

ANNEXURE - 2(a)

TECHNICAL SPECIFICATION FOR WELDING OF STATION PIPING

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Scope

This specification shall be followed for the fabrication of all types of welding joints of piping system within the battery limits of all pressure piping of station.

This specification shall apply to all suppliers, vendors, manufacturers, and fabricators of welded pipes. The **CONTRACTOR** is responsible for all and shall ensure that all components to be incorporated into the work meeting this specification.

No supplier, vendor, manufacturer or fabricator shall subcontract the welding fabrication of any item without written approval from the OWNER

The welded pipe joints shall include the following and shall not relieve the **CONTRACTOR** of his responsibilities and guarantee.

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

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Codes, Standards and Regulations

All welding performed under this Specification shall meet or exceed the requirements specified by the latest revisions of the following applicable Codes and Regulations, Indian Provincial regulations governing the welding of piping systems, argument with the following:

1. AWS (American Welding Society).
 - a) A2.4 (Symbols for Welding and Non destructive Testing).
 - b) A3.0 (Standard Welding Terms and their Definitions).
 - c) A5.1 (Specification for Mild Steel Covered Arc Welding Electrodes).
 - d) A 5.17 (Specification for Bare Carbon Steel Covered Electrodes).
 - e) A 5.18 (Specification for Carbon Steel Filler Metals for Gas Shielded Arc Welding).
 - f) A 5.20 (Specification for Mild Steel Electrodes for Flux Cored Arc Welding Electrodes).
2. ASME B 31.3 Chemical Plant and Petroleum Refinery and Process Piping.
3. ASME Sec. VIII Div. 1 - Pressure Vessels.
4. ASME Sec. IX - Welding.
5. ASME/ANSI B31.8 - Gas Transmission and Distribution Systems.
6. ASME Sec V - Non-destructive examination.
7. API Std 1104 – Standard for Welding Pipelines and Related Facilities.
8. AWS D 1.1
9. PNGRB NOTIFICATION: Technical Standards and specifications including safety standards for city or local natural gas distribution Schedule-1 network
10. ASNT/PCN/CGSB Standards for certification of Non-Destructive testing Personnel.

All welding procedures used by fabricators and **CONTRACTORS** shall have been established and qualified in accordance with the appropriate sections of one or more of the codes and standards listed above, and approved by the OWNER.

Where a conflict occurs between these specifications and / or any of the above codes or standards the more stringent shall apply.

3 WELDING PROCEDURES

3.1 CONSUMABLES

The **CONTRACTOR** shall provide at his own expenses, all the welding consumables necessary for the execution of the job such as electrodes, filler wires, argon etc, and these should bear the approval of the OWNER.

The welding electrodes and filler wires supplied by the **CONTRACTOR** shall confirm to this specification and standard codes and shall be of the make approved by the OWNER and shall submit all test certificates to the EIC for review and approval.

The **CONTRACTOR** shall submit batch test certificates from the electrodes manufacturers, giving details of physical and chemical tests carried out by them, for each batch of the electrodes to be used.

Electrode qualification test records for each batch shall be carried by **CONTRACTOR** and test records submitted, for obtaining the approval of the EIC.

The electrodes, filler wires and flux used shall be free from rust, oil, grease, earth and other foreign matter, which affect the quality of the welding.

All coated metal arc-welding electrodes shall comply with AWS specification A 5.5, A5.1 type unless approved otherwise by the OWNER.

All welding consumables including fluxes shall be supplied in sealed containers and stored in a dry location at a minimum temperature of 68°F/20°C. and a maximum relative humidity of 60%. Low-hydrogen electrodes, after removal from factory seal containers, shall be stored at a minimum temperature of 150°F/66°C and suitably dried prior to use.

The welding filler metals shall have a chemical composition as near as possible to the parent metals to be welded. The finished weld as deposited, or after post weld heat treatment (PWHT) when required, shall be at least equal to the parent metal as to unit strength, ductile, and other physical properties and in resistance to corrosion, hydrogen attack, or other operating environment factors as required. Permission to change filler metals to those other than the ones qualified in accordance with this specification must be obtained in writing, from the OWNER.

Electrode and rod diameters shall conform to the parameters of the weld procedure.

The **CONTRACTOR** shall provide adequate drying ovens and take proper precautions in the storage and handling of low-hydrogen electrodes.

Electrodes and filler rods shall be protected from mechanical damage or deterioration. All unidentified damaged or deteriorated electrodes or filler wires shall be removed from the working area and rejected. Any low hydrogen type SMAW electrodes not contained in heated quivers shall be removed from the site. Electrodes shall not be exposed to wet or high humid conditions.

Care of welding consumables is the responsibility of the **CONTRACTOR** however; the following are minimum requirements:

Low-hydrogen SMAW electrodes shall be kept in commercial electrode ovens after the factory container has been opened. The electrode holding oven temperature shall be maintained between 175°F (79°C) and 250°F (121°C). Any low-hydrogen SMAW electrodes that have been exposed for more than 4 hours prior to restocking into the holding oven or any SMAW low-hydrogen electrodes that have become wet or have damaged coatings shall not be used rejected and removed from site.

Other (non-low-hydrogen) SMAW electrodes shall be kept in a dry and dust-free enclosure after opening of the factory container. These non-low-hydrogen electrodes shall be held at a temperature below 150°F (66°C).

Bare wire and bare filler rod (GTAW) shall be stored in a dry and free from dust, grease etc.

3.2

WELDING PROCESS

Welding of various materials under this specification shall be carried out using one or more welding process as given below with the approval of the EIC.

- Shielded Metal Arc Welding Process (SMAW)
- Gas Tungsten Arc welding process (GTAW)

The **CONTRACTOR** shall have a separate welding procedure for each method of welding he intends to employ.

Automatic and semiautomatic welding processes shall be employed only with the express approval of the EIC. The welding procedure shall be adopted and consumables used shall be specifically approved.

A procedure qualification record (PQR) shall be included for each WPS. The PQR shall be witnessed by the OWNER/ OWNER's Representative or shall be supported with the lab report from the testing laboratory, if so previously agreed to by the OWNER.

A combination of different welding process could be employed for a particular joint only after duly qualifying the welding procedure to be adopted and obtaining the approval of EIC.

All testing shall be performed and certified by OWNER approved testing laboratory, agency or equivalent. The minimum acceptable written procedure shall detail information on the following parameters:

1. The scope of work performed under the procedures.
2. The base metals and applicable specifications.
3. The welding process.
4. Type, size, classification and composition of filler metals. (The specific brand name(s) of the flux-wire shall become an essential variable of the procedure qualification)
5. Type of current and voltage range As per range
6. Width of electrode weave or oscillation
7. Joint preparation and cleaning procedures.
8. Tack welding procedures. Method of marking the location of tack welds to facilitate post weld inspection shall also be included
9. Electrode polarity.
10. Applicable welding positions.
11. Preheat and inter pass temperatures. (Control method)
12. Welding travel speed.
13. Root preparation prior to welding from second side, (where applicable).
14. Removal methods for weld defects and stray arc strikes.
15. Inter pass-cleaning method.
16. Repair welding.
17. Post welding heat treatments (if required).
18. Shielding gas, and flow rates
19. Type of (GTAW) electrode, size and tip angle.
20. Welders qualified and deployed in production welds shall always bear an identity card in the manner so approved by OWNER/OWNER's representative.

The **CONTRACTOR** shall only employ welders who have a valid welding certificate for the procedures being used.

The **CONTRACTOR** shall have all welders tested in accordance with the applicable code or standard. Testing shall be at the **CONTRACTOR's** expense including test pieces. Irrespective of pre-qualification all welders proposed to be deployed in the work shall be tested and qualified as fresh.

No welder shall be allowed to make any weld for which he is not qualified.

Welding with larger-size electrodes for specific applications may be allowed only if each welder qualifies with the largest-size electrode to be used in production. This option is strictly at the OWNER discretion. OWNER shall specify the details of the welder qualification tests. For carbon steel, filler wire combinations shall be chosen such that the deposited hardness of the cap pass shall not exceed 240 BHN. For low-temperature materials and other materials heat input shall be minimized and comply with the WPS parameters.

The **CONTRACTOR** may propose alternate process in addition to those listed. Any proposed process shall require written OWNER approval and qualification prior to implementation. **CONTRACTOR** and OWNER shall agree on tests, results, and other criteria before OWNER approval is granted.

All welds in pipe smaller than 60.3 mm O/D ("NPS 2" inch) shall be made by GTAW. Root pass by gas metal arc is acceptable for pipe larger than 60.3 mm O/D (NP (2") inch).

All welds in pressure equipment must be qualified for Charpy V impact testing at 0°C for high tem, -20 °C for low tem. When the code requirements indicate that the parent material requires impact testing.

When impact tests are required, tests shall be taken from the weld metal, fusion line, 2mm from fusion line, and 5mm from fusion line.

Permanently installed backing rings shall not be used.

All butt welds in pressure equipment shall have the same chemical and mechanical properties as the parent metal.

All welding procedures must be qualified for Charpy V impact testing when the Code requirements indicate that the parent material requires impact testing.

Extreme care shall be taken to ensure that electrode separation by classification is maintained in the **CONTRACTOR**'s inventory. All storage bins and ovens for welding consumables shall be clearly labeled. In addition, all GTAW bare rod filler metals shall be tagged with the AWS designation of the filler metal. Any welding consumables not readily identifiable shall not be used.

All pressure containing welds shall be of a minimum of two passes with overlap of starts and stops. This shall include socket welds and seal welds of threaded connections.

Weld stops and starts shall be staggered so that adjacent weld passes do not contain stops/starts within 25mm (1 "inch) of each other.

The electrodes shall be purchased from the list of approved manufacturer's and the same shall be supplied with proper certificates and batch certificates.

The width of weave during production welding shall be within the acceptable limit of the OWNER approved and qualified welding procedure, qualification certificates, and production welding operating sheets. As a norm this will be limited to a maximum of 3 times the core diameter of SMAW electrodes, whichever is the lesser.

Each weld pass layer shall be completed in one full cycle/ circumference before proceeding with the next. Blocking out or segmental welding is not permitted.

All tools and equipment used in the welding operations shall be in first class operating condition and shall be of sufficient capacity to ensure welds of the specified quality are achieved throughout the work. It shall be the right of the OWNER to request at any times the re-calibration of gauges and meters etc. to ensure compliance with welding procedure-operating sheets/ WPS.

3.3 Joint Preparation

The surface of the pipe at the weld area shall be free from dust, grease, scale, paint, grit or any other foreign material, which may adversely affect the final weld quality.

Bevels shall be 37½° and all field cuts shall be normal to the axis, of the pipe, Miter welds are prohibited.

All pipes shall be beveled for welding with an approved mechanical beveling machine.

Damage to bevels, which could possibly affect the quality of the weld, shall be remedied prior to welding. If beyond repair the pipe shall be cut and the pipe end re-beveled, Lamination check by UT method shall be done prior to welding of gas cutting end pipe.

Where welding pipe both to a flange or another pipe or component, there must be a band of at least 254 mm (1" inch) wide around the internal / external joint weld preparation that is ground to bright metal, and is free of all foreign matter,

To assure proper spacing and alignment in accordance with the applicable Code, an approved lineup clamp shall be used.

All Weldments shall conform to the straightness and alignment specified herein. Correction of improperly fitted parts shall be accomplished by disassembly and refitting. Reworking by hammering or flame straightening shall not be permitted.

The ends of piping components to be joined shall be aligned as accurately as is practicable within existing commercial tolerance on diameters, wall thickness, and out of roundness. Maximum bore mismatch shall not exceed 1/16" inch (1.6 mm), Alignment shall be preserved during welding.

When joints of unequal thickness are joined, the internal offset shall not exceed 1.6 mm (1/16"). If this value is exceeded, the excess thickness of the heavier end shall be machined or ground back from the bevel on a one-to-four (1:4) taper.

Maximum bore mismatch shall not exceed 0.8mm (1/32 inch), Where ends are to be Joined and the internal misalignment due to difference in wall thickness, etc. exceeds 1.6 mm (1/16 inch), the wall extending internally shall be internally trimmed, Internal machining shall be performed so that the inside diameters of the components coincide.

When cutting pipe to length, it should be cut by mechanical means. If practical, Ends that are to have flanges attached either in the shop or field must be cut true and square.

3.4 Preheating

Preheat for pressure piping and furnace tubs shall be in accordance with ASME B31.3 and B31.8.

All pipe joints having a wall thickness greater than 9.5 mm (0.375") shall be preheated to 100°C prior to welding when the ambient temperature is less than 10°C (500 F).

Preheating shall be carried out with an approved torch system or with electrical induction coils which will provide uniform heating.

The preheating area shall be at least 200 mm (8") wide centered about the weld and shall extend around the entire circumference of the pipe.

Preheat temperatures shall be checked with temperature sensitive crayons or by other approved methods.

If a joint requires preheating, the same temperature requirements shall be maintained for each succeeding pass.

3.5 WELDING DETAILS

3.5.1 All pressure welding shall be performed in accordance with approved and qualified welding procedures as required per code.

3.5.2 Each weld shall be uniform in width and size throughout its full length.

3.5.3 Each layer or welding shall be smooth and free of slag cracks, pinholes, undercut (Internal and external), porosity and excessive bead shall be completely fused to the adjacent weld beads and base metal.

3.5.4 The cover pass shall be free of coarse ripples, irregular surface, non-uniform pattern, high crown, deep ridges or valleys undercut, arc strikes, porosity, undercut, slag, or shatter.

3.5.5 Butt welds shall be slightly convex, of uniform height, and have full penetration, unless otherwise approved.

- 3.5.6 For piping, limitations on weld reinforcement shall apply to the internal surfaces as well as to the external.
- 3.5.7 Fillet welds shall be of a specified size with full throat and the legs of uniform length.
- 3.5.8 Arcs shall only be struck in the weld groove. A controlled arc must be maintained while welding. Should an arc strike occur, it shall be removed by grinding and the area shall be etched (10% Nital) to confirm heat affected area removal, and MT examined to ensure absence of any surface cracking.
- 3.5.9 After each pass the layer of weld metal must be cleaned to remove all slag, scale dirt etc. wire brushes, grinder, or chipping hammer shall be used as needed to prepare proper surface for each succeeding weld pass.
- 3.5.10 Repair, chipping or grinding of welds shall be done in such a manner as not to gouge, groove or reduce the base metal thickness.
- 3.5.11 No welding shall be done if the temperature of the base metal is below 50°F. Nor shall there be any welding done if there is moisture, grease, or any foreign material on the joint to be welded.
- 3.5.12 A qualified welder shall make tack welds. Cracked tack welds shall be completely ground out and NDE by MT/PT prior to re-weld.
- 3.5.13 The **CONTRACTORS** shall make no substitution of materials or modifications to details without the prior written approval of the OWNER.
- 3.5.14 Welders and welding operators shall not be qualified on production welds.
- 3.5.15 The **CONTRACTOR** shall ensure that welders and welding operators are only employed on those parts of the work for which they are qualified.
- 3.5.16 Each welder and welding operator shall possess an appropriate temperature measuring device. All supervisors shall possess a copy of the approved welding procedures.
- 3.5.17 Alternatively, welding procedures may be clearly displayed at each welding location. Welders shall be familiar with the requirements of the appropriate approved welding procedures. Any welder found not complying with the approved welding procedures during production welding shall be removed from the work and the non-conforming weld(s) may be completely rejected, at the discretion of the OWNER.
- 3.5.18 No welding should be undertaken without approved WPS.
- 3.5.19 The OWNER will not provide any WPS for the **CONTRACTOR**.

3.6 Welding Techniques

3.6.1 General

All welding shall be performed in accordance with an approved and qualified welding procedure.

3.6.2 Cleaning

All weld impurities shall be removed between passes. Cleaning may be done with either hand or power tools.

All rough irregularities in the cover pass and weld spatter shall be removed.

3.7 Weld Identification

Each finished weld shall be clearly marked to identify the portion made by each welder.

3.8 Defects and Repairs

Welds containing defects not exceeding an aggregate of five (5) percent of the length of the root bead may be removed by grinding, chipping or arc gouging and re-welded in accordance

with an approved procedure. Welds containing defects exceeding that amount shall be cut out and replaced.

When defects are ground out the entire weld shall be preheated to a temperature of 150 °C (300 °F) prior to welding.

All repaired welds shall be radio graphed or by the same method of original defect detention.

3.9 Post Weld Heat Treatment (PWHT)

- 3.9.1 **CONTRACTOR** is responsible for all PWHT requirements. Which shall be performed as specified by the OWNER and in accordance with ANSI/ASME B31.3.
- 3.9.2 PWHT of pressure piping and furnace tubes shall be in accordance with ASME B31.3, B31.8 and the specification for Post Weld - Heat Treating.
- 3.9.3 Controlled atmosphere furnaces are preferred for heat treatment. Procedures using electric resistance, induction, or flame burner rings are acceptable for shop or field heat treatment. OWNER prior to heat treatment must approve these procedures.
- 3.9.4 **CONTRACTOR** must notify the OWNER prior to starting PWHT operations.
- 3.9.5 **CONTRACTOR** shall furnish a PWHT record chart. The chart must be dated, numbered and labeled with job identification. **CONTRACTOR** name and person Responsible for the PWHT. Heat-treated lane, welds and spool numbers shall be identified on the chart.
- 3.9.6 The completed PM/HT record chart shall be submitted for OWNER approval following completion of heat treatment.
- 3.9.7 Stress relieving of piping shall be performed as per ASME B31.3 ASME B31.8 as applicable.
- 3.9.8 Stress relieving may be performed by electrical induction or by electric resistance heating devices, or by furnace that has a large enough capacity to accommodate the entire piece being heat-treated.
- 3.9.9 The stress relieving temperature to be attained shall be 1100°F/593°C minimum. 1150°F/621°C maximum. The soak period of this temperature shall be one hour per 25.0 mm (1 inch) of pipe wall thickness and in no case shall the soak period be less than one hour.
- 3.9.10 Rate of heating and cooling shall be in accordance with the requirements for thermal stress relief presented in Section VIII of the ASME Boiler and Pressure Vessel Code. In any event, the rate of heating above 600°F/315°C may not be more than 400°F/205°C per hour, nor the rate of cooling more than 500°F/260°C per hour when above 600°F/315°C.
- 3.9.11 For field stress relieving, a continuous temperature record Log shall be furnished of the program from heating, soaking and cooling to 600°F. A minimum of two thermocouples shall be installed at each weld so that continuous readings can be assured in the event of thermocouple failure.
- 3.9.12 Local heat treatment of welds shall consist of heating ID pipe length completely around the circumference of the pipe welds or pipes as required to eliminate thermally induced stresses. A continuous record of time and temperature shall be maintained for at least two points on each weld during the course of heat treatment with methods other than exothermic kits.
- 3.9.13 During heat treatment, the ends of the pipe shall be temporarily plugged to minimize air-cooling. Sufficient insulation shall be applied to maintain the required heat treatment temperature. The full thickness of 75mm (3"-inch) insulation shall be continued for a minimum distance of 610 mm (2 feet) on each side of the heating elements, and shall be in place until the weld has cooled to below 100°F/37°C.
- 3.9.14 When local heat treatment is used, care shall be exercised with restrained piping so that no upsetting will be caused by thermal expansion.
- 3.9.15 A minimum 10% of all locally (field) heat-treated welds shall require Brinell hardness testing.
- 3.9.16 Unless otherwise indicated by OWNER, Brinell hardness limits apply to welds after PWHT. The hardness of the weld shall be determined by the average value of three tests (of 3 indentations) taken per 120 degrees quadrant around the weld.
- 3.9.17 The test areas of the weld shall be ground or filled to provide a suitable surface for testing. If a Tele brineller is used to measure the hardness the bar shall be as close as practical to the

- anticipated weld hardness. If a poor indentation is obtained on an individual test, a retest shall be made on an adjacent area.
- 3.9.18 Hardness tests other than Brinell may be used if the values obtained can be equated to the Brinell hardness numbers, and the proposed equipment and procedures have received prior OWNER approval.
- 3.9.19 Flange facing and threaded connections must be adequately protected against oxidation during stress relieving and must be cleaned and freed of defects after stress relieving.
- 3.9.20 No heating or welding may be applied to any piping or weld joint after stress relieving is complete.
- 3.9.21 All stress relieving equipment and execution shall be supplied at **CONTRACTOR**'s expense.

3.10 WELDING PROCEDURE QUALIFICATION

Welding procedure qualification shall be in accordance with the relevant requirement of ASME Sec. IX/ API 1104 latest edition or other applicable codes and the job requirements. The **CONTRACTOR** shall submit the welding procedure specification in format as per PQR Format immediately after the receipt of the order. Owner's representative will review, check and approve the welding procedure submitted and shall release the procedure for qualification test. The complete set of test result as per ASME sec. IX shall be submitted to the OWNER/ OWNER's representative for approval immediately after completing the procedure qualification test and at least 2 weeks before the commencement of actual work. Standard test specified in the code shall be carried out in all cases. In addition to these tests, the following test shall be carried out.

- Macro/ Micro Examination.
- Hardness test.
- Dye Penetrate examination.
- Charpy V-notch Impact test at Weld and HAZ at 0 °C for high temperature, -20 °C for low temperature

These tests shall be carried out on specimens depending upon the type of base material, operating conditions and requirements laid down in the detailed drawing and specification. It shall be the responsibility of the **CONTRACTOR** to carry out all the tests required to the satisfaction of the OWNER/ OWNER's representative.

3.11 Welder's Qualification

Welders shall be qualified in accordance with the ASME sec. IX or other applicable codes. It shall be the responsibility of the **CONTRACTOR** to carry out qualification tests of welders.

No welder shall be permitted to work without the possession of identity card.

If a welder is found to perform a type of welding or in a position for which he is not qualified, he shall be debarred from doing any further work. All welds performed by an unqualified welder shall be cut and redone by a qualified welder at the expenses of the **CONTRACTOR**.

3.12 Destructive Testing

OWNER has the authority to order the cutting of up to 0.1% of the total numbers of welds completed for subjecting to destructive test at no extra cost to OWNER. The destructive testing of joints shall be as per ASME- Sec IX welding procedure qualification.

In addition, welds already cut out for defects for any reason may also be subjected to destructive testing. The sampling and the re-execution of welds shall be carried out by the **CONTRACTOR** at his own expenses. If the results are unsatisfactory, welding operations shall be suspended and may not be restarted until the causes have been identified and the **CONTRACTORS** have adopted measures which guarantee acceptable results.

If it is necessary in OWNER opinion the procedure shall be re-qualified. The weld joint represented by unsatisfactory welds shall stand rejected unless investigation proves otherwise.

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VISUAL INSPECTION

- a) Visual examination shall be carried out before, during and after fabrication in accordance with ASME Sec. V article 9 and ASME B31.3.
- b) Cracks, (regardless of size and location) and under cutting or any evidence of poor workmanship, materials, etc., if not repairable shall be cause for rejection.
- c) Welds shall be visually inspected wherever accessible in accordance with the following requirements:

1	Internal misalignment	1.5 MM or Less
2	Cracks or lack of fusion	None permitted.
3	Incomplete penetration (for other than 100% Radiography butt-weld)	Depth shall not exceed the lesser of 0.8 MM or 0.2 times thickness of thinner component joined by butt-weld. The total length of such imperfections shall not exceed 38 MM in any 150 MM of weld length.
4	Surface porosity and exposed slag inclusions (4.7mm. Wall thickness and less)	not permitted
5	Concave root surface(SLICK UP)	For single sided welded joints concavity of the root surface shall not reduce the total thickness of joint including reinforcement to less than the thickness of the thinner of the components being joined.
6	Weld ripples irregularities	2.5 MM or Less
7	Lack of uniformity in bead width	2.5 MM or Less
8	Lack of uniformity of leg length	2.5 MM or Less
9	Unevenness of bead	2.0 MM or Less
10	Weld undercutting	0.8 MM or 'A thickness of thinner components joined by butt weld, whichever is less. (shall be smooth finished)
11	Overlap	1.5 MM or Less
12	Bead deflection	2.5 MM or Less
13	External weld reinforcement and internal weld protrusion (when backing rings are not used) shall be fused with and shall merge smoothly into the component surfaces. The height of the lesser projection of external weld reinforcement or internal weld protrusion from the adjacent base material surface shall not exceed the following limits	
	Wall thickness of thinner component joined by butt weld (MM)	Weld reinforcement or internal weld protrusion (MM) Max
	6.4 and under	1.6
	Over 6.4 – 12.7	3.2
	Over 12.7 – 25.4	4
	Over 25.4	4.8
14	Throat thickness of fillet welds: Nominal thickness of the thinner component x 0.7 or more.	
15	FLATTENING: Flattening of a bend, as measured by difference between the nominal outside diameter and minimum or maximum diameter at any cross section shall not exceed 5% of the nominal outside diameter of pipe.	
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REDUCTION OF WALLTHICKNESS: Reduction of wall thickness of a bend, as measured by difference between the nominal thickness and minimum thickness shall not exceed 10% of the nominal wall thickness of pipe. Welds having any imperfections which exceed the limitations specified in various clauses shall be repaired by welding, grinding or overlaying etc.
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However number of times of repair welding for the same weld shall be as follows:

	MATERIAL	NO. OF TIMES OF REPAIR WELDING
1.0	CS UPTO 300#	3 OR LESS
2.0	CS ABOVE 300#	2 OR LESS

5 NON-DESTRUCTIVE TESTING

5.1 GENERAL

- All NDT shall be performed in accordance with ASME B31.3 /ASME 8.31.8/ ASME code Section V except as modified by this specification.
- Category of piping are defined by categories I, II, III as shown in Table 1. The minimum requirement for extent of NDT inspection shall be as stated in Table 2.
- The **CONTRACTOR** shall prepare NDT procedure covering all aspects of the work. The NDT procedure shall be submitted to OWNER for review and approval. Approval of the NDT procedure shall be required before any NDT can be performed.
- The **CONTRACTOR** shall prepare and maintain documentation to track percentage of welds tested and the weld repair rate. The proposed documentation shall be made available for review and approval.
- Unless otherwise specified, 100% of welds in each pipe class rating shall be inspected by NDT. All non-pressure tie-in welds and all field welds, regardless of pipe class shall be examined by 100% visual, radiography, UT.
- CONTRACTOR** shall not deviate from any requirement of this specification without written approval to do so from OWNER.
- No exemption permitted in regards to full HS&E compliance.

5.2 RADIOGRAPHIC EXAMINATION

5.2.1 General

- The quality of radiographs shall meet or exceed all requirements of the appropriate International standards and applicable general specifications.
- X - Ray is the preferred radiographic method. Use of Gamma ray for examination is not permitted.
- Particular attention shall be paid to using radiographic ultra fine grain film suitable for the application, maintaining correct radiographic geometry during exposure, obtaining correct density also required by the appropriate standard and the correct placement and exposure of image quality indicators (IQI's or penetrameters).
- ASTM wire type IQI's are preferred. The OWNER may permit the use of ASTM hole type IQI's on a pre-approved basis, provided the NDT **CONTRACTOR** can demonstrate satisfactory results.
- Radiographic technique shall produce maximum contrast and good definition of IQI wires and shall obtain minimum radiographic density of 10 in the weld image. Fluorescent intensifying screens shall not be used.
- Max radiographic density shall be 4.0 in all areas of the weld and parent metal.

- g) The inability to view the appropriate wire or hole on any radiograph shall be cause for automatic rejection of that radiograph which shall be re-radiographed at no expense to the OWNER.

5.2.2 Operator Certification

- a) Radiographers supplied by the **CONTRACTOR** shall be certified to ASNT Level II, AWS QC] and as per AWS B1.10 (guide for non-destructive inspection of welds).
- b) An operator qualified to ASNT Level I may assist the Level II operator but all film and sentencing interpretation shall be carried out by a Level II or higher operator who shall sign off all report sheets.
- c) Visual welding inspection shall be conducted only by a qualified welding inspector, who shall have a minimum AWS (QC. I) CWI or CSWIP 3.1 certification.
- d) The OWNER shall review and approve all QA/QC personnel prior to deployment on the project.

5.3 MAGNETIC PARTICLE INSPECTION (WPI)

- a) MPT shall be carried out in accordance with the requirements of ASME. Section V. Article 7, & Section VIII DIV 1, Appendix 6. And as modified by this specification.
- b) AC electromagnetic yokes shall be used. A background of white contrast paint shall be used in conjunction with a black magnetic ink (wet particle). The technique shall be carried out in the continuous mode and two examinations shall be carried out at right angles to cover for both transverse and longitudinal defects. There shall be sufficient overlap to allow 100% coverage.
- c) All unacceptable or spurious indications found by this method shall be investigated and removed by grinding followed by thickness check.

5.4 DYE PENETRATE INSPECTION (DPI)

- a) DPI shall be carried out accordance with the requirements of ASME BPV, Section V, Article 6, & ASME Section VIII DIV 1, Appendix 8, and as modified by this specification.
- b) Unless requested otherwise, DPI shall be carried out using the solvent removable method.
- c) If necessary welds may be lightly dressed to facilitate DPI testing or to assist in the interpretation of any indications.
- d) All unacceptable or spurious indications found by this method shall be investigated and removed by grinding followed by thickness check.

5.5 ULTRASONIC WELD EXAMINATION (UT)

2Ultrasonic Operators

Ultrasonic operators supplied by the NDE **CONTRACTOR** shall be certified to a General Standards Board (ASNT/PCN) approved by the OWNER.

5.6 EXTENT OF INSPECTION AND TESTING

- a) Piping systems which are designed and constructed in accordance with ASME Standard B3 I.3, Chemical Plant and Petroleum Refinery Piping shall be radio graphed as per Table II.
- b) Piping systems which are designed and constructed in accordance with ASME B31.8 standard for gas pipeline systems shall have all welds radio graphically inspected for 100%,

- 5.6.1 Hardness testing shall be carried out of welds on vessels and piping in sour or corrosive service and 10% of local PWHT weld as per ASTM Specification E 10, ANSI 1331.3.

5.6.2 Ultrasonic Testing

- a) UT testing shall be carried out as per ASME B31.3 and ASME Sec. V article 5.
- b) All category 'D' welds which are not being radio graphed and all other welds configuration, which does not permit to be radio graphed, shall be ultrasonic tested.
- c) All tie-in welds where pressure testing are not possible.

TABLE-I
EXAMINATION CATEGORIES

CATEGORY I	HIGHER DUTY PIPING
	- Severe cyclic conditions as indicated in the respective isometric drawings, all service. - Carbon Steel material, ASME rating 600# all services - All ASME classes for lethal substances.(Category 'M' fluid service)
CATEGORY II	NORMAL FLUID SERVICE ASME rating 150 & 300# not covered by Categories I & III
CATEGORY III	CATEGORY 1) FLUID SERVICE
	ASME rating 150 for all systems in Category '1' Fluid services such as: - Service air - Instrument air - Open Drains

TABLE – II
EXTENT OF TESTING AND INSPECTION

METHOD	EXAMINATION CATEGORY I	EXAMINATION CATEGORY II	EXAMINATION CATEGORY III
Visual	100%	100%	100%
MPI (or DPI for nonferromagnetic materials) (Note 2)	100% examination of all branch and attachment welds	100% examination of 1 in 10 branch and attachment welds	100% examination of 1 in 10 branch and attachment welds
RT (butt weld) (Note 1)	100% examination of all welds	100% examination of 1 in 10 welds (Note 5)	100% examination Of 1 in 10 welds
UT (Branch weld) (Note 5)	100% examination of all welds	0	0
Hydro test (or pneumatic test)	Yes	Yes (Note 3)	Service Test
Minimum Duration	1 hour	1 hour	1 hour
Records	Yes	Yes	Yes

Notes:

- 1) Ultrasonic testing, in lieu of radiography, is acceptable only where radiography is not practicable e.g. branch connections.
- 2) UPI or DPI of branch welds to be performed prior to and after attachment of compensating plate if applicable.
- 3) Open drains vents or other open ended line shall be leak tested only.
- 4) For piping within skid packages, the **CONTRACTOR** shall use this table as a guide only and prepared NDE plan for review and approval by OWNER as required in the respective package specification.

- 5) Vat required where wall thickness of scanning surfaces are less than 10mm and where branch size is less than NPS 4". Non-ferrite materials shall not be examined with UT methods.
- 6) RT shall be 100% of welds for all class 600# series.

5.7 REPAIRS OF WELDS

With the prior permission of EIC welds that do not comply with the standards of acceptability shall be repaired or the joint cut out and re-welded.

A separate welding procedure specification sheet shall be formulated and qualified by **CONTRACTOR** for repair welds simulating the proposed repair to be carried out. Separate procedures are required to be qualified for (a) through thickness repair (b) external repair and (c) internal repair. Welders shall be qualified in advance for repairs. The root pass, for repairs opening the root, shall be replaced by the vertical uphill technique. The procedure shall be proven by satisfactory procedure tests to API 1104 including the special requirements of the specification, and shall also be subjected to metallographic examination, hardness surveys and Charpy test to determine the effects of repair welding on the associated structure.

Root sealing or single pass repair deposit shall not be allowed. Internal root defects shall be ground thoroughly and welded with a minimum of two passes. However, while grinding for repairs, care shall be taken to ensure that no grinding marks are made on the pipe surface anywhere.

The repair shall be subjected, as a minimum requirement, to the same testing and inspection requirements as the original weld. Re-radiography of the repaired area shall be carried out. In addition, a minimum of 6" weld length on the either side of the repaired area shall be re-radiographed. A 100% ultrasonic test shall be done at the repaired area externally. Any repaired area that is wide, irregular or rough shall be rejected and a full cut out shall be done. Repairs are limited to a maximum of 30% of the weld length. Welds containing cracks shall be cut out and rebeveled to make a joint. COMPANY shall authorize all repairs.

5.8 Weld Rejected by Accumulation of Defects

Where a weld is rejected by accumulation of defect clause, as defined by API 1104 and this specification, repairs within these limitations are permitted. Defects in the filling and capping passes shall be repaired preferentially.

5.9 INSPECTION

- 5.9.1 The **CONTRACTOR** shall extend all facilities, assistance and co-operate fully with the OWNER in all aspects of inspection and NDE and shall give adequate notice of any required fabrication inspection stages, together with sufficient time for thorough inspection by the OWNER. OWNER shall have the right to establish hold points at any point in the fabrication sequence.
- 5.9.2 Although it is the **CONTRACTOR's** primary responsibility to perform weld examination, OWNER shall have the right to observe the examination of all welds by nondestructive means. The inspection may be at any time before, during and after fabrication. The **CONTRACTOR** shall conduct daily NDE percentage of welds to assess weld quality. Up-to-date examinations are required to identify and prevent the reoccurrence of weld defects on subsequent welds. Records and evidence of all weld examinations shall be available at all times for OWNER to review and approve.
- 5.9.3 OWNER may use any method of inspection necessary to establish quality control and ensure adherence to welding procedures. OWNER shall have the right to accept or reject any weld not meeting the requirements of this specification.
- 5.9.4 OWNER reserves the right to perform inspection at shop / field where fabrication and erection of piping is in progress for (but not limited) for the following objective:

- a) To check conformance to relevant standards and suitability of various welding equipments and welding performance.
- b) To witness the welding procedure qualification.
- c) To witness the welder performance qualification.
- d) To witness the Electrode qualification Test.

5.9.5 **CONTRACTOR** shall intimate sufficiently in advance the commencement of qualification test, welding works and acceptance tests to enable the owner/ owner's representative to be present to supervise them.

5.9.6 Any discrepancies between the approved WPS and the production welds noted by OWNER, any or all of the work made under these conditions is subject to rejection.

5.10 DOCUMENTS TO BE SUBMITTED BY THE CONTRACTOR

- a) Electrode and welding consumables qualification records for the welding consumables tested and approved for the work.
- b) Batch test certificate, for the electrodes used, obtained from the Electrode Manufacturers.
- c) Proposed heat treatment chart procedure.
- d) Heat treatment chart.
- e) Weld joint tensile, hardness test, Impact test result.
- f) Welding procedure specification immediately after receipt of order.
- g) Welding procedure qualification records.
- h) Welder performance qualification records immediately after conducting welder Qualification tests.
- i) Radiography procedure and the NDT procedure.

ANNEXURE – 2(b)

STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF PIPING

1. SCOPE

This specification covers general requirements of fabrication and erection of above ground and trench piping systems at site. The specification covers the scope of work of **CONTRACTOR**, basis of work to be carried out by **CONTRACTOR** and standards, specifications and normal practice to be followed during fabrication and erection by the **CONTRACTOR**.

2. SCOPE OF WORK OF CONTRACTOR

2.1 Generally, the scope of work of **CONTRACTOR** shall include the following:

2.2 Transportation of required piping materials (as described in Cl.2.1.1), pipe support (material as described in Cl. 2.4) and all other necessary piping materials from Owner's storage point or **CONTRACTOR**'s storage point (in case of **CONTRACTOR**'s scope of supply) to work site/shop including raising store requisitions for issue of materials in the prescribed format & maintaining an account of the materials received from Owner's stores.

2.2.1 Piping materials include the following but not limited to the same.

- a. Pipes (All sizes and schedule)
- b. Flanges (All sizes, types & Pressure ratings).
- c. Fittings (All sizes, types and schedule)
- d. Valves (All sizes, types and Ratings)
- e. Gaskets (All sizes, types & Ratings)
- f. Bolts, Nuts or M/C Bolts (All types)
- g. Expansion Joint/Bellows (All types)
- h. Specialty items like online filters, ejectors, sample coolers, steam traps, strainers, and air traps etc.
- i. Online instruments like control valve, orifice flange, rotameter, safety valves etc.

2.3 Shop & field fabrication and erection of piping in accordance with documents listed under 'BASIS OF WORK' including erection of all piping materials enumerated above.

2.4 Fabrication and erection of pipe supports like shoe, saddle, guide, stops, anchors, clips, cradles, hangers, turn buckles, supporting fixtures, bracket cantilevers, struts, tee posts including erection of spring supports and sway braces.

2.5 Grinding of edges of pipes, fittings, flanges etc. to match mating edges of uneven/different thickness wherever required.

2.6 Modifications like providing additional cleats, extension of stem of valve, locking arrangement of valves etc. as and when required.

2.7 Preparation of Isometrics, bill of materials, supporting details of all NON-IBR lines up to 2- 1/2 within the unit battery limit and get subsequent approval from EIC as and when called for.

2.8 Obtaining approval for drawings prepared by **CONTRACTOR** from statutory authority, if required.

2.9 Spun concrete lining of the inside of pipes 3" NB & above including fittings and flanges as required in accordance with specification.

2.10 Rubber lining inside pipes, fittings, flanges as and when required, in accordance with specification.

2.11 Radiography, stress relieving, dye penetration, magnetic particle test etc. as required in specification.

2.12 Performing PMI using alloy analyzers as per Standard Specification at Construction Sites.

2.13 Casting of concrete pedestals and fabrication & erection of small structures for pipe supports including supply of necessary materials.

2.14 Providing insert plates from concrete structures and repair of platform gratings around pipe openings.

2.15 Making material reconciliation statement and return of Owner's supply left over materials to Owner's storage.

- 2.16 Flushing and testing of all piping systems as per standard specification for inspection, flushing and testing of piping systems.
- 2.17 Pickling (as and when applicable) as per standard specification for chemical cleaning of C.S. suction piping of compressors.
- 2.18 Submission of job execution procedure for review and approval of EIC covering all above activities.

3. BASIS FOR WORK

- 3.1 The complete piping work shall be carried out in accordance with the following:
- 3.2 “Approved for Construction” drawings and sketches issued by to the **CONTRACTOR** - Plans and/or Isometrics.
- 3.3 “Approved for Construction” drawings and sketches issued by Turn-key **CONTRACTORS** to the **CONTRACTOR** - Plans and/or Isometrics.
- 3.4 Approved Process licensor’s standards and specifications.
- 3.5 Drawings, sketches and documents prepared by **CONTRACTOR** duly approved by EIC (such as isometrics of small bore piping and offsite piping etc.)
- 3.6 Approved construction job procedures prepared by **CONTRACTOR** as stipulated in 2.18.
- 3.7 Specifications/documents as below:
 - a. Process and Instrument Diagram.
 - b. Piping Materials Specification.
 - c. Piping support standards.
 - d. Line list
 - e. Piping support indices (only in offsite), if supports are not shown in plan.
 - f. Standard specification of Non-destructive Requirement of Piping.
 - g. Welding specification charts for piping classes.
 - h. Standard specification for Pressure Testing of Erected Piping System.
 - i. Welding specification for fabrication of piping.
 - j. Any other or OTHER specifications attached with Piping Material Specification or special condition of contract (such as standard for cement lining of pipe, standard of jacketed piping, standard for steam tracing, Dimensional Tolerances etc.)
 - k. Procedure for storage, preservation and positive identification of materials at **CONTRACTORS** works/ stores.
- 3.8 Following codes, standards and regulations
 - a. ASME B 31.3 : Process Piping
 - b. ASME B 31.4 : Pipeline Transportation System for Liquid Hydrocarbons and Other.
 - c. ASME B 31.8 : Gas Transmission and Distribution Piping Systems
 - d. ASME Sec. VIII : Code for unfired pressure vessel.
 - e. IS: 823 : Code for procedure for Manual Metal Arc Welding of Mild Steel (for structural steel).
 - f. NACE Std. : Code for Sour Services material requirements MR-0 1-75
 - g. PNGRB NOTIFICATION : Technical Standards and specifications including safety standards for Dated: 27/08/08 city or local natural gas distribution network.

Note: All codes referred shall be latest edition, at the time of award of contract.

Deviations

Where a deviation from the “Basis of Work and approved job procedure described above is required or where the basis of work does not cover a particular situation, the matter shall be brought to the notice of Engineer - in - Charge and the work carried out only after obtaining written approval from him in each case.

4. FABRICATION

4.1 Piping Material

Pipe, pipe fittings, flanges, valves, gaskets, studs bolts etc. used in a given piping system shall be strictly as per the "Piping Material Specification" for the "Pipe Class" specified for that system. **CONTRACTOR** to refer attached Annexure-13 for **GEL**- Piping Material Specification. To ensure the above requirement, all piping material supplied by the Owner/**CONTRACTOR** shall have proper identification marks as per relevant standards/specifications/Licensors specification. **CONTRACTOR** shall provide identification marks on left over pipe lengths wherever marked up pipe lengths have been fabricated/ erected. Material traceability is to be maintained for A.S., S.S., NACE, LTCS, material for Hydrogen service and other exotic materials by way of transferring heat number, etc. (hard punching) as per approved procedure. This shall be in addition to color coding for all piping materials to avoid mix-up. For the purpose of common understanding the construction job procedure, to be submitted by the **CONTRACTOR**, shall include proposal for - Maximizing prefabrication, inspection and testing at fabrication shop with minimum field joints.

4.2 Positive material identification, handling, storage & preservation. Dimensional Tolerances
CONTRACTOR shall be responsible for working to the dimensions shown on the drawings. However, the **CONTRACTOR** shall bear in mind that there may be variations between the dimensions shown in the drawing and those actually existing at site due to minor variations in the location of equipments, inserts, structures etc. To take care of these variations "Field Welds" shall be provided during piping fabrication. An extra pipe length of 100 mm over and above the dimensions indicated in the drawing may be left on one side of the pipe at each of the field welds. During erection, the pipe end with extra length at each field weld shall be cut to obtain the actual dimension occurring at site. Isometrics, if supplied may have the field welds marked on them. However, it is the responsibility of the **CONTRACTOR** to provide adequate number of field welds. In any case no extra claims will be entertained from the **CONTRACTOR** on this account. Wherever errors/omissions occur in drawings and Bills of Materials it shall be the **CONTRACTOR**'s responsibility to notify the EIC prior to fabrication or erection.

4.3 Pipe Joints

The piping class of each line specifies the type of pipe joints to be adopted. In general, joining of lines 2" and above in process and utility piping shall be accomplished by butt welds. Joining of lines 1-1/2" and below shall be by socket welding/butt welding/threaded joints as specified in "Piping Material Specifications". However, in piping 1-1/2" and below where socket welding/threaded joints are specified butt - welds may be used with the approval of EIC for pipe to pipe joining in long runs of piping. This is only applicable for non-galvanized piping without lining.

Flange joints shall be used at connections to Vessels, Equipment's, Valves and where required for ease of erection and maintenance as indicated in drawings.

4.4 Butt Welded and Socket Welded Piping

End preparation, alignment and fit-up of pipe pieces to be welded, welding, pre-heating, post-heating and heat treatment shall be as described in the welding specification and NDT specification.

4.5 Screwed Piping

In general, Galvanized piping shall have threads as per IS: 554 or ANSI B2.1 NPT as required to match threads on fittings, valves etc. All other piping shall have threads as per ANSI B2.1, tapered unless specified otherwise.

Threads shall be clean cut, without any burrs or stripping and the ends shall be reamed. Threading of pipes shall be done preferably after bending, forging or heat treating operations. If this is not possible, threads shall be gauge checked and chased after welding heat treatment etc.

During assembly of threaded joints, all threads of pipes and fittings shall be thoroughly cleaned of cuttings, dirt, oil or any other foreign matter. The male threads shall be coated with thread sealant and the joint tightened sufficiently for the threads to seize and give a leak proof joint.

Threaded joints to be seal-welded shall be cleaned of all foreign matter, including sealant and made up to full thread engagement before seal welding.

4.6 Flange Connections

All flange facings shall be true and perpendicular to the axis of pipe to which they are attached. Flanged bolt holes shall straddle the normal centerlines unless different orientation is shown in the drawing.

Wherever a spectacle blind is to be provided, drilling and tapping for the jack screws in the flange, shall be done before welding it to the pipe.

4.7 Branch Connections

Branch connections shall be as indicated in the piping material specifications. For end preparation, alignment, spacing, fit-up and welding of branch connections refer welding specifications. Templates shall be used wherever required to ensure accurate cutting and proper fit-up.

For all branch connections accomplished either by pipe to pipe connections or by using forged tees the rates quoted for piping shall be inclusive of this work.

Reinforcement pads shall be provided wherever indicated in drawings/ specifications etc.

4.8 Bending

Bending shall be as per ASME B3 1.3 except that corrugated or creased bends shall not be used.

Cold bends for lines 1-1/2" and below, with a bend radius of 5 times the nominal diameter shall be used as required in place of elbows wherever allowed by piping specifications. Bending of pipes 2" and above may be required in some cases like that for headers around heaters, reactors etc.

The completed bend shall have a smooth surface, free from cracks, buckles, wrinkles, bulges, flat spots and other serious defects. They shall be true to dimensions. The flattening of a bend, as measured by the difference between the maximum and minimum diameters at any cross-section, shall not exceed 8% and 3% of the nominal outside diameter, for internal and external pressure respectively.

4.9 Forging and forming

Forging and forming of small bore fittings, like reducing nipples for piping 1-1/2" and below, shall be as per **ASME B 31.3**.

4.10 Cutting and Trimming of Standard Fittings & Pipes

Components like pipes, elbows, couplings, half-couplings etc. shall be cut/trimmed/edge prepared wherever required to meet fabrication and erection requirements, as per drawings and instructions of EIC. Nipples as required shall be prepared from straight length piping.

4.11 Galvanized Piping

Galvanized carbon steel piping shall be completely cold worked, so as not to damage galvanized surfaces. This piping involves only threaded joints and additional external threading on pipes may be required to be done as per requirement.

4.12 Jacketed Piping

The Jacketing shall be done in accordance with Specification or Licensors specification as suggested in material specification or special condition of contract.

Pre-assembly of jacketed elements to the maximum extent possible shall be accomplished at shop by **CONTRACTOR**. Position of jump over and nozzles on the jacket pipes, fittings etc. shall be marked according to pipe disposition and those shall be prefabricated to avoid damaging of inner pipe and obstruction of jacket space. However, valves, flow glasses, in line instruments or even fittings shall be supplied as jacketed.

4.13 Shop Fabrication / Prefabrication

The purpose of shop fabrication or pre-fabrication is to minimize work during erection to the extent possible. Piping spool, after fabrication, shall be stacked with proper identification marks, so as facilitate their withdrawal at any time during erection. During this period all flange (gasket contact faces) and threads shall be adequately protected by coating with removable rust preventive. Care shall also be taken to avoid any physical damage to flange faces and threads.

4.14 Miscellaneous

- **CONTRACTOR** shall fabricate miscellaneous elements like flash pot, seal pot, sample cooler, supporting elements like turn buckle's, extension of spindles and interlocking arrangement of valves, operating platforms as required by EIC.
- Spun Concrete lining
- The work of inside spun concrete lining of pipes and specials of diameter 3 and above shall be done as per material specifications and special conditions of contract.
- Fabrication of pipes from plate
- Pipes shall be fabricated at site as and when required as per the specifications and the actual Piping Material Specification.

5. ERECTION

5.1 Cleaning of Piping before Erection

Before erection all pre-fabricated spool pieces, pipes, fittings etc. shall be cleaned inside and outside by suitable means. The cleaning process shall include removal of all foreign matter such as scale, sand, weld spatter chips etc. by wire brushes, cleaning tools etc. and blowing with compressed air/or flushing out with water. Special cleaning requirements for some services, if any shall be as specified in the piping material specification or isometric or line list. S.S jacketed piping requiring pickling shall be pickled to remove oxidation and discoloring due to welding.

5.2 Piping Routing

No deviations from the piping route indicated in drawings shall be permitted without the consent of EIC.

Pipe to pipe, pipe to structure / equipments distances / clearances as shown in the drawings shall be strictly followed as these clearances may be required for the free expansion of piping / equipment. No deviations from these clearances shall be permissible without the approval of EIC. In case of fouling of a line with other piping, structure, equipment etc. the matter shall be brought to the notice of EIC and corrective action shall be taken as per his instructions.

5.3 Cold Pull

Wherever cold pull is specified, the **CONTRACTOR** shall maintain the necessary gap, as indicated in the drawing. Confirmation in writing shall be obtained by the **CONTRACTOR** from the EIC, certifying that the gap between the pipes is as indicated in the drawing, before

drawing the cold pull. Stress relieving shall be performed before removing the gadgets for cold pulling.

5.4 Slopes

Wherever cold pull is specified, the **CONTRACTOR** shall maintain the necessary gap, as indicated in the drawing. Confirmation in writing shall be obtained by the **CONTRACTOR** from the EIC, certifying that the gap between the pipes is as indicated in the drawing, before drawing the cold pull. Stress relieving shall be performed before removing the gadgets for cold pulling.

5.5 Expansion Joints / Bellows

Installation of Expansion Joints/Bellows shall be as follows:

5.5.1 All Expansion joints / Bellows shall be installed in accordance with the specification and installation drawings, supplied to the **CONTRACTOR**.

5.5.2

- a. Upon receipt, the **CONTRACTOR** shall remove the Expansion Joints/ Bellows from the case(s) and check for any damage occurred during transit.
- b. The **CONTRACTOR** shall bring to the notice of the Engineer-in- Charge any damage done to the bellows / corrugations, hinges, tie-rods, flanges / weld ends etc.
- c. Each Expansion Joint / Bellow shall be blown free of dust and foreign matter with compressed air or cleaned with a piece of cloth.

5.5.3

- a. For handling and installation of Expansion Joints, great care shall be taken while aligning. An Expansion Joint shall never be slinged from bellows corrugations / external shrouds, tie / rods, angles.
- b. An Expansion Joint / Bellow shall preferably be slinged from the end pipes / flanges or on the middle pipe.

5.5.4

- a. All Expansion Joints shall be delivered to the **CONTRACTOR** at "Installation length", maintained by means of shipping rods, angles welded to the flanges or weld ends or by wooden or metallic stops.
- b. Expansion Joints stop blocks shall be carefully removed after hydrostatic testing. Angles welded to the flanges or weld ends shall be trimmed by saw as per manufacturer's instructions and the flanges or weld ends shall be ground smooth.

5.5.5

- a. The pipe ends in which the Expansion Joint is to be installed shall be perfectly aligned or shall have specified lateral deflection as noted on the relevant drawings.
- b. The pipe ends / flanges shall be spaced at a distance specified in the drawings.

5.5.6

The Expansion Joint shall be placed between the mating pipe ends/flanges and shall be tack welded/ bolted. The mating pipes shall again be checked for correct alignment.

5.5.7

Butt-welding shall be carried out at each end of the expansion joint. For flanged Expansion Joint, the mating flanges shall be bolted.

5.5.8

After the Expansion Joint is installed the **CONTRACTOR** shall ensure that the mating pipes and Expansion Joints are in correct alignment and that the pipes are well supported and guided.

5.5.9

The Expansion Joint shall not have any lateral deflection. The **CONTRACTOR** shall maintain parallelism of restraining rings or bellows convolutions.

5.5.10

Precautions

- a. For carrying out welding, earthing lead shall not be attached with the Expansion Joint.
- b. The Expansion bellow shall be protected from arc weld spot and welding spatter.
- c. Hydrostatic Testing of the system having Expansion Joint shall be performed with shipping lugs in position. These lugs shall be removed after testing and certification is over.

5.6

Flange Connections

While fitting up mating flanges, care shall be exercised to properly align the pipes and to check the flanges for trueness, so that faces of the flanges can be pulled together, without inducing any stresses in the pipes and the equipment nozzles. Extra care shall be taken for flange connections to pumps, turbines, compressors, cold boxes, air coolers etc. The flange connections to these equipments shall be checked for misalignment, excessive gap etc. after the final alignment of the equipment is over. The joint shall be made up after obtaining approval of EIC. Temporary protective covers shall be retained on all flange connections of pumps, turbines, compressors and other similar equipments, until the piping is finally connected, so as to avoid any foreign material from entering these equipments.

The assembly of a flange joint shall be done in such a way that the gasket between these flange faces is uniformly compressed. To achieve this, the bolts shall be tightened in a proper sequence. All bolts shall extend completely through their nuts but not more than 1/4". Steel to C.I. flange joints shall be made up with extreme care, tightening the bolts uniformly after bringing flange flush with gaskets with accurate pattern and lateral alignment.

5.7 Vents and Drains

High point vents and low point drains shall be provided as per the instructions of Engineer-in-Charge, even if these are not shown in the drawings. The details of vents and drains shall be as per piping material specifications / job standards.

5.8 Valves

Valves shall be installed with spindle / actuator orientation / position as shown in the layout drawings. In case of any difficulty in doing this or if the spindle orientation / position is not shown in the drawings, the EIC shall be consulted and work done as per his instructions. Care shall be exercised to ensure that globe valves, check valves, and other uni-directional valves are installed with the "Flow direction arrow" on the valve body pointing in the correct direction. If the direction of the arrow is not marked on such valves, this shall be done in the presence of EIC before installation. Fabrication of stem extensions, locking arrangements and interlocking arrangements of valves (if called for), shall be carried out as per drawings/ instructions of Engineer-in- Charge.

5.9 Instruments

Installation of in-line instruments such as restriction orifices, control valves, safety valves, relief valves, rotameters, orifice flange assembly, venturimeters, flow meters etc. shall form a part of piping erection work. Fabrication and erection of piping upto first block valve / nozzle/flange for installation of offline Instruments for measurement of level, pressure, temperature, flow etc. shall also form part of piping construction work. The limits of piping and instrumentation work will be shown in drawings / standards specifications. Orientations / locations of take-offs for temperature, pressure, flow, level connections etc. shown in drawings shall be maintained.

Flushing and testing of piping systems which include instruments mentioned above and the precautions to be taken are covered in flushing, testing and inspection of piping. Care shall be exercised and adequate precautions taken to avoid damage and entry of foreign matter into instruments during transportation, installation, testing etc.

5.10 Line Mounted Equipments/ Items

Installation of line mounted items like filters, strainers, steam traps, air traps, de-superheaters, ejectors, samples coolers, mixers, flame arrestors, sight glasses etc. including their supporting arrangements shall form part of piping erection work.

5.11 Bolts and Nuts

The **CONTRACTOR** shall apply molycoat grease mixed with graphite powder (unless otherwise specified in piping classes) all bolts and nuts (supplied as per **GEL** data sheet) during storage,

after erection and wherever flange connections are broken and made-up for any purpose whatsoever. The grease and graphite powder shall be supplied by the **CONTRACTOR** within the rates for piping work.

5.12 Pipe Supports

Pipe supports are designed for and located to effectively sustain the weight and thermal effects of the piping system and to prevent its vibrations. Location and design of pipe supports will be shown in drawings for lines 3" NB & above. for line below 3" NB **CONTRACTOR** shall locate and design pipe supports in line with Standards and obtain approval of Engineer - in - Charge on drawings prepared by **CONTRACTOR**, before erection. However, any extra supports desired by EIC shall also be installed.

No pipe shoe/cradle shall be offset unless specifically shown in the drawings.

Hanger rods shall be installed inclined in a direction opposite to the direction in which the pipe moves during expansion.

Preset pins of all spring supports shall be removed only after hydrostatic testing and insulation is over. Springs shall be checked for the range of movement and adjusted if necessary to obtain the correct positioning in cold condition. These shall be subsequently adjusted to hot setting in operating condition. The following points shall be checked after installation, with the EIC and necessary confirmation in writing obtained certifying that:

- All restraints have been installed correctly.
- Clearances have been maintained as per support drawings.
- Insulation does not restrict thermal expansion.
- All temporary tack welds provided during erection have been fully removed.
- All welded supports have been fully welded.