APPENDIX – V

PIPING AND WELDING PROCEDURE

A. Design, Fabrication, Supply, Site Assembly, Erection & Testing of Piping, Codes and Standards

1. All piping systems including sub-contracted materials shall comply with all currently applicable statute, regulations and safety codes in the locality where the equipment will be installed. The piping shall also conform to the latest editions of the codes and standards as listed below. Nothing in this specification shall be construed to relieve the **BIDDER** of his responsibility.

2. The equipment and work under this contract shall conform to the following Standards / codes, as applicable:
   a. American National Standard ASME code - ASME B 31.3 and all other associated ASME Standards.
   b. American Society of Testing and Materials (ASTM) Specification.
   c. American Society of Mechanical Engineers (ASME) Codes.
   d. American Petroleum Institute Standards (API).
   e. The relevant British Standard Specification (BS)
   f. The relevant European Norms (EN)

3. In the case of conflict between codes & standards referred to herein and the specification, the **BIDDER** shall bring to the notice of the **PURCHASER** for resolution. The **PURCHASER**'s decision is final.

4. **Design Requirement**

   4.1 Pipe sizing & pressure drop

   The pipe sizing shall be done considering the reasonable velocities, which are generally followed in the industry. The pipe velocity selection shall be in such a way that it meets the pressure drop between two points.

   5. Description Average velocity in meter / second

   Nominal pipe size in mm below 50 50 to 150 200 & up
   Header, general service 2.0 kg/sq.cm. (g) & up - 1.5 - 2.4 2.1 - 2.4

   The process piping velocity shall be as per the process requirement and the same shall be furnished for **PURCHASER**'s review.

   The pipe size shall be selected in such a way that the actual pressure drop in all piping system is not be greater than 85% of the available pressure drop.

   For two phase flows in piping, the pipe sizing shall be critically designed and

selected in such a way that no vibrations and noise will be encountered.

The pipe diameter selection shall be for the maximum flow through the pipe, taking into consideration of margins provided in the pumps also.

6. Piping layout minimum requirement

All piping shall be routed so as to avoid interference with other pipes and their hangers and supports, electrical cable trays, ventilation ducting, structural members, equipment etc. Adequate clearances shall be ensured with respect to the above to accommodate insulation and pipe movements.

All piping shall be grouped where practicable and shall be routed to present a neat appearance.

The piping shall be arranged to provide clearance for the removal of equipment requiring maintenance and for easy access to valves and other piping accessories required for operation and maintenance.

Piping shall generally be routed above ground but where specifically indicated /approved by the **PURCHASER** / **PURCHASER**'s REPRESENTATIVE, the pipes may be arranged in trenches. Pipes at working temperatures above the ambient shall however not be buried.

Overhead piping shall have a minimum vertical clearance of 2.3 meters above walkways and working areas and 6 meters above roadways unless otherwise approved by the **PURCHASER** / **PURCHASER**'s REPRESENTATIVE.

Any specific requirement for the process piping layout has to be followed. Those specific requirements shall be clearly brought out in the drawing submitted for **PURCHASER**'s review.

7. Pipe stress analysis

The stress analysis of piping shall be carried out as per IBR standard (including latest amendments) for process steam and as per ASME B31.3 (including latest amendments) for all process piping wherever applicable. The pipe stress shall be analyzed using piping software, Caepipe or Caesar or approved equal.

The piping connected to rotating equipments shall be stress analysed and critically reviewed, even if the design temperature / operating temperature / clean out & steam out temperature is lower than 100 Deg.C

The stress analysis of piping shall be carried out for all possible operating conditions of the equipment such as normal operating, upset condition operating, working & standby operation, clean out conditions etc.

The pipe stress analysis shall be carried out for critical equipment where ever rotating equipments is involved.

Piping stress analysis is generally not required for pipe size NB 40 and below, except when specifically required for the purpose of evaluating support movements for selection of springs.

The pipe stress analysis is to be carried out in order to ensure that the stresses are well within ASME B 31.3 requirements and the piping load on the nozzles is less than the allowed load of the equipment.

The piping has to be stress analysed without friction & with friction and the most severe of these two conditions shall be used for comparing the allowable stress and allowable load.

Wind loading shall be considered for insulated pipe size of NB 600 at an elevation of around 8 M & above from the ground level.

Pipe stress report shall be submitted for **PURCHASER**'s review.

The **BIDDER** shall design and prepare all fabrication isometric drawings.

The **BIDDER** shall ensure that the design is as per ASME B 31.3. The **BIDDER** shall furnish the calculations for reinforcement for nozzle openings and calculations for welded attachments carried out on the piping.

8. Other requirements

All flanges for size up to NB 600 shall be as per ASME B 16.5 and for size above NB 600 shall be as per ASME B16.47 series A.

All pipe to pipe joints shall be by butt welding only and no couplings shall be used for size NB 65 and above.

SS fittings up to NB 350 as per A403, NB 400 and above – mitre bends – 4 piece mitre bends, R = 1.5D, NB 40 and below – SW as per B16.11/A234, NB 50 to NB 350 as per B16.9

The selection of electrodes shall be as per Table furnished below.

No rerolled pipes shall be used.

Gas cutting for bolt holes including for U clamp supports shall be prohibited Screwed end pipes and pipe fittings shall be threaded as per NPT.

For hole size NB 50 and below on pipes, shall be done by drilling only.

Welding ends for butt welding shall be as per standard – "V" bevel with an included angle of 75 Deg.

9. Branch connections:

Equal & Reducing tees shall be used up to NB 80.

From NB 100 & above, as per branching calculations, reducing tees, reinforcement pads, pipe to pipe connections shall be used.

Socket welded half coupling shall be used for pressure gauge connections of NB 15.

No branch welding shall be used for equal branch (NB 100 & above), and only tees as per ASME B 16.9 or ASME B 16.11 to be used.

All GI screwed pipes / fittings are not to be welded and shall be sealed with suitable sealing material.

For a saturation steam line, where the chances of collection of condensate during operation is envisaged, each drain point shall be provided with a drain pot arrangement with the drain pot end covered by butt welding end cap as per ASME B 16.9. The drain tapping shall be taken from the drain pot arrangement.

All saturation steam piping system and steam piping system whose operating temperature are close to saturation temperature, shall be provided with a steam trap arrangement at each drain. The steam trap shall be provided with a bypass regulating globe valve.

At all high points and low points of the piping system and wherever required as per system requirement, drains and vents shall be provided. The minimum size of the drain and vent shall be NB 25 and NB 15 respectively.

At all screwed valves and screwed connections on equipment, unions shall be provided to facilitate disassembly. Likewise, unions shall also be provided at suitable points on straight lengths of screwed pipelines.

All valves shall be located on pipelines to operate them from the nearest available platforms and for easy access for maintenance.

All local instruments shall be located on pipelines as to render them observable from the nearest available platforms and accessible for maintenance.

Piping with operating temperatures above or below the ambient shall be routed so as to provide adequate flexibility for the pipes.

Tap-off on main lines for field routed pipe work, if not indicated on **PURCHASER**'s layout drawings, shall be suitably located by **BIDDER** to suit the layout evolved by him.

At all intersection joints, it is **BIDDER**'s responsibility to design and provide suitable reinforcements as per the applicable codes and standards.

10. Specialities

The material of construction, size, type and the design parameters & selection of the steam traps, pump suction strainers, control valves, gate, globe & check valves, butterfly valves & wafer type check valves, and metallic expansion bellows shall be as mentioned in the relevant section of this bid document.

11. Materials

All materials supplied under this contract shall conform to the following:
a. Material shall be as mentioned in the relevant section of this bid document.
b. The **BIDDER** shall furnish the piping specification sheet clearly indicating the material selected for various process piping.
c. All materials shall be certified by proper material test certificates. All material test certificates shall carry proper heat number or other acceptable references to enable identification of the certificate with the material it purpose to certify. The heat number shall also be indicated on the material certified.

12. Fabrication

Pipeline NB 50 mm and above size are deemed prefabricated. **BIDDER's** shall prepare necessary fabricated isometric drawings based on **PURCHASER's** layout drawings for those piping systems. **BIDDER's** fabrication drawings shall be taken into account the requirement of this piping specifications and also all applicable codes and standards. Fabrication and erection of piping systems NB 50 mm and above size shall be as per **BIDDER's** fabrication drawings. In case of systems requiring statutory clearance, fabrication and erection shall commence only after the necessary clearance have been obtained from the statutory

authorities. **BIIDDER's** fabrication drawings including isometrics if required shall carry all details of fabrication, welding etc. as may be required for obtaining the necessary statutory clearance.

Piping NB 50 mm and above size shall be fully fabricated at **BIDDER**'s Works or in the pre-fabrication yard in the site, which shall be adequately equipped with the required machinery, templates, gauges, tools and tackles etc. The extent of fabrication at works shall be such as to restrict field welding to circumferential line joints alone. Further, the number of circumferential line joints to be performed in the field shall be held to a minimum, limited by transport considerations and erection constraints.

Pipelines having size NB 40 mm and below are deemed field run and are hence fabricated in site.

All welded attachments on pipelines shall be of same material as the parent pipeline and shall be subjected to the same fabrication and welding procedures as the associated piping.

The use of companion flanges to connect two pieces of pipe and the use of odd or short pieces of pipe in making up long runs is prohibited.

Where welded pipe or fittings are used, longitudinal welds in adjoining sections shall be staggered to a minimum of 90 degrees during fabrication. All piping shall be fabricated true to lines and elevations as indicated on the piping drawings.

No welding shall be carried out on lined pipes.

Cutting of standard elbows to odd angles as required per layouts, is included in **BIDDER**'s scope.

Neither butt nor branch joints shall be closer than twice the pipe diameter to any other joint in the same pipe except where "weldolet" type fittings are used in which case the branch weld must be made to the "weldolet".

All welded branch connections shall be of suitable structural adequacy by virtue of the intrinsic weld connection, reinforcing plates or rings or material inherent in the branch. It is the **BIDDER**'s responsibility to provide reinforcement wherever necessary for branch connections. Welded branch connections are not an acceptable alternative where tees have been specified.

All threads on piping components shall be taper pipe threads as per applicable standards. The nipples shall be fabricated by the **BIDDER** at site as required.

The **BIDDER** shall cut the pipe short for cold spring for all hot lines in accordance with the data furnished by the **PURCHASER**. In addition to the cut for cold spring, a length of pipe must be cut to attain slope when the line is in the hot position. The additional cut must not add to the cold spring in the system. In order not to add to the cold spring, the pipe must be detailed and fabricated so that the affected horizontal runs will be sloped to the proper angle when installed in the field before the final weld is made. At the point of closure, the two end of pipe should be separated only by the required amount of cold spring. **PURCHASER**'s specific approval on the correctness of cold cut gaps shall be obtained before cold pulling the pipelines if required.

No external support shall be welded on valves and specialities except as provided by the Manufacturer.

All pipe flanges and contact surfaces shall be concentric with the axis of the piping. All flanges and fittings shall be accurately machined and drilled true to the template.

No welding / gas cutting shall be done locally to valves with soft seating components in order to prevent distortion of the soft seats.

Welding and Non-Destructive Examination

Welding, non-destructive examination of welded joints and repair of weld defect areas shall conform to the specification furnished in the relevant clause of this document.

Final welding of joints shall be undertaken only after the setup of piping is fully checked with respect to layout drawings if necessary and required.

At equipment terminal points, welding shall be carried out after taking into account specific requirement and / or recommendations of the equipment **BIDDER**.

Cleaning, Flushing & blow-out

All piping including valves and specialities shall be cleaned by the **BIDDER** before and during erection to remove grease, dirt, dust scale and welding slag.

Before erection all fabricated pipe work, assemblies, sub-assemblies, fittings and components etc. shall be thoroughly cleaned internally and externally by blast cleaning or by power driven wire brushes. The brushes shall be of the same or similar material as the metal being cleaned.

After erection, all piping shall be mass flushed with water. The cleaning velocities in the piping shall be at least 1.2 to 1.5 times the operating velocities in the pipelines.

All compressed air pipe work shall be cleaned by blowing compressed air.

All fuel oil, light oil and lubricating oil lines shall be cleaned by pickling.

Alternately, these lines can be cleaned by steam blowing subject to the timely availability of steam for this purpose.

For purposes of steam blowing, **PURCHASER** will make available low pressure steam as required. It is **BIDDER's** responsibility to install necessary temporary pipe work for blowing and remove the same after blowing.

Inspection and testing

On completion of erection, the inside of all pipes, valves, fittings etc, shall be clean and free from loose scale and foreign matter before subjecting the line to any test / inspection.

All piping systems shall be tested hydrostatically pneumatically by the **BIDDER** after erection, at pressures given in the applicable codes listed in Data sheet or as given in the line designation schedule. The test pressures shall be maintained until all welded/flanged joints are inspected for leakage or at least for ten minutes.

Mechanical equipment and pressure relieving devices should be blanked-off or removed from the line during pressure testing and control valves should be set in the open position for the duration of the test.

Orifice plates should not be erected until hydrostatic testing and cleaning operations are completed.

Lines having heck valves should have the source of test pressure located on the upstream side.

Expansion joints, instruments, filters and similar equipment for which the maximum permissible cold test pressure is lower than the hydrostatic test pressure applied to the system, shall be removed or blanked off from the line before testing. The **BIDDER** shall consult the **PURCHASER** / **PURCHASER**'s **REPRESENTATIVE** for specific guidance if required.

Test pressure readings may be taken at the lowest point of the system being tested provided the effect of static head is taken into consideration.

When conditions require a test pressure to be maintained for a period of time, during which the testing medium in the system might be subject to thermal expansion, provision may be made for the relief of excess pressure thereto.

After hydrostatic test any leaky joints shall be cut out and repaired or completely replaced and test repeated until the test has been satisfactorily passed. If any valve is found to be leaking part the bonnet joint or steam gland packing, **BIDDER** shall replace the gasket or gland packing and retest the system to the satisfaction of **PURCHASER**.

After completion of hydrostatic test, orifice plates shall be withheld for the hydrostatic tests and shall be installed in an approved manner. Orifice plate shall however be installed after completion of cleaning operations.

Clean water at a temperature of not less than dew point or 10 Deg.C whichever higher, nor exceeding 50 Deg.C should be used for hydrostatic test to be ensured by **PURCHASER**.

The rate of pressure increase must not exceed 7 kg/sq.cm. per minute.

No one should be allowed near piping/equipment under test when the test pressure is near the yield strength or when test pressure over 35 kg/sq.cm. are being applied. The pressure should be lowered by 10% before inspection for the leaks.

When draining the fluid, the pipelines should be vented slowly to avoid excessive vacuum.

A block valve is required on the line from the test pump to the pipeline/equipment under test.

Only calibrated test gauges should be mounted in the upright position. Pump discharge gauge must be visible to the pump operator for the duration of the hydro test.

Painting

All piping & its appurtenances shall be adequately protected against corrosion during manufacture, fabrication, shipment and storage by appropriate protective paint. Use of grease or oil for this purpose is prohibited.

Unless otherwise stated elsewhere in the specification, after installation, all above ground pipe work which are neither galvanised nor insulated shall be finish painted for MS pipes. However the piping in Stainless steel material will not be painted.

All hangers and supports including associated auxiliary steel on all pipelines including galvanised and insulated pipelines shall be finish painted.

For detailed specification for surface preparation, mixing & application of paints including colour coding for piping and structures shall be as referred in this specification.

Prior to applying finish paint, all painted surfaces shall be furnished with two coats of primer recommended by the manufacturer of the finish paint. All MS insulated piping shall be applied with two coats of primer.

All painting materials such as paints, varnishes, primers, solvents, thinners etc. shall be supplied by the **BIDDER**.

Welding Specification for Piping System

Scope

This specification shall apply to all welded pipe joints of carbon steels including stainless steels for distillery process plant piping system. This specification is applicable to shop fabrication, site fabrication & field erection. The welded joints are hereby defined as including:

All the line joints of the longitudinal and circumferential butt-welded type.

All the attachment of castings, forgings and flanges to pipe.

Welded manifold headers and all other sub-assemblies.

Welded branch connection with or without saddles and reinforcement rings.

Fabrication of built-up fittings.

The attachment of smaller connections for drips, drains, instruments, branch lines, weldolets, sockolets, thermowells, couplings etc. If applicable.

Closure of joints for inspection plugs and similar joints.

Any other similar joint not specified above but encountered during fabrication and / or erection stage. It is imperative that the **CONTRACTOR** makes every effort to secure the same high degree of competent supervision and workmanship during field erection as is intended for shop fabrication in view of the adverse field conditions of weather, piping location etc.,

The piping systems are generally classified as follows:

Carbon steel pipe system for temperature 218° C and less and pressure 17 kg/sq.cm (g) and less.

Stainless steel piping.
7.10.2.1.3 Material specifications for the above systems are generally covered by the following.

Carbon Steel Piping
Carbon Steel Piping to ASTM A 106 Gr. A, ASTM A 106 Gr.B, ASTM A 106 Gr.C, ASTM A 53 Gr.A, ASTM A 53 Gr.B, API 5L Gr. B, ASTM A 672 Gr. B60 C1-12, ASTM A 672 Gr.B70 Cl-12, IS 3589, IS 1239 or equivalent and corresponding materials for fittings, flanges, valves etc.

Stainless Steel Piping
Stainless Steel Piping to ASTM A 312 TP 304, 316 etc. or equivalent and corresponding materials for fittings, flanges, valves etc.

Codes and Standards

The welding of fusion welded piping system shall comply with currently applicable regulations, codes and safety codes in the locality where it will be installed. It shall also conform to the latest applicable standards. Nothing in this specification shall be construed to relieve the **BIDDER** of this responsibility. In particular, the pipe welding shall conform to the latest edition of the following codes and standards.

ASME codes for process piping - ASME B 31.3.

Indian Boiler Regulation – IBR

ASME Pressure Vessel Codes
Section II Part C – Specifications for welding rods, electrodes & filler metals Section V – Non destructive examination
Section VIII – Rules for construction of pressure vessels
Section IX – Welding & Brazing qualification

Specification of the American Welding Society.

Standards of Pipe fabrication Institute.

Any other codes and standards which are required to perform the specified welding.

The above mentioned codes and standards form an integral part of this specification. In the event of conflict between this specification and the codes and standards listed above, this specification shall govern.

19. **Welding Processes**

The welding process that are used in the fabrication of pipes and fittings are restricted to shielded metal arc welding and gas tungsten arc welding (argon arc) or a combination of the two.

Argon arc root pass shall be employed for all, carbon steel piping only applicable for IBR lines. Subsequent welding, after root pass can be carried out by manual shielded metal arc welding with coated electrodes. For pipes of wall thickness less than 6 mm, the entire welding shall be carried out by tungsten inert gas welding process. When using tungsten inert gas welding process, welding without addition of filler metal shall not be done.

For critical carbon steel piping system, the TIG root pass shall be employed and subsequent welding after root pass can be carried out by manual shielded metal arc welding with coated electrodes. Only applicable for IBR lines.

For Non-critical carbon steel piping system, the entire welding including root pass may be carried out by manual metal arc welding.

Where special welding techniques are recommended by equipment manufacturer for piping connecting to equipment, appropriate qualification test and welding technique shall be followed. The specific and detailed instructions of equipment manufacturer regarding welding, preheating, stress relieving etc., shall be strictly adhered to by the **BIDDER** at no extra cost to the **PURCHASER**. Only applicable for IBR lines.

Procedure and Performance Qualification

No production welding shall be undertaken until the procedure qualification test which are to be used have been established as per ASME boiler & pressure vessel code Section IX and / or IBR. The test results and specimens from qualification test of the welding process and welding operators shall be made available to the

PURCHASER / **CONSULTANT** for approval. Where results of existing procedure qualification and of welders are acceptable to the **PURCHASER** / **CONSULTANT**, such results shall be kept on file and be subject as to review regularly. Where doubt exists regarding the acceptability of any qualification test, a retest may be required. All such qualification tests and specimen testing shall be conducted in the presence of the **PURCHASER** / **CONSULTANT** if required.

The Cost of all procedure qualification test shall be borne by the **BIDDER**.

The **BIDDER** shall prepare a written specification containing the information detailed in Section IX of ASME form QW-482, 483 & 484A (WPS, PQR & WPQ). These documents shall be provided to the **PURCHASER** / **CONSULTANT** for review if required. The **BIDDER** shall prepare certificate of welder performance qualification test containing the information detailed in ASME Section IX. These shall be kept on file and made available to the **PURCHASER** / **CONSULTANT** upon request.

Welders and Supervisors

Unless otherwise agreed, the **BIDDER** shall advise to **PURCHASER** / **CONSULTANT** in writing, at least 3 weeks before any welder is employed on the work, the names and qualifications of the proposed welders and welding supervisors. It shall be the **BIDDER**'S responsibility to ensure that the welders employed by them or their SUB-**BIDDER**, on any part of the contract either at their works or at site are fully qualified as required by the code. Each welder shall qualify for all types of welding and materials he may be called upon to weld. There will be a separate welder for carbon steel and stainless steel material welding and also different welding techniques. I.e.: Argon and metal arc welding.

Should the **PURCHASER** / **CONSULTANT** require to test or retest of any welder, the **BIDDER** shall make available at no extra cost to the **PURCHASER**, the men, equipment and materials for the test. The cost of testing the welds shall be borne by the **BIDDER**.

Welding supervisors shall have adequate qualifications and experience in supervising welding of pipe joints with knowledge of non-destructive testing.

All welding including the tacking of all welds shall be carried out by approved welders only. Any weld made by other than the unapproved welder shall be cut out and re-welded. **BIDDER** will qualify separate tack welders for doing the tack welding while during the fit up/fabrication work; the tack will be directly on pipe weld joints.

For the purposes of identification and to enable tracing the full history of each line, records of weld completed by each welder has to be maintained by the **BIDDER** and records are to be handed over to the **PURCHASER** / **CONSULTANT**

For each welder, a record card shall be maintained showing the procedures for which he is qualified. These record cards shall be specified joint details, consumables and their repair frequency. The record shall be reviewed every fortnight by the **PURCHASER** / **CONSULTANT** and those welders whose work requires a disproportionate amount of repair shall be disqualified from welding on the basis of visual inspection of weld joints. Re-qualification of welders disqualified more than two times shall be entirely at the discretion of the **PURCHASER / CONSULTANT**. This clause is applicable to IBR piping only. However, the **BIDDER** will submit the qualification/records for process piping as per their own QAC plan as mentioned in relevant sections of this contract.

Preparation of Weld Ends

The surfaces to be welded shall be smooth, uniform and free from fins, tears and other defect which would adversely affect the quality of weld. All weld faces and adjoining surfaces for a distance of at least 150mm from the edge of the welding groove or 12 mm from the toe of fillet in the case of socket weld or fillet welded joints shall be thoroughly cleaned of rust, scale, paint, oil or grease outside.

Unless otherwise specified, all pipe joints shall be butt-welded. All butt welds shall be full penetration welds. Butt Joints

Butt joints shall be prepared as per ASME B 16.25, unless otherwise specified. Groove angle of the single V butt joints shall be 37.5 +/- 2.5 Deg

Unless noted otherwise, all butt welds shall be made without using backing rings.

Tee, corner and lap joints

Fillet welds shall have a throat dimension equal to the nominal thickness of either of the joint members.

Weld edges of full penetration groove welds for Tee joints shall be prepared with minimum included angle of 45 Deg.

The ends shall be prepared by machining, grinding or flame cutting. Where flame cutting is used, the effect on the mechanical and metallurgical properties of the base metal shall be taken into consideration. Flame cutting alloy steel pipes is not allowed. However, flame cutting of carbon steel pipes is permitted. Wherever

practicable, flame cutting shall be carried out by machine. Manual flame cutting edges shall be permitted only where machine flame cutting is not practicable and with the approval of the **PURCHASER** / **CONSULTANT** and such surfaces shall be ground or dressed to a smooth finish as required by the specification and to the satisfaction of the **PURCHASER** / **CONSULTANT** if required. Slag, scale or oxides shall be removed by grinding to bright metals at least 2 mm beyond the burnt area.

Thermal cutting of carbon steel piping shall be performed under the same conditions of preheat and post heat as for the welding of carbon steel material. However post heat is not required when:

The heat affected zone produced by thermal cutting is removed by mechanical means immediately after cutting. However in any case of removing, slag, scale or oxide shall be removed by grinding to bright metals at least 2 mm beyond the burnt area, or,

Thermal cutting is part of fabrication, manufacturing or erection sequence leading to a weld end preparation where heating immediately follows.

For the piping systems that are supplied by the **PURCHASER** but being erected by the **BIDDER**, beveling of pipes for butt welds shall be required. For systems with **BIDDER** supplies and erects, the pipe ends shall be bevelled to confirm to applicable codes / standards. At connections to equipment the bevelling of piping shall confirm to the requirement of the equipment connections.

Any change in the joint configuration must be done with the acceptance of **PURCHASER / CONSULTANT**.

All weld joint fit-up shall comply with the tolerances specified on the design drawings or applicable codes and standards.

If the **BIDDER** uses the header arrangement with central location of Oxygen and Acetylene for cutting and edge preparation operation, the arrangements shall be in accordance with the best safety practices and standards and shall be approved by the **PURCHASER** / **CONSULTANT**.

Before fitting up the weld joint, the profile and dimensions of the weld end preparation shall be offered to the **PURCHASER** / **CONSULTANT**.

All fit-ups shall be offered to the **PURCHASER** / **CONSULTANT** prior to welding the root pass.

Welding of Pipes

All vertical welding shall be carried out in the "UP" direction unless otherwise approved by the **PURCHASER** / **CONSULTANT**.

The maximum face width of any manual arc or inert gas weld run shall be as per standard as specified in ASME.

No single run horizontal / vertical position manual metallic arc weld fillet shall exceed 8 mm in size.

Fillet welds shall have a throat dimension at least equal to the nominal wall thickness specified for the pipe. Each leg of the fillet weld shall have a length of at least 1.25 times in the nominal wall thickness of the pipe. Socket and fillet welds shall have a minimum of two (2) weld layers.

All tack welds shall be made using a qualified procedure and qualified welders. Any preheat requirement specified on the welding procedure shall also apply to tack welds.

All tack welds shall be examined visually for defects, and if found defective shall be completely removed.

As the welding proceeds, tack welds shall be either removed completely or shall be properly prepared by grinding or filling their stopping and starting ends so that they may be satisfactorily incorporated in the final weld.

Welded-on branches for all piping systems shall be of full penetration type connection.

Preheating prior to tack welding and welding shall be employed as a means of crack prevention and improving general weld reliability. At no time during welding, temperature of the joint shall not be allowed to fall below the minimum preheat temperature. Excessive preheating shall be avoided.

When welding alloy steel, it is strongly recommended that interruption of welding shall be avoided. Where such interruption is unavoidable, either the preheat shall be maintained during interruption or the joint shall be wrapped in dry asbestos blankets to ensure slow cooling. Before recommencing welding, preheat shall be applied again.

No welding shall be done if there is impingement of rain, snow, sleet or high wind on the weld area.

Welded on bridge pieces and temporary attachment should preferably be avoided. Where approved by the **PURCHASER** / **CONSULTANT**, they may be used material of these shall be compatible with material which they are temporarily welded. All the weld pieces shall be removed after welding of pipe joint and the weld area ground flush and subjected to Magnetic particle / Dye-penetrant examination before applying any post weld heat treatment. These pieces shall be welded by qualified welders and with electrodes compatible with the parent pipe material. The preheating requirements shall be applied and maintained during the welding of pieces. These temporary attachments shall be removed by grinding, chipping or flame gouging. When arc flame gouging is used at least 3.2 mm of metal shall be left around the pipe surfaces, which shall be removed by grinding. This clause is applicable to critical lines i.e. IBR lines.

The arc shall be struck only on those parts of the parent metal where weld metal is to be deposited. When inadvertent arc strikes are made on the base metal surfaces outside the joint groove, the arc strikes shall be removed by grinding and shall be examined by liquid penetration or magnetic particle inspection procedures.

Oxides shall not be permitted to form during welding or heat treatment or both on the internal surface of pipe, which will not be subsequently cleaned. Inert gas purging will be an acceptable method to prevent such oxidation. All joints in material which contain 1¼% or more chromium shall be purged to assure that less than 1% of oxygen is present on the joint under side before initiation of the welding. The purging operation may be terminated when 5mm thickness of weld metal is deposited into the joint. The **BIDDER** may submit examples of other procedures for consideration of the **PURCHASER** / **CONSULTANT**.

Argon gas used in GTAW process for shielding and purging gas purity shall be minimum of 99.95 %. Purging shall be carried out at the flow rate depending on diameter of pipe until six (6) times of the volume between dams is displaced. In no case shall the initial purging period be less than ten (10) minutes. After initial purging the flow of the backing gas shall be reduced to a point where only a slight positive pressure prevails. Any dams used in purging shall be fully identified and removed after welding and accounted for in order to avoid leaving them in the system.

Thorough check shall be exercised to maintain the required interpass temperature.

All equipment necessary to carryout the welding for supporting of the work, for the pre-heating and the post-heating including thermal insulation for retaining the heat and for the protection of the welder shall be provided by the **BIDDER** This clause is applicable to critical lines i.e. IBR lines if applicable.

After deposition, each layer of the weld metal shall be cleaned with a wire brush to remove all slag, scale and defects to prepare for the proper deposition of the next layer. The material of wire brush shall be compatible with pipe material. Special care shall be taken to secure complete and thorough penetration of the fusion zone into the bottom of the weld. In case, where the weld joint on pipes 100 mm NPS and larger has to be radiographed as per the requirement of this specification, it is recommended that the root run be checked by liquid penetrant or magnetic particle procedures. This clause is applicable for IBR lines.

Gouging or back-gouging of butt welds may be carried out wherever feasible by grinding, chipping, machining or other approved methods, but the surface of cut must be cleaned to remove any carbon or oxidised metal before commencing the welding.

Repair of weld metal defects shall meet Cl. 127.4.11 of ASME B31.1 and /or IBR.

Upon completion of welding, the joints shall be wrapped in dry asbestos blankets to ensure slow cooling unless post-weld heat treatment is applied immediately. This clause is applicable to critical lines i.e. IBR lines if applicable.

No welding or welded parts shall be painted, plated, galvanised or heat-treated until inspected and approved by the **PURCHASER** / **CONSULTANT** welds shall be prepared / ground in such a way that welds surfaces merge smoothly in to the base metal surface.

Except where necessary to grained flush for nondestructive examination purpose, the centre of reinforcement for butt welds shall be as below.

Component Thickness (mm) Maximum Reinforcement (mm)
Up to 13 2.0
Over 13 to 25 2.5
Over 25 to 50 3.0
Over 50 4.0

The reinforcement shall be crowned at the centre and tapered on each side of the joined members. The exposed surface of the weld shall be ground where required to present a workman like appearance and shall be free from depressions below the surface of the joined members. The exposed surface of the butt welds shall be free from under cuts greater than 0.5 mm in depth, overlaps from abrupt ridges and valleys and shall merge smoothly into the pipe surface at the weld toe. However, undercuts shall not encroach on the minimum section thickness.

All welds shall be subjected to the approval of the **PURCHASER** / **CONSULTANT**.

In the event of several unsuccessful repair attempts or if the **PURCHASER** / **CONSULTANT** feels that a satisfactory repair is not feasible, the joint shall be completely remade.

Post weld heat treatment shall be carried out as per Cl. 132 of ASME B 31.1 and / or IBR.

Identification of Welds

Whenever code symbol stamps are required on carbon steel and Ferritic alloy steel piping, they shall be applied directly to the pipe with low stress dotted design metal die stamps or to a small stainless steel plate especially provided for such marks. These plates shall be lightly tack welded to the pipe using electrodes (of diameter 2.5 mm or less) of the type specified for the material. Before making the required tack weld, the pipe material in the immediate surrounding area shall be preheated as required by electric means or propane or natural gas burners. Cooling shall take place under asbestos insulation in a draft free area. Stresses relieving of these welds are not required. Steel stamping directly on the surface of alloy steel piping with other than low stress die stamps shall not be permitted.

Seal welds

Seal welding shall be done by qualified welders and in accordance with approved drawings.

If necessary, threaded joints that are to be seal welded shall be made without the use of thread lubricating compound

Preheating
Preheating prior to tack welding and welding shall be employed as a means of crack prevention and to improve general weld reliability.

Carbon Steel

Welded joints in carbon steel piping where tensile strength is below 4900 Kg/Sq.Cm, the carbon content does not exceeding 0.3% and design thickness not exceeding 19mm need not be preheated except where the ambient temperature is below 16° C. For this condition the joint shall be heated to ambient before any welding is performed. When the thickness is 19mm and above, shall be preheated before any welding is performed as follows:

WALL THICKNESS (MM) MINIMUM PREHEAT (º C) METAL TEMPERATURE
19 TO 38 100
38.1 TO 63 125
Above 63 150

Weld joints in carbon steel piping where the tensile strength is 4900 Kg/Sq.Cm, or greater or where the carbon content exceeds 0.3% When the thickness is 19mm and above, shall be preheated before any welding is performed according to the following requirement.

WALL THICKNESS (MM) MINIMUM PREHEAT (º C) METAL TEMPERATURE
19 TO 38 125
38.1 TO 63 150
Above 63 150

Austenitic Stainless Steel
Welded joint in Austenitic Stainless Steel Piping need not be preheated except where the ambient temperature is below 0 º C. For this condition, the joint shall be heated to 40 º C by propane, natural gas or electrical means before any welding is performed.

Pre-heat for dissimilar Material

When parts of two different materials are joined together, the material requiring higher pre-heat shall govern.

Stress Relieving (applicable only for IBR piping).
Stress relieving of piping material is required when so specified and shall be performed as specified in ASME and / or IBR.

General Requirement

A complete automatic temperature recording shall be made of preheating and stress relieving operations where propane gas burners or electrical resistance coils are employed. A complete temperature record of the preheating and stress relieving operations shall be made by means of box type potentiometer. Other means of recording the temperatures are permitted subject to **PURCHASER** / **CONSULTANT** approval.

Stress relieving may be performed locally or fully in furnace. Local stress relief shall be performed with electric induction or electric resistance coils. Suitable gas burning equipment using natural gas or propane may be employed.

At no time during stress relieving / preheating cycle shall any water or liquid

cooling medium be employed.

Where members being joined are unequal in thickness the dimension of the heavier section shall govern the selection of width of the heated band and the duration of the holding period.

When local stress relief is performed, the area of the welded joint and the adjacent material extending for a distance of at least three (3) times the width and widest part of the weld on each side of the weld shall be heated by band.
Thermo couple shall be placed at least 2 locations on the weld to 180 each other. One more thermocouple shall be placed in order to measure the half peak temperature during heat treatment. Half peak distance shall be calculated from the formula.
Distance =2.5 √ rXt
r = Radius of the component.
t = Thickness of the component.
Half peak temperature shall be not less than one half of the specified weld temperature measured at the weld.

For local stress relief using electrical methods the minimum of two (2) thermocouples tack welded to the surface of the potentiometer shall be used on the pipe under at least four (4) layers of asbestos paper. The hot junctions of thermocouples shall be located on either side of the joints at least 12 mm from the edge of the joint but no further away than 100 mm. When employing induction heating, at least six (6) turns of induction cable shall be wrapped on top of the asbestos paper protecting the thermocouples with the first turn approximately of 150 mm from the centre of the weld.

Local stress relief using gas torches or ring burners may be employed. However the procedure shall be limited to pipe below 100 mm nominal bore and must be approved by **PURCHASER** / **CONSULTANT**.

The stress relieving shall be maintained for a period of time proportioned on the basis of one hour per 25 mm of wall thickness of the thickest section of the joint. The parts to be heated shall be brought slowly to the required temperature and the heating rate shall not exceed 150 °C.

For tubing joints and for socket welded joints, pads, bosses and couplings, one (1) thermocouple shall be positioned on the minimum distance of two (2) pipe wall thickness from the weld.

For welds used for attachment of base brackets, two (2) thermocouples shall be used for determination of pre-heating and stress relieving temperatures. They

shall be tack welded directly to the header located 180 Deg. apart on the circumference of the header and the mid-way between adjacent legs.

Piping on both sides on any joint shall be adequately supported throughout the preheating, welding and stress relieving operations to prevent distortion.
After PWHT, the hardness of the weld metal and the parent metal shall be jointly measured with the digital hardness tester to verify satisfactory completion of the stress relieving process.

Carbon Steel

Welded joints on carbon steel pipe where the nominal pipe wall thickness of the heaviest material being joined is greater than 19 mm shall be stress relieved upon completion of the welding operation.

When the height of the boss above OD of the pipe is 19 mm or greater the weld shall be stress relieved.

When the wall thickness of the coupling or a pad is greater than 19 mm the weld shall be stress relieved.

When local stress relief is employed, the weld joints shall be heated to a temperature of not less than 600°C. This temperature level shall be maintained within the limits of 610° C +/- 10°C for a period of time proportioned on the basis of one hour per 25 mm of wall thickness but in no case less than 30 minutes. The weld area shall be allowed to cool and undisturbed in a still air to a temperature not exceeding 300° C.

All welded joints which are locally stress relieved in pipes of 100 mm NB and larger shall be heated by means of electrical induction coils or resistance heating. Welded joints in pipes smaller than 100 mm NB shall be stress relieved by means of electrical resistance coil or suitable propane or natural gas torches only.

When full furnace stress relieving is employed for a welded assembly, the entire fabricated section shall be heated uniformly and at no time during the subsequent heating cycle, shall the temperature not be allowed to exceed 620° C or fall below 600° C. The furnace shall then be adjusted so that the material will cool at a controlled rate not to exceed 150° C until 300° C is reached. However, in no casethe cooling rate shall not exceed 150° C per hour. At that time, the furnace may be shut off, the door opened and the piping material allowed to cool normally to handling temperature.

Heating and Cooling

The carbon steel after having reached their specific stress relief temperatures may be cooled under wraps (i.e.) leaving the induction coils or resistance heaters and insulation in place. This means that at the stress relief temperature the power to the furnace or heating coils may be shut off and cooling takes place in the furnace or with all insulation and coils remaining on the pipe. The stress relieving coils and insulation shall only be removed after the pipe has cooled below 300º C.

For furnace stress relief, the doors of the furnace may be opened after the power is shut off at 300° C. The thermocouples controlling the temperature shall remain during the cooling cycle so that the excessive cooling, if it occurs, can be observed and immediately corrected. The rate of heating and cooling shall confirm to Cl. 132.5 of ASME B 31.1 and / or IBR. This stress relieving coils and insulation shall be removed only after piping has cooled to below 300° C or if stress relieved in a furnace, the pipe may be removed from the furnace and permitted to cool in still air at a temperature of not below 10° C.

Local Stress Relief (applicable only for IBR piping).
All welded joints in pipe 100 mm NPS size and larger shall be locally stress relieved by means of electric induction coils or resistance welding. Welded joints in smaller pipe sizes shall be stress relieved by means of electric resistance coils or suitable propane or natural gas torches only.
For full furnace stress relief of a welded assembly, the entire fabricated section shall be heated uniformly to the temperature specified. The temperature shall be maintained for a period of time proportioned on the basis of one hour per 25 mm of wall thickness of the piece having the greatest wall thickness in the furnace charge, but in no case less than one hour.

Austenitic Stainless Steel
Joints in Austenitic stainless steel piping need not be stress relieved after welding.

Electrodes

The specification and size of the electrodes, voltages, amperages, thickness of beads and number of passes shall be as specified in the approved welding procedure or otherwise agreed in writing. In general, basic coated electrodes shall be used which shall be deposited with weld metal having the same or higher physical properties and similar chemical composition to the members being joined. For each batch of approved brand, certificate showing compliance with the specification shall be secured and shall be submitted to the

CONSULTANT for review before being released for use on project piping. All electrodes shall be purchased in sealed containers and stored properly to prevent deterioration. All low hydrogen electrodes shall be baked in mother oven between

300 to 350° C for one hour and stored in holding oven at 80 to 100° C before being used. The recommendation of the electrode manufacturer shall be followed.

For welding of all grades of steel and alloys by the GTAW process, a two (2) percentage thoriated tungsten electrode confirming to AWS / ASME section II part C classification shall be used.

Carbon Steel
All electrodes to be used in carbon steel shall conform to ASME SEC II PART C or any other equivalent codes.

As welding electrodes deteriorate under adverse conditions of storage leading to dampness in the electrode coating, they should be normally stored in air conditioned rooms or in hot boxes or ovens in their original sealed containers whose temperatures shall be maintained within specified limits. Thermometer shall be used to monitor the room temperature in which the electrodes are stored. The condition of electrodes shall be frequently inspected. The electrodes with damage to coating shall not be used. Electrode shall remain identified until consumed.

The type of electrode used should be only those recommended by the manufacturer for the use in the position in which the welds are to be made. Electrodes which have the areas of flux covering broken away or damaged shall not be used.

All the pressure piping shall have root run carried out using "TIG" process and further run by attested electrodes for various material combination and the selection of electrodes shall be as specified in Exhibit.

Inspection and Testing

The **PURCHASER** / **CONSULTANT** shall have accessibility to inspect the welding area in other related operations at any time and at any stage of fabrication.

The **PURCHASER** / **CONSULTANT** may require non-destructive testing of any weld for reasons other than those given in the specification. The responsibility for the cost of such testing shall be mutually decided between the **PURCHASER** and the **BIDDER**.

The **BIDDER** shall inform the **PURCHASER** / **CONSULTANT** when the weld preparation and setting up for welding of various members selected by the **PURCHASER** / **CONSULTANT** is in progress so that the **PURCHASER** / **CONSULTANT** can inspect the assembly before welding starts.

The responsibility of **PURCHASER's / CONSULTANT** shall in no way reduce the **BIDDER'**s responsibility to ensure that the work is carried out in accordance with the specification.

Examination methods of welds

IBR system – Carbon steel – pressure less than 17 kg/Sq.Cm(g) and Temperature less than 218 ° C
Edge preparation DPT 10% Butt welding
- for size over NB 100 RT 10% made by each welder subject to a minimum of 2 joints per welder
- for size NB 100 and below RT 5% made by each welder subject to a minimum of 2 joints per welder Branch Welding
- for branch size over NB 100 DPT 10 % or MPT 10%
- for branch size NB 100 and less DPT 5 % or MPT 5% Fillet, Socket, Attachment and Seal Welds
DPT 10% or MPT 10%

Non - IBR system - For carbon steel the NDE requirement shall be as per ASME B 31.3.

NDE Requirement for austenitic stainless steel piping:
Edge preparation DPT 10%
Butt welding RT as per ASME B 31.3

Legend:
RT : Radiographic Examination
UT : Ultrasonic Examination
DPT : Dye Penetrant Examination
MPT : Magnetic Particle Examination

Note: Prior to commencement, all Non-destructive examination shall be performed in accordance with written procedure to meet ASME / IBR and shall be acceptable to the **PURCHASER** / **CONSULTANT**.

Penalty Clause
Penalty, where NDT carried out is less than 100%, shall be as follows:

For every weld found defective an additional penalty joint will be marked for NDT

If the defects of any welder increased above 10%, then for every defective joint two (2) additional penalty joints (one joint on each side of the repair joint) will be marked for NDT.

If the defect of any welder exceeds 20%, then all welding joints shall be subjected to 100% NDT.

Selection shall be shift-wise. The cost of any such penalty works or additional NDT shall be fully born by the **BIDDER**.

In addition, at the discretion of the **PURCHASER** and the **CONSULTANT** and where requested by them, the **BIDDER** shall perform radiography and other tests of the joints of any other piping.

Where access holes for radiography have been provided in the piping, the **BIDDER** shall employ the single wall thickness radiography. The access holes shall be plugged and seal welded only after the radiograph is found acceptable and before to carryout stress relieving. If required necessary pre-heating to be carried out for seal welding.

Where no access holes for radiography are provided in the piping, the **BIDDER** shall employ the double wall double image technique with elliptical projection or double wall single image or single wall single image technique.

The **BIDDER** shall ensure that isotopes of sufficient strength and quality are used in order that the radiographs taken are of proper density, contrast and visibility.

Access hole plug welding shall be examined by liquid penetrant or magnetic particle test methods.

Qualification and Certification of Non-Destructive Examination Personnel

Organisation performing code required, Non-destructive examination should be personnel competent and knowledgeable to the degree specified by the ASME and IBR.

Acceptance and Standards

The acceptance level of faults for visual, magnetic particle, liquid penetration, ultrasonic and radiographic test methods and examination shall conform to the requirement of ASME and IBR.

Repair Welding

All defects in welds requiring repair shall be removed by flame or arc gouging, grinding, or machining. The major repairs may involve:
i. Cutting through the weld
ii. Cutting out the length of pipe containing the weld, or
iii. Removing the weld metal down to the root depending upon the magnitude of the defect.

After removing the defect, the welds shall be examined by same non-destructive testing methods as specified for the original weld and the same acceptance criteria shall hold good.

All repair welds shall be made using the same or other specified welding procedures as those used in making the original welds including preheating and stress relieving as originally required.

All repair welds shall meet the requirement of the codes and standards specified and shall be acceptable to the **PURCHASER** / **CONSULTANT.**