JACOBS

IndianOil

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CLIENT AUTHORIZATION	:	**GAUTAMA PRIYA**
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1.0 SCOPE

1.1 This specification covers the fabrication, erection and the testing requirements regarding coils for fired heaters.

1.2 Coils shall conform to applicable clauses of ASME B 31.3, ASME Sec. VIII Div.1, ASME Sec. IX, ASME Sec. I and IBR, wherever applicable.

1.3 The above referenced codes shall be considered as follows:

ASME B 31.3	–	For fabrication and erection and for acceptance criteria.
ASME Sec. VIII Div.1, (Paragraph UW-51 and UW-52)	–	For Radiography requirements. These will be read in conjunction with ASME B 31.3 as applicable.
ASME Sec. IX	–	For welding procedure and performance qualification.

1.4 When ASME Power Boiler Code / Indian Boiler Regulations/ ISO are specified, coils shall conform to their specific requirements and to such portions of this specification which do not conflict. In case of conflict, more stringent requirements shall apply and clarifications on above will be given by Jacobs through Engineer-in-Charge.

1.5 In addition to the requirements of these specifications, instructions of the Engineer-in-charge shall be followed.

2.0 FABRICATION AND ERECTION

2.1 The coils shall be fabricated in assemblies as per requirement of material requisition and standards.

2.2 The tolerances permitted on the fabricated assemblies are as under :

C/C of tubes upto 3.75” OD	:	0.5 mm
C/C of tubes above 3.75” OD	:	1.0 mm
TCD of VC Heater upto 3 m dia	:	3.0 mm
TCD of VC Heater above 3 m dia	:	6.0 mm
TCD of Helical Coils	:	4.0 mm
Tube centre line to wall surface for vertical tubes	:	4.0 mm
Out of vertical plane for horizontal tubes	:	5.0 mm
Out of plumb for vertical tubes	:	3.0 mm
Deviation from straightness of tubes	:	L/1000 or 5 mm whichever is lower. (L is the length of the tube.
Coil thinning at any cross section in case of helical coil	:	4% of specified thickness.
Maximum wall thickness at any	:	As per applicable ASTM std.

cross section		
Flattening of cross section, i.e., the difference between max. and min. diameters at the section	:	Lower of following : i) 8% of the nominal ON ii) 2 D/R, where D is the nominal dia. of the tube and R, the mean radius of bending.

2.3 Required supports, jigs, tools, tackles, etc., to avoid damage and distortion towards fabrication, handling, transportation, erection, etc. shall be designed by the Contractor and got approved from Engineer-in-Charge.

2.4 Prior to welding, the protective grease coating shall be thoroughly removed (using chemical solvent/cleaning agents of approved quality) and wire brushed to clean metal. Outside/inside surface of coil shall be wire brushed to clean metal.

2.5 For bending (hot or cold) of coil wherever required, Contractor shall submit in detail the bending or rolling method and heat treatment that may be required.
This shall be got approved from the Engineer-in-Charge. Bending of coil shall not be less than 5 times the diameter of the tube/pipe.

2.6 Where `cold pull' is required, then arrangements for the same are to be worked out by the contractor and got approved from the Engineer-in-Charge.

2.7 Lugs, pads, spigots, couplings, anchors, guides etc., attached to coil shall be welded to coils as per the details given in the relevant standards.

2.8 Cross overs at Field Fit Joints position shall be fabricated sufficiently large so that final cutting in exact length and positioning in-situ after alignment is possible.

2.9 Erection of coils shall be done by the normal approved erection procedures and to the requirements given in the drawings.

2.10 Prior to erection of coils, tube supports shall be aligned perfectly in one straight line and shall be absolutely horizontal. Final alignment shall be done by a spirit level. The use of fillers of any kind is prohibited. Perfect contact between coils and supports shall be achieved by grinding of supports. Coils shall rest uniformly over all the supports.

2.11 For coil fabrication or erection fit up, it is recommended that after correct line up, components are tack welded together and as welding of root pass progress, tacks are ground off. On completion of root pass, dye check shall be made and spot radiography taken to ensure good root pass penetration and also to check root concavity, which should be avoided. Acceptance, rejection, repairs, etc. shall all be done as detailed in other paragraphs and as approved by the Engineer-in-Charge.

2.12 All materials shall be stored fully protected.

2.13 Coil welding, assembly, testing and connected works also form part of fabrication and erection. These shall be carried out in line with the requirements of this specification shall be kept available for examination at all times.

2.14 Records as may be necessary to verify conformance of material and fabrication to the requirements of this specification shall be kept available for examination at all times.

3.0 COIL ASSEMBLY

3.1 Coils shall be assembled in Banjos', `Hair Pins' or other forms as per the drawings. Deviations to the same will not normally be considered except in special cases and such changes are to be got approved from JACOBS.

3.2 Clauses given for fabrication, erection and welding shall be considered for assemblies also.

4.0 WELDING

4.1 General

4.1.1 The welding of coil/coil assemblies at shop and at site shall be done in accordance with the details given in this paragraph.

4.1.2 Actual welding shall proceed only after all the requirements are met and the joints to be welded are certified for welding in all respects. Welding shall be done in clean environment.

4.2 Procedure Qualification

4.2.1 All welding shall be performed in strict accordance with welding procedures qualified in accordance with ASME Section-IX and as specified in this specification/drawing.

4.2.2 The Contractor shall submit the welding procedure proposed to be adopted by him together with relevant detail of joint preparation etc.

Engineer-in-charge or his inspector will review, check and approve the welding procedure after conducting such qualification tests as necessary and decide on the procedure to be finally adopted.

Tests shall be performed in all cases on specimens depending on the type of materials, operating conditions and requirements laid down in the detailed drawings and specifications. Procedure approved by Engineer-in-Charge shall be adopted.

4.3 Welding Performance Qualification

4.3.1 All welding including non-pressure welds shall be performed by welders qualified under ASME Section IX. All operators shall be required to qualify with the procedure, materials and wall thickness range which are used for coils.

Inspectors shall witness the test and certify the qualification of each welder. Only welders approved by the inspector shall be employed. Contractor shall submit the welders qualification report before the commencement of work.

4.4 Filler wire and Electrode Material

4.4.1 The deposited weld metal for all welds shall conform to the chemical and physical requirements of the base metal to produce sound welds. When a different filler metal composition from the base metal is desired, the proposal shall be followed only after

getting express written approval JACOBS.

4.4.2 The choice of electrodes and filler wires shall be made after conducting initial qualification tests in accordance with the specifications to which they conform. These shall vetted by the Engineer-in-Charge and / or his inspector. The Contractor shall submit Batch Certificates from electrode manufacturer giving details of chemical and physical tests carried out by him for each batch of electrode supplied for the job.

4.4.3 The electrode shall be stored properly to prevent moisture absorption and shall be handled in such a manner as to avoid damage to the coating. Electrode manufacturer's recommendations and/or the instructions of the Engineer-in-Charge shall be followed in all respects including storing of electrode in holding ovens, and out-of the oven time of electrodes before they are consumed.

4.4.4 Electrodes and filler wires shall be free of rust, oil, grease, earth or any other matter, which could be harmful for the quality of welding.

4.5 Edge Preparation

4.5.1 The profiles of welding grooves shall be as shown in the drawing or as per ASME B16.25 and shall be approved by the Engineer-in-Charge.

4.5.2 The edges or surfaces of the parts to be welded shall be prepared by grinding / machining. All surfaces shall be cleaned to remove dust, oil or rust by light grinding and using suitable solvents. All defects shall be removed by grinding. When the outside surface of the tube is not suitable, it may be machined to sound metal when making the weld preparation.

4.5.3 Where required, pipes may be cut by machining, grinding, flame cutting, plasmas or combinations thereof and as approved by Engineer-in-charge. Where flame cutting method is used, the metal shall be preheated prior to cutting in accordance with the Appendix 9.3 at end of this spec. Arc cutting is generally not allowed except in special cases and until detailed procedure is approved in writing. After cutting, the joint surface shall be ground to bright metal prior to welding. The extent of grinding shall be enough to remove the heat affected zones in the case of thermal, plasma and arc cut surfaces, and the same shall be demonstrated to the satisfaction of the Engineer-in-charge.

4.5.4 Where required, the Contractor shall prepare the ends which are to be welded by others, Detail shall be as given in the drawing.

4.5.5 Where special welding / joint details are specified, weld joint geometric and groove profiles shall conform to drawings unless approved in writing prior to welding.

4.6 Weld Joint Completion

4.6.1 Welded joints shall have complete penetration and fusion. All welds shall have complete fusion at the root. The internal surface shall be free of oxide.

4.6.2 Weld grooves shall be completely filled such that the surface of the weld metal at any point does not fall below the surface of the adjacent pipe. The root penetration

shall be limited to the requirements of applicable codes.

4.6.3 Weld reinforcements shall not protrude above pipe surfaces more than 1/ 16" for pipes upto 1/2" wall thickness; and 1/8" for pipes above ½" wall thickness. The surface of the weld shall blend smoothly into the adjacent base metal surface. Undercuts shall not exceed 0.8 mm or 12.5% of the wall thickness whichever is less. Length of undercuts shall be limited to the requirements of applicable codes and must be reviewed by the Engineer-in-Charge.

4.6.4 The cover pass and base metal adjacent to all welds shall be suitable for dye penetrant examination.

4.6.5 Completed joints shall be thoroughly cleaned to remove all dirt, slag, weld spatter, etc., by means of stainless steel wire brushes.

4.6.6 For Inconel, Incolony and Austenitic Stainless Steel coils, care shall be taken that wire brushes shall be stainless steel and not previously used on materials other than stainless steel or nickel-based alloys.

4.6.7 Completed joints shall be inspected to requirements laid down in para 5.0 and 6.0 of this specification. Welds joining steels of dissimilar alloys will be examined by the method required for steel having the higher alloy content. However, the proposed inspection method for dissimilar joints shall be got cleared from Jacobs.

4.7 Welding Process

4.7.1 The welding shall be shielded metal arc welding with root pass by GTAW process for alloy and stainless steel. For carbon steel, the root pass may be either shielded metal arc or GTAW process.

4.7.2 For shielded metal arc welding process, flux covered electrodes shall be used. Full side-to-side weaving of the electrode shall be employed for the filler passes.
Other welding processes may be used in special cases subject to the approval of the Engineer-in-charge in special cases.

4.7.3 Purging inside the tubes for TIG welding shall be done with Argon of 99.98% purity. Shielding Argon shall have 99.995% purity. Rate of flow shall be as established during the procedure qualification testing.

4.7.4 The welding consumables shall be as described in Appendix 9.2 of this spec. Guide and support lugs, except carbon steel to carbon steel shall be welded with electrodes conforming to class EniCrFe-3 (Inconel 182), or an equivalent approved by JACOBS.

4.7.5 Backing strips or consumable inserts shall not be used. Vertical down technique or welding shall not be used for tubes in horizontal position unless specially permitted by the Engineer-in-Charge.

4.7.6 Coil groove welding procedure shall be selected in accordance with Appendix 9.1 of this specification.

4.7.7 Welding procedure for welding bridging pieces shall be as follows :

4.7.7.1 Complete the tube weld joint following the procedure given in other clauses of this specification; with preheat PWHT requirements as per Appendices 9.3 and 9.4 respectively.

4.7.7.2 After the welding of the joint and PWHT, hardness check, radiography, repair if required, etc. shall be performed and sound joint assured. Post weld heat treatment shall be repeated after the repairs.

4.7.7.3 Weld the bridging pieces, as specified in the clauses 4.7.7.4 to 4.7.7.7

4.7.7.4 C.S., C-1/2 Mo & SS tubes

Weld continuously only one run using stringer head technique with a thin electrode (less than 2.0 mm dia) with the size of weld restricted to 2 or 3 mm. No preheating and PWHT required.

4.7.7.5 Cr-Mo tubes:

Preheat the tube around bridging pieces location to approximately 125 deg.C weld bridging pieces with one run only using a stringer head technique with a thin electrode. Wrap the completed joint with insulating blanket and allow gradual cooling. No PWHT, hardness check, and radiography required.

4.7.7.6 Bridging pieces shall be spaced as close as possible, depending upon the tube diameter and as detailed in HMTD standard No. 7-17-608, subject to approval of Engineer-in-Charge.

4.7.7.7 Choice of electrodes shall be as per Appendix 9.1 of this specification.

4.7.8 Welding of skin point thermocouples shall also be carried out as mentioned above. Contractor shall verify the junction material from the Engineer-in-charge while choosing the electrode for welding of thermocouple to tube. Welding of thermocouples shall be done under the supervision of instrument and welding specialists. Typical details are indicated in Appendix 9.5.

4.7.9 Brand of electrodes is subject to the approval of the Engineer-in-Charge.

4.7.10 Interruption during welding of a joint is not normally allowed. However, if required under special circumstances, it may be done as specified in the respective clause under “Preheating” (para 4.8) and as approved by Engineer-in-Charge.

4.8 Preheating

4.8.1 Preheating shall be done as per the following clauses in addition to ASME B 31.3. ASME Boiler Code and further recommendations of the Engineer-in-Charge.

4.8.2 Preheating of joints to the required temperature prior to actual welding shall be as per Appendix 9.3. No welding shall be done with the temperature less than the preheat temperature.

4.8.3 The preheat temperature shall be maintained without interruption until welding is completed except as stated in the clause 4.8.4.

4.8.4 For circumferential butt joints in pipe and tubing upto 1” maximum wall thickness, the welding and also the preheating may be interrupted provided at least one third of the

weld joint thickness or two layers (whichever is greater) has been deposited. Prior to resumption of welding, preheating shall be restored.

4.8.5 For welding in the case of dissimilar alloy combinations, the preheat temperature shall be according to the alloy requiring the higher temperature.

4.8.6 In case of 5 Cr-1/2 Mo and 9 Cr-1 Mo steels, upon completion of welding, the joint shall be allowed to cool to the ambient temperature in a perfectly slow and uniform manner under the covering of mineral wool after holding at a temperature of 300 °C (minimum) for about 30 minutes. Other Cr-Mo steels shall be cooled under the cover of mineral wool from the recommended preheat temperature.

4.9 Post Weld Heat Treatment – PWHT

4.9.1 PWHT may be done by the electric induction method, electric resistance method, or gas or electric heated furnaces, properly equipped to control and record temperatures and as approved by the Engineer-in-Charge.

4.9.2 Heat treatment of weld between dissimilar materials shall conform to the requirements of the steel having the higher alloy content.

All welds of low chrome alloys welded with austenitic chrome-nickel electrodes should be preheated to 400 0F minimum and post weld heat treatment shall be required unless otherwise exempted as per notes of Appendix 9.4.

4.9.3 Welded joints shall be heat treated as per ASME B31.3 and Appendix 9.4 of this specification. Heat treatment shall be done after completion of all welding.

4.9.4 Where restraint conditions necessitate post weld heat treatment of the chrome-moly tubes immediately upon completion of the welding, it is recommended that the welds be cooled to 125 - 175 degree C after welding and prior to initiating PWHT.

4.9.5 Suggested rate of cooling for 1-1/4Cr. 2-1/4 Cr and 5 Cr tubes shall be 50-75 °C per hour and for 9 Cr and 12 Cr tubes shall be 50-60 °C per hour. These values be followed in concurrence with inspector's suggestions and approval of the PWHT cycle.

5.0 TESTING AND INSPECTION

5.1 General

In addition to any required code inspection, all fabrication and materials shall be subjected to inspection by representatives of Jacobs and Owner and / or their nominated inspecting authority

5.2 Hydrostatic Test

Coil shall be hydrostatically tested at shop for prefabricated assemblies and again at site for the completed coil. All segments of the coil shall be thoroughly drained immediately after the test is completed and shall be cleaned by blowing compressed air and shall be kept closed at the ends to prevent entry of foreign matter.

5.3 Radiographic Examination

5.3.1 All welds in heater coils shall be 100% radiographically examined using X-radiation.

The radiographic technique employed shall conform to paragraph UW-51 of ASME Sec. VIII Div. I. Interpretation shall be as per paragraph UW-52.

5.3.2 Gamma ray source will be permitted for radiography for pipe wall thicknesses higher than 8 mm subject to the approval of Engineer-in-Charge. For Gamma rays, fine grain, highest contrast film shall be used as approved by Engineer-in-Charge.

5.3.3 Joints which need post-weld heat treatment shall be radiographed after PWHT. If contractor wishes to radiograph root pass or completed joint before PWHT, he may do so, but this radiography result will not be considered for acceptance of the joint. Only radiography done after PWHT and found satisfactory will be acceptable.

5.3.4 The radiographic procedure including type of source to be used shall be got approved from the Inspector. Film shall have at least 2% sensitivity over the full area being inspected as shown by approved penetrameter. The Contractor shall be responsible for carrying out radiography, rectification of defects if required and re-radiography of the welds rectified. He shall make necessary arrangements for the equipment as well as radiographic films for the satisfactory completion of the job.

5.3.5 Radiography shall be carried out in the presence of inspector. The Contractor shall submit all the radiographs to the inspection immediately after processing the radiographs. The details of radiographs shall be entered and signed by him in a register and shall be submitted to the Inspector for approval.

5.3.6 The Contractor shall provide all the necessary facilities to the Inspector to view the radiographs, such as dark room with controlled temperature, viewer etc.

5.3.7 Welds joining steels of dissimilar chemical analysis shall be examined by a method suitable for both the steels and shall bear the prior approval of Jacobs.

5.4 Dye Penetrant Inspection

5.4.1 Completed welds shall be examined by dye penetrant inspection, if required. This examination shall normally be in the as-welded condition.

6.0 DEFECTS, REPAIRS AND REJECTION

6.1 Any repairs and rectification of defects in fabrication, assembly, erection, welding, testing, etc. shall be done strictly in accordance with relevant codes, specifications and as instructed by the Engineer-in-Charge.

6.2 Defects in welding shall be removed by chipping, gouging or grinding and the required weld shall be heat treated again (if required) and re-examined for freedom from defects.

6.3 More than two repairs per joint will not be allowed. If number of repairs exceeds two, the joint shall be cut, prepared again and rewelded to these specifications and drawings.

6.4 Material supplied by Contractor, and welds on coils, indicating irremediable or injurious defects, improper fabrication, excessive repairs etc. will be rejected.

7.0 **PROTECTIVE COATINGS**

7.1 All fabricated assemblies and other items shall be coated with an easily removable rust preventive.

7.2 Coil ends bevelled for welding shall be coated with heavy grease.

8.0 MARKING, PACKING AND SHIPPING

8.1 On completion, of fabrication and prior to shipment, coil assemblies shall be shop cleaned to remove all dirt, slag, weld spatter etc.

8.2 All assemblies and joints shall be marked as shown in the drawing for assembly number with an alkyd-based paint. Hard stamping is forbidden, and any marking materials used shall not contain metals or metal salts such as lead, zinc, copper or similar low melting materials such as sulphur or chlorides which could be corrosive in service.

8.3 All fabricated assemblies and other items shall be packed and suitable protected from damage during shipment and handling. Small parts shall not be shipped loose, but shall be bagged, boxed or otherwise, suitably protected from damage or loss. Open ends of tubing etc. shall be plugged or capped to prevent entrance of foreign matter.

9.0 **APPENDICES**

9.1 Table of Recommended Welding Practices

9.2 Welding Consumables

9.3 Preheating Requirements

9.4 Post Weld Heat Treatment Requirements

9.5 Skin Thermocouple (Typical Details)

APPENDIX 9.1

TABLE OF RECOMMENDED WELDING PRACTICES

	CS	C ½ Mo	1.1/4 Cr ½ Mo	2.1/4 Cr 1 Mo	5 Cr- ½ Mo	9 Cr – 1 Mo	12 Cr	SS 304	SS 316	SS 321	SS 347	SS 309	SS 310	BK	HT	INCOLONY 800
C.S.	A/B 1-A	B/C 1-A	B 2-B	B 2-B	B 2-C	B 3-C	B/K 3-C	M/K 1-N	M/K 1-N	M/K 1-N	M/E 312 1-N	M/K 1-N	M/L 1-N	M 1-N	M 1-N	M 1-N
C-1/2 Mo		C 1-A	C 2-B	C 2-B	C 2-C	C 3-C	C/K 3-C	M/K 1-N	M/K 1-N	M/K 1-N	M/E 312 1-N	M/K 1-N	M/L 1-N	M 1-N	M 1-N	M 1-N
1-1/4 Cr-1//2Mo			D 2-C	D 2-C	D 2-C	D 3-C	D/K 3-C	M/K 2-N	M/K 2-N	M/K 2-N	M/E 312 2-N	M/K 2-N	M/L 2-N	M 2-N	M 2-N	M 2-N
2 –1/4Cr-1Mo				E 2-C	E 2-C	E 3-C	E/K 3-C	M/K 2-N	M/K 2-N	M/K 2-N	ME 312 2-N	M/K 2-N	M/L 2-N	M 2-N	M 2-N	M 2-N
5Cr-1/2Mo					F 2-C	F 3-C	F/K 3-C	*	*	*	*	*	*	*	*	*
9 Cr – 1Mo						G 3-C	G/K 3-C	*	*	*	*	*	*	*	*	*
12 Cr							O/M 3-C	*	*	*	*	*	*	*	*	*
SS 304								B 1-D	B 1-D	B 1-D	B1-D	B 1-D	K 1-D	K/M 1-D	K/M 1-D	M 1-D
SS 316									I 1-D	I 1-D	I 1-D	I 1-D	K/L 1-D	K/M 1-D	K/M 1-D	M 1-D
SS 321										J 1-D	J 1-D	J 1-D	K/L 1-D	K/M 1-D	K/M 1-D	M 1-D
SS 309											K 1-D	K 1-D	K/L 1-D	K/M 1-D	K/M 1-D	M 1-D
SS 310													L 1-D	L/M 1-D	L/M 1-D	M 1-D
BK														K/M 1-D	M 1-D	M 1-D
HT															M 1-D	M 1-D
INCOLONY																M 1-D

800																

NOTE:	1. In the box: Top line indicates welding conumables (Refer Appendix 9.2); Bottom line left indicates preheat requirements (Refer Appendix 9.3),
	Bottom line right indicates post weld heat requirements (Refer Appendix 9.4)
	2. (*) These combinations may be joined by welding. Heat treatment may however, adversely affect the properties of one of the bass metals, Contact JH&G for further information.
	3 (*) PWHT may affect the corrosion resistance properties of the austenitic stainless steel weld metal under some conditions, Confirm with JH&G before use.

APPENDIX 9.2

WELDING CONSUMABLES

*A	E-6010 for Root and E-7018 for Cover passes
B	E7016, E7018, ER70S-2 Bare Wire
C	E7016-A1, E7018-A1, ER80S-D2
D	E8016-B2, E8018-B2, ER80S-2, ER80SB2L
E	E9016-B3, E9018-B3, ER80S-B3, E 312
F	E502-15 (5 Cr – ½ Mo) , ER 502 Bare Wire
G	E505-15, (9Cr – 1 Mo), ER 505 Bare Wire
H	E308-15, E308-16, ER 308 Bare Wire
I	E316-15, E316-16, ER 316 Bare Wire
J	E347-15, E347, Bare Wire
K	E309-15, E309-16, Bare Wire ER 309
L	E310-15, E310-16, Bare Wire ER 310
M	Eni Cr Fe-3 (Inconel 182), ER Ni Cr-3 (Inconel 82) Bare Wire
N	E 310-15 HG
+O	E 410-15, E410-16, ER 410 Bare Wire
*	For pipe or tube sizes upto 4” O.D. or ½” wall thickness, maximum
+	For special requirements of impact test and BHN, Chroloy No.414 is recommended.

APPENDIX 9.3

PREHEATING REQUIREMENTS

1. 50 ^{0}F for Carbon Steel with thickness less than 1" and min. specified tensile strength not exceeding 71000 psi.
   50 ^{0}F Carbon-moly steel upto ½" thickness, and min. specified tensile strength not exceeding 71000 psi.
   50 ^{0}F for all thickness of alloys 304, 316, 321, 347, 309, 310, HK and Incoloy 800.
   175 ^{0}F Carbon-moly steel over ½" or with min. specified tensile strength exceeding 71000 psi.
   175 ^{0}F Carbon steel 1" and over or with min. specified tensile strength exceeding 71000 psi.
2. 300 ^{0}F for 1-1/4 Cr – ½ Mo Steel
   350 ^{0}F for 2-1/4 Cr – ½ Mo and 5 Cr – ½ Mo Steels
3. 400 ^{0}F for 9 Cr – 1 Mo and 12 Cr steels.

APPENDIX 9.4

POST WELD HEAT TREATMENT REQUIREMENTS

A 1100 ^{0}F - 1200 ^{0}F See Note 1
B 1250 ^{0}F - 1350 ^{0}F See Note 1
C 1325 ^{0}F - 1350 ^{0}F See Note 1
D See Note 2
N Not required where the ferritic member is within the limits shown in Note 1. For situations outside these limits, Jacobs will provide specific instructions.

Note 1:

PWHT is not required for the following conditions:

a) Carbon steel Tubing or Piping of less than ¾" wall thickness.

b) Carbon-moly tubing or piping upto ¾" wall thickness, and min. specified tensile strength not exceeding 71000 psi.

c) Chrome-moly tubing or piping that meets all of the following requirements :
   i) A maximum specified chromium content of 3%
   ii) A maximum wall thickness of ½"
   iii) A minimum preheat of 350 ^{0}F (300 ^{0}F for Cr content not exceeding 2%).

d) Fillet welds attaching external non-pressure parts such as lugs or other pipe supporting elements to carbon steel, carbon-moly, 1-1/4 Cr – ½ Mo, 2-1/4 Cr – 1 Mo pipe or tube provided the throat thickness of the fillet weld does not exceed.
   i) ½" for attachments to carbon steel and carbon-moly
   ii) ¼" for attachments to chrome-moly pipe or tubes.
   The minimum preheat temperature shall be as specified in Appendix 9.3 based on the pipe or tube wall thickness.

e) Fillet welds used in slip-on and socket welding flanges and connections, as follows :
   i) Carbon steel materials, regardless of thickness, when the weld throat thickness does not exceed 5/8".
   ii) Carbon-moly steel and chrome-moly steel (upto 3% max. chrome content), regardless of thickness, when the weld throat thickness does not exceed ½".
   iii) The minimum preheat temperature shall be as specified in Appendix 9.3 based on the pipe or tube wall thickness.

Note 2:

No post weld heat treatment normally required. However, when service conditions require post

weld heat treatment, Jacobs will provide specific instructions.

APPENDIX 9.5

SKIN POINT THERMOCOUPLES

- Skin point thermocouples are the safety instruments to ensure that the tube metal temperature does not exceed the recommended metal temperature.
  Generally use of Inconel 182 filler wire/electrode is recommended for welding of the thermocouple. Refer electrode selection chart for different metallurgy of coil and thermocouple.
  Following points shall be ensured while welding of the skin point thermocouples:
- Ensure that the thermocouples are of "K" type. K type of thermocouple generally consists of SS sheathing ½" O.D. x 0.12.5" thick filled with insulating material such as Magnesium oxide. End of the element is shaped in "V" shaped pad and the junction of the thermocouple is located in the centre of "V" shaped pad.
- Profile of the thermocouple shall be suitable for the tube size.
- Ensure proper cleaning of the tube surfaces to sound metal so that good weld joint is made.
- Employ qualified welds under supervision of welding specialists as well as instrumentation engineer to make sure proper welding.
  Typical welding procedure followed for welding of thermocouples
- "V" shaped pad shall be welded to the tube surface after proper preparation and thoroughly welded following the proper welding procedure involving low heat TIG welding.
- Clean the tube area 3" (75) long x 2" (50) wide by grinding, Wire brushing alone is not considered adequate.
- Locate the clamp firmly in place in desired location (centre of "V" pad must touch the tube surface). Weld the clamp in place.
- Make root, secondary and final weld passes using low heat TIG welding with proper filler wire.
- It should be noted that improper welding could give false results and create undue panic.

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1.0 GENERAL

1.1 This specification covers requirement towards fabrication, assembly, erection, testing, handling etc., and completion of the job in all respects for FIRED HEATERS along with the works related to the Air Preheating Systems. Where supply is involved, this specification covers requirements towards supply as well.

1.2 This specification and the detailed specifications noted herein are general specifications for all types of heaters and relevant applicable clauses are to be considered for a particular job. The contractor is deemed to have studied all details written herein and to have understood the details and job in totality. All activities connected with the scope are to be considered while working out cost of different rates. This specification and the other specifications referred herein shall be read along with the "Job Specification" which are complimentary to each other.

1.3 The items of work in this specification are categorised as follows :

1.3.1 Steel work fabrication and erection.

1.3.2 Coil fabrication, assembly, erection and welding.

1.3.3 Erection of coil support castings.

1.3.4 Erection of equipment's forming part of the heater, (e.g.: Burner, Soot blower, APH, Fan, Damper, etc.)

1.3.5 Refractory lining application including fixing tie backs.

1.3.6 Assistance during job execution.

1.4 All the items of work shall be executed in accordance with these technical specifications, along with other referred specifications, and codes. However, additional/alternate specifications and instructions may have to be followed, as and when required. The work shall be executed to sound engineering practices following the above specifications and instructions. In case of conflict between specifications, the more stringent ones or the instructions given will govern. All activities towards execution and/or all requirements/formalities to be met towards completion of the job in all aspects as noted in this specification are to be done to the complete satisfaction of the Engineer-in-Charge.

1.5 This specification does not cover the following works for which separate specifications may be referred.

1.5.1 Foundation works, but grouting is covered here.

1.5.2 Instrumentation works, but welding of skin point thermocouple is covered here.

1.5.3 Electrical works

1.5.4 Refractory dry out, but assistance required is covered here.

1.5.5 Final painting but primer including heat resistant coat is covered here.

1.5.6 External piping works.

1.6 The total work involved is grouped into major activities as outlined in the Job Specification and schedule of rates. Other connected works detailed and noted in these specifications are also to be done within the prices quoted for the major grouped activities. Works of minor nature not mentioned here but forming part of the

work towards completion of the job in all respects are also to be accounted in the quoted rates. No extra for such activities will be paid unless the same is well defined as an addition to the scope of work outlined in the tender/enquiry.

1.7 For details regarding material supply in contractor's or owner's scope, `SCOPE OF SUPPLY' para in "Job Specification" shall be referred.

1.8 Drawings or standards accompanying the tender document / enquiry are indicative whereas job execution shall be done on the basis of `Issued for Construction' drawings released after job award including subsequent revisions. All residual engineering, preparation of all detailed and fabrication drawings including obtaining approval of same from Jacobs shall be the contractor's responsibility. For detail requirements of fabrication drawings and submission refer para 7.0 of this specification.

1.9 Any tests required extra other than regular tests required by codes/specifications shall also be done when doubts arise.

1.10 All repairs, rectifications etc. required due to unsatisfactory workmanship or test results will have to be rectified without delay. The decision of the Engineer-in-Charge will be final on all these matters.

1.11 Records, certifications, test results and other documentation as required shall be completed and handed over in required format and required number of copies.

1.12 All temporary arrangements, jigs, tools, fixtures, etc., for executing any job shall also be arranged to the satisfaction of Engineer-in-charge.

1.13 Formalities towards approval of drawings, procedure, materials, qualifications of skilled personnel, documentation, fabrication, erection, testing, etc., shall all be got done before the actual commencement of the particular operation.

1.14 All liaison work with statutory organisations (such as Boiler Inspectorate, Pollution Control, etc.) and preparation of drawings and documents for these approvals are to be done by the contractor at no extra cost.

1.15 Stainless steel nameplate supplied by owner shall be welded to heater casting in the indicated location. Contractor's nameplate as approved by Jacobs may be welded to the heater casing in the indicated place.

1.16 All materials supplied by Owner shall be collected at issue points and shall be stored / kept safely under safe custody and handled properly with all precautions during job execution. All unused materials shall be safely returned to the stores. Wastages as allowed will be accounted.

1.17 Details of "Free Issue" material are given in "Scope of Supply" para of "Job Specification", (all material other than those) specified, that are required for the completion of the job, are to be procured and supplied by contractor.
All details are required to be studied and got clarified since no extra claims will be entertained later on this issue.

1.18 The entire work shall be done either at a workshop at site or shall be done in prepackaged / modular construction in an outside shop with bare minimum of in-situ

work. Following paragraphs describe both alternates. However, in case specified alternative has already been mentioned in Job Specification the same shall be adopted for the work. While bidding for the job the Contractor shall visit the site to assess the site conditions and all factors shall be considered while bidding for the job.

1.18.1 Site Work

The entire fabrication shall be done at site in a site shop set up for this purpose and all refractory and field works done in situ or at grade near the site. For this purpose, the contractor shall set up a site shop for executing all works.

1.18.2 Modular / Package Constructions :

1.18.2.1 The work shall be done in prefabricated sections/ modules either in contractor's own shop or in a fabrication shop set up by the contractor at a suitable location for this purpose. This is mainly due to the considerations that section-by-section fabrication at site would not be possible due to various constraints and this particular method would reduce IN SITU site work, time and HOT WORK at site. In this regard, the following shall form the basis of deciding the extent of pre-fabrication outside the site.

- Contractor's handling facilities in the shop which include lifting, handling, space availability, tools, tackles, auxiliary facilities like refractory lining, testing facilities etc.
- Transport facilities in terms of weight, OD consignment etc.
- Handling facilities at site including unloading, lifting facilities etc. including the facilities that can be arranged by Contractor himself.
- The erection sequence and schedule, which may decide the sizing of safe, permissible loads of module sizes.

1.18.2.2 Contractor has to submit, along with the bid, an indicative schedule and sequence of modular fabrication, erection and field work.

This will be scrutinized and evaluated and is likely to be one of the main considerations along with requirements specified in the earlier clause, for award of contract, for modular construction option.

1.19 Materials supplied by owner shall be given proper care during storage, handling, transportation, fabrication, erection etc. Any damage done at any time shall be made good without any cost implication to the client and without delay.

Alternately Owner/Jacobs shall do such activities themselves and back charge the expenses to the contractor.

1.20 Necessary facilities and precautions shall be provided towards avoiding damage, distortions, etc. to fabricated assemblies during handling, transportation, erection, etc.

1.21 Required material, consumables, skilled and unskilled labours, supervisory staff, tools, tackles, scaffoldings, safety gadgets, equipments for measurements, recording and such activities, all appliances towards preheating, stress relieving, welding, radiography, etc., all handling, transportation and erection equipments, all kinds of

temporary arrangements, protection facilities where required, alignment facilities, equipments for refractory preparations and application, shuttering materials, inspection, examination and testing facilities and all such materials required towards completing the job in all respects are all required to be provided.

Cost towards all the activities, whether noted in this specification or not, is to be accommodated in the quoted price, given under major categories in the schedule of prices.

1.22 The main scope of work is classified into :

i) Supply
ii) Fabrication,
iii) Erection

All other activities connected with the work such as supply, receipt and return of materials, storage, safety of materials, handling, transportation, assembly, fabrication, erection, welding, bolting, testing, recording, arranging for statutory regulations etc. including requirements given in the previous paragraph and all connected activities including setting up of shop, temporary or other facilities towards execution of the job in all respects are also to be done as written in the specification and are to be considered in any one or all of the three main activities given above in this paragraph.

1.23 All codes and specifications to be followed which are referred to in this specification and the detailed specifications shall be the latest revision. In addition, heater fabrication, erection shall be done in line with the requirements of API 560.

2.0 STEEL WORK

2.1 The heater steel work consists of framework, shell, casing, stack, off-take ducts, header boxes, tube sheets, platforms, staircases, ladders, handrails, air preheater structure, flue gas and combustion air ducting, plenums, etc., and shall be executed in accordance with steel work specifications.

2.2 Following appurtenances also form part of steel work.

2.21 Access doors, pressure relief doors, painters trolley rail, floor peep holes, tube handling devices, different sleeves and such appurtenances attached to the steel work.

2.2.2 Guide vanes, fabricated expansion joints, combustion air plenums, distribution ducts etc., which are part of the air preheat system.

2.2.3 Auxiliary connections for instruments, snuffing steam etc., attached to the casing. These shall be installed as required.

2.2.4 Shut off blades and operating mechanism :

2.2.5 Fabricated Damper :

These shall be shop assembled and installed for smooth operation. It shall be ensured that damper blades clear the insulation.

All items are to be supplied covering blade, spindle, bush, bearings, bolts and nuts,

counter weight, etc., when supply is included. Damper bearings shall be self-aligning, high temperature, non-seizing, self-lubricating, sealed for life.

2.2.6 Damper Control Arrangement :
These shall be installed with all materials supplied such as wire, thimbles, sleeves, bolts and nuts, winches, etc. and ensuring smooth operation of the control unit and damper. Dampers will be provided with fail safe facilities.

2.2.7 Stainless Steel Work :
Sleeves, brick shelf flats, soot blower shield plates, corbel plates, retainer plates an such items attached to the heater steel work, are covered in this category.

2.2.8 All above items will be accounted in weights as shown in the schedule of rates. Where the Schedule of Rates is silent, those items will be measured as part of steel work. No extra charges towards supply will be made and they shall be accounted in steel work rates.

2.2.9 Cast Iron Sight Doors :
These shall be supplied in the assembled form and fixed in position along with required bolting materials.

2.3 Wherever fabrication involved materials other than mild steel, (such as CS, SS, etc.) relevant Indian and /or other codes approved by the Engineer-in-Charge shall be followed.

2.4 Gaps and openings/ expansions joints shall be packed or left carefully and free expansion shall be ensured. Sealing materials shown at these locations shall be accounted in the steel work rates.

3.0 HEATER COIL

3.1 The heater coil comprises convection coils, radiant coil, crossovers, jumps overs, manifolds, terminal assemblies etc.

3.2 These shall be fabricated, assembled and erected meeting all requirements of the specifications enclosed.

3.3 To the extent possible, the coil work will consist of shop welded and tested joints with minimum number of site/field weld. Where field-fit-up is required, provision for 100mm extra tube length is to be kept to take care of final adjustments and cold pull where specified.

3.4 Dressing and minor tube and rectification works to pipes and other materials are to be done for materials supplied by the owner. All precautions shall be taken to prevent any damage to the materials during job execution. Major repairs other than dressing and rectification of tube ends, will be compensated by the Client.

3.5 Tubes for heater coils will be supplied in one or more lengths with bevelled ends, when supplied by the Owner. In case of supply in two or more lengths, each full length tube shall be built to the required length from these cut lengths. For crossover coils, cutting to required lengths and bevelling the ends are also to be done. Tubes for helical coils will be supplied in unbevelled random lengths (Random lengths of 5 to 7 m generally). It shall be ensured that none of the weld joints in built up length

falls at any of the supports location in cold or in operating conditions.

3.6 When coil materials are supplied by the contractor, these shall be exactly to the specifications noted and full details of supply shall be furnished. Materials shall be procured only from Vendors approved by Jacobs.

3.7 In some cases, the radiant coil consists of certain number of cast plug headers, or cast fittings, welding of which has to be done with special care.

3.8 The coil includes provision for thermowells, vents, drains, and such auxiliary connections. Welding of all these, bolting flanges etc., where required and connected works shall also be taken into account in coil fabrication and erection. These projections are not accounted for in the quantity indicated. However, weld joints for these provisions are accounted.

3.9 Welding lugs, pads, spigots, couplings, anchor materials etc., attached to the coil as supports/guides shall be included in the quoted rates of fabrication and erection of the coil and no separate payment will be made towards the same.

3.10 Tubes and fittings supplied with bevelled ends will be in accordance with ASME B16.25 to suit the pipe wall thickness to which the fitting is welded.

3.11 The skin point thermocouples welded to coils and shown in arrangement drawings are indicative for position and are to be welded to coils. Contractor shall make necessary provision sin refractory and steel work for accommodating these skin point thermocouples in their respective positions.

3.12 The process thermowells will be fixed by other agency whereas fittings and flanges for these shall be fabricated and welded to coils. Contractor shall provide for accommodating these in refractory and steel work of the heater.

3.13 All steam service coils are under IBR. Contractor shall comply with all IBR regulations for these coils. Engineering drawings and calculations for these coils will be provided by Engineer-in-Charge / Owner and Contractor shall arrange for IBR approvals and inspection of coils.

3.14 Intermediate joints for extended surface tubes where specified involve welding of bridging pieces as well, apart from welding of tubes. These bridging pieces are to be welded as given in coil fabrication, assembly and erection specification. Bridging pieces shall also be supplied by the Contractor to the same material composition as studs / fins.

4.0 COIL SUPPORT CASTINGS

4.1 The coil supports comprise of intermediate tube sheets, tube sheet supports, wall tube hangers, roof tube hangers, connecting bars, locking-bars, guides, etc., and are made of cast steel materials of high/medium alloys or carbon steels.

4.2 These are to be transported to site/shop and fixed in position. The bolts, nuts and washers required for fixing these supports are to be supplied by contractor.

4.3 All coil supports shall be aligned perfectly in position before the coils are placed in position and welded. Aligning shall be done to such an extent that the tubes will rest uniformly on all supports. Final alignment shall be done by a spirit level. Perfect

contact between coils and supports shall be achieved by grinding of supports. The erected tubes shall be in perfect horizontal / vertical position as the case may be and also be absolutely parallel to the side walls. The alignment done shall be to the complete satisfaction of the Engineer-in-Charge.

4.4 Following tolerances are allowed :

Horizontal tube supports + 2 mm
Vertical tube supports + 2 mm

5.0 **EQUIPMENT ERECTION**

5.1 Equipments comprise of Burners, Soot Blowers. Bought out Dampers, Drop out Doors, FD Fan and Motor, ID Fan and Motor, Suction Stack and Venturi, Air Preheater, Spring Supports, etc.

5.2 These are to be supplied in the assembled or sub-assembled form as received from the manufacturer. Contractor shall carry out transportation and erection, bolts, nuts, gaskets, washers, etc. to fix these items shall be supplied by the Contractor.

In addition to this specification, instructions from the supplier/manufacturer of the equipment shall also be complied with.

For fans, fan erection specification shall be followed. In addition to supplier / manufacturer's instructions. Presence of the manufacturer's representative or the Engineer-in-Charge as the case may be to supervise the erection of fans has to be ensured at proper time.

5.3 Special precautions shall be taken to keep sensitive and valuable parts fully protected as directed by the Engineer-in-Charge.

5.4 If required, contractor shall dismantle and reassemble the equipment as referred for ease of erection.

5.5 All precautions shall be taken to keep these equipments clean and safe.

5.6 When supplied by the Contractor, these shall be supplied, exactly to details furnished to the contractor and transported, handled and erected to details already written in the above paragraphs.

5.7 In some cases, following main equipments have attached equipment, as shown , and these also have to be erected along with the main equipments. These will be located in the heater area itself. Extent of work involved will be given in the Job Specification.

5.7.1 Burner
- Burner firing / lighting transformer, cabling and ignition arrangement.
- Burner management panel with necessary wiring, tubing etc.

5.7.2 Soot Blowers
- Sequential Control Panel.

5.7.3 Bought Out Drop put doors and dampers
- Instrument unit/control arrangement winch, pulleys ropes etc., Erection shall be done as per following paragraph :

5.7.3.1 Site contractor shall erect the dampers / panels in the duct work as per drawings /

specifications / instructions.

5.7.3.2 The dampers shall be installed in the duct work and bolted with asbestos gaskets / bolting to ensure leak proof joints. The actuators, positioners limit switches, if removed for transportation to site, shall be remounted and linkages, readjusted if found necessary.

5.7.3.3 Once the actuators are installed, the damper control panels shall be mounted and hooked up. The tubing/SS hoses / wiring shall be done according to the control schemes. Limit switches shall be mounted to ensure correct signalling of damper blade position.

5.7.3.4 Damper vendor shall depute concerned operating/erection staff for conducting the testing and correct installation of dampers / panels etc. to ensure correct installation of dampers.

- functional performance
- inching through positioners
- fail safe operation
- crack opening test if so specified
- actuation times for fully Open/Close.

The contractor shall provide all assistance to damper suppliers to carry out following tests :

5.7.4	Fabricated stack Damper	-	Pneumatic cylinder and control unit alongwith winch, pulleys, ropes etc.
5.7.5	ID/FD fans	-	As received from Supplier.
5.7.6	Air Preheaters	-	As per the following paragraph

5.7.6.1 The air preheater vendor would send the APH Unit to site, duly match marked as follows :

a) The air preheater shall be in modules. Each module shall be a complete assembly duly tested at airpreheater manufacturer's shop. Lifting lugs shall be provided on the modules for handling/erection.

b) Return headers shall be sent loose to site. Depending on size of the headers these may be each in two pieces. Each header (or sub-assembly of header) shall be provided with lifting lugs.

c) Gaskets / bolting needed for assembling modules one on top of other shall be supplied by air preheater vendor. Gaskets / bolting for assembling the header pieces and headers with air preheater shall be supplied by air preheater vendor.

5.7.6.2 In addition the following requirements shall also be taken care of during residual engineering and finalising the APH scheme's details.

a) For maintenance of the equipment, flue gas inlet duct shall have a spool piece at APH end. This shall be easily removable.

b) Flue gas inlet duct shall have two manways (opposite each other) of 600 x 600 mm with centre line 800 mm above the APH top flange.

c) Flue gas outlet duct is attached to underside of APH as shown in the setting plan. It is recommended that an intermediate spool piece be provided at APH outlet end in flue gas duct. During the subsequent maintenance, in case the outlet duct needs to be removed, the spool piece can be left attached to APH. A manway (600 x 600) should be provided in the outlet flue gas duct. Outlet duct should also have a 4" NB connection for draining out water used for washing air preheater during shut down.

d) Air inlet and outlet ducts shall have a 600 x 600 manway each, near the APH end for inspection of internal bolting.

e) APH when fouled is to be washed with water jet. It is proposed that a water connection for this purpose be provided near the APH top (recommended 1.5m to 2 m above the top of APH with gate valve and end suitable for connection of water hose). Plant water (or fire water) at about 4 kg/cm2 is adequate

f) Ground area near the APH structure towards the return header end (i.e. wall no.3) shall be used for placing the air preheater modules before being assembled on the support structure or during maintenance. This area shall preferably be equal to the APH plan area with sufficient clearance all round.

g) Crane approach should be considered for picking up the modules from this area and assembling on the support structure.

5.7.6.3 The air preheater erection contractor shall carry out the following :

a) Place the lowermost module on the air preheater supporting structure. Slotted holes have been provided in the APH base plate to allow for thermal movement of the cloumn 502, 503, 504. Holding down high tensile bolts/ nuts / washers shall be in the scope of the erection contractor. Bolt up the base plate to the support structure through these high tensile bolts.

b) Mount the subsequent modules (refer setting plan for module sequencing) one on top of the other. Bolt up the top beam of the lower module and the lower beam of the top module to each other through asbestos gasket and bolting. Similarly, bolt up the lower and upper side panels through the beams and also the side base plates with asbestos gasket and bolting. Ensure that all the joints are leak tight. Check the panel columns bolted up in modular form are in a straight line without eccentricity.

c) Bolt up headers in case these are split in two segments. Use asbestos gasket 6 thk x 65 wide and CS bolting.

d) Connect up the return header using 6 thk. Asbestos gasket and CS bolting to the air preheater.

e) Connect inlet and outlet flue gas and air ducts. Gaskets, bolting and tapered washers for interconnection of flue gas and air (inlet and outlet) ducts shall be supplied by erection contractor.

f) Provide outer insulation (of mineral wool) on return headers.

g) Paint the structure as per painting specification and column coding scheme.

6.0 REFRACTORY AND INSULATION WORKS

6.1 The refractory and insulation works comprise mainly of Brick and Block work, Castable lining, Block and Castable lining and ceramic fibre lining as indicated in the Job Specification and Schedule of Rates. Besides these, many items such as Tar paper, Heat resistant adhesives, asbestos tap/cloth/gasket, corrosion inhibitor, sealing materials, gap packing materials, refractory wash, emulsion paint, mortars and silicates spray etc. also form part of the work. The hot insulation covers mineral wool or other insulations with fixing arrangements.

6.2 The Job Specification and Schedule of Rates indicate the main lining of the heater. Miscellaneous materials are not shown there and are indicated in the drawings, standards and specifications only. The cost of supply and application of these miscellaneous materials shall be included in the rates quoted for the main lining.

6.3 Exterior of hot air ducts, plenums APH return headers and ID fans casings are to insulated with mineral wool with aluminium cladding comprised of cleats, straps, screws, bituminous felt stips, aluminium sheets etc. Material and applications shall be as defined in the respective specification enclosed. Part of the burners hot air individual duct shall also be lined with mineral wool.

6.4 Refractory materials supplied shall be of a make given in the detailed specification. Equivalents shall be as approved by the Engineer-in-Charge and no alternate specification is acceptable. Brand names where specified are specific requirements and only those materials shall be procured. Source of supply shall be indicated in the offers. None of the refractory materials shall be purchased from the stockists.

6.5 Miscellaneous materials shall be of standard make available in the market and as approved by the Engineer-in-Charge.

6.6 All expansion joints in lining or gaps shown in the lining around castings, burners or other items shall be packed properly with packing materials. Loose bricks shall be laid maintaining required gaps and expansion provisions.

6.7 Insulation blocks are designed as back up lining between bricks and casing plates and shall be placed carefully as specified in refractory material spec. A thin layer of corrosion inhibitor shall be applied to the steel surface in contact with the insulation block.

6.8 There is no joining mortar or compounds required between steel to blocks, steel to concrete, block to block , block to brick or block to concrete.

6.9 The corbelling of refractory in convection section is to be done with great care and to be done exactly to the details shown in the drawings. Maximum corbelling shall be limited to 114 mm.

6.10 Sufficient overage (min.15%) over and above the S.O.R/estimated installed quantity for the refractory quantity for working and other losses shall be accounted, no extras will be considered for payment.

6.11 All materials supplied shall be marked clearly for identification as instructed during execution of work.

6.12 Adequate measures for proper storage and handling of refractory materials including all precautions to prevent deterioration in quality/ property of the materials, expiry of shelf life before installation shall be taken. For this purpose, the contractor shall make a go down of his own at site in the allotted space and procure the materials at the correct time depending on installation planned.

6.13 Apart from manufacturer's test certificates, the contractor shall carry out the tests on insulation concrete if required at shop and/or at sites for mixing procedures, application etc. These test certificates and test results shall be got approved from Engineer-in-Charge before starting any work.

6.14 Sub-contract of site work is allowed only with the prior permission and prior approval of the Engineer-in-Charge. Conditions for supply of material by Sub-contractor shall be same as listed in this tender document. Left over material from any of the earlier jobs shall not be used without written permission of Jacobs.

6.15 Where refractory lining is applied at grade and steel work erected with refractory, any damage that is caused during handling and erection shall be made good in situ without delay and without any compensation thereof.

6.16 Necessary precautions for protection of burners during lining or packing of joints and their cleaning at the end of the job, shall be provided.

6.17 Fabrication of lugs and fixing of refractory anchors to steel work shall be carried out to steel work specification.

6.18 Contractor shall depute his representative with workmen during drying out operation to be carried out by the Owner. Any defects arising due to Contractor's workmanship or defective materials supplied by the Contractor shall be immediately rectified or replaced as directed by Engineer-in-Charge, at the Contractor's cost and without delay.

6.19 After drying out, any defects and repairs noticed shall be rectified immediately.

6.20 Cracks in concrete are not to exceed 1 mm width and should be limited to half the thickness of insulation. More than three cracks per square meter are not permissible. Cracked bricks are not acceptable.

6.21 Tolerance allowed for materials shall be as per referred codes and for workmanship shall be as per applicable specifications and as approved by the Engineer-in-Charge.

6.22 For application of insulation concrete, fire bricks, ceramic fibre blankets and mineral wool hot insulation separate specifications are written which are also to be followed. For the details not covered in these specifications and the instructions of the Engineer-in-charge shall be followed.

6.23 In order to ensure good quality of refractory work, contractor must submit to Jacobs

for approval the details specifications, make and grades of all materials being procured by him, the application procedure for various items, and the refractory detailed drawings, indicating refractory, anchors location and details.

7.0 **FABRICATION DRAWINGS SUBMISSION BY CONTRACTOR:**

Unless noted otherwise in "Job Specification" or "Special Condition of Contract", contractor is required to furnish, as a minimum, the following drawings/documents before taking up execution of 'Heater ad APH System" related job activities.

7.1 For tseel work, detailed fabrication drawings submission shall be as per Jacobs specification.

7.2 For Coil / pressure parts, detailed fabrication drawing showing all weld joint locations, components bill of material, sub assemblies scheme etc., shall be submitted to Jacobs specification.

7.3 Refractory & Insulation Work

7.3.1 Contractor must submit all details of various refractory materials being procured by him covering materials make, grade, properties and specifications along with supplier catalogues.

7.3.2 Contractor shall submit detail application procedures along with supplier's recommendation.

7.3.3 Contractor shall also submit the detailed fabrication drawings for each refractory items covered in tender. These drawings must indicate the details of arrangement, specially at the corners and joining areas of two different type of lining, the refractory anchors / tie backs spacing and details bill of materials. In case of ceramic fibre linings the supplier'' recommendations regarding tie back system and various other details should also be covered in the documents being submitted for Jacobs approval.

8.0 **ASSISTANCE DURING JOB EXECUTION**

8.1 Contractor is required to offer assistance to the Engineer-in-Charge/Owner in all possible manners towards smooth execution of the job.

8.2 In particular, manpower assistance as required during refractory dry out and pre-commissioning activities, shall be offered to Jacobs/Owner.

Carbon Steels		
API 5L Gr B	Pink	Seamless
API 5L Gr B	Pink / White	Welded
A 106 Gr B	Red	IBR
A 106 Gr B	Yellow	Non IBR
Welded and seamless fittings	Red	IBR
Welded and seamless fittings	Yellow	Non IBR
Welded fittings	Yellow / White	Normalized
Miters	Silver	
Class 22 fittings	Silver / Pink	Stress relieved at shop
IS 3589- IS 12239	No Paint	Non-critical
Alloy Steels		
P1, F1. WP1, WP1W etc.	Green / Red	
P12, F12, W12 etc.	Green / Yellow	
P22, F22, WP22 etc.	Green / Silver	
P11, F11, WP11 etc.	Green / Orange	
P5, F5, WP5 etc.	Green / Blue	
P9, F9, WR9 etc.	Green / Pink	

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Standard Specification		Document No: IND-SS-Z-005	Page: 1 of 12
Piping - Welding		Supersedes: Rev 1	Revision: 2 Issue Date : 21-Mar-11
Issuing Department: Construction – Asia Region	Functional Manager: AL.Benny@jacobs.com	Previous Rev. & Issue Date: Rev 1, 2-Aug-04	Effective Date: 01-Apr-11

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1.0 PUPOSE

This purpose of this specification is to define the construction requirements of welding for pipelines.

2.0 SCOPE

2.1 This specification supplements the applicable code requirements / specifications / drawings for fabrication, erection, inspection, testing of pipelines.

2.2 Engineering drawings/ codes/ standards shall take precedence over this specification if there are any conflicting clauses.

3.0 INTRODUCTION

The specification shall be adopted to all welded pipe joints of Carbon Steel and Stainless Steel piping system coming under the Plant.

The welded pipe joints are defined as under:-

a) All line joints of the longitudinal and circumferential butt welded and socket welded type.

b) Split sleeve joints on certain S. S. Pipes.

c) Attachments of castings, forging, flanges and other supporting attachments to pipes.

d) Welded manifold headers and other sub-assemblies.

e) Welded branch connections with or without reinforcing pads.

f) Manufacture of welded / fabricated piping components.

g) The attachment of smaller connections for vents, drains, drips and other instrument tappings.

All welding, heat treatment, other ancillary welding equipment and the welding personnel shall be in accordance with the following accepted standards, codes and procedures, latest editions as applicable.

a)	Code for Petroleum Refinery Piping	- ANSI B31.3
b)	Standard for Welding Pipes and other Related Facilities	- API 1104
c)	Welding Qualifications	- ASME Sec. IX
d)	Code of Procedure for Metal and Welding of C.Steel	- IS-823
e)	The Indian Boiler Regulations	- IBR

In the event of any variation due to additional requirements over and above those that are obligatory as per codes, this specification shall be binding.

4.0 WELDING EQUIPMENT AND ACCESSORIES

All welding machines, line up clamps, levelling machines and other equipment's used in connection with the welding work must be satisfactory and must be kept in good mechanical condition so as to produce sound welds. Only D.C. Motor generator welding sets or Rectifier Welding sets shall be used for welding on pipes.

For TIG welding on stainless steel pipes high frequency units shall be used in conjunction with D.C. Motor generator welding sets or Rectifier Welding Sets.

5.0 WELDING PROCESS

5.1 No welding process or procedure shall be adopted without prior approval of the Owner / Consultant.

5.2 All piping shall be welded using either the Shielded Metal Arc Welding (SMAW). Process or the Gas Tungsten Arc Welding (GTAW) process or a combination of the two.

5.3 Oxy-acetylene brazing shall be used for brazing copper and copper alloys where used. Oxy-acetylene soldering process shall be used for soldering bronze to C.S. and Cast Bronze to copper.

5.4 For welding of all grades of Steel and Nickel alloys by the GTAW process, a 2% Thoriated Tungsten Electrode confirming to AWS a5, 12-69 EW TH - 2 classification shall be used.

5.5 Any other welding process, if proposed by the Contractor, shall require specific approval of Owner / Consultant.

5.6 A combination of different welding processes or a combination of electrodes of different classes / makes could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of Owner / Consultant.

6.0 WELDER'S QUALIFICATION AND PROCEDURE TESTS

6.1 WELDER'S QUALIFICATION

Any Welder who is entrusted with the performance of welding work shall pass the pipe Welder Test to ASME Section IX. Prior to his assignment in the field, the Welder shall weld a test specimen in a horizontal and vertical position or as directed by Owner / Consultant as per the requirement of ASME Section IX. API 1104 or other equivalent / applicable code as may be required and get him qualified for welding on the job.

Depending on the pipe welding shall be done on one or several pipes.

For all welding coming under IBR, Welders shall be qualified by Boiler Inspectorate possessing IBR.

Certificate in addition to above shall only be employed.

The Owner / Consultant shall witness the test and certify the qualifications of each welder separately.

IBR Welders shall be approved by the Boiler Inspector before deployment on the Job.

The test specimen shall be 100% radiographed.

The test specimen 2.5 cm in width, shall be taken out from the pipe piece at right angles to weld. The test specimens shall be subjected to root bend, face bend, tests. These tests shall be arranged by the Contractor at his own cost but shall be witnessed by the Owner / Consultant.

The manner of performing the test and the results required shall be in accordance with ASME Section IX, API - 1104 and ASME Boiler and Pressure Vessel Code as may be applicable.

The contractor shall submit the Welders qualification test report in the standard format as required by Owner / Consultant.

The Welder shall not be entrusted with any work until the test specimen has been fully evaluated and approved.

If a Welder is found to perform a type of welding or in a position for which he is not qualified, he shall be debarred from doing further work. All such welds performed by an unqualified Welder shall be out and redone by a qualified welder at the expense of the Contractor.

6.2 Welding procedure qualification tests shall be carried out in accordance with job requirements and the relevant requirements laid down in Section IX of ASME Boiler and Pressure Vessel code or other applicable codes and the job requirement. The Contractor shall submit the welding procedure to the Owner / Consultant who will check and approve the welding procedure and shall release the procedure for procedure qualification tests. Standard tests shall be performed in all cases. In addition to these standard tests. Tests like micro-examination, hardness tests, dye-penetration examination, charpy V notch and U notch impact tests, etc., shall be carried out on specimens depending on the type of base, materials, operating conditions and requirements laid down in specification. It shall be the responsibility of the Contractor to carry out all such tests free of charge. The procedure qualification test shall be carried out by the Contractor at his expenses.

It shall be the responsibility of the Contractor to carry out all the tests required to the satisfaction of the Owner / Consultant.

7.0 WELDER'S SYMBOL

After qualification, the Welder's symbol shall be confirmed and recorded in a list. This symbol (die stamp) shall be used for identifying all welds made by that welder.

For thin-walled and alloy steel pipes, the welding superintendent may decide that the Symbol will be applied to the work piece by painting.

8.0 WELDING PROCEDURE

8.1 EDGE PREPARATION

The edges to be welded shall be prepared to meet the joint design requirement by any of the following methods given below:

a) Carbon Steel
Gas cutting, machining or grinding methods shall be used. After gas cutting oxides shall be removed by chipping or grinding.

b) Low Alloy Steel Containing up to 2.5% Chromium

Gas cutting, machining or grinding methods shall be used. After gas cutting machining or grinding shall be carried out on the cut surfaces.

c) Stainless Steel

Plasma cutting, hacksaw cutting, machining or grinding methods shall be used. Plasma cutting out shall be machined or ground smooth.

8.2 CLEANING

The ends to be welded shall be properly cleaned to remove paint, oil, grease, rust, oxides, sand, earth and other foreign matters. The ends shall be completely dry before the welding commences.

8.3 ALIGNMENT

The pipe shall be aligned so that the longitudinal mill weld in the pipe is on the top 90 degrees of the pipe lines (except on vertical bends) and in such a way that the longitudinal Mill welds are staggered not less than 45 degrees.

Elements to be joined by welding shall be aligned with the aid of internal or external centering facilities. Root opening and root gap shall depend on the root welding procedure and as per code specified.

The welding butts as well as the surroundings must have a bright finish and be free of grease.

For pipes of wall thickness 5 mm and above the ends to be welded shall be secured in position with the aid of couplers, yokes, and 'c' Clamps to maintain perfect alignment. Yokes shall be welded to the pipes with the electrodes suitable for welding the parent pipe material and shall be detached after the completion of weld, without causing any surface irregularities. Any irregularity caused on the pipe surface must be suitably repaired to the satisfaction of the Owner / Consultant.

Tank welds, for maintaining the alignment, of pipe joints shall be made only by qualified welders. Since the tack welds become part of the final weldment they shall be executed carefully and shall be free from defects. Defective tack welds must be removed prior to the actual welding of the joints. Tack welds should be equally spaced - Minimum number of tacks shall be:

2 tacks - for 2 ½" dia, and smaller
4 tacks - for 3" to 12" pipe dia.
6 tacks - for 14" pipe dia, and larger

8.4 WEATHER CONDITIONS

The parts being welded and the welding personnel should be adequately protected from the rain and strong winds. In the absence of such a protection no welding shall be carried out.

During field welding using CTAW process, particular care shall be exercised to prevent any air current affecting the welding process.

General Welding Requirements

a) Surfaces to be welded shall be free from paint, rust, oil, grease, dust or any other contamination.

b) Root passes shall be made with electrodes / filler wires recommended in the welding specification chart and as approved in procedure test. The preferable size of the electrodes is 2.5 mm diameter (12 SWG) but in any case not greater than 3.15 mm (10 SWG).

c) Upward technique shall be adopted for welding pipes held fixed with its axis horizontal.

d) The root pass of butt joints should be executed properly so as to achieve full penetration with complete fusion of the root edge without under cutting along the sides of the weld.

e) Welds shall be cleaned between passes to remove all traces of slag and flux before successive beads or layers are deposited. The craters at the starting and stopping points of each individual bead shall be carefully examined and any defects shall be removed by grinding. Wire brushed used for cleaning stainless steel joints shall have stainless steel wires and the grinding wheels used for grinding stainless steel shall be of a suitable type. Separate grinding wheels and wire brushes should be used for Carbon steel and stainless steel.

f) Welding shall be continuous and uninterrupted during a pass.

g) While the welding is in progress care should be taken to avoid any kind of movement of the components.

h) Fillet weld shall be made by shielded metal arc / CTAW welding process irrespective of the thickness and class of piping. Fillet welds shall preferably be slightly convex and shall be free from undercutting and overlap at the tee of the weld.

i) Peening shall not be permitted.

j) Dams used for conserving inert gas during purging, shall be removed after completion of the welding and shall be accounted for.

k) Joint shall be completed using the class of electrodes recommended in the welding specification chart.

l) Two weld beads shall not be started at the same point in different layer.

m) Butt joints shall be completed with a cover layer that would effect good fusion at the joint edges and a gradual notch free surface.

n) The welding shall be free from under cuts and other defects.

9.0 CLEANING OF WELD JOINTS

All weld joints shall be free from adherent weld spatters, slag, swarp, dirt or foreign matter. This can be achieved by brushing. For stainless steel, brushes with only stainless steel bristles shall be used.

10.0 INSPECTION AND TESTING GENERAL

a) Owner / Consultant shall have free access to all concerned areas, where the actual work is being performed.

b) Owner / Consultant shall be entitled to inspect at shop or field where prefabrication and erection of pipe lines are being done with the following objectives:

i) To supervise the welding procedure qualification.

ii) To supervise the welder performance qualification.

iii) To check the conformance to relevant standards and suitability of various welding equipment's and the welding performance.

iv) Any other checking / inspection work connected with Construction work.

v) For welding of all grades of steel and nickel alloys by the GTAW process, a 2% Thoriated Tungsten electrode confirming to AWS AS 12-69 EWTH - 2 classification shall be used.

vi) Argon Gas Cylinder (Min. purity 99.95%) with regulator and flow meters.

vii) Nitrogen Gas Cylinder (Min. purity 99.95%) with regulator and flow meter.

viii) The power source shall consist of a meter generator welding set connected with a high frequency unit or rectifier welding set connected with a high frequency set.

ix) Inspection of all welds shall be carried out as per ANSI and other relevant applicable codes, latest edition. All finished welds shall be visually inspected for parallel and axial misalignment of the work, excessive reinforcement, concavity of welds shrinkage, cracks, inadequate penetration, un-repaired

burn through under cuts, dimensions, of the weld, surface porosity and other surface defects.

INTERNAL WELD PROTRUSION (INCLUDING PENETRATION BEAD)

Normal Pipe Size	**All Protrusion in mm**
Upto 1" NB	1.0 mm or 3% of pipe outside dia. whichever is less.
Over 1" NB upto 2 ½" NB	1.5mm or less
Over 2 ½" NB upto 10" NB	2.0mm or less
Over 10" NB upto 18" NB	2.5mm or less

Normal Pipe Size		**All Protrusion in mm**
i)	Over 18" NB	3.0mm or less
ii)	Weld ripple irregularities	2.5mm or less
iii)	Lack of uniformity in Bead	2.5mm or less
iv)	Lack of uniformity of leg length	2.5mm or less
v)	Unevenness of Bead	2.5mm or less
vi)	Weld undercutting (Weld undercutting of 0.5mm or less shall be smoothly finished)	2.5mm or less
vii)	Overlaps	1.5mm or less
viii)	Bead Deflection	2.5mm or less
ix)	Thickness of weld reinforcement	

Nominal Wall Thickness	
Upto 12mm	2.5mm or less
Upto 12mm upto 25mm	3.0mm or less
Upto 25mm upto 50mm	3.5mm or less
Upto 50mm	4.0mm or less

10.1 SHIELDING AND PURGING

Purging at a flow of approx. 0.28. m^3 / hr subjected to maximum of 1.4m^3 / hr depending on diameter of pipe until 6 times the volume of the Section of piping between the dams has been replaced is usually adequate. In no case should the initial purge be for less than 10 Minutes.

10.2 After the initial purging is completed the flow of Backing gas during welding should be reduced to a point where only a slight positive pressure prevails. For systems which have a small volume (up to 14 liters) to be purged during welding a gas flow rate of 0.14 m^3 / hr is usually adequate. Systems of larger volume may require higher flow rates and these should be established at the procedure test. Purging is not required on socket type welded joints, provided it is ensured that oxidation does not take place in case of stainless steel material. Argon Gas shall be used for shielding purpose.

The rate of flow for shielding purposes shall be established in the procedure qualification.

10.3 The filler wire shall be of approved quality and test certificates for the batch production of filler wire from the manufacturer shall be furnished by the Contractor to the Owner / Consultant for approval.

TIG Welding shall be done in stringer runs.

11.0 EXAMINATION METHODS AND REQUIREMENTS

The type and extent of weld examination shall be as per the piping specification attached.

11.1 VISUAL EXAMINATION

As a matter of principle the exterior of all weld joints must be examined visually and as far as possible the interior also before starting any other examination.

11.2 RADIOGRAPHY EXAMINATION

11.2.1 The radiography examination shall be carried out in accordance with the piping specification.

11.2.2 The procedure and quality of radiography examination limits of acceptability, repair and removal of defects etc., shall be as per API Standard 1104, ANSI 1331.3 and other applicable codes.

11.2.3 Where 10% radiography is called for, this shall be spread uniformly over all pipe diameters in a particular system as follows:

In diameter up to and including 500mm shall mean 10% of the joints in each pipe diameter encountered.

11.2.4 The radiographers employed shall be qualified as stipulated in the said codes and must be fully familiar with radiographic equipments and methods including safety procedure and thoroughly experienced in the field of radiographic work.

11.3 DYE PENETRATION TEST

Liquid penetrant examination is a method of non destructive examination which for the detection of discontinuities open to the surface in ferrous and non ferrous material which are non porous. Typical discontinuities detectable by this method are cracks, seams, laps, cold shuts and laminations.

11.3.1 Surface Preparation

a) In general satisfactory results may be obtained when the surface is in the as-welded, as-rolled, as-cast, or as-forged condition. When the surface irregularities mask the indication of defects, grinding or machining of the surface will be required.

b) Prior to liquid penetrant examination, the surface to be tested and any adjacent area within atleast 25mm of the surface to be tested shall be dry and free of any dirt, grease, lint, scale, welding flux, spatters, oil or any extraneous matter that would obscure surface openings or otherwise interfere with the test.

11.3.2 Drying

Drying of the surface to be tested, after steaming can be accomplished by normal evaporation.

11.3.3 Penetrant Application

a) The penetrant solution confirming to the code IS 3658 / 1966 shall be applied by dipping, brushing or spraying.

b) Penetration time is critical. In general, the finer and tighter the discontinuity, the longer the penetration time should be. At temperature between, 16°C and 52°C, the penetration time shall be atleast 10 minutes, but this minimum time may have to be extended under certain conditions.

c) Penetrant shall not be allowed to become "tacky". If a long penetration is required, fresh penetrant shall regularly be applied to the surface to ensure that the surface is wet at all times.

d) After the penetration time specified in the procedure has elapsed, any penetrant remaining on the surface shall be removed.

11.3.4 Developing

a) The developer shall be applied as soon as possible after the penetrant removal operation and the interval shall not exceed the time as specified in standard document and codes.

b) The developer is a suspension of powder in water or a volatile solvent and shall be applied by dipping or spraying.

11.3.5 Examination

a) It is a good practice to observe the surface during the application of the developer in order to detect the nature of certain indications, which might tend to bleed out profusely. Final interpretation however, shall be made after allowing the penetrant to bleed out for a minimum of seven (7) minutes to a maximum of thirty (30).

b) The developer should form a more or less uniform coating. Surface defects are indicated by bleeding out of the penetrant, which is normally of a deep red colour.

11.4 ULTRASONIC TEST

The ultrasonic test may be performed, provided that the work pieces are of suitable material and wall thickness and that qualified personnel is available.

12.0 DEFECTS

Defects revealed by visual inspection as well as radiographic inspection and / or dye penetrant check of welds shall be repaired / rectified by the Contractor at his cost to the satisfaction of the Owner / Consultant. The repaired portion shall be re-examined by dye check and / or radiographically at no extra cost to the Owner. The repairs carried out shall meet the approval of the Owner / Consultant. For Weld Joints other than 10% radiography, 2 additional checks shall be carried out for each weld joint judged "Not applicable" and these shall be made on welds done by the welder who is responsible for defective workmanship at no extra cost to the Owner.

A register of welding checks shall be maintained and continually updated by the Contractor, said register shall indicate the opinions expressed by the Owner on examining welding joints, welding to be repaired and the reference of welder who has performed the work. A register revised to the date of their last entry shall be consigned to the Owner at the end of work.

All radiographic films submitted by the Contractor or the independent Agency carrying out the radiographic inspection of welds shall be the property of the Owner / Consultant. All cost and expenses involved in radiographic inspection including but not limited to the cost of labour,

materials, equipment, tools and payments to the independent agency by the relevant item of the Schedule of Rates. Repeat radiography due to defective unclear and un-sharp films or in repaired joints due to contractor's fault shall be carried out at Contractor's cost.

13.0 WELDING CONSUMABLES

The welding consumables used shall meet requirements of the relevant codes and shall produce a deposit with, which is compatible in chemical analysis and similar in mechanical properties to the parent material.

Only consumables which have received the prior approval of the Owner / Consultant shall be used.

SS Consumables

max. Ferrite contents	6% permissible
max. Copper	0.2% permissible

Before proceeding with welding, Contractor shall submit for approval to the Owner / Consultant for type, brand and size for each batch of consumables for use in each class of piping.

Different grades of electrodes shall be completely separated. The Contractor shall have facilities available for storing electrodes at recommended temperatures where specified. The consumables shall be stored and handled at all times during construction so as to avoid damage to them and to the containers in which they are transported. Those in open containers shall be protected from excessive moisture changes. Electrodes, filler wires and fluxes that show signs of damage or deterioration shall not be used. Electrodes shall be stored in electrode storage ovens at 250°C - 300°F or as otherwise, recommended by manufacturer.

14.1 APPENDIX 1 WELDING SPECIFICATION CHART

Sr. No.	Material	P. No.	MOC Specification	Pipe size and thickness	Welding process		Material		Type of Joints	Purging	Shielding	Remarks
					Root Pass	Filler Pass	Root Pass	Filler Pass				
1	Carbon Steel	P1	A 53 Gr. 'B' API 5L Gr.'B' A 285 Gr.'C' IS 1239 IS 2062	Pipe Size 2" & above with wall thickness upto 19mm	SMAW	SMAW	E 6010	E6013	BUTT WELD	NA	NA	
2	Carbon Steel	P1	A 106 Gr.'B' A 105 A 216 Gr. WCB A 181	Pipe Size 2" & above with wall thickness above 19mm	SMAW	SMAW	E6010 / E7016 / E7018	E7016 / E7018	BUTT WELD	NA	NA	
3	Carbon Steel	P1	A 53 Gr. 'B' API 5L Gr.'B', IS 1239, A 106 Gr. 'B', A 105	Pipe size 1½" and below irrespective of thickness	SMAW	SMAW	E7018	E7018	FILLET WELD	NA	NA	
4	Carbon Steel	P1	As in Sr. No. 1&2	Pipe Size 2" & above with wall thickness upto 19mm	GTAW	SMAW	ER70S2	E7018 / E7016	BUTT WELD	NA	Argon	
5	Stainless Steel	P8	A 312 TP 304 A 312 TP 304L	Pipe Size 2" & above with wall thickness upto 12mm	GTAW	SMAW/ GTAW	ER308/ ER308 L	E308L E308	BUTT WELD	Nitrogen	Argon	
6	Stainless Steel	P8	A 312 TP 304 A 312 TP 304L	All sizes thickness > 12mm	GTAW	SMAW	ER308/ ER308 L	E308-15/ E308-16	BUTT WELD	-Do-	-Do-	
7	Stainless Steel	P8	A 312 TP 321	All size, All thickness	GTAW	SMAW	ER347	E347-15/ E347-16	BUTT WELD	Nitrogen	Argon	

14.1 APPENDIX 1 WELDING SPECIFICATION CHART

Sr. No.	Material	P. No.	MOC Specification	Pipe size and thickness	Welding process		Material		Type of Joints	Purging	Shielding	Remarks
					Root Pass	Filler Pass	Root Pass	Filler Pass				
8	Stainless Steel	P8	A 312 TP 316 A 312 TP 316L	All sizes, All thickness	GTAW	GTAW/ SMAW	ER316L ER316	ER316 - L/ E316 - L	BUTT WELD	Nitrogen	Argon	
9	Low Alloy Steel	P1	A 333 Gr. 6	All sizes, All thickness	GTAW	SMAW	ER70 S 2	E7018-Al E8018-Cl	BUTT WELD	NA	Argon	
10	Low Alloy Steel	P9 B	A 333 Gr. 3	All sizes, All thickness	GTAW	SMAW	ER80SNi 3	E8016-C2 / E8018-C2	BUTT WELD	NA	Argon	
11	Low Alloy Steel	P3	A 335 P1	All sizes	GTAW	SMAW	ER80S D2	E7010A1 E7018A1	BUTT WELD	NA	Argon	
12	Low Alloy Steel	P4	A 335 P 11	All sizes, All thickness	GTAW	SMAW	ER80S B2	E8018 B2 E8015 B2 E8016 B2 E8018 B2 L	BUTT WELD	NA	Argon	
13	Low Alloy Steel	P5	A 335 P 22	All sizes, All thickness	GTAW	SMAW	ER90S B3	E8018 B2 E8015 B2 E8016 B2 E8016 B2L	BUTT WELD	NA	Argon	

NA - Not Applicable.

NOTE : This is for guidance only and actual site requirement shall be decided as per applicable codes.