straight and nuts shall turn freely on the stud.

f) No external load shall be used to align the flanges.

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5.2.4 Corrective measures

a) Faces with pitting, indentations or radial tool marks, or scratches that form leakage paths or with the surface finish not in accordance with design requirements shall be replaced or re-machined to specified surface finish.

b) If necessary, gasket seating face should be cleaned using wire brush (SS bristles on alloy components) and/or suitable solvent.

c) Damaged gaskets shall be replaced.

d) If holding gasket in place after installation is a problem, a thin adhesive tape should be used along the outside edge of gasket.

5.2.5 Lubrication/anti-seize compound

a) Threads and nuts to flange contact face should be lubricated with suitable lubricant. Thread compound or lubricant, suitable for line temperature, may be used.

b) Gaskets should not be lubricated.

c) Lubricant shall not be applied on bolts, used in oxygen services.

d) Some of the types of lubricants used are as follows:

Molybdenum Lead oxide (graphite based)
Molykote G-n plus
Molykote P37
Molykote HSC Plus / Never Seez nickel special
API SA2
Molykote 1000
Machine oil
Graphite grease

5.2.6 Assembly

a) Suitable lubricant (refer cl. 5.2.5) to be applied to the threads and the face of the nut that contacts the flange.

b) Four studs should be placed in positions 1, 2, 3 and 4 according to "Stud Tightening Pattern" in Fig.1, as centring guides for the gasket.

c) Balance studs should be inserted next.

d) Nuts should be run down by hand in such a way that an equal number of threads project at each end.

5.2.7 Torque/tension calculation

a) Bolting load calculation and stress analysis used for computation of the listed tightening torque and tension values primarily follow the procedures outlined in ASME Section VIII Division 1/ Division 2.

b) Basic formulae used for torque calculation takes care of friction between bolt threads and nut threads as well as that between nut and back face of flange.

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c) A frictional co-efficient of 0.15 is assumed for calculation of torque values for the lubricant - graphite grease. When a lubricant with different co-efficient of friction (μ) is used, the calculated values get multiplied by the ratio μ/0.15. The approximate μ values of some of the lubricants are as follows:

Type of Lubricant	Co-efficient of friction (μ)
Molybdenum lead oxide + graphite based	0.085
Molykote G-n plus	0.09
Molykote P37	0.10
Molykote HSC Plus / Never Seez nickel special	0.11
API SA2	0.117
Molykote 1000	0.13
Graphite grease / Machine oil	0.15

However, it is advisable to obtain the appropriate co-efficient of friction (μ) value from the lubricant manufacturer.

5.2.8 The PMS classes included in this specification are given in Table 3.

Table 3: PMS classes included in this specification

Sl. no	Piping class	Sl. no	Piping class	Sl. no	Piping class	Sl. no	Piping class
From Standard PMS (6-44-0005 rev 7)							
1	A1A	26	B1A	51	B6N	76	F2D
2	A2A	27	B2A	52	D1A	77	F2G
3	A4A	28	B4A	53	D2A	78	G2G
4	A6A	29	B5A	54	D4A		
5	A7A	30	B6A	55	D5A		
6	A8A	31	B9A	56	D9A		
7	A9A	32	B13A	57	D16A		
8	A11A	33	B16A	58	D19A		
9	A13A	34	B19A	59	D1D		
10	A15A	35	B32A	60	D2D		
11	A16A	36	B1D	61	D5D		
12	A19A	37	B5D	62	D5E		
13	A20A	38	B1E	63	D1K		
14	A32A	39	B3F	64	D2K		
15	A33A	40	B4F	65	E1A		
16	A4F	41	B4G	66	E2A		
17	A4G	42	B1K	67	E5A		
18	A1K	43	B2K	68	E9A		
19	A2K	44	B4K	69	E19A		
20	A6K	45	B5K	70	E5E		
21	A11K	46	B6K	71	F1A		
22	A1M	47	B1M	72	F2A		
23	A1N	48	B3M	73	F5A		
24	A4Y	49	B5M	74	F9A		
25	A33Y	50	B1N	75	F19A		

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5.2.9 Torque and tension values

Table 4 contains the tension and torque values to be used for bolt tightening of each bolt using hydraulic bolt tensioner and torque wrench respectively. These values are listed PMS class and flange size wise. The tension values specified are the target load per bolt intended after the bolt tensioning operation is complete. This means any allowance inherent in bolt tensioning equipment (viz. backlash etc.) shall also to be taken care of as recommended by the equipment manufacturer.

5.2.10 Notes to Torque and tension values in Table 4

a) The **maximum allowed** design pressure & temperature combination and test pressure values are listed in Table 4. These values corresponds to PMS rating table values, except as stated in c) below. **Recalculation** of torque and tension is necessary if the design condition exceeds these limits.

b) Values in the table are **not** valid if the design condition for pipe wall thickness calculation is lower than 80% of the class rating condition. **Recalculation** of torque and tension is necessary in such cases.

c) It may be noted that for the sizes above 24" and rating class above 150 (except Lists B-1 and B-2), the calculations are carried out for 80% of the pressure used for sizes up to 24".

d) Torque / tension computation of sizes and pipe thickness, which are not covered in the respective classes of the standard PMS, are carried out based on approximate calculated pipe thickness for the specified pressure and temperature condition.

e) The "Flange Std" column of table 4 is the standard rating class followed by a suffix. Suffixes to the rating class numbers denote the flange dimensional standard and are as follows:

S - ASME B16.5 B - ASME B16.47 Series B

f) The values in the tables are not valid for non-standard flanges or flanges conforming to any other dimensional standards, e.g., ASME B16.47 Series A, AWWA (American Water Works association) etc.

g) All pressure values are in kg/cm^2 (g) and all temperature values are in °C

h) Bolt tightening torque or tension values at equipment interface flanges, if specified by the equipment vendor, shall be used.

5.3 Bolting Operation

5.3.1 General

a) Categorisation of joints for tension or torque application shall be as per cl. 5.1.

b) Bolt tightening tension or torque value shall be as per cl. 5.2.9.

c) Guidelines and safety requirements provided by the manufacturer bolt tightening equipment should be followed.

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5.3.2 Hydraulic bolt tension application

a) Hydraulic pressure adequate to get the target bolt load can be calculated dividing the bolt load by the load cell hydraulic seal area. This pressure should be applied simultaneously to all load cells.

b) 4 load cells equally spaced should be used.

c) Nuts should be run down to flange surface manually.

d) Load cells should be shifted following the Criss-cross Pattern shown in Fig. 1 but in-groups of 4 bolts each (i.e. 1-2-3-4, 5-6-7-8, 9-10-11-12 etc.) and the tensioning of all bolts should be completed.

e) Tensioning operations should be repeated once again applying the same pressure.

5.3.3 Stud bolt torque application

a) Bolt torque application sequence shall be in accordance with "Criss-cross Stud Tightening Pattern" (Fig. 1).

b) Properly calibrated torque wrenches should be used.

c) Torque wrench should be held perpendicular to the axis of the bolt and if hydraulic wrench is used, it has to be ensured that it reacts against a rigid support parallel to the axis of bolt.

d) Torque should be applied using a minimum of following five steps:

i. All the nuts should be made snug tight with a short wrench (Criss-cross Pattern – Fig.1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

ii. Tightening to 30% of the final torque value (Criss-cross Pattern – Fig. 1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

iii. Tightening to 60% of the final torque value (Criss-cross Pattern – Fig.1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

iv. Tightening to the final torque value (Criss-cross Pattern – Fig. 1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).

v. Tightening should be continued with the final torque in a clockwise manner (bolt to bolt) until no further rotation is observed.

e) In the event of nut seizure, the nut should be backed off and additional lubricant should be applied or the nut or/and bolt should be replaced, if necessary.

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5.3.4 Testing of joints

Checking up of the individual joints for any leak during system pressure testing should be carried out using special tapes, soap solutions.

6.0 RESPONSIBILITIES / APPROVALS

6.1 All procedures/documents to be used during Construction should be submitted by the Contractor to Engineer-in-charge at site in advance.

6.2 The equipment supplier shall be subjected to EIL/Owner approval.

6.3 The details of hydraulic tensioner equipment to be used for tightening shall be intimated to Engineer-in-charge before application.

6.4 Boxing up and tightening of flange joints shall be done by skilled technicians, qualified and approved by Contractor and EIL/Owner.

6.5 Any conflict between the requirements of this standard specification and applicable codes, licensor specification, standards, data sheets, drawings, requisitions etc. shall be referred to client/ consultant. Agency carrying out bolt tightening shall list and describe all the deviations from this standard specification and the related reference documents.

7.0 DOCUMENTATION

7.1 History sheet for flange joints shall be maintained as per Annexure-I.

7.2 Sequence of the activities involved for reopening/ making/ blinding/ de-blinding/ wedge opening of flange joints shall be as per Annexure-II.

7.3 All joints shall be boxed-up and the record shall be maintained of salient points and names of the persons involved in the execution/inspection of boxing-up operation.

7.4 All critical joints shall be boxed-up under the supervision of the Contractor's representative and EIL's Engineer-in-charge or his representative and separate records shall be maintained for such joints.

7.5 Box up records of interface joints and on-line instrument joints, like control valves, safety valves, turbine flow meters etc., which are not subjected to hydro test shall be maintained separately.

7.6 If mentioned in project specification, complete set of Bolt Tensioning Equipment/ Torque Wrenches shall be supplied by Contractor to the Owner, after commissioning of the plant, as mandatory spares.

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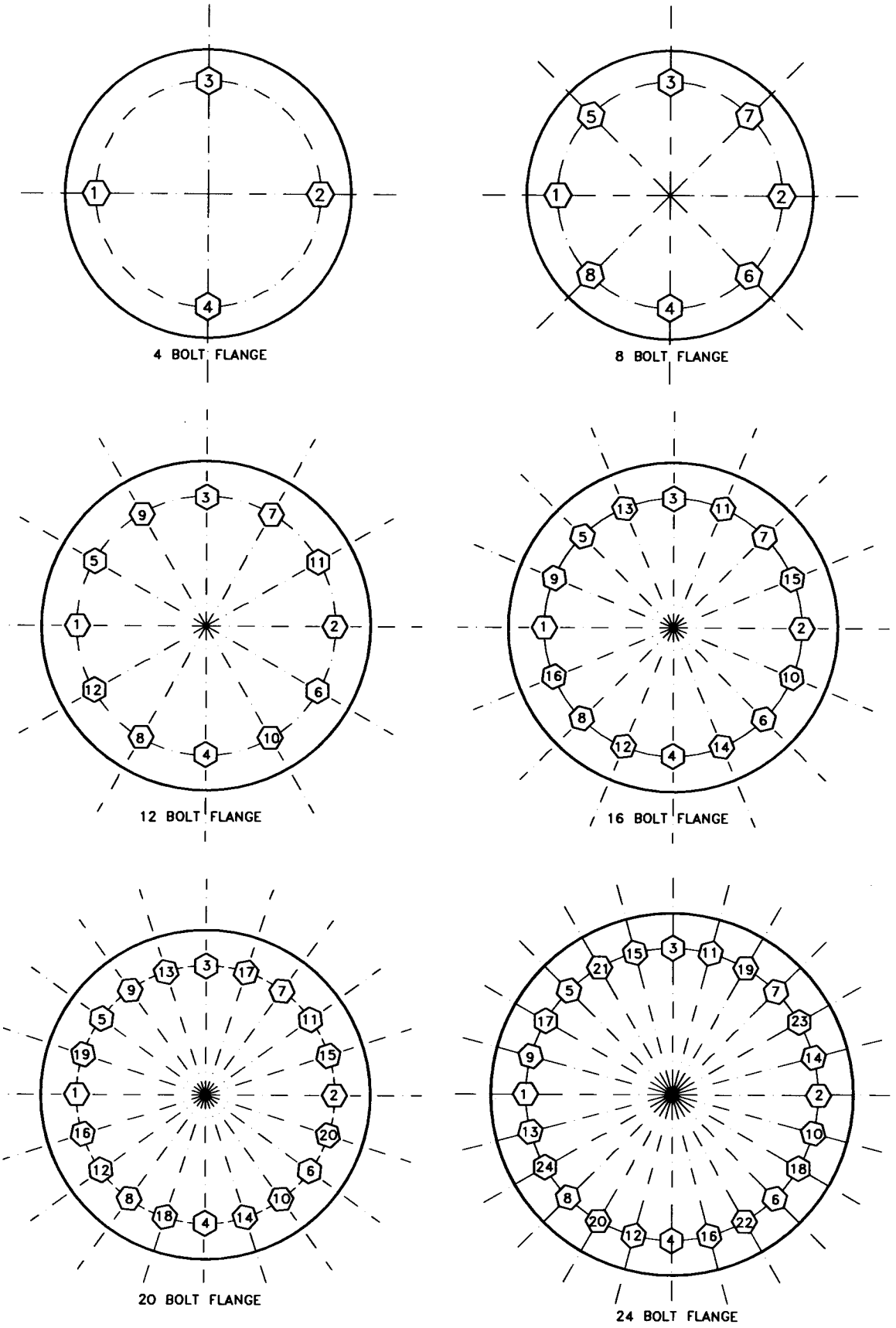

Figure 1 Typical "Criss-cross" Bolt tightening/Torque application pattern

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Page 351 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

Table 4: Bolt Tension and Torque Values

Refer cl. 5.2.8, 5.2.9 and 5.2.10 for applicability of these values

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-1													
A1A	PMS rated Temperature / Pressure		371 / 7.73	Up to 48"	7.73	371	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	3/4	1/2	4	855	2.6
				A672 Gr. B60	7.73	371	30.05	150S	1	1/2	4	1027	3.1
A2A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150S	1-1/2	1/2	4	1597	4.8
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	2	5/8	4	2562	9.4
				A672 Gr. B60	7.73	371	30.05	150S	3	5/8	4	3020	11.1
A6A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	4	5/8	8	2471	9.1
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	6	3/4	8	3972	17.2
				A672 Gr. B60	7.73	371	30.05	150S	8	3/4	8	4931	21.3
A7A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	10	7/8	12	5135	25.5
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	12	7/8	12	5326	26.5
				A672 Gr. B60	7.73	371	30.05	150S	14	1	12	6249	35.2
A9A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150S	16	1	16	5999	33.8
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	18	1-1/8	16	8583	53.7
				A672 Gr. B60	7.73	371	30.05	150S	20	1-1/8	20	8583	53.7
A11A	PMS rated Temperature / Pressure		371 / 7.5	Up to 48"	7.73	371	30.05	150S	24	1-1/4	20	11379	78.3
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	26	3/4	36	4111	17.7
				A672 Gr. B60	7.73	371	30.05	150B	28	3/4	40	4111	17.7
A13A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150B	30	3/4	44	4385	18.9
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	32	3/4	48	4522	19.5
				A672 Gr. B60	7.73	371	30.05	150B	34	7/8	40	6274	31.2
A19A	PMS rated Temperature / Pressure		371 / 7.73	Up to 36"	7.73	371	30.05	150B	36	7/8	44	6274	31.2
	A105	A193 Gr. B7	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150B	38	1	40	7750	43.7
				A 672 Gr.B 60 Cl.22	7.73	371	30.05	150B	40	1	44	7750	43.7
					7.73	371	30.05	150B	42	1	48	7750	43.7
					7.73	371	30.05	150B	44	1	52	7750	43.7
					7.73	371	30.05	150B	46	1-1/8	40	11230	70.3
					7.73	371	30.05	150B	48	1-1/8	44	10570	66.2

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	30.05	150B	**50**	1-1/8	48	**10570**	**66.2**
					7.73	371	30.05	150B	**52**	1-1/8	52	**10240**	**64.1**
					7.73	371	30.05	150B	**54**	1-1/8	56	**10240**	**64.1**
					7.73	371	30.05	150B	**56**	1-1/8	60	**10240**	**64.1**
					7.73	371	30.05	150B	**58**	1-1/4	48	**13488**	**92.8**
					7.73	371	30.05	150B	**60**	1-1/4	52	**13488**	**92.8**
LIST A-2													
A4Y	PMS rated Temperature / Pressure		50 / 10.55	Up to 12"	10.55	186	15.80	150S	**1/2**	1/2	4	**684**	**2.1**
	A105	A307 GR.B	BUTYL RUBBER	API 5L GR.B PSL1	10.55	186	15.80	150S	**3/4**	1/2	4	**855**	**2.6**
					10.55	186	15.80	150S	**1**	1/2	4	**1027**	**3.1**
					10.55	186	15.80	150S	**1-1/2**	1/2	4	**1255**	**3.8**
					10.55	186	15.80	150S	**2**	5/8	4	**2013**	**7.4**
					10.55	186	15.80	150S	**3**	5/8	4	**2013**	**7.4**
					10.55	186	15.80	150S	**4**	5/8	8	**2013**	**7.4**
					10.55	186	15.80	150S	**6**	3/4	8	**3014**	**13.0**
					10.55	186	15.80	150S	**8**	3/4	8	**3014**	**13.0**
					10.55	186	15.80	150S	**10**	7/8	12	**4184**	**20.8**
					10.55	186	15.80	150S	**12**	7/8	12	**4184**	**20.8**
					10.55	186	15.80	150S	**14**	1	12	**5499**	**31.0**
					10.55	186	15.80	150S	**16**	1	16	**5499**	**31.0**
					10.55	186	15.80	150S	**18**	1-1/8	16	**7263**	**45.5**
					10.55	186	15.80	150S	**20**	1-1/8	20	**7263**	**45.5**
					10.55	186	15.80	150S	**24**	1-1/4	20	**9272**	**63.8**
LIST A-3													
A4A	PMS rated Temperature / Pressure		204 / 14.06	Up to 48"	14.06	204	27.95	150S	**1/2**	1/2	4	**684**	**2.1**
	A 350 GR.LF2 CL.1	A320 GR.L7	Spiral wound SS	A 333 GR.6	14.06	204	27.95	150S	**3/4**	1/2	4	**855**	**2.6**
				A 671 GR.CC60 CL.32	14.06	204	27.95	150S	**1**	1/2	4	**1027**	**3.1**
					14.06	204	27.95	150S	**1-1/2**	1/2	4	**1597**	**4.8**
					14.06	204	27.95	150S	**2**	5/8	4	**2562**	**9.4**
					14.06	204	27.95	150S	**3**	5/8	4	**3020**	**11.1**
					14.06	204	27.95	150S	**4**	5/8	8	**2471**	**9.1**
					14.06	204	27.95	150S	**6**	3/4	8	**3972**	**17.2**
					14.06	204	27.95	150S	**8**	3/4	8	**4931**	**21.3**

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Page 352 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					14.06	204	27.95	150S	10	7/8	12	5135	25.5
					14.06	204	27.95	150S	12	7/8	12	5326	26.5
					14.06	204	27.95	150S	14	1	12	6249	35.2
					14.06	204	27.95	150S	16	1	16	5999	33.8
					14.06	204	27.95	150S	18	1-1/8	16	8583	53.7
					14.06	204	27.95	150S	20	1-1/8	20	8583	53.7
					14.06	204	27.95	150S	24	1-1/4	20	11379	78.3
					14.06	204	27.95	150B	26	3/4	36	4111	17.7
					14.06	204	27.95	150B	28	3/4	40	4111	17.7
					14.06	204	27.95	150B	30	3/4	44	4385	18.9
					14.06	204	27.95	150B	32	3/4	48	4522	19.5
					14.06	204	27.95	150B	34	7/8	40	6274	31.2
					14.06	204	27.95	150B	36	7/8	44	6274	31.2
					14.06	204	27.95	150B	38	1	40	7750	43.7
					14.06	204	27.95	150B	40	1	44	7750	43.7
					14.06	204	27.95	150B	42	1	48	7750	43.7
					14.06	204	27.95	150B	44	1	52	7750	43.7
					14.06	204	27.95	150B	46	1-1/8	40	11230	70.3
					14.06	204	27.95	150B	48	1-1/8	44	10570	66.2
LIST A-4													
A8A	PMS rated Temperature / Pressure		65 / 19.17	Up to 6"	8.78	343	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	3/4	1/2	4	855	2.6
					8.78	343	30.05	150S	1	1/2	4	1027	3.1
A15A	PMS rated Temperature / Pressure		343 / 8.78	Up to 16"	8.78	343	30.05	150S	1-1/2	1/2	4	1597	4.8
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	2	5/8	4	2562	9.4
				A672 Gr. B60	8.78	343	30.05	150S	3	5/8	4	3020	11.1
A20A	PMS rated Temperature / Pressure		343 / 8.78	Up to 18"	8.78	343	30.05	150S	4	5/8	8	2471	9.1
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	6	3/4	8	3972	17.2
				A672 Gr. B60	8.78	343	30.05	150S	8	3/4	8	4931	21.3
A32A	PMS rated Temperature / Pressure		280 / 11.19	Up to 3"	8.78	343	30.05	150S	10	7/8	12	5135	25.5
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	12	7/8	12	5326	26.5
					8.78	343	30.05	150S	14	1	12	6249	35.2

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Page 353 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
A33A	PMS rated Temperature / Pressure		65 / 18.9	Up to 48"	8.78	343	30.05	150S	16	1	16	5999	33.8
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150S	18	1-1/8	16	8583	53.7
				IS-3589 GR.410	8.78	343	30.05	150S	20	1-1/8	20	8583	53.7
A33Y	PMS rated Temperature / Pressure		65 / 18.9	Up to 48"	8.78	343	30.05	150S	24	1-1/4	20	11379	78.3
	A105	A193 GR.B7	BS7531 GR X	A 106 GR.B	8.78	343	30.05	150B	26	3/4	36	4111	17.7
				IS-3589 GR.410	8.78	343	30.05	150B	28	3/4	40	4111	17.7
					8.78	343	30.05	150B	30	3/4	44	4385	18.9
					8.78	343	30.05	150B	32	3/4	48	4522	19.5
					8.78	343	30.05	150B	34	7/8	40	6274	31.2
					8.78	343	30.05	150B	36	7/8	44	6274	31.2
					8.78	343	30.05	150B	38	1	40	7750	43.7
					8.78	343	30.05	150B	40	1	44	7750	43.7
					8.78	343	30.05	150B	42	1	48	7750	43.7
					8.78	343	30.05	150B	44	1	52	7750	43.7
					8.78	343	30.05	150B	46	1-1/8	40	11230	70.3
					8.78	343	30.05	150B	48	1-1/8	44	10570	66.2
					8.78	343	30.05	150B	50	1-1/8	48	10570	66.2
					8.78	343	30.05	150B	52	1-1/8	52	10240	64.1
					8.78	343	30.05	150B	54	1-1/8	56	10240	64.1
					8.78	343	30.05	150B	56	1-1/8	60	10240	64.1
					8.78	343	30.05	150B	58	1-1/4	48	13488	92.8
					8.78	343	30.05	150B	60	1-1/4	52	13488	92.8
LIST A-5													
A16A	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.05	150S	1/2	1/2	4	684	2.1
	A105	A193 Gr. B7M	Spiral wound SS	A106 Gr. B	7.73	371	30.05	150S	3/4	1/2	4	855	2.6
				A672 Gr. B60	7.73	371	30.05	150S	1	1/2	4	1027	3.1
					7.73	371	30.05	150S	1-1/2	1/2	4	1597	4.8
					7.73	371	30.05	150S	2	5/8	4	2562	9.4
					7.73	371	30.05	150S	3	5/8	4	3020	11.1
					7.73	371	30.05	150S	4	5/8	8	2471	9.1
					7.73	371	30.05	150S	6	3/4	8	3972	17.2
					7.73	371	30.05	150S	8	3/4	8	4931	21.3
					7.73	371	30.05	150S	10	7/8	12	5135	25.5

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Page 354 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	30.05	150S	12	7/8	12	5326	26.5
					7.73	371	30.05	150S	14	1	12	6249	35.2
					7.73	371	30.05	150S	16	1	16	5999	33.8
					7.73	371	30.05	150S	18	1-1/8	16	8583	53.7
					7.73	371	30.05	150S	20	1-1/8	20	8583	53.7
					7.73	371	30.05	150S	24	1-1/4	20	11379	78.3
LIST A-6													
A4F	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.57	150S	1/2	1/2	4	798	2.4
	A182 Gr.F5	A193 Gr.B16	Spiral wound SS	A 335 GR.P5	7.73	371	30.57	150S	3/4	1/2	4	970	2.9
				A 691 GR.5Cr CL.42	7.73	371	30.57	150S	1	1/2	4	1141	3.4
					7.73	371	30.57	150S	1-1/2	1/2	4	1540	4.6
					7.73	371	30.57	150S	2	5/8	4	2745	10.1
					7.73	371	30.57	150S	3	5/8	4	3020	11.1
					7.73	371	30.57	150S	4	5/8	8	3020	11.1
					7.73	371	30.57	150S	6	3/4	8	5205	22.5
					7.73	371	30.57	150S	8	3/4	8	5274	22.8
					7.73	371	30.57	150S	10	7/8	12	6277	31.2
					7.73	371	30.57	150S	12	7/8	12	6277	31.2
					7.73	371	30.57	150S	14	1	12	8249	46.5
					7.73	371	30.57	150S	16	1	16	7249	40.9
					7.73	371	30.57	150S	18	1-1/8	16	11885	74.4
					7.73	371	30.57	150S	20	1-1/8	20	11554	72.4
					7.73	371	30.57	150S	24	1-1/4	20	14751	101.5
					7.73	371	30.57	150B	26	3/4	36	4109	17.7
					7.73	371	30.57	150B	28	3/4	40	4383	18.9
					7.73	371	30.57	150B	30	3/4	44	4520	19.5
					7.73	371	30.57	150B	32	3/4	48	4794	20.7
					7.73	371	30.57	150B	34	7/8	40	6847	34.0
					7.73	371	30.57	150B	36	7/8	44	7037	35.0
					7.73	371	30.57	150B	38	1	40	8748	49.3
					7.73	371	30.57	150B	40	1	44	8748	49.3
					7.73	371	30.57	150B	42	1	48	8498	47.9

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Page 355 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-7													
A4G	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	30.57	150S	1/2	1/2	4	798	2.4
	A182 Gr.F9	A193 Gr.B16	Spiral wound SS	A 335 GR.P9	7.73	371	30.57	150S	3/4	1/2	4	970	2.9
				A 691 GR.9Cr CL.42	7.73	371	30.57	150S	1	1/2	4	1255	3.8
					7.73	371	30.57	150S	1-1/2	1/2	4	1825	5.5
					7.73	371	30.57	150S	2	5/8	4	3203	11.8
					7.73	371	30.57	150S	3	5/8	4	3386	12.4
					7.73	371	30.57	150S	4	5/8	8	3386	12.4
					7.73	371	30.57	150S	6	3/4	8	5342	23.1
					7.73	371	30.57	150S	8	3/4	8	5342	23.1
					7.73	371	30.57	150S	10	7/8	12	7037	35.0
					7.73	371	30.57	150S	12	7/8	12	6847	34.0
					7.73	371	30.57	150S	14	1	12	8748	49.3
					7.73	371	30.57	150S	16	1	16	7999	45.1
					7.73	371	30.57	150S	18	1-1/8	16	12215	76.5
					7.73	371	30.57	150S	20	1-1/8	20	11885	74.4
					7.73	371	30.57	150S	24	1-1/4	20	15594	107.3
					7.73	371	30.57	150B	26	3/4	36	4383	18.9
					7.73	371	30.57	150B	28	3/4	40	4589	19.8
					7.73	371	30.57	150B	30	3/4	44	4726	20.4
					7.73	371	30.57	150B	32	3/4	48	5137	22.2
					7.73	371	30.57	150B	34	7/8	40	7132	35.5
					7.73	371	30.57	150B	36	7/8	44	7132	35.5
					7.73	371	30.57	150B	38	1	40	9123	51.4
					7.73	371	30.57	150B	40	1	44	9123	51.4
					7.73	371	30.57	150B	42	1	48	8998	50.7
LIST A-8													
A2K	PMS rated Temperature / Pressure		120 / 15.32	Up to 24"	15.32	120	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	15.32	120	29.00	150S	3/4	1/2	4	855	2.6
				A 358 GR.304	15.32	120	29.00	150S	1	1/2	4	1141	3.4
					15.32	120	29.00	150S	1-1/2	1/2	4	1597	4.8
					15.32	120	29.00	150S	2	5/8	4	2379	8.7
					15.32	120	29.00	150S	3	5/8	4	3203	11.8

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Page 356 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					15.32	120	29.00	150S	4	5/8	8	2837	10.4
					15.32	120	29.00	150S	6	3/4	8	4383	18.9
					15.32	120	29.00	150S	8	3/4	8	5068	21.9
					15.32	120	29.00	150S	10	7/8	12	5516	27.4
					15.32	120	29.00	150S	12	7/8	12	5896	29.3
					15.32	120	29.00	150S	14	1	12	7499	42.3
					15.32	120	29.00	150S	16	1	16	6749	38.1
					15.32	120	29.00	150S	18	1-1/8	16	9574	59.9
					15.32	120	29.00	150S	20	1-1/8	20	9574	59.9
					15.32	120	29.00	150S	24	1-1/4	20	12644	87.0
					15.32	120	29.00	150B	26	3/4	36	4109	17.7
					15.32	120	29.00	150B	28	3/4	40	4246	18.3
					15.32	120	29.00	150B	30	3/4	44	4383	18.9
					15.32	120	29.00	150B	32	3/4	48	4520	19.5
					15.32	120	29.00	150B	34	7/8	40	5896	29.3
					15.32	120	29.00	150B	36	7/8	44	5991	29.8
LIST A-9													
A1K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	7.73	371	29.00	150S	3/4	1/2	4	798	2.4
				A 358 GR.304	7.73	371	29.00	150S	1	1/2	4	913	2.7
A6K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1-1/2	1/2	4	1141	3.4
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	7.73	371	29.00	150S	2	5/8	4	2562	9.4
				A 358 GR.304L	7.73	371	29.00	150S	3	5/8	4	3020	11.1
A11K	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	4	5/8	8	2471	9.1
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	7.73	371	29.00	150S	6	3/4	8	3972	17.2
				A 358 GR.304L	7.73	371	29.00	150S	8	3/4	8	4931	21.3
					7.73	371	29.00	150S	10	7/8	12	5135	25.5
					7.73	371	29.00	150S	12	7/8	12	5326	26.5
					7.73	371	29.00	150S	14	1	12	6249	35.2
					7.73	371	29.00	150S	16	1	16	5999	33.8
					7.73	371	29.00	150S	18	1-1/8	16	8583	53.7
					7.73	371	29.00	150S	20	1-1/8	20	8583	53.7
					7.73	371	29.00	150S	24	1-1/4	20	11379	78.3

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Page 357 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

Page 358 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST A-10													
A1M	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	29.00	150S	1/2	1/2	4	570	1.7
	A 182 GR.F316	A193 GR.B7	Spiral wound SS	A 312 TP316	7.73	371	29.00	150S	3/4	1/2	4	798	2.4
				A 358 GR.316	7.73	371	29.00	150S	1	1/2	4	913	2.7
					7.73	371	29.00	150S	1-1/2	1/2	4	1141	3.4
					7.73	371	29.00	150S	2	5/8	4	2562	9.4
					7.73	371	29.00	150S	3	5/8	4	3020	11.1
					7.73	371	29.00	150S	4	5/8	8	2471	9.1
					7.73	371	29.00	150S	6	3/4	8	3972	17.2
					7.73	371	29.00	150S	8	3/4	8	4931	21.3
					7.73	371	29.00	150S	10	7/8	12	5135	25.5
					7.73	371	29.00	150S	12	7/8	12	5326	26.5
					7.73	371	29.00	150S	14	1	12	6249	35.2
					7.73	371	29.00	150S	16	1	16	5999	33.8
					7.73	371	29.00	150S	18	1-1/8	16	8583	53.7
					7.73	371	29.00	150S	20	1-1/8	20	8583	53.7
					7.73	371	29.00	150S	24	1-1/4	20	11379	78.3
LIST A-11													
A1N	PMS rated Temperature / Pressure		371 / 7.73	Up to 24"	7.73	371	24.26	150S	1/2	1/2	4	570	1.7
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	7.73	371	24.26	150S	3/4	1/2	4	798	2.4
				A 358 GR.316L	7.73	371	24.26	150S	1	1/2	4	913	2.7
					7.73	371	24.26	150S	1-1/2	1/2	4	1426	4.3
					7.73	371	24.26	150S	2	5/8	4	2562	9.4
					7.73	371	24.26	150S	3	5/8	4	3020	11.1
					7.73	371	24.26	150S	4	5/8	8	2471	9.1
					7.73	371	24.26	150S	6	3/4	8	3972	17.2
					7.73	371	24.26	150S	8	3/4	8	4931	21.3
					7.73	371	24.26	150S	10	7/8	12	5135	25.5
					7.73	371	24.26	150S	12	7/8	12	5326	26.5
					7.73	371	24.26	150S	14	1	12	6249	35.2
					7.73	371	24.26	150S	16	1	16	5999	33.8
					7.73	371	24.26	150S	18	1-1/8	16	8583	53.7
					7.73	371	24.26	150S	20	1-1/8	20	8583	53.7

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PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					7.73	371	24.26	150S	24	1-1/4	20	11379	78.3
LIST B-1													
B1A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	1/2	1/2	4	741	2.2
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	3/4	5/8	4	1373	5.0
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	1	5/8	4	1647	6.0
B2A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	1-1/2	3/4	4	2740	11.8
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	2	5/8	8	2105	7.7
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	3	3/4	8	3972	17.2
B5A	PMS rated Temperature / Pressure		230 / 43.66	Up to 24"	28.82	427	79.10	300S	4	3/4	8	5205	22.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	6	3/4	12	5205	22.5
				A 672 GR.B60 CL.32	28.82	427	79.10	300S	8	7/8	12	7608	37.8
B6A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	10	1	16	8748	49.3
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	12	1-1/8	16	11554	72.4
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	14	1-1/8	20	8913	55.8
B9A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	16	1-1/4	20	10958	75.4
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300S	18	1-1/4	24	11801	81.2
				A 672 GR.B60 CL.12	28.82	427	79.10	300S	20	1-1/4	24	14330	98.6
B13A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	24	1-1/2	24	17849	144.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300B	26	1-1/4	32	13065	89.9
				A 672 GR.B60 CL.12	28.82	427	79.10	300B	28	1-1/4	36	13065	89.9
B19A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300B	30	1-3/8	36	15197	114.0
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300B	32	1-1/2	32	18487	150.1
				A 672 GR.B60 CL.22	28.82	427	79.10	300B	34	1-1/2	36	18168	147.5
B32A	PMS rated Temperature / Pressure		427 / 28.82	Up to 3"	28.82	427	79.10	300B	36	1-5/8	32	23630	206.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	28.82	427	79.10	300B	38	1-5/8	36	25154	219.9
				A 672 GR.B60 CL.12	28.82	427	79.10	300B	40	1-5/8	40	24392	213.2
					28.82	427	79.10	300B	42	1-3/4	36	29631	277.5
LIST B-2													
B4A	PMS rated Temperature / Pressure		204 / 43.23	Up to 24"	28.82	427	79.10	300S	1/2	1/2	4	741	2.2
	A350 Gr.LF2 CL.1	A320 Gr.L7	Spiral wound SS	A333 Gr.6	28.82	427	79.10	300S	3/4	5/8	4	1373	5.0
				A671 Gr.CC60 CL.32	28.82	427	79.10	300S	1	5/8	4	1647	6.0
B16A	PMS rated Temperature / Pressure		427 / 28.82	Up to 24"	28.82	427	79.10	300S	1-1/2	3/4	4	2740	11.8
	A105	A193 Gr.B7M	Spiral wound SS	A106 Gr.B	28.82	427	79.10	300S	2	5/8	8	2105	7.7

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Page 359 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
				A672 Gr.B60 CL.22	28.82	427	79.10	300S	3	3/4	8	3972	17.2
					28.82	427	79.10	300S	4	3/4	8	5205	22.5
					28.82	427	79.10	300S	6	3/4	12	5205	22.5
					28.82	427	79.10	300S	8	7/8	12	7608	37.8
					28.82	427	79.10	300S	10	1	16	8748	49.3
					28.82	427	79.10	300S	12	1-1/8	16	11554	72.4
					28.82	427	79.10	300S	14	1-1/8	20	8913	55.8
					28.82	427	79.10	300S	16	1-1/4	20	10958	75.4
					28.82	427	79.10	300S	18	1-1/4	24	11801	81.2
					28.82	427	79.10	300S	20	1-1/4	24	14330	98.6
					28.82	427	79.10	300S	24	1-1/2	24	17849	144.9
					28.82	427	79.10	300B	26	1-1/4	32	13065	89.9
					28.82	427	79.10	300B	28	1-1/4	36	13065	89.9
					28.82	427	79.10	300B	30	1-3/8	36	15197	114.0
LIST B-3													
B1D	PMS rated Temperature / Pressure		538 / 15.11	Up to 24"	15.11	538	79.10	300S	1/2	1/2	4	741	2.2
	A182 Gr. F11 Cl. 2	A193 Gr. B16	Spiral wound SS	A335 Gr. P11	15.11	538	79.10	300S	3/4	5/8	4	1007	3.7
				A691 Gr.1.25Cr Cl.42	15.11	538	79.10	300S	1	5/8	4	1647	6.0
B5D	PMS rated Temperature / Pressure		538 / 15.11	Up to 24"	15.11	538	79.10	300S	1-1/2	3/4	4	3014	13.0
	A182 Gr. F11 Cl. 2	A193 Gr. B16	Spiral wound SS	A335 Gr. P11	15.11	538	79.10	300S	2	5/8	8	2196	8.1
				A691 Gr.1.25Cr Cl.42	15.11	538	79.10	300S	3	3/4	8	4794	20.7
B3F	PMS rated Temperature / Pressure		538 / 14.06	Up to 24"	15.11	538	79.10	300S	4	3/4	8	5205	22.5
	A 182 GR.F5	A193 GR.B16	Spiral wound SS	A 335 GR.P5	15.11	538	79.10	300S	6	3/4	12	5205	22.5
				A 691 GR5CR CL.42	15.11	538	79.10	300S	8	7/8	12	7228	35.9
B4F	PMS rated Temperature / Pressure		538 / 14.06	Up to 24"	15.11	538	79.10	300S	10	1	16	9498	53.6
	A 182 GR.F5	A193 GR.B16	Spiral wound SS	A 335 GR.P5	15.11	538	79.10	300S	12	1-1/8	16	11885	74.4
				A 691 Gr. 5CR CL.42	15.11	538	79.10	300S	14	1-1/8	20	9574	59.9
					15.11	538	79.10	300S	16	1-1/4	20	11801	81.2
					15.11	538	79.10	300S	18	1-1/4	24	12222	84.1
					15.11	538	79.10	300S	20	1-1/4	24	14751	101.5
					15.11	538	79.10	300S	24	1-1/2	24	17849	144.9
					12.09	538	63.28	300B	26	1-1/4	32	10958	75.4
					12.09	538	63.28	300B	28	1-1/4	36	10958	75.4

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Page 360 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					12.09	538	63.28	300B	30	1-3/8	36	12577	94.3
					12.09	538	63.28	300B	32	1-1/2	32	15937	129.4
					12.09	538	63.28	300B	34	1-1/2	36	15299	124.2
					12.09	538	63.28	300B	36	1-5/8	32	19819	173.2
					12.09	538	63.28	300B	38	1-5/8	36	22105	193.2
					12.09	538	63.28	300B	40	1-5/8	40	21343	186.5
					12.09	538	63.28	300B	42	1-3/4	36	26937	252.3
LIST B-4													
B1E	PMS rated Temperature / Pressure		538 / 18.63	Up to 24"	18.63	538	79.10	300S	1/2	1/2	4	855	2.6
	A 182 GR.F22 CL.3	A193 Gr. B16	Spiral wound SS	A335 Gr. P22	18.63	538	79.10	300S	3/4	5/8	4	1098	4.0
				A691 Gr.2.25Cr Cl.42	18.63	538	79.10	300S	1	5/8	4	1830	6.7
B4G	PMS rated Temperature / Pressure		538 / 17,92	Up to 24"	18.63	538	79.10	300S	1-1/2	3/4	4	3287	14.2
	A 182 GR.F9	A193 GR.B16	Spiral wound SS	A 335 GR.P9	18.63	538	79.10	300S	2	5/8	8	2288	8.4
				A 691 GR9CR CL.42	18.63	538	79.10	300S	3	3/4	8	4931	21.3
					18.63	538	79.10	300S	4	3/4	8	5342	23.1
					18.63	538	79.10	300S	6	3/4	12	5342	23.1
					18.63	538	79.10	300S	8	7/8	12	7418	36.9
					18.63	538	79.10	300S	10	1	16	9748	55.0
					18.63	538	79.10	300S	12	1-1/8	16	12215	76.5
					18.63	538	79.10	300S	14	1-1/8	20	10234	64.1
					18.63	538	79.10	300S	16	1-1/4	20	12644	87.0
					18.63	538	79.10	300S	18	1-1/4	24	13065	89.9
					18.63	538	79.10	300S	20	1-1/4	24	15173	104.4
					18.63	538	79.10	300S	24	1-1/2	24	18487	150.1
					14.90	538	63.28	300B	26	1-1/4	32	11801	81.2
					14.90	538	63.28	300B	28	1-1/4	36	11801	81.2
					14.90	538	63.28	300B	30	1-3/8	36	13625	102.2
					14.90	538	63.28	300B	32	1-1/2	32	17212	139.8
					14.90	538	63.28	300B	34	1-1/2	36	16574	134.6
					14.90	538	63.28	300B	36	1-5/8	32	21343	186.5
					14.90	538	63.28	300B	38	1-5/8	36	23630	206.5
					14.90	538	63.28	300B	40	1-5/8	40	22868	199.9
					14.90	538	63.28	300B	42	1-3/4	36	28733	269.1

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Page 361 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

Piping Class	PMS class data: Temperature, pressure, materials and size range				Calculation Data								
	Flange	Bolt	Gasket	Pipe	Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
LIST B-5													
B6K	PMS rated Temperature / Pressure		427 / 24.25	Up to 24"	24.25	427	63.27	300S	1/2	1/2	4	570	1.7
	A 182 GR.F304L	A193 GR.B7	Spiral wound SS	A 312 TP304L	24.25	427	63.27	300S	3/4	5/8	4	915	3.4
				A 358 TP304L CL.1	24.25	427	63.27	300S	1	5/8	4	1281	4.7
					24.25	427	63.27	300S	1-1/2	3/4	4	2192	9.5
					24.25	427	63.27	300S	2	5/8	8	1464	5.4
					24.25	427	63.27	300S	3	3/4	8	2466	10.6
					24.25	427	63.27	300S	4	3/4	8	2740	11.8
					24.25	427	63.27	300S	6	3/4	12	3150	13.6
					24.25	427	63.27	300S	8	7/8	12	4945	24.6
					24.25	427	63.27	300S	10	1	16	5249	29.6
					24.25	427	63.27	300S	12	1-1/8	16	7263	45.5
					24.25	427	63.27	300S	14	1-1/8	20	6933	43.4
					24.25	427	63.27	300S	16	1-1/4	20	8851	60.9
					24.25	427	63.27	300S	18	1-1/4	24	9694	66.7
					24.25	427	63.27	300S	20	1-1/4	24	11379	78.3
					24.25	427	63.27	300S	24	1-1/2	24	14662	119.1
LIST B-6													
B1K	PMS rated Temperature / Pressure		454 / 27.77	Up to 24"	5.97	704	75.93	300S	1/2	1/2	4	798	2.4
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	5.97	704	75.93	300S	3/4	5/8	4	1281	4.7
				A 358 TP304 CL.1	5.97	704	75.93	300S	1	5/8	4	1464	5.4
B2K	PMS rated Temperature / Pressure		120 / 40.14	Up to 24"	5.97	704	75.93	300S	1-1/2	3/4	4	2740	11.8
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	5.97	704	75.93	300S	2	5/8	8	2105	7.7
				A 358 TP316L CL.1	5.97	704	75.93	300S	3	3/4	8	3561	15.4
B4K	PMS rated Temperature / Pressure		704 /8.08	Up to 24"	5.97	704	75.93	300S	4	3/4	8	3972	17.2
	A 182 GR.F304H	A453 GR.660CL.A	Spiral wound SS	A 312 TP304H	5.97	704	75.93	300S	6	3/4	12	4109	17.7
					5.97	704	75.93	300S	8	7/8	12	6086	30.3
B5K	PMS rated Temperature / Pressure		704/8.08	Up to 24"	5.97	704	75.93	300S	10	1	16	7499	42.3
	A 182 GR.F304H	A453 GR.660CL.A	Spiral wound SS	A 312 TP304H	5.97	704	75.93	300S	12	1-1/8	16	9574	59.9
					5.97	704	75.93	300S	14	1-1/8	20	8253	51.7
					5.97	704	75.93	300S	16	1-1/4	20	10537	72.5
					5.97	704	75.93	300S	18	1-1/4	24	11379	78.3
					5.97	704	75.93	300S	20	1-1/4	24	12644	87.0

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Page 362 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					5.97	704	75.93	300S	24	1-1/2	24	15937	129.4
					4.78	704	60.74	300B	26	1-1/4	32	10537	72.5
					4.78	704	60.74	300B	28	1-1/4	36	11801	81.2
					4.78	704	60.74	300B	30	1-3/8	36	12577	94.3
					4.78	704	60.74	300B	32	1-1/2	32	15937	129.4
					4.78	704	60.74	300B	34	1-1/2	36	15937	129.4
					4.78	704	60.74	300B	36	1-5/8	32	19819	173.2
					4.78	704	60.74	300B	38	1-5/8	36	20581	179.9
					4.78	704	60.74	300B	40	1-5/8	40	19819	173.2
					4.78	704	60.74	300B	42	1-3/4	36	25142	235.5
LIST B-7													
B1M	PMS rated Temperature / Pressure		427 / 29.52	Up to 24"	26.66	538	75.95	300S	1/2	1/2	4	570	1.7
	A 182 GR.F316	A193 GR.B7	Spiral wound SS	A 312 TP316	26.66	538	75.95	300S	3/4	5/8	4	1373	5.0
				A 358 TP316 CL.1	26.66	538	75.95	300S	1	5/8	4	1373	5.0
B3M	PMS rated Temperature / Pressure		538 / 25.66	Up to 24"	26.66	538	75.95	300S	1-1/2	3/4	4	2192	9.5
	A 182 GR.F321	A453 GR.660CL.A	Spiral wound SS	A 312 TP321	26.66	538	75.95	300S	2	5/8	8	1556	5.7
				A 358 TP321 CL.1	26.66	538	75.95	300S	3	3/4	8	2603	11.2
B5M	PMS rated Temperature / Pressure		538 / 24.60	Up to 24"	26.66	538	75.95	300S	4	3/4	8	3972	17.2
	A 182 GR.F316H	A453 GR.660CL.A	Spiral wound SS	A 312 TP316H	26.66	538	75.95	300S	6	3/4	12	3972	17.2
					26.66	538	75.95	300S	8	7/8	12	5706	28.4
					26.66	538	75.95	300S	10	1	16	6999	39.5
					26.66	538	75.95	300S	12	1-1/8	16	8253	51.7
					26.66	538	75.95	300S	14	1-1/8	20	7593	47.5
					26.66	538	75.95	300S	16	1-1/4	20	9694	66.7
					26.66	538	75.95	300S	18	1-1/4	24	10537	72.5
					26.66	538	75.95	300S	20	1-1/4	24	12222	84.1
					26.66	538	75.95	300S	24	1-1/2	24	16256	132.0
					20.53	538	60.82	300B	26	1-1/4	32	10537	72.5
					20.53	538	60.82	300B	28	1-1/4	36	10537	72.5
					20.53	538	60.82	300B	30	1-3/8	36	11791	88.4
					20.53	538	60.82	300B	32	1-1/2	32	14981	121.6
					20.53	538	60.82	300B	34	1-1/2	36	14343	116.5
					20.53	538	60.82	300B	36	1-5/8	32	17913	156.6

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Page 363 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					20.53	538	60.82	300B	38	1-5/8	36	19056	166.6
					20.53	538	60.82	300B	40	1-5/8	40	18294	159.9
					20.53	538	60.82	300B	42	1-3/4	36	22897	214.4
LIST B-8													
B1N	PMS rated Temperature / Pressure		454 / 23.90	Up to 24"	23.90	454	63.27	300S	1/2	1/2	4	570	1.7
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	23.90	454	63.27	300S	3/4	5/8	4	915	3.4
				A 358 TP 316L CL.1	23.90	454	63.27	300S	1	5/8	4	1281	4.7
B6N	PMS rated Temperature / Pressure		427 / 24.25	Up to 24"	23.90	454	63.27	300S	1-1/2	3/4	4	2192	9.5
	A 182 GR.F316L	A193 GR.B7	Spiral wound SS	A 312 TP316L	23.90	454	63.27	300S	2	5/8	8	1464	5.4
				A 358 TP 316L CL.1	23.90	454	63.27	300S	3	3/4	8	2466	10.6
					23.90	454	63.27	300S	4	3/4	8	2740	11.8
					23.90	454	63.27	300S	6	3/4	12	3150	13.6
					23.90	454	63.27	300S	8	7/8	12	4945	24.6
					23.90	454	63.27	300S	10	1	16	5249	29.6
					23.90	454	63.27	300S	12	1-1/8	16	7263	45.5
					23.90	454	63.27	300S	14	1-1/8	20	6933	43.4
					23.90	454	63.27	300S	16	1-1/4	20	8851	60.9
					23.90	454	63.27	300S	18	1-1/4	24	9694	66.7
					23.90	454	63.27	300S	20	1-1/4	24	11379	78.3
					23.90	454	63.27	300S	24	1-1/2	24	14662	119.1
LIST D-1													
D1A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	1/2	1/2	4	970	2.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	3/4	5/8	4	1373	5.0
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	1	5/8	4	2013	7.4
D2A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	1-1/2	3/4	4	4520	19.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	2	5/8	8	3112	11.4
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	3	3/4	8	5205	22.5
D5A	PMS rated Temperature / Pressure		230 / 86.96	Up to 24"	58.00	427	156.08	600S	4	7/8	8	7228	35.9
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	6	1	12	8998	50.7
				A 672 GR.B60 CL.32	58.00	427	156.08	600S	8	1-1/8	12	12875	80.6
D9A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	10	1-1/4	16	14751	101.5
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	12	1-1/4	20	14751	101.5
				A 672 GR.B60 CL.12	58.00	427	156.08	600S	14	1-3/8	20	17294	129.7

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Page 364 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
D16A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	16	1-1/2	20	21037	170.8
	A105	A193 GR.B7M	Spiral wound SS	A 106 GR.B	58.00	427	156.08	600S	18	1-5/8	20	27441	239.8
				A 672 GR.B60 CL.22	58.00	427	156.08	600S	20	1-5/8	24	26679	233.2
D19A	PMS rated Temperature / Pressure		427 / 58.00	Up to 24"	58.00	427	156.08	600S	24	1-7/8	24	34482	343.7
	A105	A193 GR.B7	Spiral wound SS	A 106 GR.B	46.40	427	124.90	600B	26	1-5/8	28	25917	226.5
				A 672 GR.B60 CL.22	46.40	427	124.90	600B	28	1-3/4	28	28733	269.1
					46.40	427	124.90	600B	30	1-7/8	28	35527	354.2
					46.40	427	124.90	600B	32	2	28	39708	420.7
					46.40	427	124.90	600B	34	2-1/4	24	55895	661.6
					46.40	427	124.90	600B	36	2-1/4	28	49684	588.1
					46.40	427	124.90	600B	38	2-1/4	28	54342	643.2
					46.40	427	124.90	600B	40	2-1/4	32	51237	606.4
					46.40	427	124.90	600B	42	2-1/2	28	66195	865.9
LIST D-2													
D4A	PMS rated Temperature / Pressure		204 / 86.47	Up to 24"	86.47	204	147.05	600S	1/2	1/2	4	970	2.9
	A 350 GR.LF2 CL.1	A320 GR.L7	Spiral wound SS	A 333 GR.6	86.47	204	147.05	600S	3/4	5/8	4	1373	5.0
				A 671 GR.CC60 CL.32	86.47	204	147.05	600S	1	5/8	4	2013	7.4
					86.47	204	147.05	600S	1-1/2	3/4	4	4520	19.5
					86.47	204	147.05	600S	2	5/8	8	3112	11.4
					86.47	204	147.05	600S	3	3/4	8	5205	22.5
					86.47	204	147.05	600S	4	7/8	8	7228	35.9
					86.47	204	147.05	600S	6	1	12	8998	50.7
					86.47	204	147.05	600S	8	1-1/8	12	12875	80.6
					86.47	204	147.05	600S	10	1-1/4	16	14751	101.5
					86.47	204	147.05	600S	12	1-1/4	20	14751	101.5
					86.47	204	147.05	600S	14	1-3/8	20	17294	129.7
					86.47	204	147.05	600S	16	1-1/2	20	21037	170.8
					86.47	204	147.05	600S	18	1-5/8	20	27441	239.8
					86.47	204	147.05	600S	20	1-5/8	24	26679	233.2
					86.47	204	147.05	600S	24	1-7/8	24	34482	343.7

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Page 365 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST D-3													
D1D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	1/2	1/2	4	1084	3.3
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	3/4	5/8	4	1373	5.0
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	1	5/8	4	2196	8.1
D2D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	1-1/2	3/4	4	4246	18.3
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	2	5/8	8	3295	12.1
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	3	3/4	8	5342	23.1
D5D	PMS rated Temperature / Pressure		538 / 30.23	Up to 24"	30.23	538	158.20	600S	4	7/8	8	7798	38.8
	A 182 GR.F11 CL.2	A193 GR.B16	Spiral wound SS	A 335 GR.P11	30.23	538	158.20	600S	6	1	12	9498	53.6
				A 691 GR.1.25Cr CL.42	30.23	538	158.20	600S	8	1-1/8	12	13535	84.8
					30.23	538	158.20	600S	10	1-1/4	16	16016	110.2
					30.23	538	158.20	600S	12	1-1/4	20	15594	107.3
					30.23	538	158.20	600S	14	1-3/8	20	18342	137.6
					30.23	538	158.20	600S	16	1-1/2	20	21674	176.0
					30.23	538	158.20	600S	18	1-5/8	20	28966	253.2
					30.23	538	158.20	600S	20	1-5/8	24	28203	246.5
					30.23	538	158.20	600S	24	1-7/8	24	36572	364.6
					24.19	538	126.56	600B	26	1-5/8	28	26679	233.2
					24.19	538	126.56	600B	28	1-3/4	28	30529	285.9
					24.19	538	126.56	600B	30	1-7/8	28	35527	354.2
					24.19	538	126.56	600B	32	2	28	40911	433.4
					24.19	538	126.56	600B	34	2-1/4	24	55895	661.6
					24.19	538	126.56	600B	36	2-1/4	28	49684	588.1
LIST D-4													
D5E	PMS rated Temperature / Pressure		538 / 37.61	Up to 24"	37.61	538	158.20	600S	1/2	1/2	4	1255	3.8
	A182 Gr. F22 Cl. 3	A193 Gr. B16	Spiral wound SS	A335 Gr. P22	37.61	538	158.20	600S	3/4	5/8	4	1556	5.7
				A 691 GR2.25CR CL.42	37.61	538	158.20	600S	1	5/8	4	2471	9.1
					37.61	538	158.20	600S	1-1/2	3/4	4	4657	20.1
					37.61	538	158.20	600S	2	5/8	8	3478	12.8
					37.61	538	158.20	600S	3	3/4	8	5479	23.7
					37.61	538	158.20	600S	4	7/8	8	7798	38.8
					37.61	538	158.20	600S	6	1	12	9748	55.0
					37.61	538	158.20	600S	8	1-1/8	12	13535	84.8

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Page 366 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					37.61	538	158.20	600S	10	1-1/4	16	16437	113.1
					37.61	538	158.20	600S	12	1-1/4	20	16437	113.1
					37.61	538	158.20	600S	14	1-3/8	20	19914	149.3
					37.61	538	158.20	600S	16	1-1/2	20	22949	186.3
					37.61	538	158.20	600S	18	1-5/8	20	29728	259.8
					37.61	538	158.20	600S	20	1-5/8	24	28966	253.2
					37.61	538	158.20	600S	24	1-7/8	24	38662	385.4
					30.09	538	126.60	600B	26	1-5/8	28	28203	246.5
					30.09	538	126.60	600B	28	1-3/4	28	32325	302.7
					30.09	538	126.60	600B	30	1-7/8	28	37617	375.0
					30.09	538	126.60	600B	32	2	28	43318	458.9
					30.09	538	126.60	600B	34	2-1/4	24	59000	698.3
					30.09	538	126.60	600B	36	2-1/4	28	52789	624.8
LIST D-5													
D1K	PMS rated Temperature / Pressure		454 / 55.54	Up to 24"	55.54	454	114.00	600S	1/2	1/2	4	627	1.9
	A 182 GR.F304	A193 GR.B7	Spiral wound SS	A 312 TP304	55.54	454	114.00	600S	3/4	5/8	4	915	3.4
				A 358 TP304 CL.1	55.54	454	114.00	600S	1	5/8	4	1281	4.7
D2K	PMS rated Temperature / Pressure		120 / 80.12	Up to 24"	55.54	454	114.00	600S	1-1/2	3/4	4	2466	10.6
	A 182 GR.F304	A320 GR.B8CL.2	Spiral wound SS	A 312 TP304	55.54	454	114.00	600S	2	5/8	8	1647	6.0
				A 358 TP304 CL.1	55.54	454	114.00	600S	3	3/4	8	3150	13.6
					55.54	454	114.00	600S	4	7/8	8	5135	25.5
					55.54	454	114.00	600S	6	1	12	6249	35.2
					55.54	454	114.00	600S	8	1-1/8	12	8913	55.8
					55.54	454	114.00	600S	10	1-1/4	16	9272	63.8
					55.54	454	114.00	600S	12	1-1/4	20	10115	69.6
					55.54	454	114.00	600S	14	1-3/8	20	12053	90.4
					55.54	454	114.00	600S	16	1-1/2	20	15299	124.2
					55.54	454	114.00	600S	18	1-5/8	20	19056	166.6
					55.54	454	114.00	600S	20	1-5/8	24	19056	166.6
					55.54	454	114.00	600S	24	1-7/8	24	25078	250.0
					44.44	454	91.20	600B	26	1-5/8	28	18294	159.9
					44.44	454	91.20	600B	28	1-3/4	28	20652	193.4
					44.44	454	91.20	600B	30	1-7/8	28	24033	239.6

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Page 367 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
LIST E-1													
E1A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	1/2	3/4	4	2877	11.9
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	3/4	3/4	4	3698	15.3
				A 672 GR.B60 CL. 12	86.83	427	234.12	900S	1	7/8	4	4565	21.7
E2A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	1-1/2	1	4	6999	37.7
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	2	7/8	8	5135	24.4
				A 672 GR.B60 CL. 12	86.83	427	234.12	900S	3	7/8	8	6847	32.6
E5A	PMS rated Temperature / Pressure		230 / 130.63	Up to 24"	86.83	427	234.12	900S	4	1-1/8	8	8583	51.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	6	1-1/8	12	10234	61.3
				A 672 GR.B60 CL. 32	86.83	427	234.12	900S	8	1-3/8	12	15197	109.0
E9A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	10	1-3/8	16	16245	116.5
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	12	1-3/8	20	17294	124.1
				A 672 GR.B60 CL. 22	86.83	427	234.12	900S	14	1-1/2	20	21674	168.3
E19A	PMS rated Temperature / Pressure		427 / 86.83	Up to 24"	86.83	427	234.12	900S	16	1-5/8	20	26679	223.0
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	86.83	427	234.12	900S	18	1-7/8	20	35527	338.8
				A 672 GR.B60 CL. 22	86.83	427	234.12	900S	20	2	20	40911	414.6
					86.83	427	234.12	900S	24	2-1/2	20	62301	779.5
					69.47	427	187.30	900B	26	2-1/2	20	60354	755.2
					69.47	427	187.30	900B	28	2-3/4	20	66799	915.6
					69.47	427	187.30	900B	30	3	20	77472	1152.8
LIST E-2													
E5E	PMS rated Temperature / Pressure		538 / 56.24	Up to 24"	56.24	538	237.28	900S	1/2	3/4	4	3150	13.0
	A182 Gr. F22 Cl. 3	A193 Gr. B16	RTJ - 5Cr-0.5Mo	A335 Gr. P22	56.24	538	237.28	900S	3/4	3/4	4	3835	15.8
				A 691 GR2.25CR CL.42	56.24	538	237.28	900S	1	7/8	4	5326	25.3
					56.24	538	237.28	900S	1-1/2	1	4	7749	41.8
					56.24	538	237.28	900S	2	7/8	8	5896	28.0
					56.24	538	237.28	900S	3	7/8	8	6467	30.7
					56.24	538	237.28	900S	4	1-1/8	8	9904	59.3
					56.24	538	237.28	900S	6	1-1/8	12	10894	65.3
					56.24	538	237.28	900S	8	1-3/8	12	16245	116.5
					56.24	538	237.28	900S	10	1-3/8	16	16770	120.3
					56.24	538	237.28	900S	12	1-3/8	20	17818	127.8
					56.24	538	237.28	900S	14	1-1/2	20	22949	178.2

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Page 368 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					56.24	538	237.28	900S	16	1-5/8	20	28203	235.8
					56.24	538	237.28	900S	18	1-7/8	20	36572	348.7
					56.24	538	237.28	900S	20	2	20	44521	451.1
					56.24	538	237.28	900S	24	2-1/2	20	68142	852.6
					56.24	538	189.83	900B	26	2-1/2	20	64248	803.9
					56.24	538	189.83	900B	28	2-3/4	20	73956	1013.8
					56.24	538	189.83	900B	30	3	20	83211	1238.2
LIST F-1													
F1A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	1/2	3/4	4	3014	12.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	3/4	3/4	4	3972	16.4
				A 672 GR.B60 CL.12	144.83	427	390.74	1500S	1	7/8	4	4945	23.5
F2A	PMS rated Temperature / Pressure		427 / 144.46	Up to 24"	144.83	427	390.74	1500S	1-1/2	1	4	7499	40.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	2	7/8	8	6467	30.7
				A 672 GR.B60 CL.22	144.83	427	390.74	1500S	3	1-1/8	8	12215	73.2
F5A	PMS rated Temperature / Pressure		230 / 217.79	Up to 24"	144.83	427	390.74	1500S	4	1-1/4	8	16016	105.4
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	6	1-3/8	12	19914	142.8
				A672 Gr. B60 Cl. 22	144.83	427	390.74	1500S	8	1-5/8	12	29728	248.5
F9A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	10	1-7/8	12	41797	398.5
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	12	2	16	43318	439.0
				A 672 GR.B60 CL.12	144.83	427	390.74	1500S	14	2-1/4	16	55895	632.8
F19A	PMS rated Temperature / Pressure		427 / 144.83	Up to 24"	144.83	427	390.74	1500S	16	2-1/2	16	70089	877.0
	A105	A193 GR.B7	RTJ - Soft Iron	A 106 GR.B	144.83	427	390.74	1500S	18	2-3/4	16	85884	1177.3
				A672 Gr. B60 Cl. 22	144.83	427	390.74	1500S	20	3	16	103296	1537.0
					144.83	427	390.74	1500S	24	3-1/2	16	142889	2467.4
LIST F-2													
F2D	PMS rated Temperature / Pressure		538 / 75.93	Up to 24"	75.93	538	395.48	1500S	1/2	3/4	4	3972	16.4
	A 182 GR.F11 CL.2	A193 GR.B16	RTJ - 5Cr-0.5Mo	A 335 GR.P11	75.93	538	395.48	1500S	3/4	3/4	4	4931	20.4
				A 691 GR.1.25Cr CL.42	75.93	538	395.48	1500S	1	7/8	4	6277	29.8
					75.93	538	395.48	1500S	1-1/2	1	4	9248	49.9
					75.93	538	395.48	1500S	2	7/8	8	7037	33.5
					75.93	538	395.48	1500S	3	1-1/8	8	13205	79.1
					75.93	538	395.48	1500S	4	1-1/4	8	16858	110.9
					75.93	538	395.48	1500S	6	1-3/8	12	20962	150.4

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Page 369 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure kg/cm²(g)	Des Temp. °C	Test Pressure kg/cm²(g)	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					75.93	538	395.48	1500S	8	1-5/8	12	30490	254.9
					75.93	538	395.48	1500S	10	1-7/8	12	41797	398.5
					75.93	538	395.48	1500S	12	2	16	46927	475.5
					75.93	538	395.48	1500S	14	2-1/4	16	55895	632.8
					75.93	538	395.48	1500S	16	2-1/2	16	72036	901.3
					75.93	538	395.48	1500S	18	2-3/4	16	88270	1210.0
					75.93	538	395.48	1500S	20	3	16	106165	1579.7
					75.93	538	395.48	1500S	24	3-1/2	16	146858	2535.9
LIST F-3													
F2G	PMS rated Temperature / Pressure		538 / 127.95	Up to 24"	127.95	538	395.48	1500S	1/2	3/4	4	3972	16.4
	A182 Gr. F91	A193 GR.B16	RTJ - 9Cr-1Mo	A 335 GR.P91	127.95	538	395.48	1500S	3/4	3/4	4	4931	20.4
				A 691 GR.P91 CL.42	127.95	538	395.48	1500S	1	7/8	4	6277	29.8
					127.95	538	395.48	1500S	1-1/2	1	4	9248	49.9
					127.95	538	395.48	1500S	2	7/8	8	7037	33.5
					127.95	538	395.48	1500S	3	1-1/8	8	13205	79.1
					127.95	538	395.48	1500S	4	1-1/4	8	16858	110.9
					127.95	538	395.48	1500S	6	1-3/8	12	20962	150.4
					127.95	538	395.48	1500S	8	1-5/8	12	30490	254.9
					127.95	538	395.48	1500S	10	1-7/8	12	41797	398.5
					127.95	538	395.48	1500S	12	2	16	46927	475.5
					127.95	538	395.48	1500S	14	2-1/4	16	55895	632.8
					127.95	538	395.48	1500S	16	2-1/2	16	72036	901.3
					127.95	538	395.48	1500S	18	2-3/4	16	88270	1210.0
					127.95	538	395.48	1500S	20	3	16	106165	1579.7
					127.95	538	395.48	1500S	24	3-1/2	16	146858	2535.9
LIST G-1													
G2G	PMS rated Temperature / Pressure		538 / 213.02	Up to 12"	213.02	538	510.00	2500S	1/2	3/4	4	5068	20.9
	A182 Gr. F91	A193 GR.B16	RTJ - 5Cr-0.5Mo	A 335 GR.P91	213.02	538	510.00	2500S	3/4	3/4	4	5479	22.6
				A 691 GR.P91 CL.42	213.02	538	510.00	2500S	1	7/8	4	7228	34.4
					213.02	538	510.00	2500S	1-1/2	1-1/8	4	13535	81.1
					213.02	538	510.00	2500S	2	1	8	9748	52.6
					213.02	538	510.00	2500S	3	1-1/4	8	15594	102.6
					213.02	538	510.00	2500S	4	1-1/2	8	24224	188.1

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Page 370 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

PMS class data					Calculation Data								
Piping Class	Temperature, pressure, materials and size range				Des Pressure $kg/cm^2(g)$	Des Temp. °C	Test Pressure $kg/cm^2(g)$	Flange Std	Flange size inch	Bolt Dia inch	No. of Bolts	Tension kg	Torque kg-m
	Flange	Bolt	Gasket	Pipe									
					213.02	538	510.00	2500S	6	2	8	46927	475.5
					213.02	538	510.00	2500S	8	2	12	46927	475.5
					213.02	538	510.00	2500S	10	2-1/2	12	70089	877.0
					213.02	538	510.00	2500S	12	2-3/4	12	95426	1308.1

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Page 371 of 435 ; B862-101-EE-MR-6029-77-REQ ; Rev. A

Page 372 of 435 ; B862-101-EE-MR-6029-77-REO ; Rev. A

HISTORY SHEET FOR FLANGE JOINTS

Annexure - I

Project : _____
Unit : _____
System/Sub System Description : _____
Line No. : _____

Test loop No. : _____
ISO Drawing No.: _____
Connected P & ID No.: _____

Flange Joint No.	Flange Parallelity OK/Not OK		Flange Dia & Rating	Gasket		Studs *				Nuts		Torque Value	Bolt Tension Value	Flange joint Acceptance	
	Upstream	Down Stream		Spec.	OK/ Not OK	Size	Spec	Total Nos.	Accepted/ Nos Accepted	Spec.	Nos Accepted			Contractor	Owner/ EIL

* Special Care to be taken for tapped hole and it is to be certified by Contractor that full engagement of stud is there to the tapped hole. Contractor to carry out 100% verification

Acceptance by Licensor/Owner.

1. Pre-commissioning .....
   (Signature with Name and Date)
2. Commissioning .....
   (Signature with Name and Date)

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Annexure - II

SEQUENCE OF ACTIVITIES INVOLVED FOR REOPENING / MAKING / BLINDING / DEBLINDING / WEDGE OPENING OF FLANGE JOINTS

Sl. No.	Activity	Checked by Contractor (Signature)
1	Compliance of all check points.	
2	Availability and use of recommended tools i.e. Standard tools / Non-sparking tools/Pneumatic of Hydraulic torque wrench with suitable sockets and other accessories / Hydraulic bolt tensioner etc depending upon service pressure temperature rating of the line on which job is to be carried out.	
3	Skilled manpower with protective clothing, safety shoes etc.	
4	Proper access to flange joints for all bolts, proper scaffolding etc if required.	
5	Proper escape route	
6	Readiness of proper type, size & rating of blinds/gaskets/wedges & fasteners etc	
7	Loosening of the flange joints, starting from 6 '0' clock position (vertical joints)	
8	Check for leakage of any hot water / gas / steam / hydrocarbon etc and wait for depressurization of line, if any product leakage is observed.	
9	Complete opening of flange joint with recommended tools	
10	Removal of gasket / blind / wedge etc. and checking of old gaskets for improper loading from marking on gasket surface.	
11	Checking of old fasteners for proper metallurgy, sizing, length etc and ensure replacement of fasteners based on observations during final box up and also ensure that all fasteners to be of same size for uniform loading.	
12	Making gap in flange joints with proper tools (flange spreader etc.) For proper observations of gasket sitting area. Ensure proper cleaning of gasket seating surface with suitable non-sparking tools and inspection of gasket face.	
13	Ensure use of recommended gaskets of proper type and size for blinding / final box up	
14	Placing of fasteners in bottom half of flange joint (vertical joints).	
15	In case of blinding ensure that tail of the blind is vertically upward and blind is of proper size and not interfering with studs movement.	
16	Ensure proper placement of gasket on raised face/ring groove/serrated area.	
17	Ensuring slight tightening of studs in random in bottom half vertical joint(s) for holding of gasket in proper position	
18	Fixing all fasteners in position and tightening of nuts by hand to ensure uniform stud length on both sides.	
19	Tightening of all studs as per tightening sequence by recommended tools.	

ACCEPTANCE BY OWNER / EIL

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विक्रेता कार्यशाला में सकारात्मक सामग्री पहचान के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR POSITIVE MATERIAL IDENTIFICATION (PMI) AT SUPPLIER'S WORKS

Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	23.12.21	REVISED AND RE-ISSUED	HKM	CS	RK	S Majumdar
3	19.09.16.	REVISED AND RE-ISSUED	TKK	HP	RKS	RN
2	20.10.11	REVISED AND RE-ISSUED	RKS	SCG	AKC	DM
1	15.07.08	REVISED AND RE-ISSUED	NKR	SSL	SKP	VC
0	07.12.00	ISSUED AS STANDARD SPECIFICATION	AKC	AKB	AKB	MI

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Abbreviations:

API	:	American Petroleum Institute
AS	:	Alloy Steel
HIC	:	Hydrogen Induced Cracking
LSTK	:	Lump Sum Turn Key
NACE	:	National Association of Corrosion Engineers
PMI	:	Positive Material Identification
RTJ	:	Ring Type Joint
Sch	:	Schedule
SS	:	Stainless Steel
TPI or TPIA	:	Third Party Inspection Agency

Inspection Standards Committee

Convenor: Mr. Rajeev Kumar

Members: Mr. Rajesh Sinha
Mr. Himangshu Pal
Mr. R. Muthuramalingam (RPO Representative)
Mr. Chandrashekhar
Mr. Avdhesh Agrawal
Mr. P V Satyanarayana (Engg. Representative)
Mr. Mahendra Mittal

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CONTENTS

1.0 SCOPE 4
2.0 REFERENCE DOCUMENTS 4
3.0 DEFINITIONS 4
4.0 PMI EXAMINATION 5
5.0 ACCEPTABLE METHODS FOR PMI 5
6.0 EXTENT OF PMI EXAMINATION 6
7.0 ACCEPTANCE CRITERIA 6
8.0 REJECTION CRITERIA 7
9.0 RECORDING AND DOCUMENTATION 7
10.0 MARKING 7

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1.0 SCOPE

1.1 This specification applies to the requirements for Positive Material Identification (PMI) to be performed at the Supplier's works on Metallic Materials procured either directly by the Owner/EIL/ LSTK contractor or indirectly through the sub-Suppliers.

1.2 This specification covers the procedures and methodology to be adopted to assure that the chemical composition of the material is consistent with the material specifications as specified in purchase documents using 'Alloy Analyzer' at the time of final inspection before dispatch.

1.3 The scope of this specification shall include but shall not be limited to Positive Material Identification (PMI) to be performed on Materials listed below:

1.3.1 For alloy Steel materials as below:

- Alloy Steel Pipes including Clad Pipes
- Alloy Steel Flanges & Forgings
- Alloy Steel Fittings including Clad Fittings
- Alloy Steel Fasteners
- Alloy Cast & Forged steel valves
- Alloy Steel Instrumentation Items (Control Valves, Safety Valves etc.)
- Longitudinal Pipe & Fittings Welds.
- Gaskets (for Ring Type Joints)

1.3.2 For Carbon Steel materials as below:

- All Carbon Steel Piping items under NACE or HIC or H2 or Wet Hydrogen Sulfide (H_2S), Hydrofluoric acid (HF), Sulfuric acid (H_2SO_4) services etc.
- Carbon Steel flanges and valves (Rating 900# and above)
- LTCS items

Following items shall be excluded from scope of PMI examination.

- Gaskets other than for Ring Type Joints
- Internal Components of Valves

1.4 All grades of material supplies including Stainless Steels shall be liable for PMI test at site. In case of any defective materials being found at site, the Supplier shall be responsible to effect replacement of such defective materials at project site without any delays to the satisfaction of EIL site RCM (Resident Construction Manager).

2.0 REFERENCE DOCUMENTS

2.1 API Recommended Practice 578 (Third Edition, Feb 2018) - Material Verification Program for New and Existing Alloy Piping Systems.

3.0 DEFINITIONS

3.1 **Supplier:** Any Supplier or Manufacturer on whom an order is placed for the supply of referred items. This definition shall also include any sub-Supplier or manufacturer on whom a sub-order is placed by the Supplier.

3.2 **Inspection Lot:** A group of items offered for inspection covered under same size, Heat and Heat treatment lot.

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3.3 **Alloy Material:** Any metallic material (including welding filler materials) that contains alloying elements such as Chromium, Nickel, Molybdenum or Vanadium, which are intentionally added to enhance mechanical or physical properties and/or corrosion resistance.

4.0 PMI EXAMINATION

4.1 The Supplier shall submit a procedure of PMI to comply with the requirements of this Specification. Approval of PMI Procedure shall be obtained from Owner / EIL / TPIA prior to commencing manufacture / inspection of product.

4.2 PMI examination of materials is independent of any certification, markings or colour coding that may exist and is aimed at verifying that the alloy used are as per specified grades.

4.3 The Supplier shall identify all incoming alloy materials and maintain full traceability of all alloy
materials, including all off-cuts. Transfer of identification marks shall be undertaken prior to cutting to ensure maintenance of identification on off-cuts.

4.4 The Supplier shall ensure that all alloy materials are segregated and stored in separately identified locations to prevent the mix up of materials of different alloy specifications or alloy material with carbon steel. Non ferro-magnetic materials shall be segregated at all times from ferro-magnetic materials.

4.5 PMI examination is subject to surveillance inspection by Owner / EIL / TPIA.

5.0 ACCEPTABLE METHODS FOR PMI

5.1 The method used for PMI examination shall provide a quantitative determination of the alloying elements like Chromium, Nickel, Molybdenum or Vanadium in Alloy Steel items.

5.2 Instruments or methods used for PMI examination shall be able to provide quantitative, recordable, elemental composition results for positive identification of alloying elements present.

5.3 The acceptable instruments for alloy analyzer shall be either "Portable X-Ray fluorescence" or "Optical Emission" type each capable of verifying the percentage of alloy elements within specified range.

5.4 Chemical spot testing, magnets, alloy sorters and other methods using eddy current or triboelectric testing methods are not acceptable for PMI examination.

5.5 The PMI instrument used shall have the sensitivity to detect the alloying elements in the specified range.

5.6 All PMI instruments shall have been serviced within a 6 month period of the time of use to verify the suitability of batteries, sources etc., and the data of the last service shall be stated on the PMI Report Form (Sample enclosed).

5.7 Each analyzer must be calibrated according to the manufacturer's specification at the beginning and end of each shift. Instrument must be checked against known standard for each alloy type to be inspected during the shift.

5.8 Certified samples, with full traceability, of a known alloy materials shall be available for use as a random spot check on the instrument calibration.

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5.9 The surfaces to be examined shall be prepared by light grinding or abrasive paper and solvent cleaner. Evidence of Arc burn resulting from examination shall be removed by light grinding or abrasive paper. No permanent marks, which are injurious to the usage of product in service, are acceptable.

5.10 Alloy Steel ring type joint Gaskets shall be inspected by using portable X-Ray fluorescence instrument.

5.11 Testing shall be done as per the procedures outlined by the manufactures of alloy analyzer being used. Modification of these procedures if any must be approved by Owner/EIL.

5.12 The persons performing PMI shall demonstrate their capabilities to the satisfaction of Owner/EIL/TPIA visiting engineer. If the Supplier has qualified operator on their rolls, he may perform the examination. Otherwise PMI examination shall be sub-contracted to an independent testing agency approved by EIL.

5.13 Whenever material is identified as not meeting requirements by the visiting engineer a rejection note shall be issued.

6.0 EXTENT OF PMI EXAMINATION

Following sampling plans shall be applicable for PMI examination of various items.

A. Flanges, Fittings Valves, RTJ Gaskets - 100% by Supplier and 10% @ random witness by EIL/TPIA

B. Pipes - 100% (for pipes procured from traders)
2 random samples drawn from each Size/Heat/Lot (for pipes procured directly from mills)

C. Fasteners -

Lot Size	**Sample Size for** EIL/TPIA	Sample size for Supplier
Upto 100	2% (Min 2)	Min 10%
101 to 500	1% (Min 3)	Min 10%
501 and above	0.5% (Min 5)	Min 10%

Note:

a. For Welded Pipes and Fittings and flanges like Fig 8, Spacer and blinds etc. PMI shall be performed on Base Metal as well as weldments.

7.0 ACCEPTANCE CRITERIA

7.1 Base Metal

PMI test results showing presence of characteristic elements upto 10% less than the minimum specified value in the material specification and upto 10% more than the maximum specified value in the material specification shall be acceptable.

7.2 Deposited Weld Metal

For deposited weld metal using welding consumables matching with base metals, the recorded presence of characteristic elements upto 12.5% less than the minimum specified value in the

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welding consumable specification and upto 12.5% more than the maximum specified value in the welding consumable specification shall be acceptable.

8.0 REJECTION CRITERIA

8.1 If PMI test results fall outside the acceptable range as specified in 7.0 above, the supplier shall obtain a quantitative check analysis performed by a laboratory acceptable to Owner / EIL / TPIA for a complete chemical analysis. Alternatively, the item can be tested with a spark analyser for verification. Results of this analysis shall be submitted to Owner / EIL / TPIA for final decision.

Decision of Owner / EIL / TPIA shall be final in this regard.

8.2 If any sample drawn to PMI test on the basis of percentage selection as per 6.0 above, fails to meet specification requirements, 100% of items of lot shall be tested for PMI by supplier. Any failure thereafter during sample check shall mean rejection of whole lot.

9.0 RECORDING AND DOCUMENTATION

The results of PMI examination shall be recorded in a Report Format as enclosed with this specification.

10.0 MARKING

10.1 All alloy materials tested by PMI shall be identified using either of the following methods by indicating "PMI OK"

a) Bar Code/Hologram Sticker
b) A low stress stamp marking

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	POSITIVE MATERIAL IDENTIFICATION REPORT BULK MATERIALS							Page of
Project:		Client						Job No.
PMI Report No.		Supplier/Sub-Supplier						
Purchase Order No.		Testing Agency						
Purchase Requisition No:		PMI Location						
Bulk Item Type (as per Requisition)								
Material Specification/Grade Number of items in Lot								
Requisition Item No./ Description		Major content, Weight Percent						Remarks Accept/Reject
Element	Cr	Ni	Mo	V	Ti *	Cb/ Nb **	Mn ***	
Specified Range								
Actual observations 1.								
2.								
3.								
4.								
5.								
6.								
7.								
8.								
Instrument Type / ID Last Service Date		Inspection Agency						Witnessed By

* To be reported in case of SS321 Material
** To be reported in case of SS347 Material
*** To be reported in case of LTCS Material

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हीट एक्सचेंजर्स के लिए
निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
HEAT EXCHANGERS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	
4	14.05.2020	REVISED AND RE-ISSUED	SK	CS	RKS	SKS
3	09.09.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	15.07.2011	REVISED AND RE-ISSUED	HP	SCG	AKC	DM
1	25.10.2005	GENERAL REVISION	TSSR	PRV	SY	VC
0	01.11.02	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	GRR

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Abbreviations:

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

Inspection Standards Committee

Convener: Mr. R.K. Singh

Members:

Mr. Rajesh Sinha
Mr. Chandrasekhar
Mr. Mahendra Mittal
Mr. Himangshu Pal
Mr. Avdhesh Agrawal
Mr. R. Muthuramalingam (RPO- Representative)
Mr. P V Satyanarayana (Engg. Representative)

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1.0 SCOPE

This Inspection and test plan covers the minimum testing requirements of Heat exchanger

2.0 REFERENCE DOCUMENTS

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

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	**Procedures**						
1.1	Hydro test, heat treatment, NDT, hot forming and other Procedures	Documented procedures.	100%	Procedure documents	-	H	R
1.2	Weld Plan & NDT Plan	As per PR/ Purchase Specification/ Applicable codes	100%	Procedure documents	-	H	R – CS A-AS/SS/ CLAD
1.3	WPS/ PQR /WPQ/Mock up	Documented procedures.	100%	Procedure documents	-	H	R-Existing W-New
2.0	**Materials Procurement**						
2.1	Plates, pipes, Forgings, Expansion Bellows, Anodes, Fittings, Fasteners, Gaskets, etc (As applicable) (Note – 3)	As per PR/Purchase Specification	100%	Mill TC	H	H	R
2.2	Tube sheets, Tubes & Non standard flanges (Note-3)	As per PR/Purchase Specification	100%	Mill TC / TPIA'S IRN	H	H	R-CS W-AS/SS
3.0	**In process inspection**						

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.1	Materials identification of pressure parts	Review of test certificates, markings visual & dimensional inspection, identity correlation & transfer of identity	100%	Material clearance record	-	H	H
3.2	Non Pressure Parts	Review of test certificates	100%	Material test certificate	W	R	R
3.3	Inspection of formed components	NDT of weld seam as applicable	100%	NDT Reports / RT Films	H	H	R
		NDT on knuckle portion (both inside and outside) and weld overlay, as applicable	100%	Inspection report	H	H	R
		HT chart review as applicable	100%	HT Chart	W	W	R
		Test coupon as applicable	100%	Inspection report	W	W	W
		Visual & dimensional (min. thickness, profile, ovality etc) inspection	100%	Inspection report	H	H	W
		UT for lack of bond (after final heat treatment, if any) formed from clad plates as applicable	100%	Inspection report	H	H	R
3.4	Welding consumable	Chemical , mechanical properties & IGC as applicable	100%	Batch test certificates	H	H	R

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.5	Weld edge preparation & Set up of pressure Parts	Visual & dimensional inspection, weld edge, root gap, offset, alignment, cleanliness etc.	100%	Inspection check list	-	W	-
		NDT of weld edges as applicable	100%	Inspection check list	-	W	-
3.6	Intermediate Inspection of Welding	Visual, welding parameters/ DPT (as applicable)	100%	Inspection report	-	W	R
		Heat treatment as applicable	100%	HT chart		H	R
3.7	Inspection of tube sheet	Hole diameter, drift, layout, groove depth, ligament, tube hole surface finish etc.	100%	Inspection report	H	H	H
3.8	Inspection of Baffles	Hole diameter, drift, layout, etc	100%	Inspection report	W	W	-
3.9	Skeleton of tube bundle before tube insertion	Visual, dimensions, Completeness of assembly	100%	Insp Report	-	H	-
3.10	Tube bundle assembly	Visual, dimensions, Completeness of assembly	100%	Insp Report	-	H	H
3.11	Floating head assembly (as applicable)	Visual & Dimensions	100%	Insp Report	-	H	R
		NDT, as applicable	100%	Inspection Report	-	W	-
		Heat treatment, as applicable	100%	HT chart		H	R
3.12	Pull through test of shell	Passing of Gauge	100%	Insp Report	-	H	R
3.13	Tube to tube sheet joint (welding/expansion)	% thinning, Length of expansion, weld visual and DP as applicable	100%	Insp. report	-	H	RW

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.14	Pneumatic Test of RF Pads & Tube to Tube sheet joints (after root run & final)	Leak Test	100%	Inspection Report	H	H	R- RF Pads W-TTJ
4.0	**Final inspection**						
4.1	Visual and dimensional inspection (internals & externals) including welds of shell, channel shell, shell cover etc. (before PWHT as applicable)	Visual, dimensions, completeness of assembly and weld visual for reinforcement, undercuts, Surface defects, etc.	100%	Inspection report	-	H	H
4.2	PMI, as applicable	Chemical check	Each component and weld	Inspection report	-	H	RW
4.3	Inspection of completed welds	PWHT as applicable	100%	HT chart		H	R
		NDT as applicable	Spot/100%	NDT report / RT films	-	H	R
		Production test coupon testing as applicable	as per specification / drawing	Inspection report	-	H	H
		Sample selection for weld overlay chemistry, as applicable	as per specification / drawing	Inspection report	-	H	W
		Weld chemical results for undiluted chemistry, as applicable	as per specification / drawing	Inspection report	-	H	R
		Hardness for weld /HAZ, as applicable	As per spec.	Inspection report		H	RW

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SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.4	Pressure Test (Hydrostatic, Pneumatic, Helium etc. as applicable)	Leak check	100%	Inspection report	-	H	H
4.5	Pickling/ passivation, drying of equipment (as applicable)	Visual inspection for cleanliness	100%	Inspection report	-	W	R
4.6	Ferroxyl test (as applicable)	Fe pick-up check	100%	Inspection report	-	W	RW
4.7	Drying and Nitrogen -Purging	Visual, Gas pressure	100%	Inspection report	-	W	-
5.0	**Painting**						
5.1	Final painting (as applicable)	Visual inspection (after surface preparation and final painting for workmanship, uniformity) DFT check	100%	Inspection report	-	H	-
6.0	**Documentation and IC**						
6.1	Final stamping, review of inspection documents and issue of IC	Verifying stamping details and review of inspection documents	100%	IC / Inspection reports	-	H	H
6.2	Final documents as per PR	Verification & compilation of inspection & test records for submission to customer	100%	Final dossier	-	H	H

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

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NOTES (As applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable. (Unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
3. Third Party Certifications shall be as per EN 10204 Type 3.2 for Clad Plates, CS Plates (NACE/H2/HIC), Anodes, Tubes, Tube sheets, Non-standard Flanges, Forgings, Fittings and Expansion Bellows; and TPIA shall be arranged by supplier. Certifications shall be as per EN 10204 Type 3.1 for Pipes, CS Plates (non-NACE/H2/HIC), Gaskets and Fasteners.
4. For EPC jobs, all inspection shall be carried out by TPIA, unless notified otherwise.

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बोलीकर्ता / आपूर्तिकर्ताओं / ठेकेदारों से गुणवत्ता प्रबंधन प्रणाली अपेक्षाओं हेतु विनिर्देश

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

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

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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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CONTENTS

Clause	Title	Page No.
1.0	SCOPE	4
2.0	DEFINITIONS	4
3.0	REFERENCE DOCUMENTS	4
4.0	QUALITY MANAGEMENT SYSTEM – GENERAL	4
5.0	QUALITY SYSTEM REQUIREMENTS	4
6.0	AUDITS	6
7.0	DOCUMENTATION REQUIREMENTS	7

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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/duringcontract 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.

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5.2 BIDDER shall identify all specified or implied statutory and regulatory requirements and communicate the same to all concerned in his organization and his sub contractor's organization for compliance.

5.3 BIDDER shall deploy competent and trained personnel for various activities for 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.

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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.

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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 SUPPLIERS

Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convener	Standards Bureau Chairman
					Approved by	
3	29-09-2025	General Revision	QMS Standards Committee	QMS Standards Committee	AK	MN
2	01-06-2020	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

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Abbreviations:

DCI	Document Control Index
EIL	Engineers India Limited
EPS	Electronic Procurement System
FOA	Fax of Acceptance
IC	Inspection Certificate
IRN	Inspection Release Note
ITP	Inspection and Test Plan
LOA	Letter of Acceptance
LR	Lorry Receipt
MR	Material Requisition
ODC	Over Dimension Consignment
PO	Purchase Order
PR	Purchase Requisition
PVC	Polyvinyl Chloride
QAP	Quality Assurance Plan
QMS	Quality Management System
RPO	Regional Procurement Office
TPIA	Third Party Inspection Agency
URL	Universal Resource Locator
V-Portal	Vendor Portal

QMS Standards Committee

Convener: Mr. 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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CONTENTS

Clause	Title	Page No.
1.0	SCOPE	4
2.0	DEFINITIONS	4
3.0	REFERENCE DOCUMENTS	4
4.0	DOCUMENTATION REQUIREMENTS	4

Annexures:

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

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1.0 SCOPE

This specification establishes the Documentation Requirements from Suppliers.

All documents/data against the PO / PR / MR shall be developed and submitted to EIL/Owner by the suppliers for review / records, in line with this specification.

2.0 DEFINITIONS

2.1 Supplier

For the purpose of this specification, the word "SUPPLIER" means the person(s), firm, company or organization who has entered into a contract with EIL / Owner for delivery of some products and/orservices.The word is considered synonymous to bidder, contractor or vendor.

2.2 Owner

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

3.0 REFERENCE DOCUMENTS

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

4.0 DOCUMENTATION REQUIREMENTS

4.1 Order Acknowledgement and Assigning Project Manager

After placement of order, Supplier shall acknowledge order through V-Portal within 7 days of receipt of FOA/PO. Supplier shall assign a Project Manager for that order though online portal and provide requisite details. Project Manager details shall include e-mail address, mailing address, mobile/telephone nos., fax nos. and name of Project Manager. All the system generated emails pertaining to that order shall be sent to the assigned Project Manager.

4.2 Documents/Data to be submitted by the Supplier

4.2.1 The Supplier shall submit the documents and data against the PO/PR/MR as per the list given in respectivePO/PR/MR.

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

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	-	1week
Document Control Index	-	2weeks
Other Documents/Drawings	-	As per approved Document Control Index

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4.2.4 Documents as specified in PO/PR/MR are minimum requirements.Supplier shall submit any other document/data required for completion of the job as per EIL/Owner instructions.

4.3 Style and Formatting

4.3.1 All Documents shall be in ENGLISH language and in M.K.S(Meter-Kilogram-Second) System of units.

4.3.2 Before forwarding the drawings and documents, contractor shallobtain the title block from EIL and ensure that the following information are properly mentioned in each drawing:

- Purchase Requisition Number
- Name of Equipment / Package
- Equipment / Package Tag No.
- Name of Project
- Client
- Drawing / Document Title
- Drawing / Document No.
- Drawing / Document Revision No. and Date

4.4 Review and Approval of Documents by Supplier

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

4.5 Document Category

Following review codes shall be used for review of supplier 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.Resubmitfor review.

Code R - Document is retained for Records. Proceed with Manufacturing / fabrication as per Tender/ ContractRequirement.

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

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4.6 Methodology for Submission of Documents to EIL/Owner

4.6.1 Document Control Index (DCI)

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

4.6.2 Submission of Drawings/Documents / Data

Drawings/documents, data and DCI shall be uploaded on the EIL Vendor Portal as per approved DCI. The detailed guidelines for uploading documents on EIL VendorPortal are available on URL:**http://edocx.eil.co.in/vportal**

4.6.3 Statutory Approvals

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

4.6.4 Manufacturing Schedule

Supplier shall prepare milestone based(milestones such as document submission, sub ordering, manufacturing, Inspection, dispatches, etc.) manufacturing schedule for the order, to meet delivery as per FOA/PO terms. Supplier shall submit manufacturing schedule to concerned Regional Procurement Office (RPO) of EIL, with a copy to Head office monitoring team/Owner for review within 7 days from date of FOA/PO.Same shall be uploaded in the EPS portal of EILi.e.,https://www6.eil.co.in/epsinspection/supp

4.6.5 Schedule and Progress Reporting

Supplier shall submit Monthly Progress Report(MPR) on or before the 9th of every monthindicating following milestone-based progress details as minimum:

- Drawing submission and approval status and schedule for submission of revised drawing / fresh Drawing requiring approval as per approved DCI
- Sub-ordering plan/details for all major items indicating item description, sub-order number, Date of sub-ordering, sub-vendor name, Location, contractual delivery data and expected delivery dates at main vendor's shop and other critical details requiring timely receipt of sub-ordered items at shop.
- Shop manufacturing progress indicating major milestone progress, in case of missing any milestone date, catch up plan for the same and expected dispatch date from shop and expected delivery date at site.
- Area requiring special attention/concern and proposed action plan to resolve the same.

First Monthly Progress Report (MPR) shall be submitted within2 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 supplier shall furnish such reports promptly without any price implication.Format for progress report shall be submitted by the Supplier during kick off meeting or within 2 weeks of receiving FOA/LOA, whichever is earlier.

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4.7 Inspection and Testing

4.7.1 Quality Assurance Plan/Inspection and Test Plan

If Inspection and test plans (ITP)are attached with MR/PR same shall be followed along with additional tests requirement (if any) mentioned in MR/ PR. However for cases wherein EIL Standard ITPs not available/ have not been attached with MR/PR, Supplier shall submit within one week of receiving FOA/LOA, the Quality Assurance Plan for inspection & testing at various stages of production, quality control records for critical bought out items/ materials and site assembly & testing as may be applicable to the specific order and obtain approval from concerned Regional procurement Office of EIL/third party inspection agency, as applicable.

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

4.7.2 Inspection Requirements:

Supplier shall perform internal inspection as per ITP/ approved QAP at their works based on approved documents/drawings. Upon satisfactory internal inspection, supplier shall raise inspection call through Inspection call Module of EPS (https://www6.eil.co.in/epsinspection) to concerned Regional Procurement Office (RPO) of EIL/ TPIA/ Owner with advance notice as per contractalong with Internal test reports. Where inspection is not in the scope of EIL and is carried out by nominated Third Party Inspection agency (TPIA), Inspection Release Note (IRN) issued by the nominated TPIA along with Manufacturer's Test Certificate (MTC) shall be uploaded in EIL EPS Portal (https://www6.eil.co.in/epsinspection).

All changes w.r.t. PR shall be recorded through agreed variations or Concessions & Deviations. Conflict, if any, between PR / Job specifications and approved drawings, shall be brought to the notice of EIL / owner bythe supplier/ contractor. Decision of EIL / owner will be binding on the supplier and to be complied without time and cost implications.

Identified bought out items/ raw material shall be procured under TPIA as per ITP.

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

IRN/ IC shall be issued by EIL Inspector/ third party inspection agency on successful inspection, review of test reports/ certificates as per specifications &ITP/ agreed quality plan (as applicable) and only after all the drawings/documents as per DCI are submitted and are accepted under review code-1or code R. Supplier shall ensure that necessary documents/manufacturing and test certificates are made available to EIL/TPIA as and when desired.

Note 1: Non fulfilling above requirement shall result into appropriate penalty or with- holding of payment as per conditions of PO/PR/MR.

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

a) PR document number
b) List of drawings/documents with EIL approval code
c) Tests witnessed, documents reviewed

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d) Compliance statement by TPIA that product meets the requirement as specified in EIL PR, standard specifications, Inspection Test Plan/QAP and approved documents.

4.8 Transportation Plan

Transportation Plan for Over Dimensional Consignments (ODC), if any, shall be submitted within 2 weeks of receiving FOA/LOA, for approval. Unless otherwise specified, 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 Rout survey for ODC movement shall be submitted to EIL within 8 weeks of receiving FOA / LOA.

4.9 Dispatch Details

Upon receipt of IRN/IC from EIL inspector/TPIA, supplier shall dispatch items within 2 days. Item wise dispatch details shall be uploaded in EIL's EPS module within 24 hours of any item dispatched from shop, indicating PR item no, Quantity dispatched, Transporter's name, LR Number/ LR date.

4.10 Vendorshall ensure timely uploading of Manufacturing Schedule, Monthly Progress Report,Inspection Certificate (IRN)issued by the TPIA (as applicable for PO where Inspection is under nominated Third Party Inspection Agency)and updation ofitem wise dispatch details in EPS portal of EIL (https://www6.eil.co.in/epsinspection).

4.11 Final Documentation

4.11.1 Supplier shall prepare final documents in line with VDR(Vendor Document Requirements) attached with PR/Tender. A copy of final document along with filled in Format for Completeness of Final Documentation (Format No. 3-78-0004) to be submitted to EIL Inspector/TPIA for review & approval within 2 weeks from dispatch. Upon receipt of EIL/TPIA endorsement on Completeness of Final Documents, supplier shall submit soft/hard copies of Final documents to EIL/Owner in requisite quantity as per PO/PR details, along with covering letter. A copy of covering letter to be submitted to the concerned Regional Procurement Office (RPO) of EIL/Owner.

4.11.2 As Built Drawings

Minor Shop changes made by Supplier after approval of drawings under 'Code 1' by EIL and deviations granted through online system, if any, shall be marked in hard copies of drawings which shall then be stamped 'As-built' by the supplier.These 'As-built' drawings shall be reviewed and stamped by EIL Inspector/TPIA.Supplier shall prepare scanned images files of all marked – up 'As – built' drawings. Simultaneously Supplier shall incorporate the shop changes in the native soft files of the drawings also.

4.11.3 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.

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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 that 75 mm thick. It may be of several volumes and each volume shall have a volume number, index of volumes and index of contents of that particular volume.Where number of volumes are more, 90mm thickness can be used.Each volume shall have top PVC sheet of minimum 0.15 mm thick duly fixed and pressed on folder cover and will have 2 lever 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 supplier.Spiral/Spico bound documents shall not be acceptable.As mentioned above, books should be in hard board plastic folders with sheets punched and having 2/4 lever clips arrangement.

Each volume shall contain on cover a Title Block indicating package Equipment Tag No. & Name, PO/Purchase Requisition No., Name of Project and Name of Customer.Each volume will have hard front cover and a reinforced spine to fit thickness of book.These spines will also have the title printed on them.Title shall include also volume number (say 11 of 15) etc.

4.11.4 Submission of Soft Copies

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

In addition to hard copies, Supplier shall submit soft copies of all the final drawings and documents in pen drive or any other specified medium with proper identification tag, all text documents prepared on computer, scanned images of all important documents (not available 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 EILVendor Portal and if applicable on Client Server also.

4.11.5 Completeness of Final Documentation

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

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COMPLETENESS OF FINAL DOCUMENTATION

Name of Supplier/Contractor	:	
Customer	:	
Project	:	
EIL's Job No.	:	
Purchase Order No./ Contract No.	:	
Purchase Requisition No./ Tender No.	:	Rev. No.:
Name of the Work/ Equipment	:	
Tag. No.	:	
Supplier's/ Contractor's Works Order No.	:	

Certified that the Engineering Documents/ Manufacturing & Test Certificates submitted by the supplier (as per Index sheet mentioned in Annexure-1) are complete in accordance with the Vendor Data Requirements of Purchase Requisition / Tender.

Signature	: ……	Signature	: ……
Date	: ……	Date	: ……
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……
	Supplier/Contractor		EIL/TPIA

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Annexure-1

Final Documentation Index Sheet			
PR/PO/Tender No.		Revision No.	
Serial No.	Document Title	Page/ Folder No.	No. of Pages

Signature	: ……	Signature	: ……
Date	: ……	Date	: ……
Name	: ……..	Name	: ……..
Designation	: ……	Designation	: ……
Department	: ……	Department	: ……

Supplier / Contractor

EIL / TPIA

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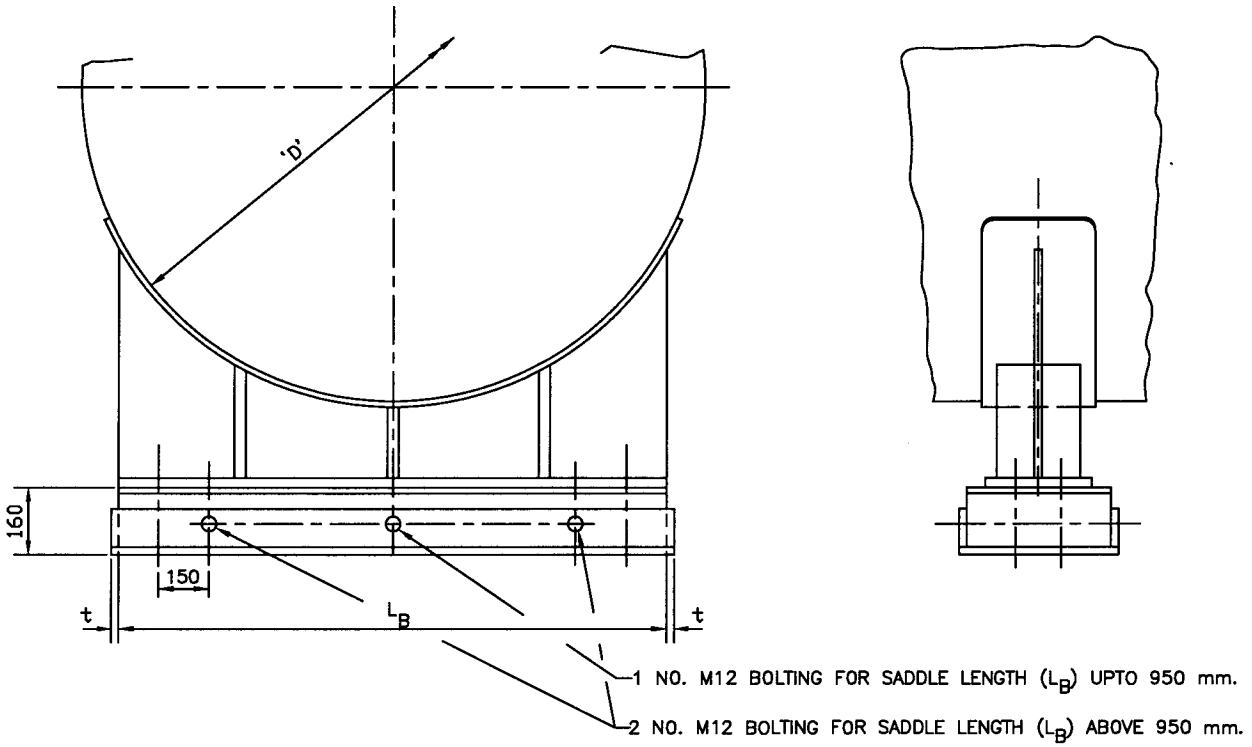
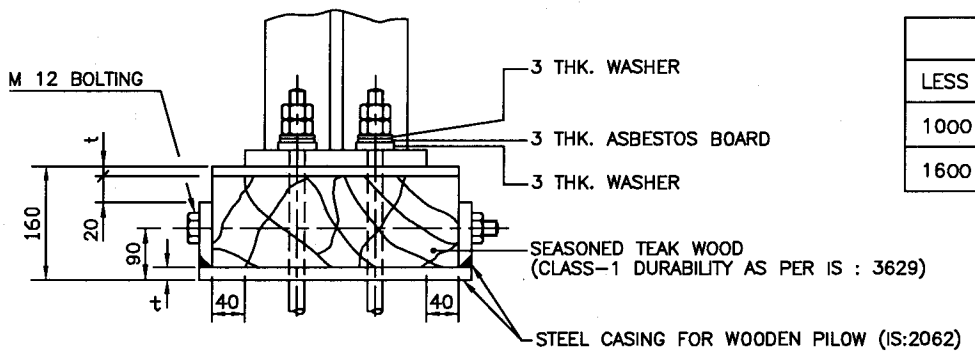
WOODEN PILLOWS FOR SADDLE SUPPORT





D	t
LESS THAN 1000	8
1000 TO 1599	10
1600 TO 4000	12

NOTES

1. ALL DIMENSIONS ARE IN mm UNLESS OTHERWISE STATED.
2. THIS STANDARD IS APPLICABLE FOR ALL HORIZONTAL VESSELS WITH DESIGN TEMPERATUE BELOW 0°C
3. FOR SADDLE DIMENSIONS REFER STANDARD 7–12–0002.
4. 2–WEEP HOLES OF 20 mm DIA SHALL BE PROVIDED AT THE BOTTOM OF THE FRAME.
5. UNLESS OTHERWISE SPECIFIED THE WOODEN PILLOWS REQUIRED FOR SADDLE SUPPORTS SHALL BE SUPPLIED BY MECHANICAL ERECTION CONTRACTOR.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
7	18.01.2022	REAFFIRMED AND REISSUED AS STANDARD	NIKHIL	SK	NK	SM
6	31.10.2016	REAFFIRMED AND REISSUED AS STANDARD	JIT SINGH	SK/KJH	RKT	RN

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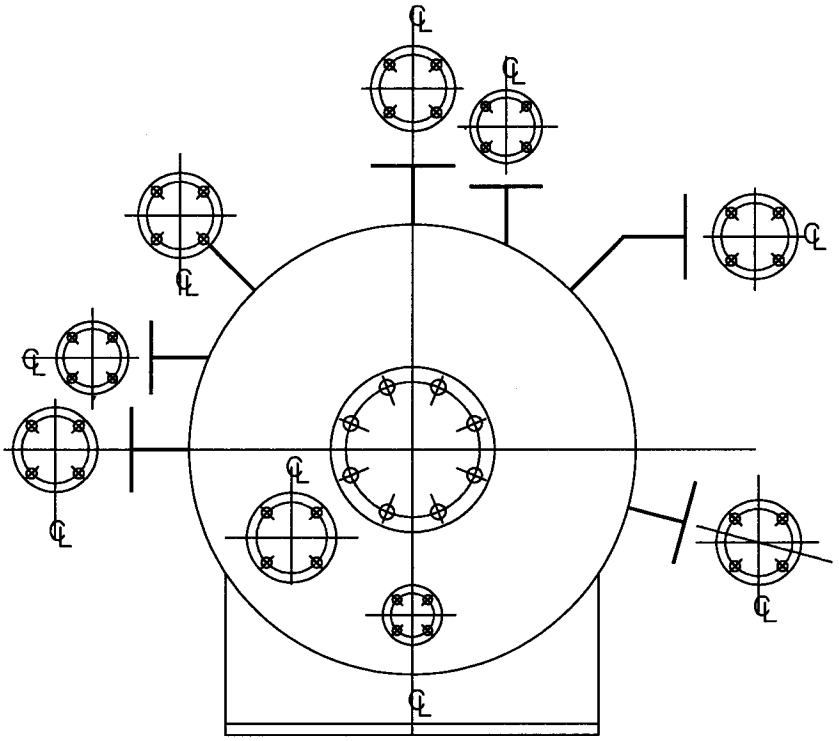
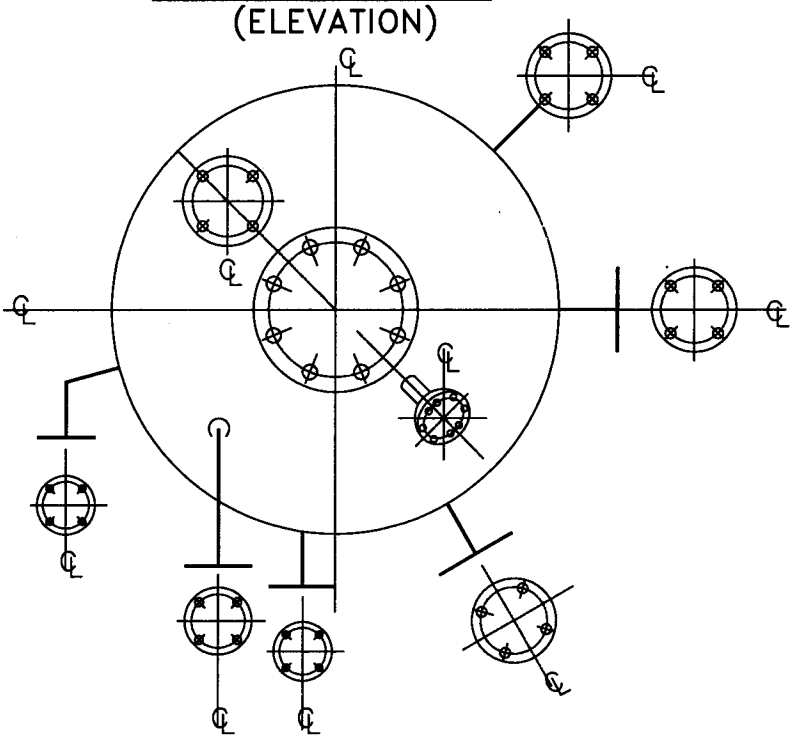


HORIZONTAL VESSEL
(ELEVATION)



VERTICAL VESSEL
(PLAN)

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
7	18.01.2022	REAFFIRMED AND REISSUED AS STANDARD	NIKHIL	TK	NK	SM
6	31.10.2016	REAFFIRMED AND REISSUED AS STANDARD	JIT SINGH	SK/KJH	RKT	RN

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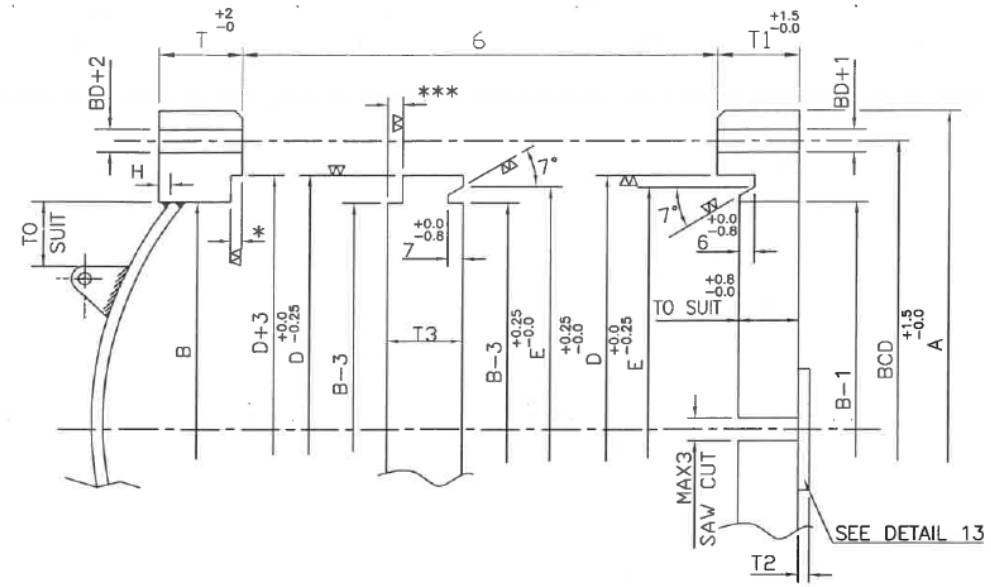

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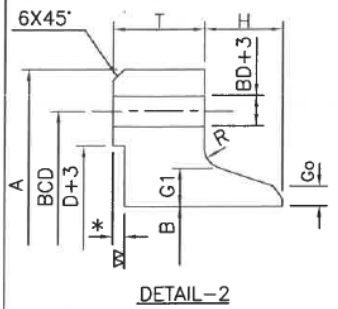

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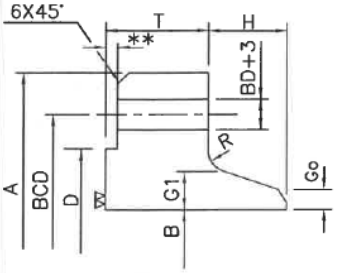

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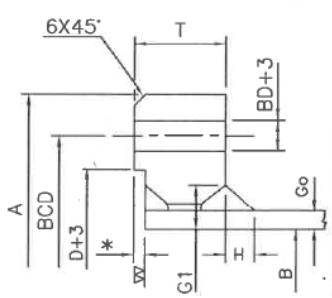

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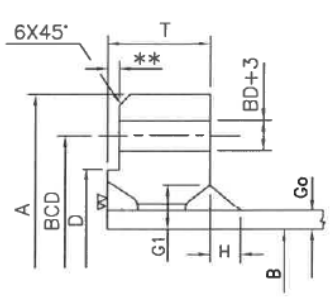

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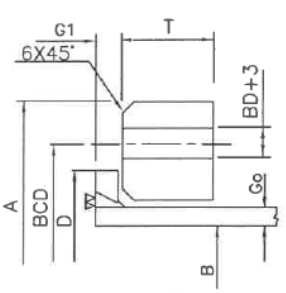

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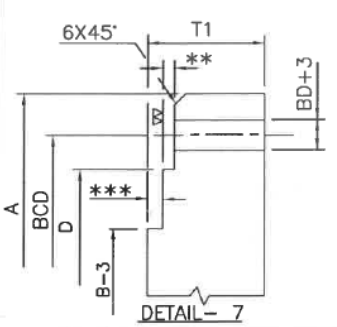

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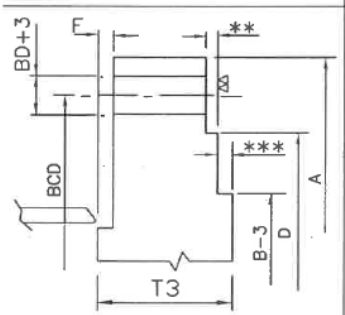

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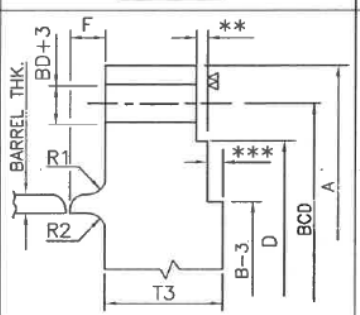

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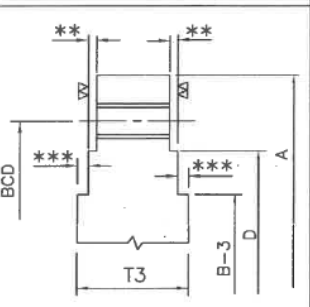

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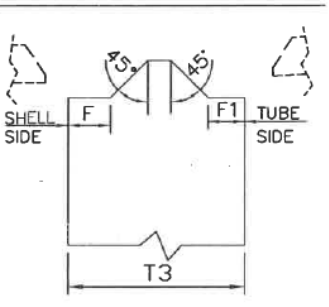

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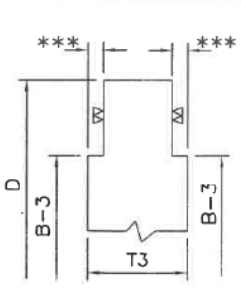

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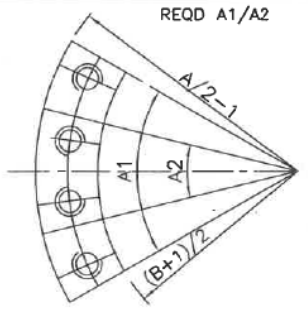

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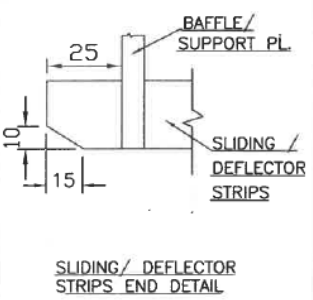

SLIDING/ DEFLECTOR STRIPS END DETAIL

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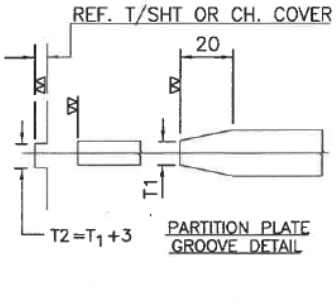

DETAIL– 15

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	02.12.24	REVISED AND REISSUED AS STANDARD	J.SINGH	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT
4	06.05.14	REVISED AND REISSUED AS STANDARD	GCP	KA	RKT	SC

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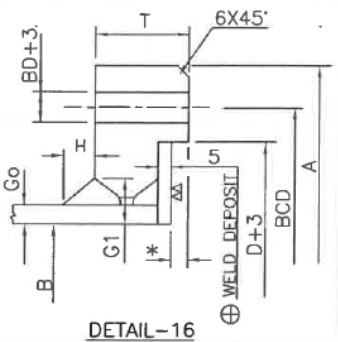

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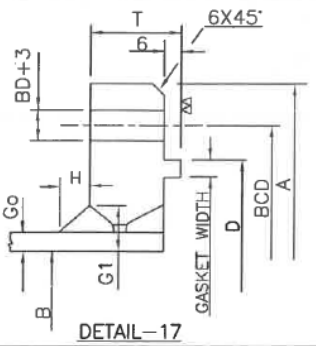

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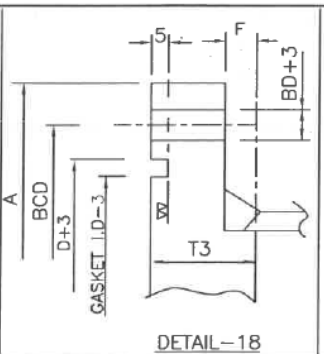

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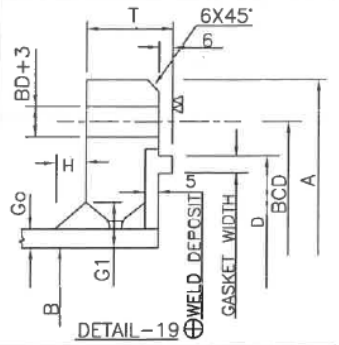

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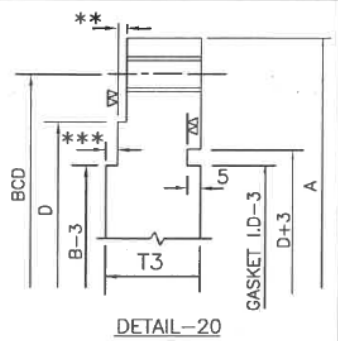

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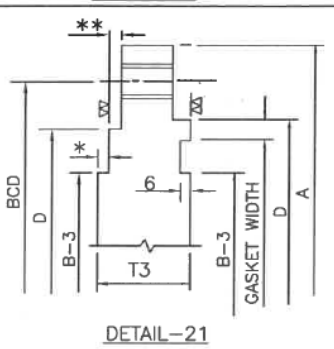

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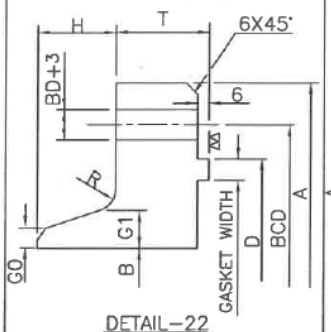

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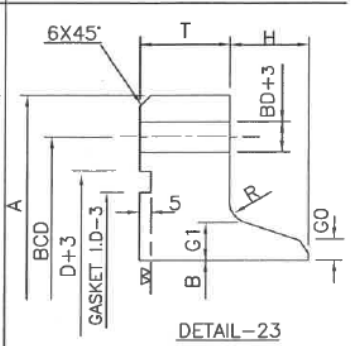

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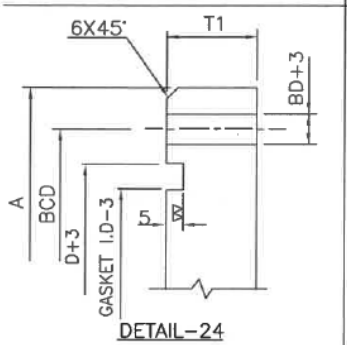

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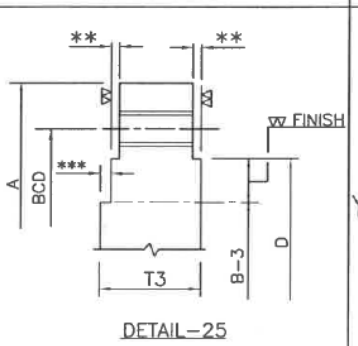

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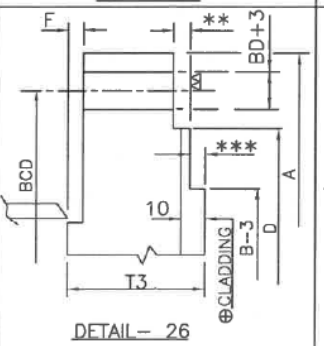

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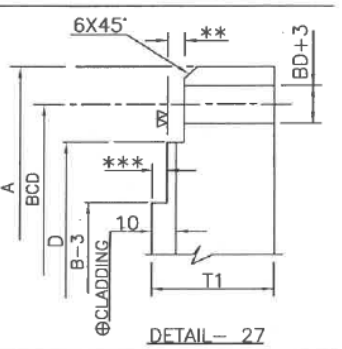

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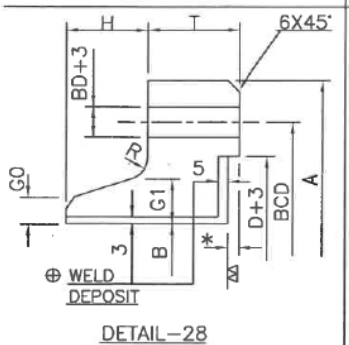

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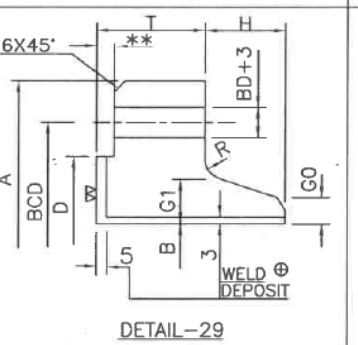

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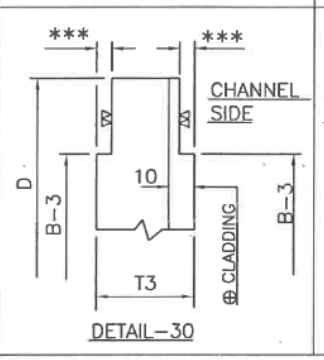

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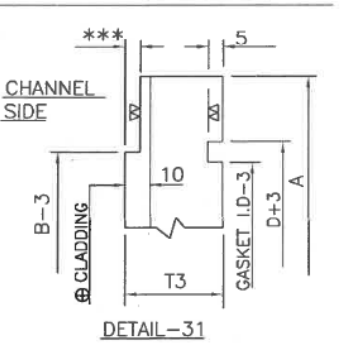

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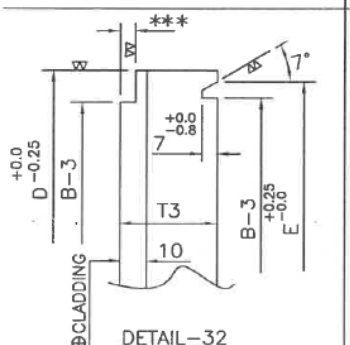

DETAIL–32

TABLE NO.– 1

DIMENSIONS	*	**	***
FOR METAL JACKETED GASKET & NON ASBESTOS / ELASTOMER GASKET.	5	6	5
FOR 4.5 mm SPWD GASKET	6	7	6
FOR 6.35 mm SPWD GASKET	8	9	7

NOTES:–

1. FOR CHANNEL COVER & TUBE SHEET A, BCD & D ETC. SHALL BE SAME AS FOR MATING FLANGES.
2. IF SPIRAL WOUND GASKET IS USED FOR A JOINT:–
   a) DIAMETER OF TUBE SHEET & CHANNEL COVER 'D' SHALL BE GASKET OD + 8 mm.
   b) DIAMETER OF FLANGE RECESS FOR GASKET SHALL BE GASKET OD + 11 mm.
3. ⊕ WELD DEPOSIT OR CLADDING SHALL BE AS SPECIFIED ON EQUIPMENT DRAWING.
4. FOR ASTERISK MARKS REFER TABLE–1.
5. WHEREVER 'R' IS SPECIFIED, IT IS TO BE RADIUSED.
6. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.

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6	02.12.24	REVISED AND REISSUED AS STANDARD	J.SINGH	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT
4	06.05.14	REVISED AND REISSUED AS STANDARD	GCP	KA	RKT	SC

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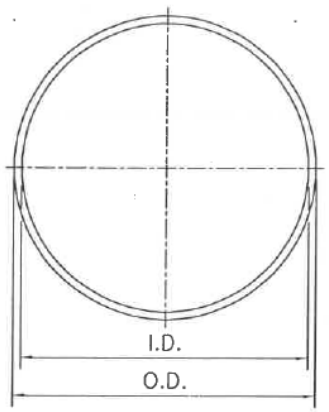

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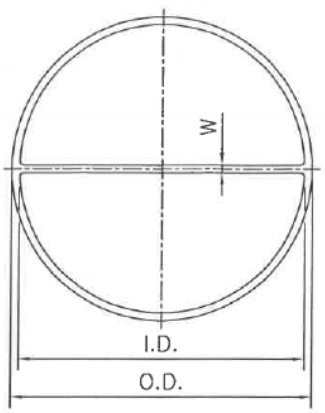

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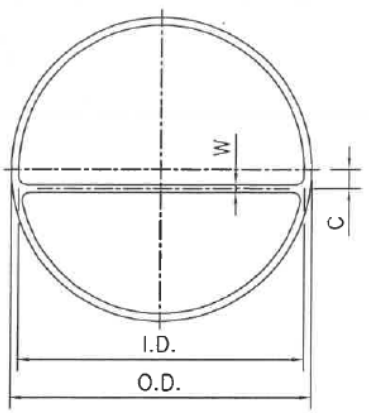

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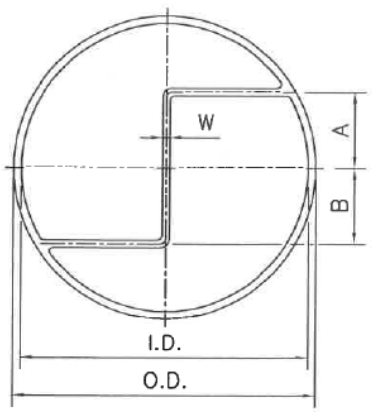

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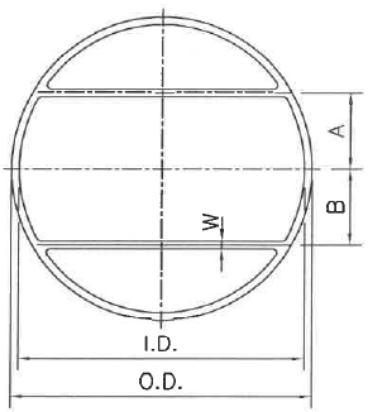

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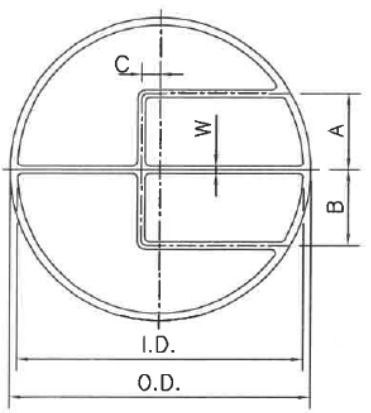

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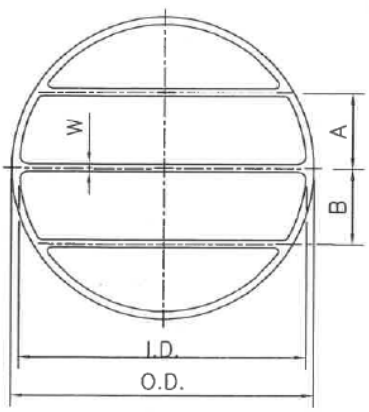

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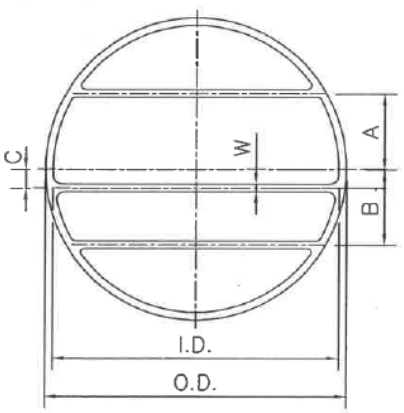

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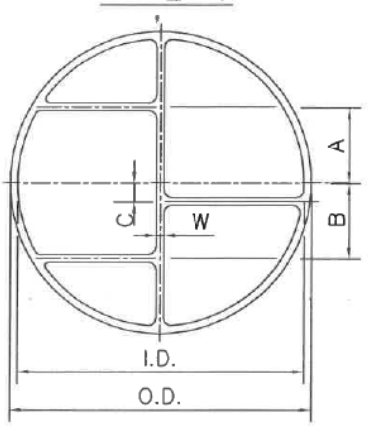

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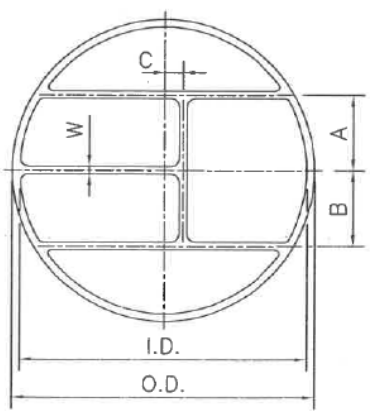

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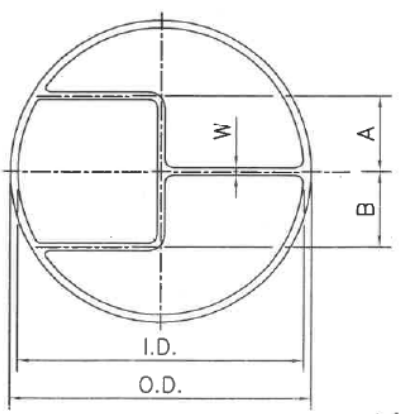

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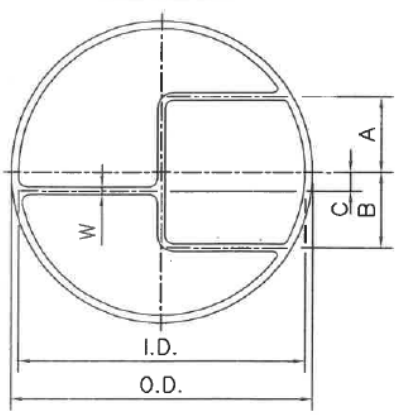

TYPE–12

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					Approved by	
6	02.12.24	REVISED AND REISSUED AS STANDARD	J.SINGH	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

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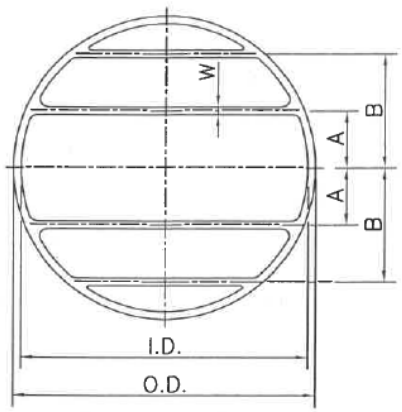

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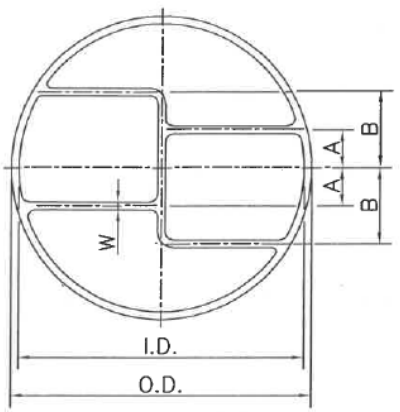

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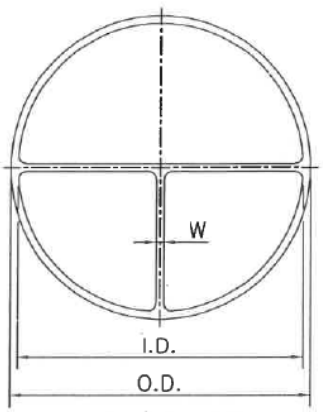

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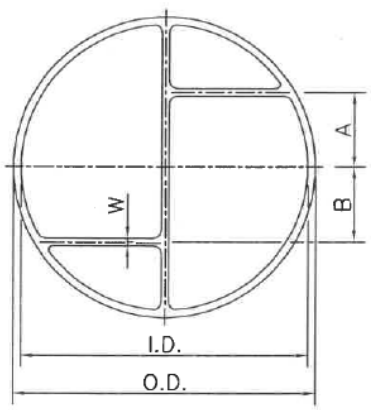

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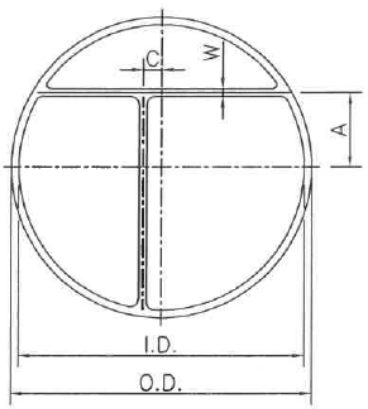

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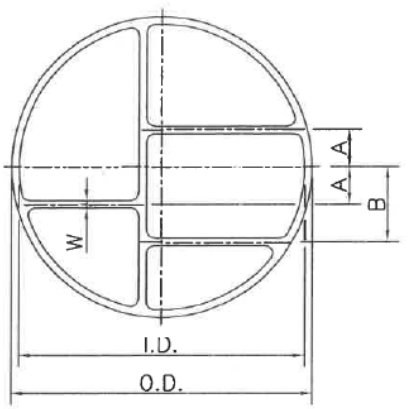

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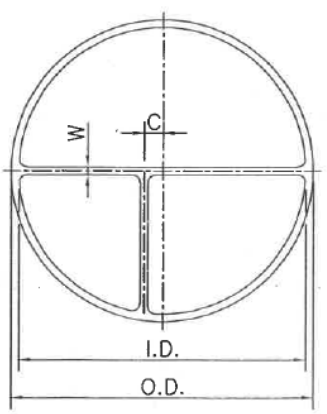

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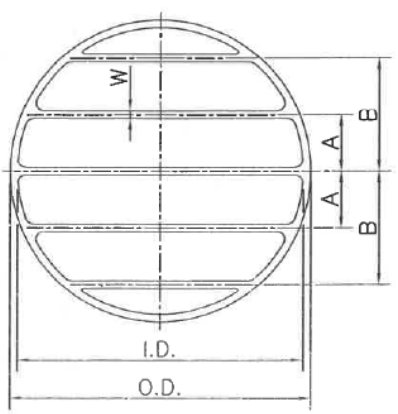

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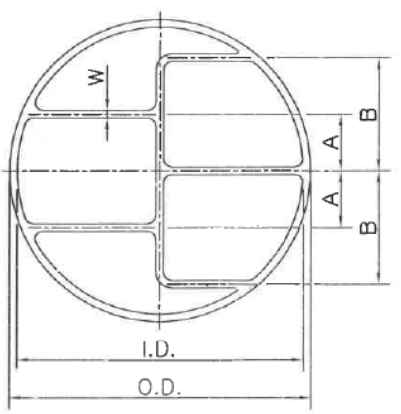

TYPE–21

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6	02.12.24	REVISED AND REISSUED AS STANDARD	J.SINGH	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

Approved by

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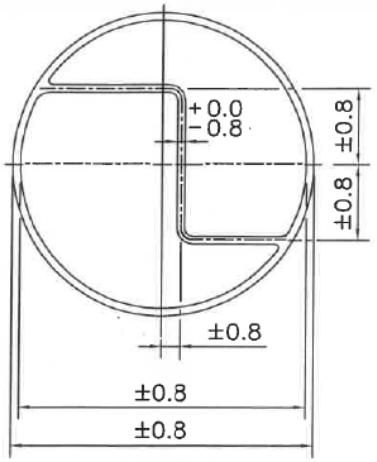
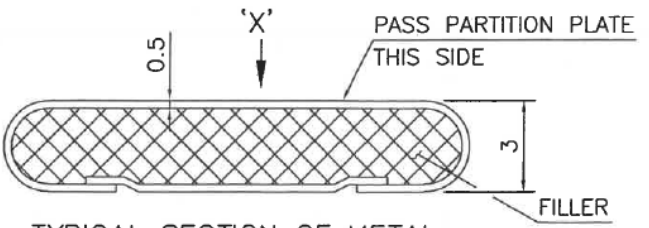
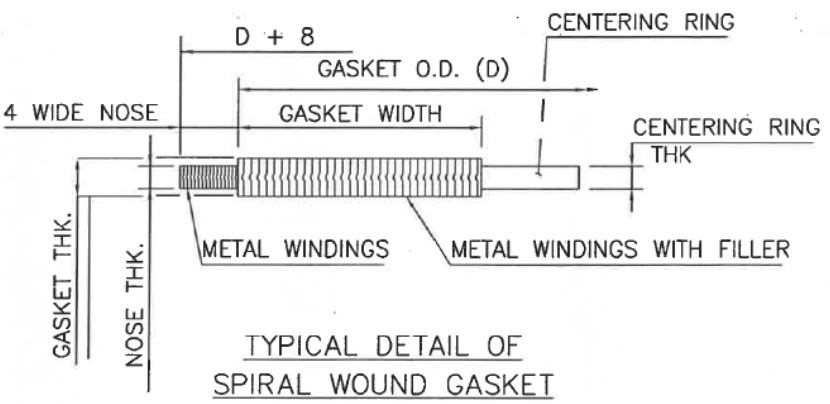
PERMISSIBLE TOLERANCES





TYPICAL SECTION OF METAL JACKETED GASKETS



TYPICAL DETAIL OF SPIRAL WOUND GASKET

GENERAL NOTES:–

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. THE HARDNESS OF THE METAL FOR SOLID OR CLAD GASKETS SHALL BE MINIMUM 15 BHN LOWER THAN THAT OF THE MATERIAL OF THE FLANGE GASKET SEATING SURFACE AND IN ANY CASE NOT TO EXCEED THE FOLLOWING.

(a) LOW CARBON STEEL / LAS	–	110 BHN
(b) 5 Cr. 1/2 Mo.	–	130 BHN
(c) STAINLESS STEEL	–	160 BHN
(d) 11 – 13 Cr.	–	170 BHN
(e) MONEL	–	130 BHN
(f) SOFT IRON	–	90 BHN
(g) COPPER, BRASS	–	50 BHN
(h) ALUMINIUM	–	30 BHN

3. FILLER IN METAL JACKETED GASKETS SHALL NOT BE OF COMPRESSED TYPE.
4. ALL GASKETS SHALL BE MADE IN ONE CONTINUOUS PIECE ALL AROUND INCLUDING THE PASS PARTITION RIBS AND THEREFORE MUST BE CUT FROM ONE SHEET.
5. THE CORNER RADII OF ALL GASKETS TO BE 10 mm.
6. SOLID FLAT METAL GASKET SHALL BE 2 mm. THK.
7. FOR SPIRAL WOUND GASKETS:–
   a) THE PASS PARTITION RIB SHALL BE OF METAL JACKETED WELDED TO CENTRING RING.
   b) CENTERING RING THK. SHALL BE SAME AS NOSE THK.
   c) GASKET THK. SHALL BE AS SPECIFIED IN EQUIPMENT DRAWINGS. IT SHALL BE MIN. 4.5 FOR SHALL DIA UP TO 1000 & MIN. 6.35 FOR SHALL DIA MORE THAN 1000, IF NOT SPECIFIED.
8. 'm' AND 'y' VALUES SHALL BE AS PER ASME SEC. VIII DIV. I.
9. GASKET PLAN IS VIEWED FROM DIRECTION 'X' .
10. FILLER SHALL BE ARAMIDE FIBRE UNLESS SPECIFIED OTHERWISE IN DRAWINGS & ASBESTOS NOT TO BE USED.

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6	02.12.24	REVISED AND REISSUED AS STANDARD	J.SINGH	TKh	KA/NK	MN
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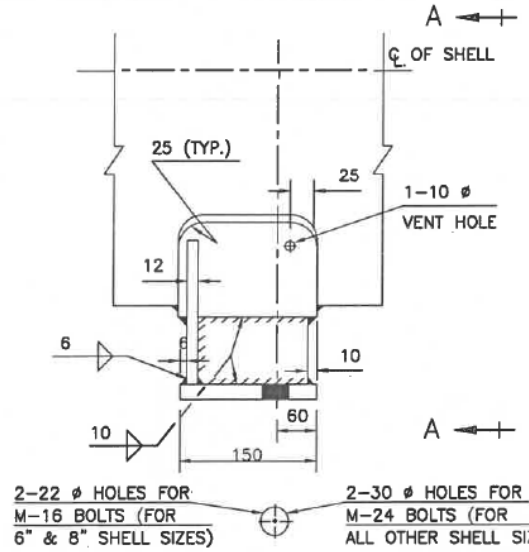
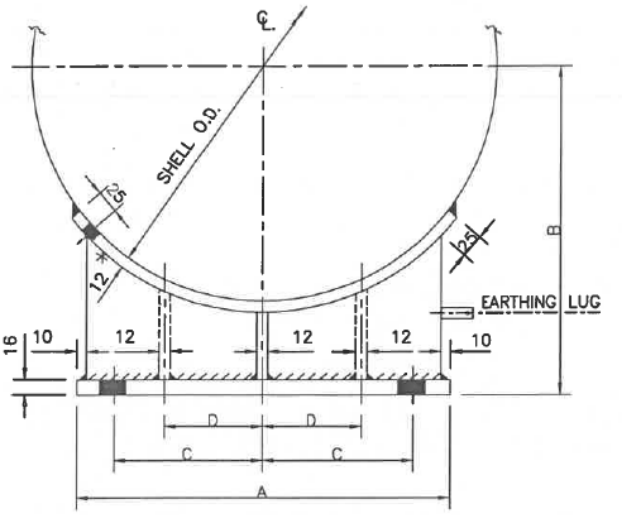
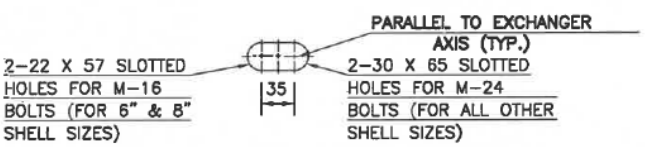




VIEW AT 'A–A'



SADDLE NO.	UNIT SIZE O.D. mm	A	B	C	D	NO. OF RIBS	TOTAL WT. OF 2 SADDLES (kg.)	REMARKS
1	168.3	160	200	50	–	1	17	
2	219.1	160	230	50	–	1	18	
3	273	220	260	70	–	1	21	
4	323.8	230	270	75	–	1	22	
5	355.6	260	280	90	–	1	26	
6	406.4	300	310	110	–	1	30	
7	457.2	350	330	135	80	2	36	
8	500	400	350	160	105	3	44	
9	550	400	380	160	105	3	44	
10	600	430	400	175	120	3	46	
11	650	460	430	190	135	3	50	
12	700	510	450	215	160	3	56	
13	750	530	480	225	165	3	60	
14	800	590	500	240	180	3	82	
15	850	610	530	255	195	3	84	
16	900	660	550	280	220	3	92	
17	950	690	580	295	235	3	98	

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. INTERMEDIATE SADDLES TO BE TAKEN TO THE NEAREST SIZE.
* 3. FOR S.S. 10 mm THK. FOR SADDLE NOS. 1 TO 17 & 14 mm THK. FOR SADDLE NOS. 18 TO 37.

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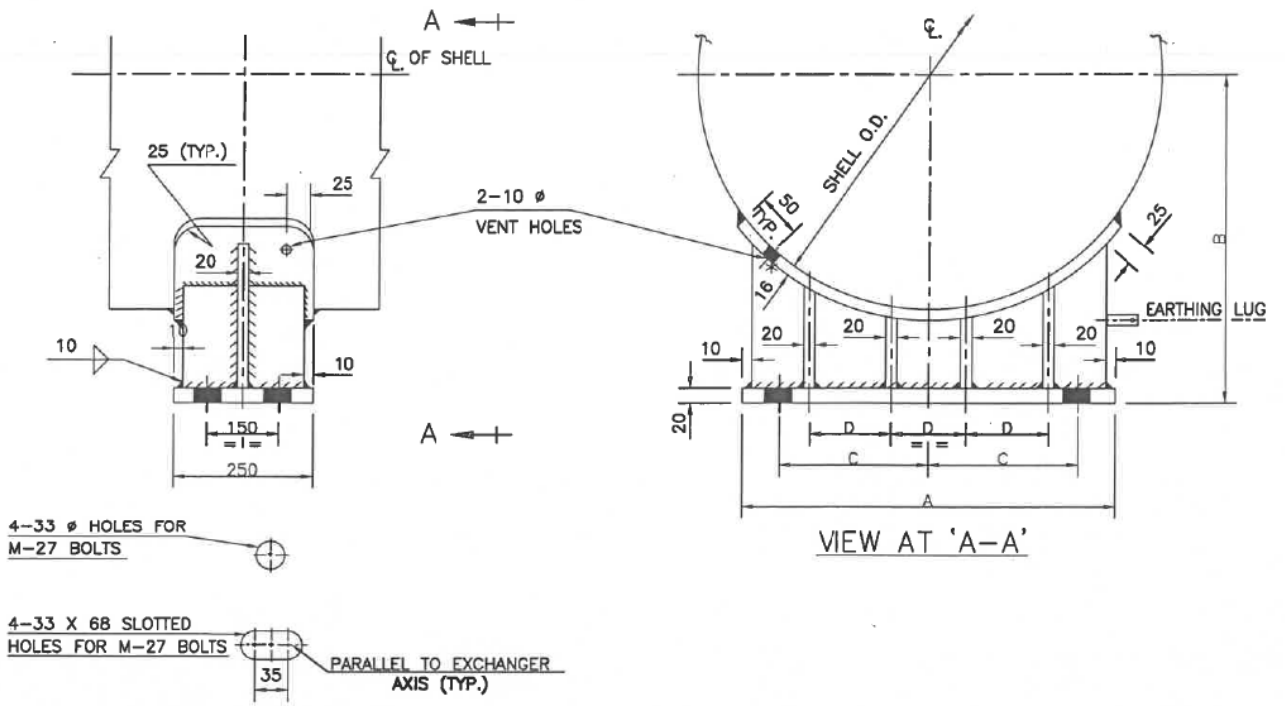

SADDLE NO.	UNIT SIZE O.D. mm	A	B	C	D	NO. OF RIBS	TOTAL WT. OF TWO SADDLES (kg)	REMARKS
18	1000	900	650	370	180	8	258	
19	1050	950	675	390	200		278	
20	1100	1000	700	420	220		290	
21	1150	1050	725	440	230		302	
22	1200	1100	750	470	250		320	
23	1250	1150	775	490	270		336	
24	1300	1200	800	520	280		348	
25	1350	1200	825	520	280		356	
26	1400	1250	850	540	300		368	
27	1450	1300	875	570	320		380	
28	1500	1350	900	590	340		398	
29	1600	1400	950	620	350		406	
30	1700	1500	1000	670	380		440	
31	1800	1600	1050	720	420		472	
32	1900	1700	1100	770	450		516	
33	2000	1800	1150	820	480		546	
34	2100	1850	1200	840	500		568	
35	2200	1950	1250	890	530		602	
36	2300	2000	1300	920	550		606	
37	2400	2100	1350	970	580		640	

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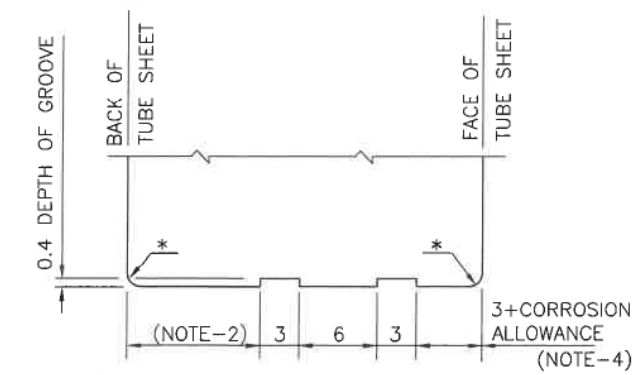

FIG.-1

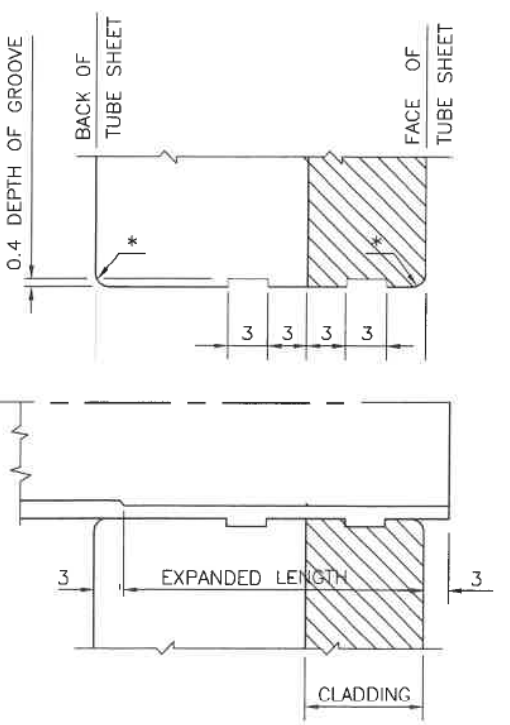

FIG.-2

NOTES :-

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. FOR TUBESHEET THICKNESS WHERE THE GAP BETWEEN 2ND GROOVE & BACK OF TUBE SHEET IS LOWER THAN 6 mm DELETE 2ND GROOVE.
3. FOLLOW SPECIAL CLOSE FIT AS PER TEMA / API 661 UNLESS SPECIFIED OTHERWISE.
4. FOR CORROSION ALLOWANCE LESS THAN 4 mm., INCREASE THIS DIMENSION TO TUBE SHEET THICKNESS MINUS 18 mm. BUT NOT TO EXCEED 7 mm.

* 5. CHAMFER (1X45°) OR RADIUS (R=1).

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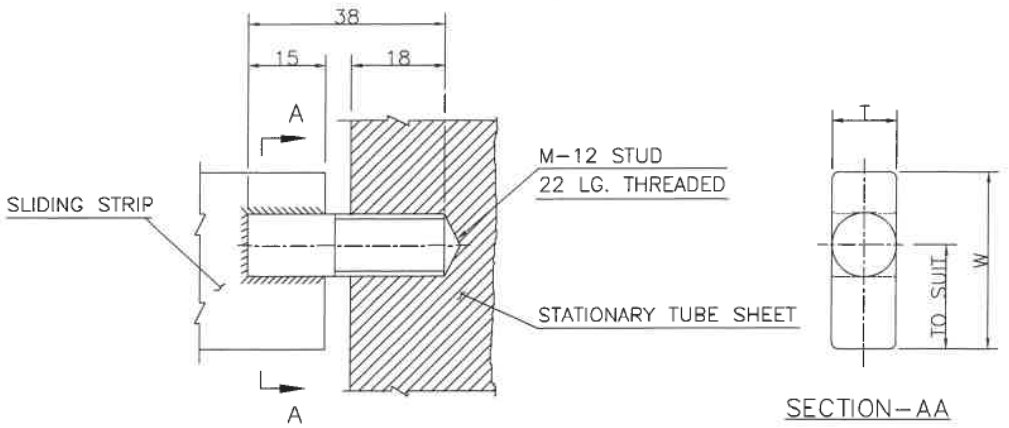
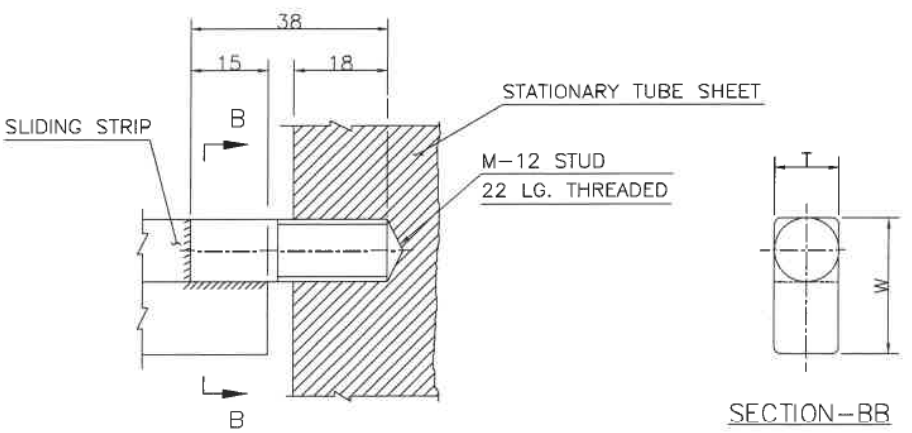


TYPE – 1



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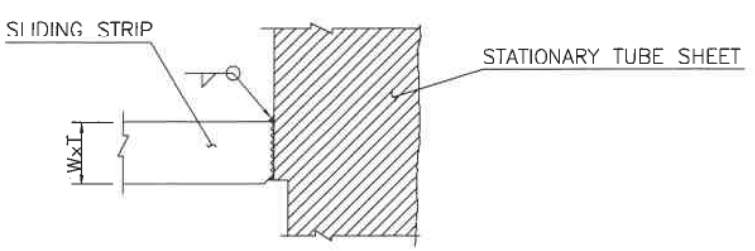

TYPE – 3

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. USE TYPE–1 WHEN SLIDING STRIP & TUBE SHEET MATERIAL IS DIFFERENT & W $\geq$ 25
3. USE TYPE–2 WHEN SLIDING STRIP & TUBE SHEET MATERIAL IS DIFFERENT & W $<$ 25
4. USE TYPE–3 WHEN SLIDING STRIP & TUBE SHEET MATERIAL IS SAME
5. FOR DIMENSIONS 'T' AND W' REFER GUIDE LINES FOR TUBE LAYOUT.
6. FOR DEFLECTOR STRIPS UNLESS SPECIFIED OTHERWISE USE DETAILS AS ABOVE.

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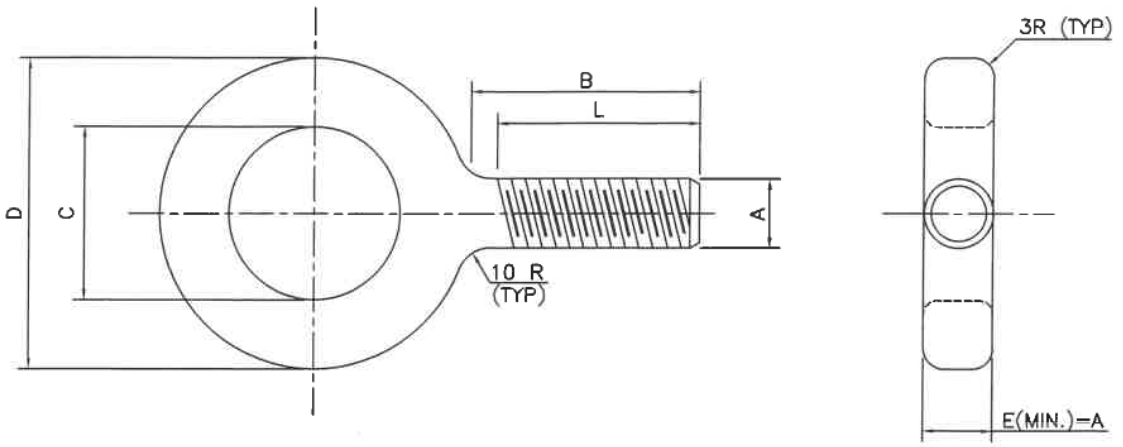

NOM. BOLT DIA A	THREAD LENGTH L	STOCK B	I. DIA. C	O. DIA. D	SAFE LOAD IN kg
M10	20	32	26	42	600
M12	24	38	30	52	1000
M16	32	45	35	64	1800
M20	40	50	38	72	2700
M22	44	58	44	84	3000
M24	48	64	46	92	3300
M27	54	70	50	102	4200
M33	66	76	56	114	6800
M39	78	90	64	132	8100
M45	90	96	74	154	9900
M48	96	102	84	162	11400
M56	112	127	102	168	14200

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. EYE BOLT SHALL BE MADE OF FORGING.
3. MATERIAL OF CONSTRUCTION CARBON STEEL HAVING U.T.S OF 42 kg/mm^2 MIN.
4. UPTO M22 COARSE THREAD SERIES, M24 & ABOVE SHALL HAVE 3 mm PITCH.

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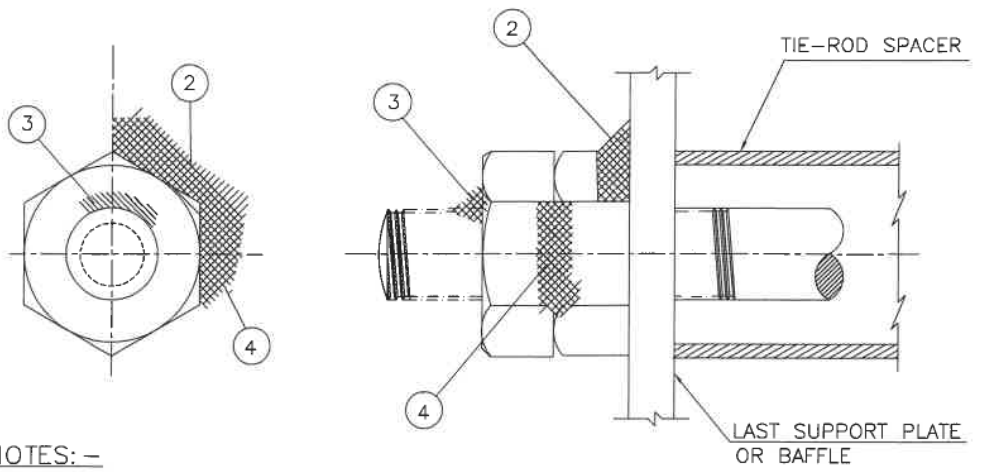
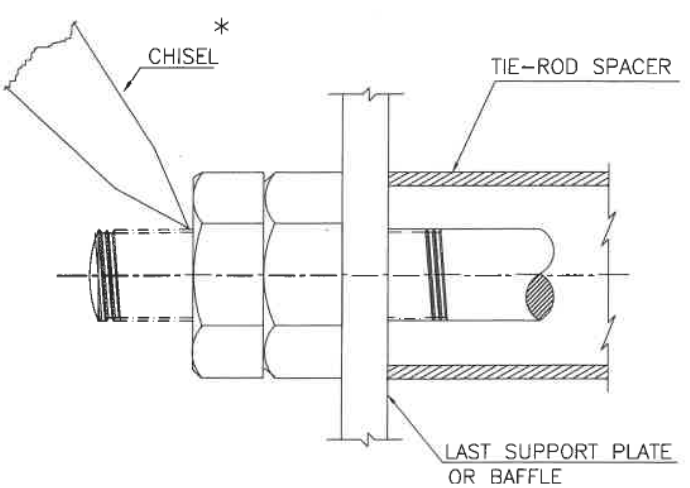
STEEL TIE-ROD



NOTES:-

1. ALL DIMENSIONS ARE IN mm. UNLESS STATED OTHERWISE.
2. WELD 1st NUT TO SUPPORT PLATE
3. WELD 2nd NUT TO TIE-ROD
4. WELD BOTH NUTS TOGETHER
5. ALL WELDS TO EXTEND THE LENGTH OF ONE FLAT OF NUT.

NON FERROUS TIE-ROD



NOTE:-

* BREAK THREAD OF TIE-ROD IN TWO PLACES NEAR LAST NUT WITH BLUNT CHISEL TO LOCK TIE-ROD NUTS IN PLACE.

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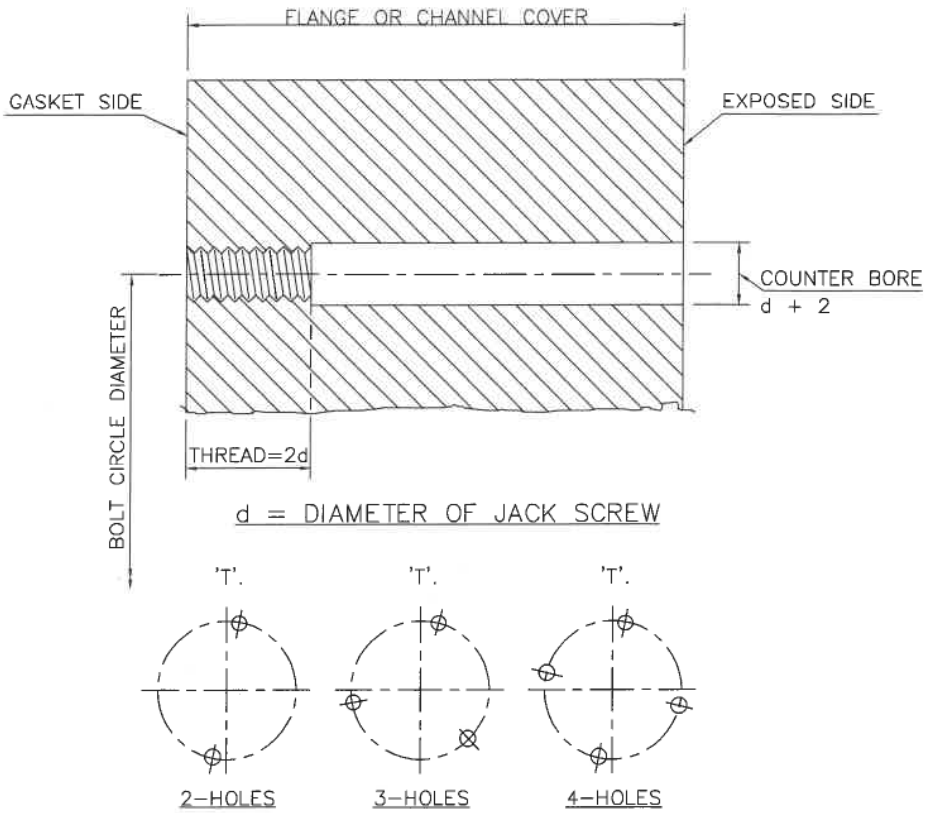

NO. REQD.	'd'	SHELL I.D.
2	14	UPTO & INCL. 300
3	16	301 TO & INCL. 580
4	20	581 & LARGER

LOCATION OF JACK SCREW TAPPING HOLES

1. HOLES ARE TO BE LOCATED ON THE BOLT CIRCLE DIAMETER OF FLANGE AND HALF WAY BETWEEN ADJACENT HOLES.
2. FIRST HOLE SHALL BE LOCATED BETWEEN FIRST AND SECOND BOLT HOLE COUNTING CLOCKWISE FROM MARK 'T'.
3. HOLES SHALL BE SPACED AS FOLLOWS
   2-HOLES LAYOUT 180° APART
   3-HOLES LAYOUT APPROX 120° APART
   4-HOLES LAYOUT 90° APART.

NOTES:-

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. JACK SCREW SHALL BE OF STAINLESS STEEL MATERIAL.

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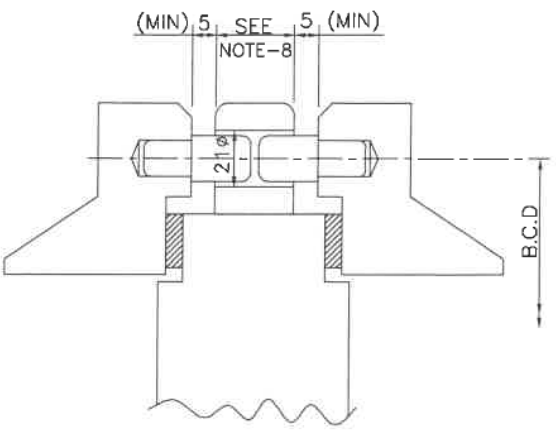
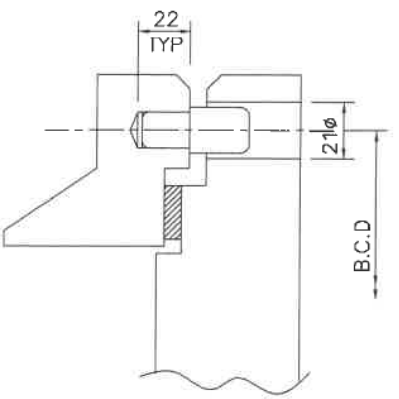
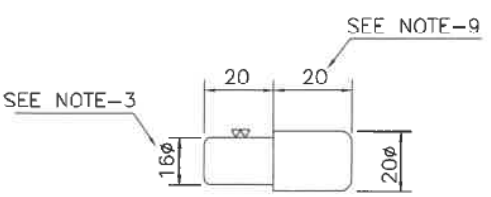


FIXING DETAIL OF DOWEL PINS
(AT STATIONARY TUBE SHEET)



FIXING DETAIL OF DOWEL PINS
(AT CHANNEL COVER)



NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. DOWEL PINS TO BE PROVIDED ONLY WHEN CHANNEL CONSISTS OF PASS–PARTITION PLATE/S.
3. DOWEL PIN SHALL BE OF CARBON STEEL UNLESS SPECIFIED OTHERWISE.
4. MIN. 2 DOWEL PINS SHALL BE PROVIDED FOR EACH FLANGE & SHALL NOT BE LOCATED AT 180° APART.
5. ALL SHARP EDGES OF DOWEL PINS SHALL BE ROUNDED OFF.
6. SMALL END OF DOWEL PIN SHALL BE HELD IN POSITION BY TIGHT FIT.
7. LUG TO BE WELDED TO TUBESHEET. HOWEVER LUG FOR DOWEL PIN MAY BE THREADED AND SCREWED IN TUBE SHEET TO AVOID PWHT IN SPECIFIC CASES. MATERIAL OF LUG SHALL BE COMPATIBLE WITH TUBE SHEET MATERIAL.
8. WHEN GAP BETWEEN SHELL & CHANNEL FLANGES IS 25 MM. OR LESS, DOWEL PINS SHALL BE PROVIDED IN CHANNEL FLANGE ONLY.
9. AT THE LARGER END OF DOWEL PIN THE LENGTH CAN BE REDUCED IN CASE OF A SMALLER GAP BETWEEN SHELL AND CHANNEL FLANGES.

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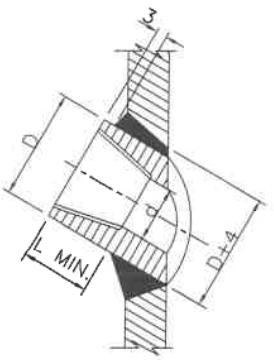
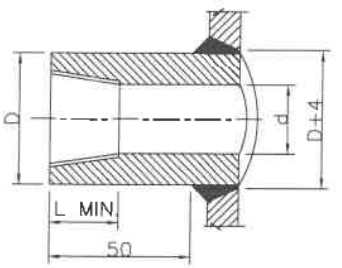


TYPE–1



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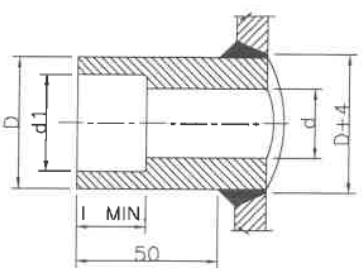

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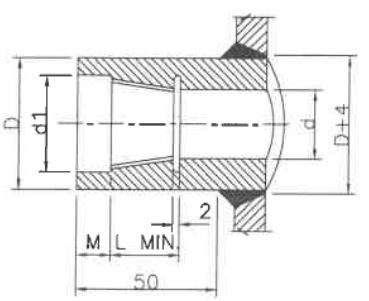

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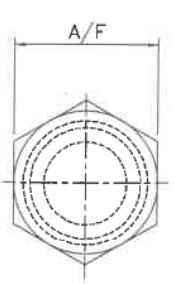

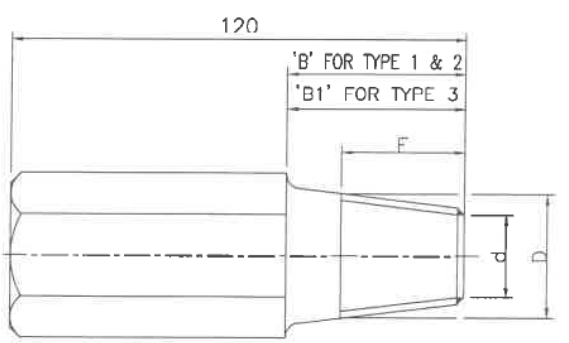

PLUG DETAIL

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COUPLINGS: –

NOM. DIA. (INCHES)	D (ø)		L	d (ø) (APP)	d1 (ø)	M
	3000 #	6000 #				
1/8"	19	22	12	7	–	
1/4"	19	25	13	9	–	–
3/8"	22	32	15	12.5	–	–
1/2"	29	38	17	16.6	21.7	13
3/4"	35	45	18	21.8	27	15
1"	45	57	21	27.5	33.8	16
$1^1/2$"	64	76	23	42.1	48.6	19
2"	76	92	24	54.1	61.1	23

PLUGS: –

NOM. DIA. (INCHES)	A / F	B	D (ø)	F	B1	
1/8"	16	20	10.2	10	–	
1/4"	21	25	13.7	15	–	
3/8"	23	26	17.2	15.5	–	
1/2"	27	30	21.3	19.8	37	
3/4"	32	30	26.7	20.2	39	
1"	41	35	33.4	25	43	
$1^1/2$"	54	36	48.2	26.1	46	
2"	67	37	60.3	26.9	50	

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. ONLY THREADED COUPLINGS TO BE USED FOR SIZES BELOW 1/2"
3. TAPER ON THREADS 1:16 (MEASURE ON DIAMETER) AS PER ASME B 2.1

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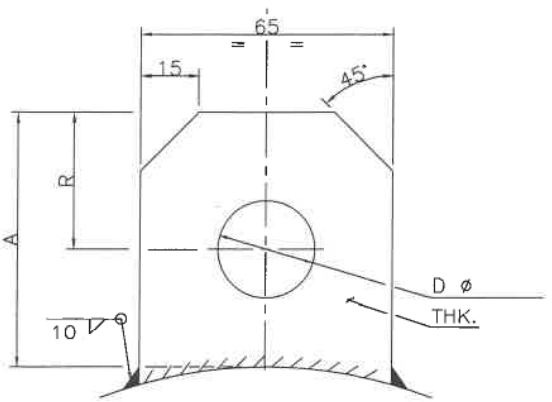
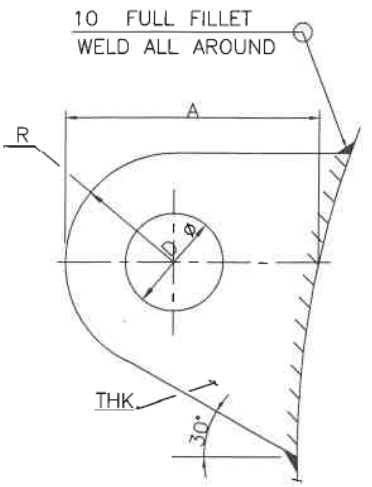


LIFTING LUG FOR SHELL COVER, CHANNEL AND CHANNEL COVER



LIFTING LUG FOR FLOATING HEAD COVER

SHELL I. D.	A	D	R	THK.
UPTO 450	65	25	28	12
451 – 1000	75	30	35	16
1001 – 1200	100	30	35	20
1201 & ABOVE	CUSTOM DESIGN			

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. MATERIAL SHALL BE COMPATIBLE WITH PART IT IS WELDED TO. (USE BOILER QUALITY FOR CARBON STEEL)
3. USE TWO LIFTING LUGS EACH FOR CHANNEL AND SHELL COVER AND ONE FOR CHANNEL COVER AND FLOATING HEAD COVER.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	05.11.24	REAFFIRMED AND REISSUED AS STANDARD	AS	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

Approved by

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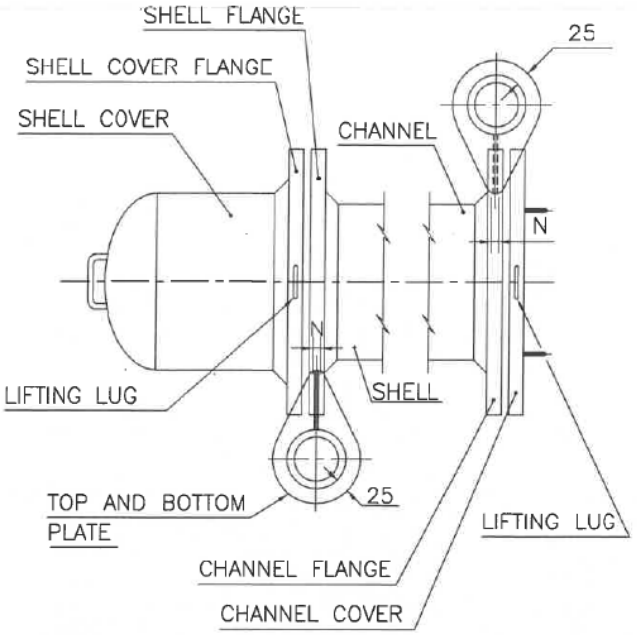
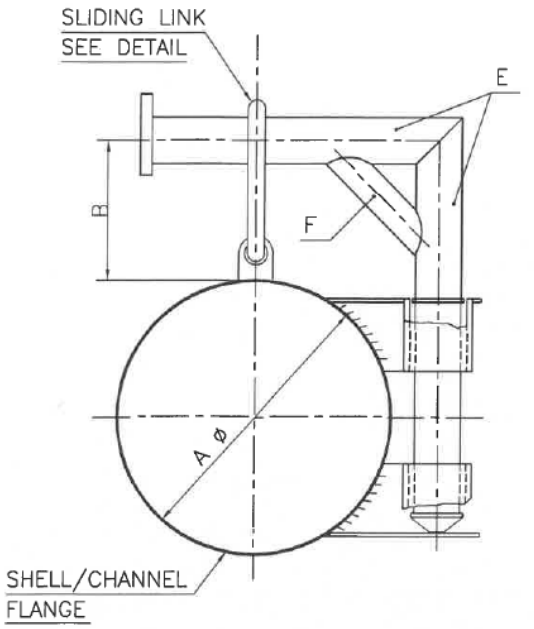
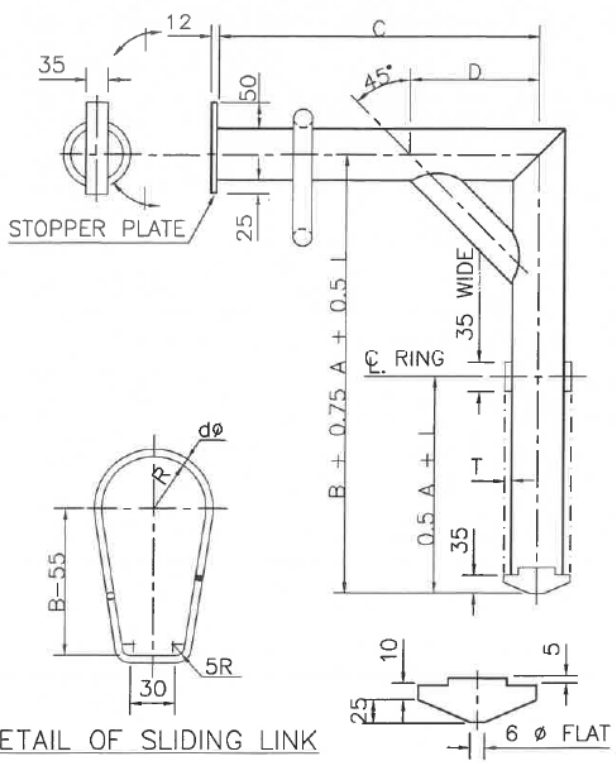


PLAN OF DAVIT SUPPORT

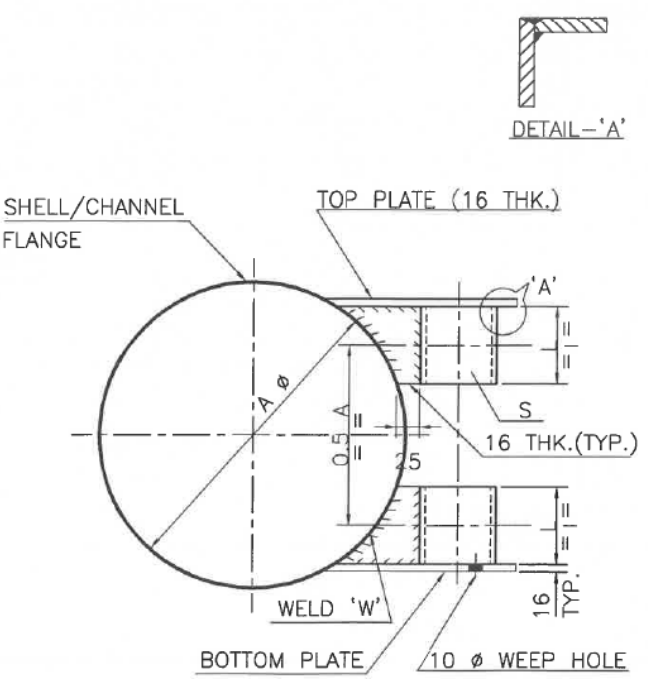


ASSEMBLY OF DAVIT ON EXCHANGER



DETAIL OF SLIDING LINK

DETAIL OF DAVIT



DETAIL OF DAVIT SUPPORT

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	22.01.25	REVISED AND REISSUED AS STANDARD	SM/RS	TKh	AA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

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DAVIT FOR SHELL COVER TABLE–1

DAVIT DIMN.	DIMENSION–A																					
	UPTO 500	501 TO 600	601 TO 700	701 TO 800	801 TO 900	901 TO 1000	1001 TO 1100	1101 TO 1200	1201 TO 1300	1301 TO 1400	1401 TO 1500	1501 TO 1600	1601 TO 1700	1701 TO 1800	1801 TO 1900	1901 TO 2000	2001 TO 2100	2101 TO 2200	2201 TO 2300	2301 TO 2400	2401 TO 2500
B	230	230	250	250	250	250	275	275	275	300	300	300	325	325	325	325	325	325	325	325	325	325
C	580	650	750	800	850	900	1000	1050	1100	1190	1240	1290	1360	1410	1460	1510	1560	1610	1660	1710	1760	
D (NOTE-4)	260	260	300	300	300	300	340	350	380	390	400	430	430	430	430	450	450	460	460	480	480	
L	125	150	180	200	230	250	280	300	330	350	390	400	430	450	480	500	530	550	580	600	630	
N	20	20	25	25	30	30	30	30	30	30	30	30	30	30	30	30	40	40	40	40	40	
d	16	16	20	20	20	20	20	20	20	25	25	25	25	25	30	30	30	30	30	30	30	

DAVIT FOR CHANNEL COVER TABLE–2

DAVIT DIMN.	DIMENSION–A																					
	UPTO 500	501 TO 600	601 TO 700	701 TO 800	801 TO 900	901 TO 1000	1001 TO 1100	1101 TO 1200	1201 TO 1300	1301 TO 1400	1401 TO 1500	1501 TO 1600	1601 TO 1700	1701 TO 1800	1801 TO 1900	1901 TO 2000	2001 TO 2100	2101 TO 2200	2201 TO 2300	2301 TO 2400	2401 TO 2500	
B	180	180	200	200	200	200	200	230	230	260	260	260	260	260	290	290	290	290	290	290	290	
C	350	400	450	525	575	625	675	750	800	875	925	975	1025	1075	1150	1200	1225	1275	1325	1375	1425	
D (NOTE-4)	210	210	250	250	260	260	270	300	300	350	350	350	375	375	410	410	410	425	425	450	450	
L	125	150	180	200	230	250	280	300	330	350	380	400	430	450	480	500	530	550	580	600	630	
N	20	20	25	25	30	30	30	30	30	30	30	30	30	30	30	30	40	40	40	40	40	
d	16	16	20	20	20	20	20	20	20	25	25	25	25	30	30	30	30	30	30	30	30	

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	22.01.25	REVISED AND REISSUED AS STANDARD	SM/RS	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

Approved by

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TABLE – 3

WT. X C. (TON) (MTR)	DIMENSIONS/SIZE OF DAVITS				
	E NB SCH	F NB SCH	T	R	S NB SCH
UPTO 0.1	2"–160	1-1/2"-160	3	32	3"–160
0.11–0.3	3"–160	2"–160	3	47	4"–80
0.31–0.6	4"–160	2"–160	13	59	6"–80
0.61–1.25	6"–80	3"–160	10	86	8"–80
1.26–2.5	8"–80	3"–160	11	112	10"–60
2.6–4.0	10"–60	4"–120	8	139	12"–60
4.1–6.3	10"–120	4"–120	8	139	12"–60
6.4–7.8	10"–160	4"–120	8	139	12"–60

NOTES: –

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE INDICATED.
2. WHEN DAVITS ARE REQUIRED, USE THE FOLLOWING PROCEDURE TO FIND OUT THE DIMENSIONS
   2.1 IDENTIFY THE DIMENSION A, i.e. THE MAXIMUM DIAMETER OF THE COMPONENT TO BE HANDLED.
   2.2 REFER TABLE–1 OR TABLE–2 (AS THE CASE MAY BE) FOR THE DIMENSIONS AND SIZES B,C,D,L,N & d INDICATED IN THE COLUMN CORRESPONDING TO DIMENSION A.
   2.3 DETERMINE WEIGHT OF THE PART TO BE HANDLED (i.e. WT. OF SHELL COVER ASSEMBLY OR CHANNEL COVER)
   2.4 CALCULATE THE PRODUCT OF WEIGHT (IN TONNES) X DIMENSION C (IN METRES)
   2.5 REFER TABLE–3 & OBTAIN DIMENSION AND SIZES E,F,T,S & R INDICATED IN THE ROW AGAINST THE PRODUCT CALCULATED AT 2.4 ABOVE.
3. MATERIALS OF CONSTRUCTION–a. TOP/BOTTOM/RIB PLATE– COMPATIBLE WITH PART IT IS WELDED TO (USE BOILER QUALITY FOR CARBON STEEL)
   b. OTHERS IS 1239 OR EQUIV
4. THE VALUE OF 'D' MAY BE SUITABLY REDUCED IN CASE OF ANY FOULING, ON CASE TO CASE BASIS.
5. VENDOR TO ENSURE PROPER FUNCTIONING OF DAVIT AND GUARANTEE THEIR HOLDING CAPACITY WITHOUT ANY FAILURE OF WELDED JOINTS/FILLETS/ EYEBOLTS/LINKS ETC. BY TESTING AT VENDOR'S SHOP AS BELOW:–KEEP THESE HANDLING ITEMS IN HANGED POSITION ALONG WITH CONNECTED BLIND FLANGES/ASSEMBLY ETC. KEPT OPENED & HANGED FOR A CONTINUOUS DURATION OF 8 HOURS MINIMUM.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	22.01.25	REVISED AND REISSUED AS STANDARD	SM/RS	VKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

Approved by

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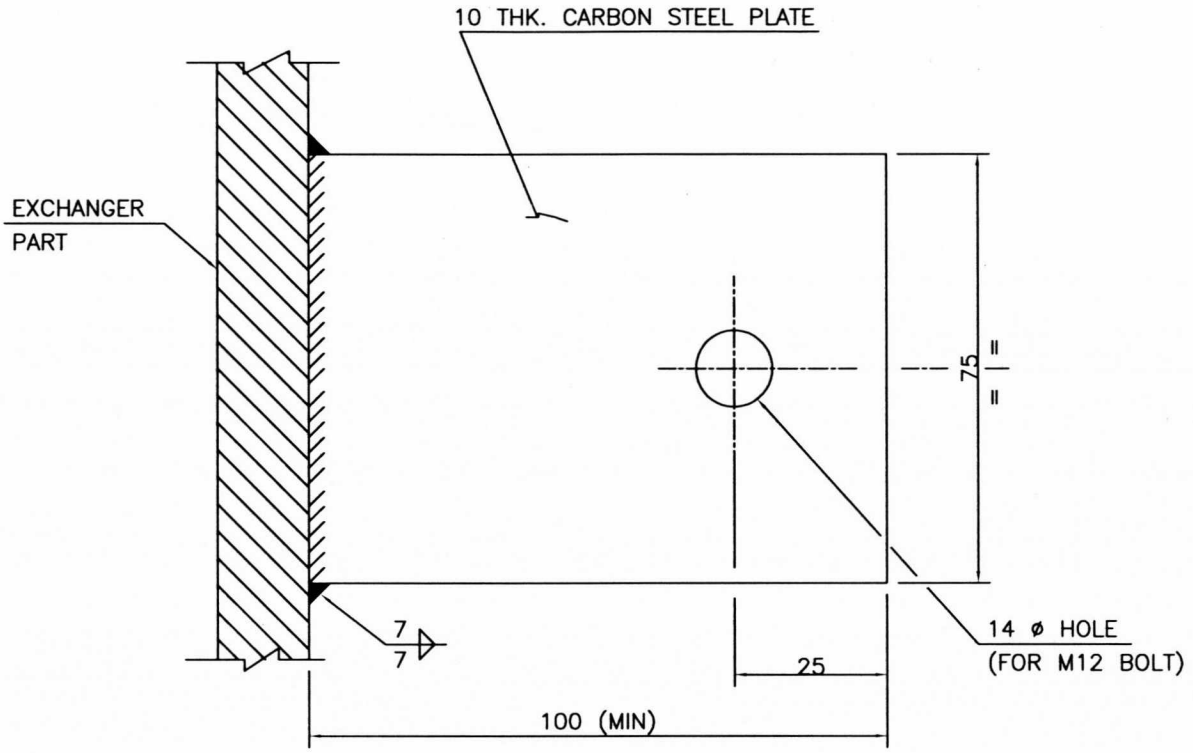

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. DO NOT WELD EARTHING LUGS TO PRESSURE PARTS. IF REQUIRED,TAKE PRIOR APPROVAL OF COMPANY.
3. EARTHING LUG TO PROTRUDE OUT OF INSULATION, WHEREVER REQUIRED.
4. ALL EXCHANGERS TO BE FITTED WITH 2 EARTHING LUGS.
5. LOCATION OF EARTHING LUGS :–
   (i) FOR VERTICAL EXCHANGER WITH 2 LUG SUPPORTS :– ON BOTH LUG SUPPORTS AT VERTICAL WEB.
   (ii) FOR VERTICAL EXCHANGER WITH 3 LUG SUPPORTS :– ON ANY TWO AT VERTICAL WEB.
   FOR VERTICAL EXCHANGER WITH 4 LUG SUPPORTS :– ON ANY TWO DIAMETRICALLY OPPOSITE AT VERTICAL WEB.
   (iii) FOR HORIZONTAL EXCHANGER :– ONE ON CENTRAL WEB OF EACH SADDLE SUPPORT.
   (iv) EARTHING LUG SHOULD BE LOCATED SUCH THAT IT WILL NOT FOUL WITH ANCHOR BOLT DURING ERECTION.
6. EARTHING LUG SHOULD BE PAINTED / GALVANISED.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	16.11.2022	REVISED AND REISSUED AS STANDARD	NS	TK	NK	SM
5	20.03.2018	REVISED AND REISSUED AS STANDARD	JIT SINGH	SK/KJH	RKT	RN
4	30.09.2011	REVISED AND REISSUED AS STANDARD	JS	RKT	AKM/SC	DM

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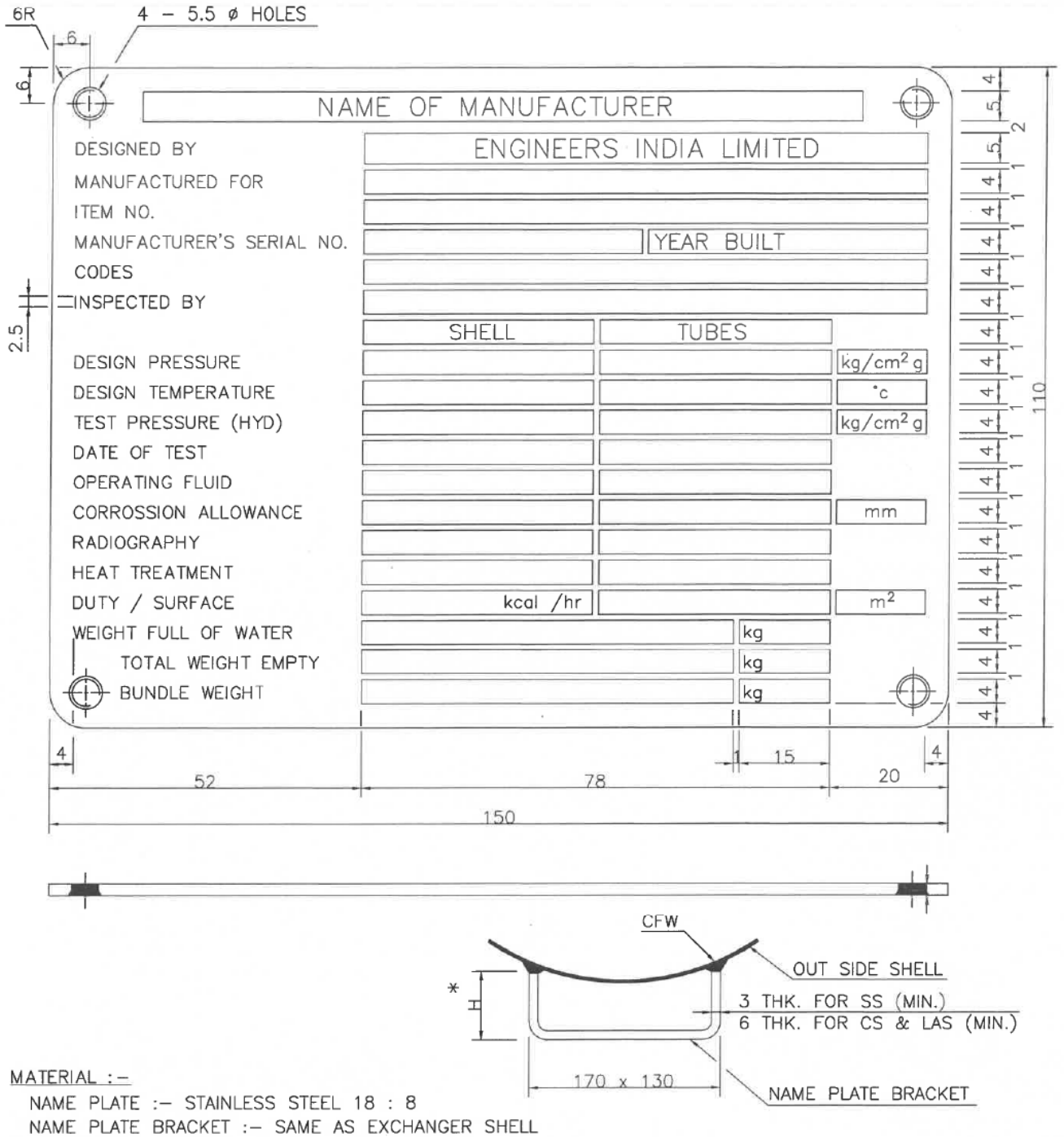
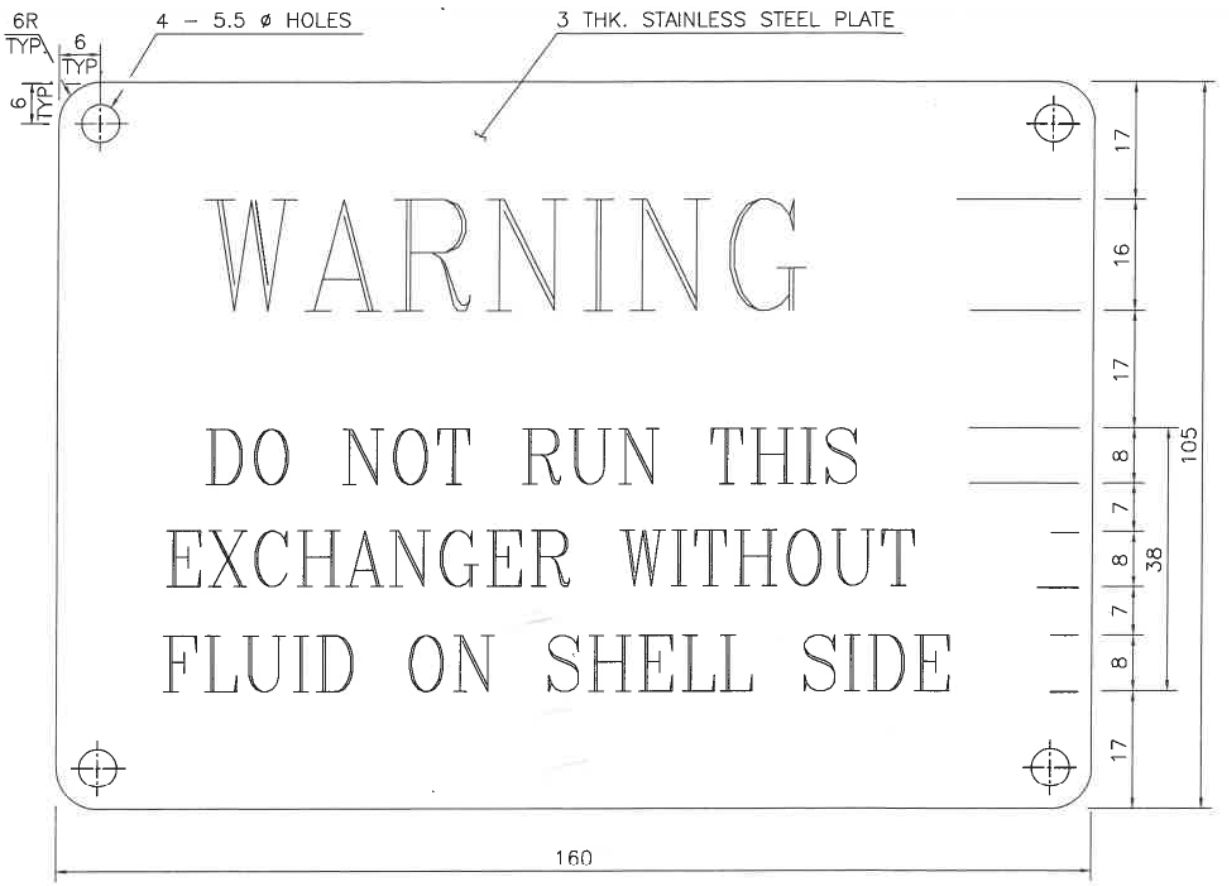
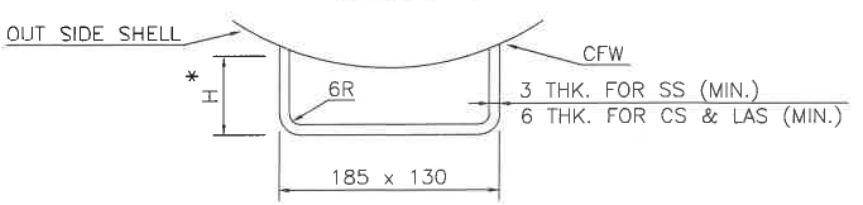

6R
4 – 5.5 ø HOLES
6
6
NAME OF MANUFACTURER
DESIGNED BY
ENGINEERS INDIA LIMITED
MANUFACTURED FOR
ITEM NO.
MANUFACTURER'S SERIAL NO.
YEAR BUILT
CODES
INSPECTED BY
2.5
SHELL
TUBES
DESIGN PRESSURE
kg/cm² g
DESIGN TEMPERATURE
°c
TEST PRESSURE (HYD)
kg/cm² g
DATE OF TEST
OPERATING FLUID
CORROSION ALLOWANCE
mm
RADIOGRAPHY
HEAT TREATMENT
DUTY / SURFACE
kcal /hr
m²
WEIGHT FULL OF WATER
kg
TOTAL WEIGHT EMPTY
kg
BUNDLE WEIGHT
kg
4 5 2 1 1 4 4 4

WARNING PLATE
(SHELL & TUBE EXCHANGERS)



DETAIL – 1



WARNING PLATE BRACKET DETAIL

MATL. SPEC.:– SAME AS EXCHANGER SHELL

* H = 75 OR 'INSULATION THK. + 10 WHICHEVER IS GREATER.

NOTES: –

1. ALL DIMENSIONS ARE IN mm UNLESS STATED OTHERWISE.
2. MATERIAL TO BE 18:8 STAINLESS STEEL FOR WARNING PLATE.
3. ALL LETTERING WITH THE EXCEPTION OF WORD 'WARNING' TO BE ENGRAVED 2 mm. WIDE x 2 mm. DEEP AND FILLED WITH BLACK PAINT AFTER ENGRAVING.
4. THE WORD "WARNING" IS TO BE ENGRAVED 2.5 mm. WIDE x 2 mm. DEEP AND FILLED WITH RED PAINT AFTER ENGRAVING.
5. WARNING PLATE TO BE HELD WITH 5 ø ALUMINIUM RIVETS ON WARNING PLATE BRACKET AND SHALL BE TACK WELDED TO BRACKET ON ALL FOUR SIDES.
6. BRACKET WITH WARNING PLATE TO BE LOCATED AS MARKED ON DRAWING.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	05.11.24	REAFFIRMED AND REISSUED AS STANDARD	AS	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

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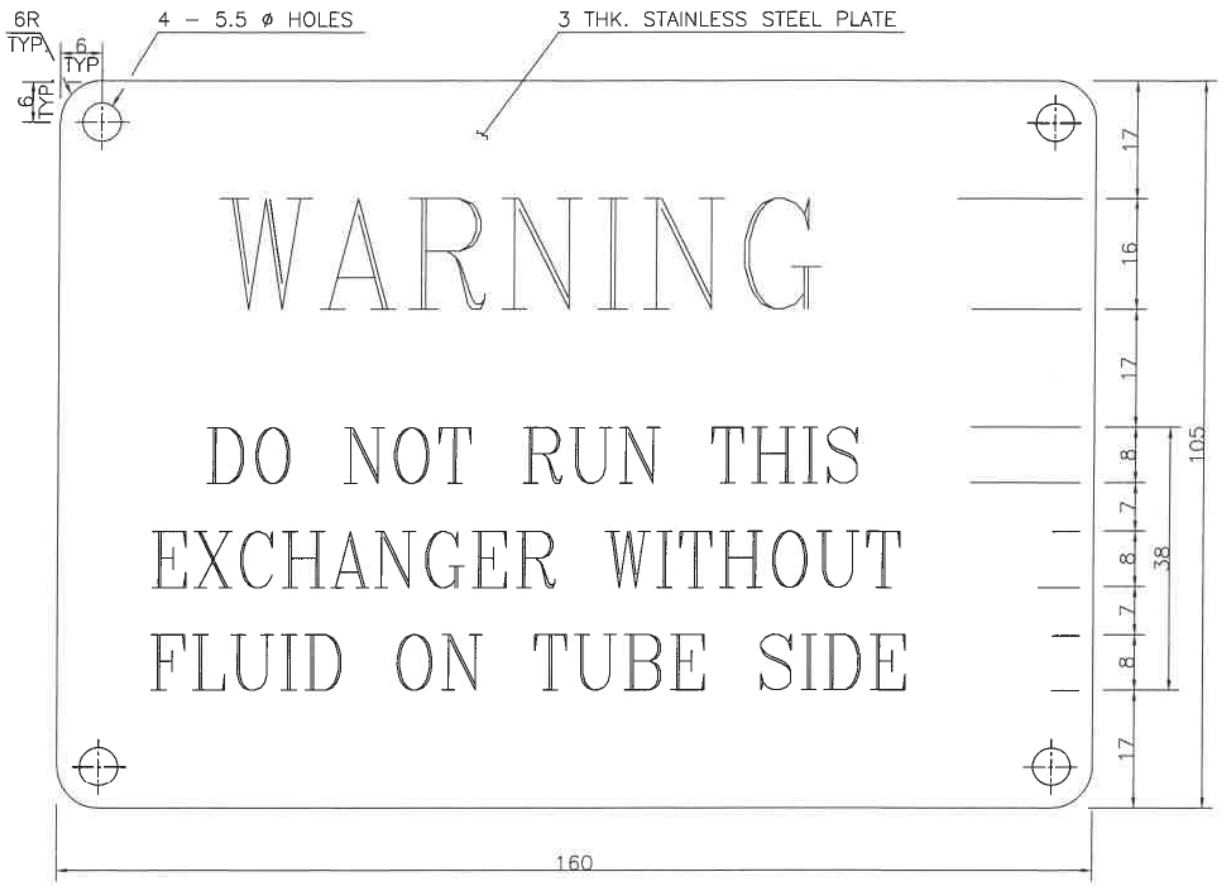

DETAIL – 2

FOR NOTES REFER SHEET 1 OF 2.

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	05.11.24	REAFFIRMED AND REISSUED AS STANDARD	AS	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

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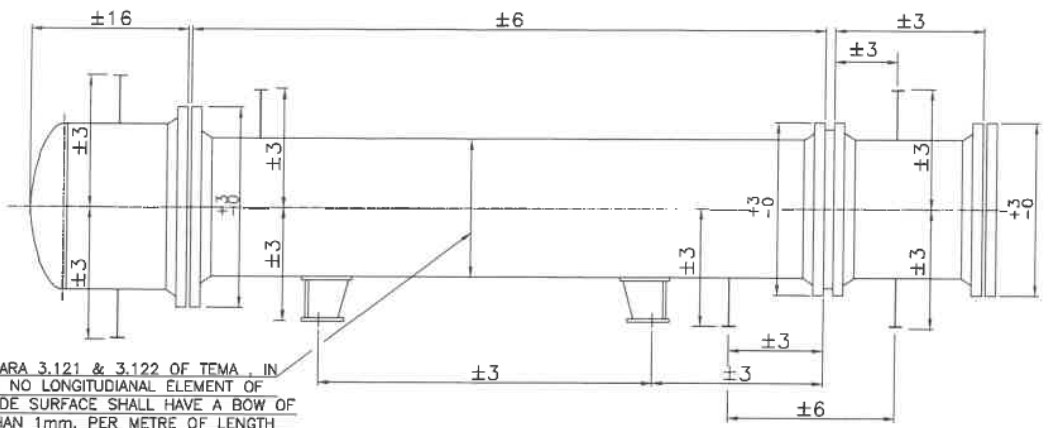
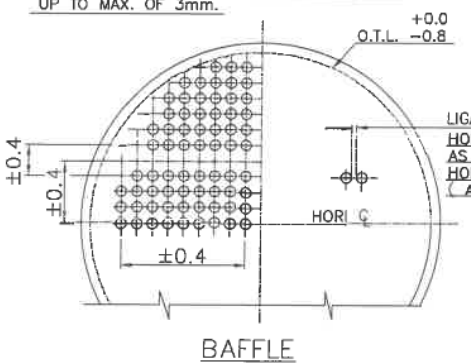
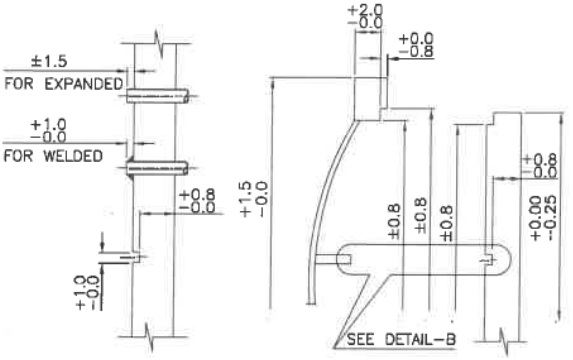


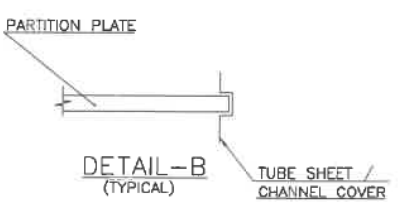


BAFFLE

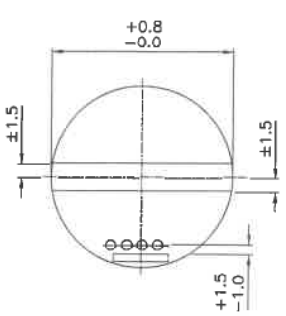


TAKE (−) TOLERANCE WHEN CUT IS ON THE ℄ OF TUBES

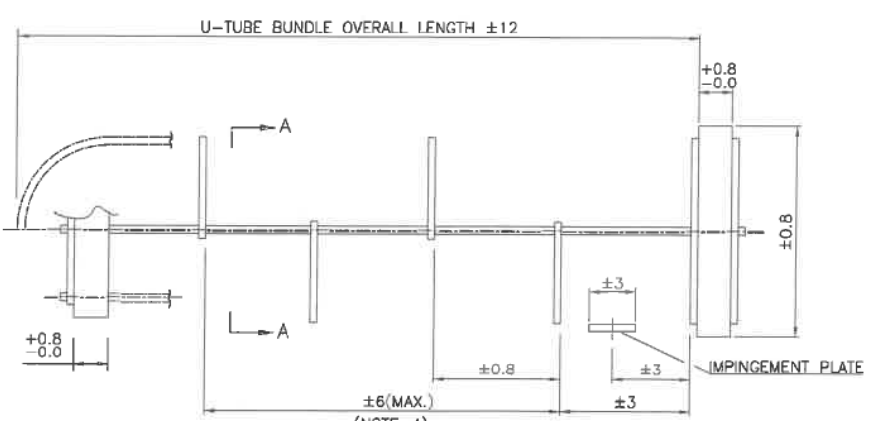
TAKE (+) TOLERANCE WHEN CUT IS IN BETWEEN THE TUBES



DETAIL−B
(TYPICAL)



SECTION−AA



Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
					Approved by	
6	21.11.24	REAFFIRMED AND REISSUED AS STANDARD	JSINGH	TKh	KAYNK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

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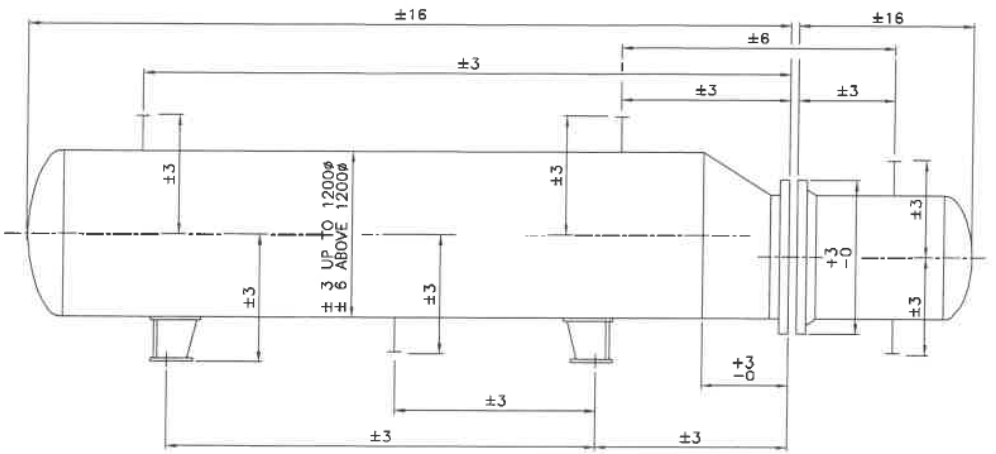

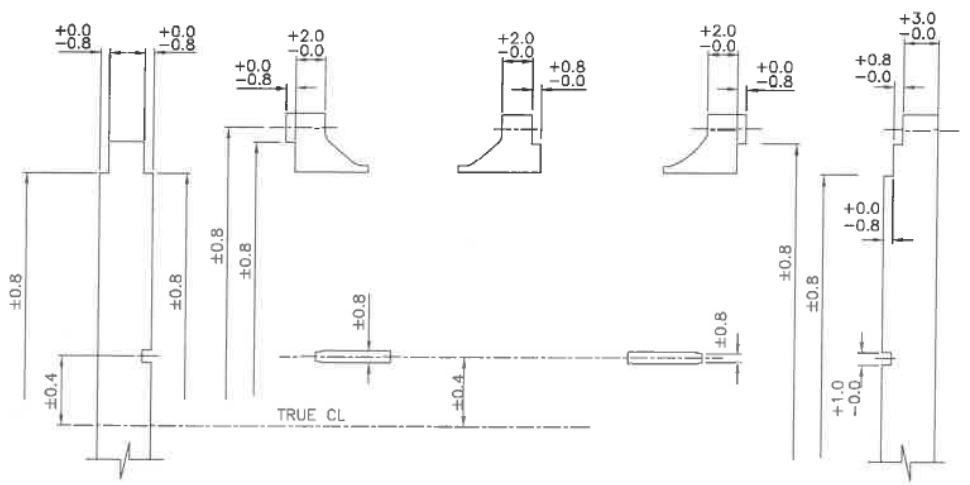

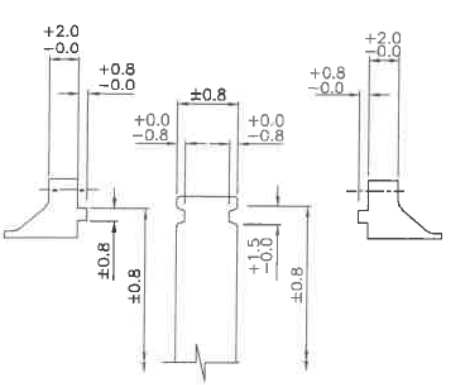

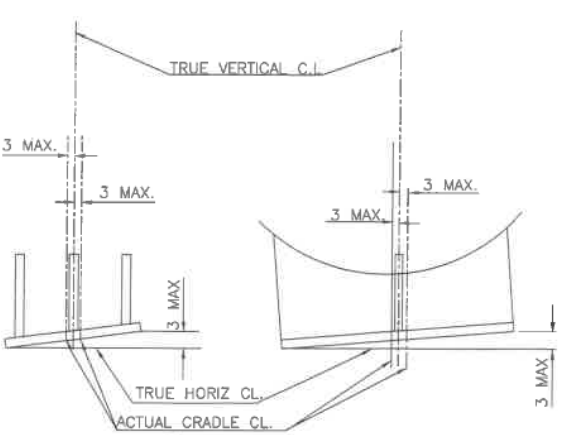

Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
6	21.11.24	REAFFIRMED AND REISSUED AS STANDARD	JSINGH	TKh	KA/NK	MN
5	31.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	NSK	KJH	RKT

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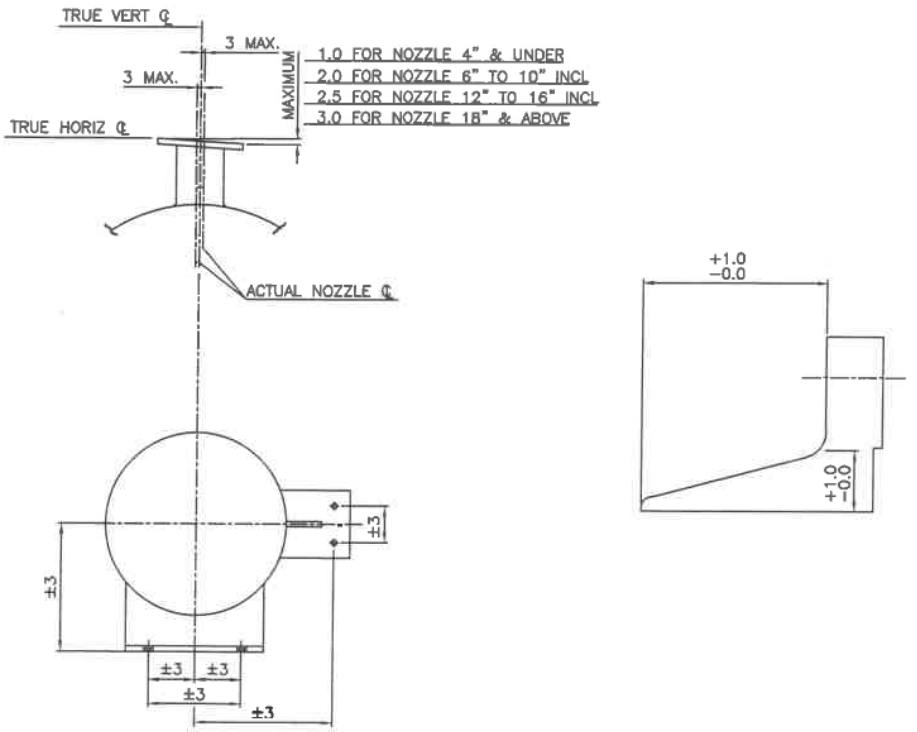

GENERAL NOTES:–

1. CUMULATIVE TOLERANCES ON CONSECUTIVE DIMENSIONS SHALL BE LIMITED BY OVERALL DIMENSION TOLERANCE.
2. SPECIFIC TOLERANCES DESIRED FOR ANY PART SHALL BE SHOWN ON THE DRAWING AND SHALL BE GIVEN PREFRENCE TO THOSE GIVEN IN THIS STANDARD.
3. TUBE HOLE TOLERANCES SHALL BE AS PER TEMA.
4. ONLY WHEN NUMBER OF BAFFLE PITCHES EXCEED EIGHT.

Rev. No.	Date	Purpose	Prepared by	Checked	Stds. Committee Convenor	Stds. Bureau Chairman
6	21.11.24	REAFFIRMED AND REISSUED AS STANDARD	JSINGH	TKh	KA/NK	MN
5	21.10.19	REAFFIRMED AND REISSUED AS STANDARD	DP	[illegible]	[illegible]	[illegible]

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