

पाइपिंग की रचना तथा उत्थापन हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR FABRICATION AND ERECTION OF PIPING

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Abbreviations:

A.S.	:	Alloy Steel
ASME	:	American Society of Mechanical Engineers
C.I.	:	Cast Iron
C.S.	:	Carbon Steel
HMTD	:	Heat & Mass Transfer Division
IBR	:	Indian Boiler Regulations
LTCS	:	Low Temperature Carbon Steel
NACE	:	National Association of Corrosion Engineers
NB	:	Nominal Bore
NDT	:	Non Destructive Testing
P&ID	:	Piping and Instrumentation Diagram
PMI	:	Positive Material Identification
S.S.	:	Stainless Steel
SMMS	:	Specialist Material & Maintenance Services

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CONTENTS

1.0	SCOPE.....	4
2.0	SCOPE OF WORK OF CONTRACTOR.....	4
3.0	BASIS OF WORK.....	7
4.0	FABRICATION.....	8
5.0	ERECTION.....	11

1.0 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.

2.0 SCOPE OF WORK OF CONTRACTOR

Generally the scope of work of Contractor shall include the following:

2.1 Transportation of required piping materials (as described in Cl.2.1.1), pipe support (material as described in Cl. 2.3) 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.

2.1.1 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, air traps, springs, silencers, snubbers, steam and condensate manifolds, injection nozzles, MOVs, sight glass, spray nozzles, integrated steam traps, hoses, hose couplings, etc.
- i. Online instruments like control valve, orifice flange, rotameter, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, annubar, magnetic flow meter, ultrasonic flow meter, Coriolis mass flow meters, venturi PG/PT/ Flow transmitter, ejectors, static mixers, flame arrestors, thermal flow switches, pre-fabricated hook-ups etc.
- j. Shut Down Valves with and without fire box.

2.2 Shop & field fabrication and erection of piping in accordance with documents listed under Cl.3.0 i.e. 'BASIS OF WORK' including erection of all piping materials enumerated above.

2.3 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, sway braces, dummy pipes, corrosion pads/protection shields, low friction pads, clamps, special support, expansion bellows, steam and condensate manifolds supports etc. Corrosion Pads/Protection shields, stiffeners and stiffening rings, if not covered in the specifications/standards, shall be of the same material as of parent pipes.

2.4 Site fabrication of Piping items

Site fabrication of Piping items shall include but not be limited to the following

- 2.4.1 Fabrication of piping specials like special radius bends, reducers, mitres etc.
- 2.4.2 Fabrication of plain and threaded nipples from pipes as required during erection.
- 2.4.3 Fabrication of swage nipples as and when required.
- 2.4.4 Fabrication of odd angle elbow like 60°, 30° or any other angle from 90°/45° elbows as and when required.
- 2.4.5 Fabrication of flange, reducing flange, blind flange, spectacle blinds as and when required.
- 2.4.6 Fabrication of stub-in connection with or without reinforcement.
- 2.4.7 Grinding of edges of pipes, fittings, flanges etc. to match mating edges of uneven/different thickness wherever required.
- 2.4.8 Fabrication of circular pipe for steam rings, fire water lines, utility lines.
- 2.4.9 Threading of all small bore piping as per piping material specifications.
- 2.4.10 Drilling on blind flange for inserting / joining small bore lines.
- 2.4.11 Fabrication and welding of reinforcement pads at branch pipe locations wherever required.
- 2.4.12 Equipment nozzle reinforcement with pads, jacket & stiffeners wherever required.
- 2.4.13 Fabrication of injection nozzles as per details provided wherever required.
- 2.4.14 Fabrication of chain operation arrangement for valves, wherever required. All material required for this modification shall be supplied by Contractor.
- 2.4.15 Fabrication and erection in position of funnels required for OWS/ SS/ Condensate blow down system as per direction of Engineer-in-charge.
- 2.4.16 Grinding/ finishing of uneven surfaces/ joints after welding. Internal grinding of welds of orifice flanges to render smooth surface.
- 2.4.17 Tapping and drilling of holes in flanges, blind flanges, piping connections for jack screw, if required.
- 2.4.18 Providing bird screens at the outlet of lines open to atmosphere.

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

2.6 Piping isometrics for main process/utility lines shall be provided to the Contractor.

Preparation of miscellaneous small bore isometrics with bill of materials for process and utility lines (up to 1½" size) like instruments & pump flushing / cooling, sample connection, purging, pump casing vents & drains, pump base plate drains, control valve drains / vent to flare, instrument drains & vents, steam tracing (non-IBR) from steam supply stations up to condensate recovery station, and lines specified as field routed within the Unit battery limit

as and when required are in Contractor's scope of work. Approval for these isometrics prepared by the Contractor shall be taken from Engineer-in-charge before erection.

Small bore piping isometrics given by Owner shall be rechecked by Contractor before erection and installation.

- 2.7** Obtaining approval for drawings prepared by Contractor from statutory authority, if required.
- 2.8** Spun concrete lining of the inside of pipes 3" NB & above including fittings and flanges as required in accordance with specification.
- 2.9** Rubber lining inside pipes, fittings, flanges as and when required, in accordance with specification.
- 2.10** Radiography, stress relieving, dye penetration, magnetic particle test etc. as required in specification.
- 2.11** Performing PMI using alloy analyzers as per 'Standard Specification for Positive Material Identification at Construction Sites, 6-82-0002'.
- 2.12** Casting of concrete pedestals and Fabrication and erection of small structures/ platforms for pipe supports and valve operation / attending some instruments, spectacle blinds etc., providing brackets, modification / extension of platforms, providing additional platforms / ladders for improving / providing accessibility.
- 2.13** Providing insert plates with anchor fasteners in concrete structures / paved floors and repair of platform gratings around pipe openings and providing suitable members for support under the platform grating.
- 2.14** Making material reconciliation statement and return of Owner's supply left over materials to Owner's storage.
- 2.15** Flushing and testing of all piping systems as per standard specification for inspection, flushing and testing of piping systems (Specification No. 6-44-0013). The accessories required for blinding the line like flange, blind flange, gasket (all sizes, type and rating), stud-bolts, flexible hoses etc. are to be arranged by the Contractor. During flushing the discharged water / air shall be drained / routed as directed by the Engineer – In Charge.
- 2.16** Contractor shall prepare welding specifications for all weld joints where dissimilar welding will be performed, and obtain approval from EIL.
- 2.17** Contractor to ensure meeting all requirements for carrying out work in shutdown/running plant.
- 2.18** Pickling (as and when applicable) as per Job specification(s) for chemical cleaning of CS suction piping of compressors, SS Piping, Weldments etc, as applicable.
- 2.19** Chemical Cleaning/ Hydro jet cleaning as per marked-up P&IDs with supply of chemicals, consumables, DM water, equipments, boilers, coupons, tools & tackles and other testing equipments required for the same.

3.0 BASIS FOR WORK

3.1 The complete piping work shall be carried out in accordance with the following:

3.1.1 "Approved for Construction" drawings and sketches issued by EIL to the Contractor - Plans and/or Isometrics.

3.1.2 "Approved for Construction" drawings and sketches issued by Turn-key bidders to the Contractor - Plans and/or Isometrics.

3.1.3 Approved Process Licensor's standards and specifications.

3.1.4 Drawings, sketches and documents prepared by Contractor duly approved by Engineer-in-Charge (such as isometrics of small bore piping and offsite piping etc.).

3.1.6 EIL specifications/documents as below:

- a. Process and Instrument Diagram.
- b. Job Piping Materials Specification (****-6-44-0005). **** denotes job number.
- c. Piping support, engineering standards.
- d. Line list
- e. Piping support indices (only in offsite), if supports are not shown in plan.
- f. Job specification of Non-destructive Requirement of Piping (****-6-44-0016)
- g. Job Welding Specification Charts for Piping Classes (****-6-77-0005)
- h. Job Welding specification for fabrication of piping (****-6-77-0001).
- i. Any other EIL 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.)
- j. Standard specification for positive material identification (PMI) at construction sites, 6-82-0002
- k. Standard Spec for application of torque & hydraulic bolt tension for flange joints (6-76-0002) and its addendum, if any.

3.1.7 Following codes, standards and regulations

- a. ASME B 31.3 : Process Piping
- b. ASME Sec. VIII : Code for unfired pressure vessel.
- c. IBR Regulations
- d. ASME Sec. IX : Qualification standard for welding and brazing procedures, welders, brazers and welding and brazing operators.

- e. NACE Std. : Code for Sour Services material requirements
MR-0175/MR0103/Job spec(NACE), as applicable

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

3.2 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.

4.0 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. To ensure the above requirement, all piping material supplied by the Owner / Contractor shall have proper identification marks as per relevant standards / EIL 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 colour 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.
- Positive material identification, handling, storage & preservation.

4.2 Dimensional Tolerances

Dimensional tolerances for piping fabrication shall be as per EIL Standard No. 7-44-0486. The 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 Engineer-in-Charge prior to fabrication or erection.

4.3 IBR Piping

- 4.3.1 Contractor shall obtain approval for the piping systems falling under purview of IBR from the statutory Indian Boiler Regulations (IBR) authority of the state where the plant is

situated. The Owner shall provide documentation for the IBR System. The Contractor shall carry out the fabrications, erection and testing of this piping as per requirements of Indian Boiler Regulations and to the entire satisfaction of the local Boiler Inspector. The Contractor shall also get the approval of IBR inspector for all fabrication and testing done by him at his own cost. All certificates of approval shall be in proper IBR forms.

- 4.3.2 IBR Package for residual, field routed and site modified steam lines shall be prepared by the Contractor. IBR approval for the same shall be in Contractor's scope, at his own cost.

4.4 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 Engineer-in-Charge 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.

4.5 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 Job welding specification (****-6-77-0005) and NDT specification (****-6-44-0016).

4.6 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 leakproof 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.

4.7 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 jack screws are to be provided, drilling and tapping for the jack screws in the flange, shall be done as per EIL Standard before welding it to the pipe.

4.8 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.

4.9 Bending

Bending shall be as per ASME B31.3 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.

4.10 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.

4.11 Mitre Bends and Fabricated Reducers

The specific application of welded mitre bends and fabricated reducers shall be governed by the Piping Material Specifications. Reducers shall be fabricated as per directions of Engineer-in-Charge. The radiographic requirements shall be as per Material Specifications for process and utility systems and NDT Specification for steam piping under IBR, radiographic requirements of IBR shall be complied with.

4.12 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 Engineer-in-Charge. Nipples as required shall be prepared from straight length piping.

4.13 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.

4.14 Jacketed Piping

The Jacketing shall be done in accordance with EIL 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.

4.15 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 fabricated by coating with removable rust preventive. Care shall also be taken to avoid any physical damage to flange faces and threads.

4.16 Miscellaneous

4.16.1 Contractor shall fabricate miscellaneous elements like flash pot, seal pot, sample cooler, supporting elements like turn-buckles, extension of spindles and interlocking arrangement of valves, operating platforms as required by Engineer-in-Charge.

4.16.2 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 condition contract.

4.16.3 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.

5.0 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 discolouring due to welding.

5.2 Piping Routing

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

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 Engineer-in-Charge.

In case of fouling of a line with other piping, structure, equipment etc. the matter shall be brought to the notice of Engineer-in-Charge 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 Engineer-in-Charge, 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

Slopes specified for various lines in the drawings / P&ID shall be maintained by the Contractor. Corrective action shall be taken by the Contractor in consultation with Engineer-in-Charge wherever the Contractor is not able to maintain the specified slope.

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 / 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 Joints shall never be slinged from bellows corrugations/ external shrouds, tie / rods, angles.
 - b. An Expansion Joints / 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
- For carrying out welding, earthing lead shall not be attached with the Expansion Joint.
 - The Expansion bellow shall be protected from arc weld spot and welding spatter.
 - 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 Engineer-in-Charge.

Hydraulic bolt tensioning & torque tensioning shall be performed on flange joints as per the requirements specified in "Standard Specification for application of Torque & Hydraulic Bolt Tension for flange joints," 6-76-0002 and its addendum, if any.

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, if any, 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 Engineer-in-Charge 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 Engineer-in-Charge 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 control valve, orifice flange, rotameter, safety valves, restriction orifice, rupture disc, de-super heaters, corrosion probes, annubar, magnetic flow meter, ultrasonic flow meter, Coriolis mass flow meters, venturi PG/PT/ Flow transmitter, ejectors, etc. and Shut Down Valves with fireboxes 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 (EIL Spec. 6-44-0013). Care shall be exercised and adequate precautions taken to avoid damage and entry 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, desuperheaters, 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 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 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 2" NB & above. For lines 1½"NB & below Contractor shall locate and design pipe supports in line with EIL Stds. In case of IBR Lines 1½"NB & below only indicative supporting shall be provided & detailing of such supports is in Contractor's scope. Contractor shall obtain approval of Engineer - in - Charge on drawings prepared by Contractor, before erection. However, any extra supports desired by Engineer-in-Charge 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 move 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 Engineer-in-Charge 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.

पाइपिंग निकायों के निरीक्षण, प्रक्षालन तथा परीक्षण हेतु मानक विनिर्देश

STANDARD SPECIFICATION FOR INSPECTION, FLUSHING AND TESTING OF PIPING SYSTEMS

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Approved by							

Abbreviations:

ASME :	The American Society of Mechanical Engineers
IBR :	Indian Boiler Regulations
PMI :	Positive Material Identification
ppm :	Parts per million
SS :	Stainless Steel

Piping Standards Committee

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CONTENTS

1.0	SCOPE.....	4
2.0	REFERENCES.....	4
3.0	INSPECTION.....	4
4.0	FLUSHING.....	4
5.0	PRESSURE TESTING.....	5

1.0 SCOPE

This specification covers the general requirements for inspection, flushing and testing of piping systems. However, testing of steam lines falling under IBR shall also be governed by Indian Boiler Regulations.

Flushing and testing of all piping systems shall be witnessed by the Engineer-In-Charge.

2.0 REFERENCES

ASME B31.3	:	Process Piping
IBR	:	Indian Boiler Regulations
EIL SPEC 6-82-0002	:	Standard Specification for Positive Material Identification (PMI) at Construction Sites

3.0 INSPECTION

During various stages and after completion of fabrication and erection, the piping system shall be inspected by the Engineer-In-Charge to ensure that:

- Proper piping material has been used.
- PMI has been performed as per EIL specification '6-82-0002'.
- Piping has been erected as per drawings and instructions of Engineer-In-Charge.
- All supports have been installed correctly.
- Test preparations mentioned in this specification have been carried out.

4.0 FLUSHING

Flushing of all lines shall be done before pressure testing.

Flushing shall be done by 'fresh potable water' or by 'dry compressed air wherever water flushing is not desirable to clean the pipe of all dirt, debris or loose foreign material.

Required pressure for water flushing shall meet the fire hydrant pressure or utility water pressure. For air flushing, the line/system shall be pressurized by compressed air at the required pressure which shall be 3.5 kg/cm²g maximum. The pressure shall then be released by quick opening of a valve, already in line or installed temporarily for this purpose. This procedure shall be repeated as many times as required till the inside of the pipe is fully cleaned.

In line instruments like control valves, orifice plates, rotameters, safety valves and other instruments like thermowells which may interfere with flushing shall not be included in flushing circuit.

The screens/meshes shall be removed from all permanent strainers before flushing. Screens/meshes shall be reinstalled after flushing but before testing.

During flushing temporary strainers shall be retained. These shall be removed, cleaned and reinstalled after flushing, but, before testing.

In case any equipment such as column, vessel, exchanger etc. form part of a piping circuit during flushing, this shall be done with the approval of Engineer-In-Charge. However, equipments thus included in the circuit shall be completely drained and dried with compressed air after flushing is completed.

During flushing discharged water/air shall be drained to the place directed by the Engineer-In-Charge. If necessary, proper temporary drainage shall be provided by the contractor.

Care shall be taken during flushing so as not to damage/spoil work of other agencies. Precautions shall also be taken to prevent entry of water/foreign matter into equipments, electric motors, instruments, electrical installations etc. in the vicinity of lines being flushed.

The contractor shall carry out all the activities required before, during and after the flushing operation, arising because of flushing requirements, such as but not limited to the following:

Dropping of valves, specials, distance pieces, inline instruments and any other piping part before flushing. The flanges to be disengaged for this purpose shall be envisaged by the contractor and approved by the Engineer-In-Charge. These flanges shall be provided with temporary gaskets at the time of flushing.

After flushing is completed and approved, the valve distance pieces, piping specials etc. shall be reinstalled by the contractor with permanent gaskets. However, flanges at equipment nozzles and other places where isolation is required during testing, only temporary gaskets shall be provided.

Records in triplicate shall be prepared and submitted by the contractor for each piping system for the flushing done in the proforma provided/approved by the Engineer-in-Charge.

5.0 PRESSURE TESTING

Pressure testing, in general shall be as per clause 345 of ASME B31.3, unless otherwise specified, herein. Lines carrying highly hazardous/poisonous fluids must have a sensitive leak test. For IBR lines, 'IBR Regulations' shall also be followed.

5.1 Extent of Testing

With the exclusion of instrumentation, piping systems fabricated or assembled in the field shall be tested irrespective of whether or not they have been pressure tested prior to site welding or fabrication.

To facilitate the testing of piping systems, vessels and other equipments may be included in the system with the prior approval of Engineer-In-Charge if the test pressure specified is equal to or less than that for the vessels and other equipments.

Pumps, compressors and other rotary equipments shall not be subjected to field test pressure.

Lines which are directly open to atmosphere such as vents, drains, safety valves discharge need not be tested, but all joints shall be visually inspected. Wherever necessary, such lines shall be tested by continuous flow of fluid to eliminate the possibility of blockage. However, such lines if provided with block valve shall be pressure tested up to the last block valve.

Seats of all valves shall not be subjected to a pressure in excess of the maximum cold working pressure of the valve. Test pressure applied to valves shall not be greater than the manufacturer's recommendation nor less than that required by the applicable code. Where allowable seat pressure is less than test pressure, test shall be made through an open valve.

Instruments in the system to be tested shall be excluded from the test by isolation or removals, unless approved otherwise by the Engineer-In-Charge.

Restrictions which interfere with filling, venting, draining such as orifice plates etc. shall not be installed unless testing is complete.

Control valves shall not be included in the test system. Where bypasses are provided test shall be performed through the bypass and/or necessary spool shall be used in place of the control valve.

Pressure gauges which are part of the finished system, but cannot withstand test pressure shall not be installed until the system has been tested. Where piping systems to be tested are directly connected at the battery limits to piping for which the responsibility rests with other agencies, the piping to be tested shall be isolated from such piping by physical disconnection such as valve or blinds.

5.2 General Requirements / Test Preparation for Testing

Testing shall be carried out with permanent gaskets installed unless specified otherwise or instructed by the Engineer-in-Charge.

No pressure test shall be carried out against closed valve unless approved by the Engineer-in-Charge

The Engineer-in-Charge shall be notified in advance by the Contractor, of the testing sequence and programme, to enable him to be present for witnessing the test. The Contractor shall be fully responsible for making arrangements with the local boiler inspector to witness the tests for steam lines falling under IBR. IBR certificates for these tests shall be obtained in the relevant IBR forms and furnished to the Engineer-in-Charge.

Before testing, all piping shall be cleaned by flushing to make it free from dirt, loose scale, debris and other loose foreign materials.

All piping systems to be hydrostatically tested shall be vented at the high points and the systems purged of air before the test pressure is applied.

Wherever in the line any void exists due to any reasons, like absence of control valves, safety valves, check valves etc. it shall be filled with temporary spools.

All joints welded, screwed or flanged shall be left exposed for examination during the test. Before pressurizing the lines, each weld joint shall be cleaned by wire brush to free it from rust and any other foreign matter.

Where a system is to be isolated at a pair of companion flanges, a blank shall be inserted between the companion flanges. Minimum thickness of the blank shall be designed in accordance with applicable design code.

Open ends of piping system where blanks cannot be used, such as pumps, compressors, turbines or wherever equipment or pipe spools have been recovered or disconnected prior to hydrostatic testing, shall be blinded off by using standard blind flanges of same rating as the piping system being tested.

Pressure gauges used in testing shall be installed as close as possible to the lowest point in the piping system to be tested, to avoid overstressing of any of the lower portions of the system.

For longer lines and vertical lines, two or more pressure gauges shall be installed at locations decided by the Engineer-in-Charge.

For lines containing check valves any of the following alternatives shall be adopted for pressure testing:

- Whenever possible pressurize up-stream side of valve.
- Replace the valve by a temporary spool and reinstall the valve after testing.
- Provide blind on valve flanges and test the upstream and downstream of the line separately and remove the blind after testing. At these flanges, temporary gaskets shall be provided during testing and shall be replaced by permanent gaskets subsequently.
- For check valves in lines 1½" and below flapper or seat shall be removed during testing (if possible). After completion of testing the flapper/seat shall be refitted.

Gas lines when hydrostatically tested shall be provided with additional temporary supports during testing as directed by the Engineer-in-Charge.

Piping which is spring or counter-weight supported shall be temporarily supported, where the weight of the fluid would overload the support. Retaining pins for spring supports shall be removed only after testing is completed and test fluid is completely drained.

When testing any piping system, air or steam of approximately 2 kg/ cm²g may be used as preliminary test to detect missing gaskets etc. as this avoids the necessity of draining the line to make repairs. However, steam shall not be used for this purpose, if the steam temperature is more than the design temperature of the line.

For jacketed pipes testing of core pipes shall be done on individual pieces where the pipe is continuously jacketed, before it is jacketed. The outer jacket shall be tested separately as a system. For piping with discontinuous jacketing the core pipe and the jacket shall be tested as separate continuous systems.

5.3 Testing Media, Test Pressure and Test Pressure Gauges

5.3.1 Testing Media

In general all pressure tests shall be hydrostatic using iron free water, which is clean and free of silt. Maximum chloride content in water for hydrostatic testing for SS piping shall be 15-20 ppm.

Air shall be used for testing only if water would cause corrosion of the system or overloading of supports etc. in special cases as directed by Engineer-in-Charge.

If operating fluid in the line is much lighter than testing fluid, the additional weight of testing fluid may render piping supports (as designed) inadequate. This will call for additional temporary supports. The typical examples are flare and vapor lines. It is preferable that hydrostatic testing is avoided in such systems and instead pneumatic testing may be specified.

Where air/water tests are undesirable, substitute fluids such as gas oil, kerosene, methanol etc. shall be used as the testing medium, with due consideration to the hazards involved. These test fluids shall be specified in the line list given to the contractor.

5.3.2 Test Pressure

The hydrostatic/ pneumatic test pressure shall be as indicated in the line list or as per the instruction of Engineer-in-Charge.

The selection of the piping system for one individual test shall be based on the following:

- Test pressure required as per line list.
- Maximum allowable pressure for the material of construction of piping.

Depending upon the above requirements and based on construction progress, maximum length of piping shall be included in each test.

5.3.3 Test Pressure Gauge

All gauges used for field testing shall have suitable range so that the test pressure of various systems falls in 35% to 65% of gauge scale range. Pressure gage dial shall be minimum of 150 mm. Size of Bourdon shall not be less than 75% of nominal diameter of dial range. Gauge shall be of a good quality and in first class working condition.

Prior to the start of any test or periodically during the field test programme, all test gauges shall be calibrated using a standard dead weight gauge tester or other suitable approved testing apparatus. Any gauge showing an incorrect zero reading or error of more than $\pm 2\%$ of full scale range shall be discarded. The Engineer-in-Charge shall check the accuracy of master pressure gauge used for calibration. Calibration certificate shall be furnished for the pressure gages.

5.4 Testing Procedure

5.4.1 Hydrostatic Test

All vents and other connections used as vents shall be left open while filling the line with test fluid for complete removal of air. In all lines for pressurizing and depressurizing the system, temporary isolation valves shall be provided if valved vents, drains do not exist in the system.

Pressure shall be applied only after the system / line is ready and approved by the Engineer-in-charge.

Pressure shall be applied by means of a suitable test pump or other pressure source which shall be isolated from the system as soon as test pressure is reached and stabilized in the system.

A pressure gauge shall be provided at the pump discharge for guidance in bringing the system to the required pressure.

The pump shall be attended constantly during the test by an authorized person. The pump shall be isolated from the system whenever the pump is to be left unattended.

Test pressure shall be maintained for a sufficient length of time not less than 10 minutes. Test pressure shall be released only after physical checking of all the joints and attachments are completed, to permit thorough inspection of all joints and connections for leakage or signs of failure. Any joint found leaking during a pressure test shall be retested to the specified pressure after repair.

The pump and the piping system to be tested are to be provided with separate pressure indicating test gauges.

Care shall be taken to avoid increase in the pressure due to temperature variation during the test.

5.4.2 Pneumatic Test

When testing with air, pressure shall be supplied by means of a compressor. The compressor shall be portable type with a receiver, after cooler and oil separator.

Piping to be tested by air shall have joints covered with a soap and water solution so that the joints can be examined for leaks.

All other details shall be same as per hydrotesting procedure (specified above).

5.5 Completion of Testing

After the hydrostatic test has been completed, pressure shall be released by opening the vents, in a manner and at a rate so as not to endanger personnel or damage equipments.

All vents shall be opened before the system is to be drained and shall remain open till all draining is complete, so as to prevent formation of vacuum in the system. After draining, lines / systems shall be dried by air. In services like dry air, ethylene etc., small traces of water can cause problem. For such lines hot air drying is to be done after hydro-test.

After testing is completed the test blinds shall be removed and equipment / piping isolated during testing shall be connected using the specified gaskets, bolts and nuts. These connections shall be checked for tightness in subsequent pneumatic tests to be carried out by the contractor for complete loop / circuit including equipments (except rotary equipments).

Pressure test shall be considered complete only after approved by the Engineer-in-Charge. Defects, if any, noticed during testing shall be rectified immediately and retesting of the system / line shall be done by the contractor at his cost.

5.6 Test Records

Records in triplicate shall be prepared and submitted by the contractor for each piping system, for the pressure test done in the proforma provided/approved by the Engineer-in-Charge. Records shall also be submitted for the PMI undertaken as per EIL Std. Specification No. 6-82-0002.

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TECHNICAL NOTES FOR PIPES

5	31.12.13	REVISED AND ISSUED AS STANDARD SPECIFICATION	<i>[Signature]</i> UK	<i>[Signature]</i> SH	<i>[Signature]</i> AK	<i>[Signature]</i> RN	<i>[Signature]</i> SC
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Abbreviations:

ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
BHN	:	Brinell Hardness Number
BIS	:	Bureau of Indian Standards
E.FS.W	:	Electric Fusion Weld
E.R.W	:	Electric Resistance Weld
HAZ	:	Heat Affected Zone
HIC	:	Hydrogen Induced Cracking
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
IS	:	Indian Standard
LT	:	Low Temperature
MR	:	Material Requisition
NACE MR	:	National Association of Corrosion Engineers : Material Requirement
NB	:	Nominal Bore
NPT	:	Nominal Pipe Thread
PMI	:	Positive Material Identification
PR	:	Purchase Requisition
SMYS	:	Specified Minimum Yield Strength
SS	:	Stainless Steel

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CONTENTS

1.0	GENERAL	4
2.0	IBR PIPES.....	6
3.0	ACCEPTABLE DEVIATIONS.....	7
4.0	HYDROSTATIC TEST	7
5.0	MARKING AND DESPATCH	10
6.0	REFERENCES.....	10

1.0 GENERAL

- 1.1 All pipes and their dimensions, tolerances, chemical composition, physical properties, heat treatment, hydrostatic test and other testing and marking requirements shall conform to the latest codes and standards specified in the material requisition (MR). Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted. Post Order Waiver/ Deviation format 5-0000-0180-F1 as mentioned in Cl. 5.18 of Specification for Quality Management System Requirements from Bidders (6-78-0001) is not applicable.

1.2 Testing

- 1.2.1 Test reports shall be supplied for all mandatory tests as per the applicable material specifications. Test reports shall also be furnished for any supplementary tests as specified in the MR & Clauses 1.10 & 1.11.
- 1.2.2 Material test certificates (physical property, chemical composition & heat treatment report) shall also be furnished for the pipes supplied.
- 1.2.3 PMI shall be performed as per the scope and procedures as defined in the spec for PMI at Supplier's Works (6-81-0001).
- 1.2.4 Refer to specification nos. 6-81-0002 and 6-81-0003 for Inspection & Test plans for welded pipes and seamless pipes respectively.

1.3 Manufacturing Processes

- 1.3.1 Steel made by acid Bessemer process shall not be acceptable.
- 1.3.2 All longitudinally welded pipes other than IS 3589 should employ only automatic welding.
- 1.4 Pipe shall be supplied in single or double random length of 4 to 7 and 7 to 14 meters respectively.
- 1.5
- a. Seamless and E.R.W. pipes shall not have any circumferential seam joint in a random length. However, in case of E.F.S.W pipe, in one random length one welded circumferential seam of same quality as longitudinal weld is permitted. This weld shall be at least 2.5 m from either end. The longitudinal seams of the two portions shall be staggered by 90°. Single random length in such cases shall be 5 to 7 m.
 - b. Unless otherwise mentioned in the respective material code, E.F.S.W pipes < 36" shall not have more than one longitudinal seam joint and E.F.S.W pipes ≥ 36" shall not have more than two longitudinal seam joints.
- 1.6 Pipe with screwed ends shall have NPT external taper pipe threads conforming to ASME/ANSI B1.20.1 up to 1.5" NB & IS 554 for 2" to 6" NB.

- 1.7 Pipe with beveled ends shall be in accordance with ASME B16.25. Weld contours shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Up to 22 mm	Figure 2 Type A
	> 22 mm	Figure 3 Type A
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Up to 10 mm	Figure 4
	> 10 mm & Up to 25 mm	Figure 5 Type A
	> 25 mm	Figure 6 Type A

- 1.8 Galvanized pipes shall be coated with zinc by hot dip process conforming to IS 4736 / ASTM A 153.

- 1.9 All austenitic stainless steel pipes shall be supplied in solution annealed condition. All types of 321 or 347 stainless steel pipes shall be in a stabilized heat treated condition. Stabilizing heat treatment shall be carried out subsequent to the normal solution annealing. Soaking time & holding temp. for stabilizing heat treatment shall be 4 hrs & 900°C respectively.

1.10 I.G.C. Test for Stainless Steels

- 1.10.1 For all austenitic stainless steel pipes inter-granular corrosion test shall have to be conducted as per following:

ASTM A262 Practice “B” with acceptance criteria of “60 mils/year (max.)”.

OR

ASTM A262 Practice “E” with acceptance criteria of “No cracks as observed from 20X magnification” & “Microscopic structure to be observed from 250X magnification”.

- 1.10.2 When specifically asked for in MR for high temperature application of some grades of austenitic stainless steel (eg. SS 309, 310, 316, 316H etc.) ASTM A262 Practice “C” with acceptance criteria of “15 mils/year (max.)” shall have to be conducted.

- 1.10.3 For the IGC test as described in 1.10.1 & 1.10.2, two sets of samples shall be drawn from each solution annealing lot; one set corresponding to highest carbon content and the other set corresponding to the highest pipe thickness. When testing is conducted as per Practice “E”, photograph of microscopic structure shall be submitted for record.

- 1.11 All welded pipes indicated as ‘CRYO’ & ‘LT’ in MR shall be impact tested per requirement & acceptance criteria of ASME B31.3. The impact test temperature shall be -196°C & -45°C for stainless steel and carbon steel respectively unless specifically mentioned otherwise in MR.

1.12 NACE/HIC Requirements

- 1.12.1 Pipes under “NACE” category and those designated as “HIC1” shall meet the requirements given in NACE MR-0103 unless mentioned otherwise.

- 1.12.2 Pipes made from plates and designated as “HIC1” shall meet the HIC requirements of EIL specification 6-79-0013 unless mentioned otherwise.

- 1.13** Specified heat treatment for carbon steel and alloy steel and solution annealing for stainless steel pipes shall be carried out after weld repairs. Number of weld repairs at the same spot shall be restricted to maximum two by approved repair procedure.
- 1.14** For black or galvanized pipes to IS 1239, the minimum percentage of elongation shall be 20%.
- 1.15** All 1Cr-½Mo and 1¼Cr-½Mo seamless pipes shall be normalised and tempered.
- 1.16** For all welded alloy steel pipes with mandatory requirement of heat treatment and radiography, radiography shall be performed after heat treatment.
- 1.17** For Hydrogen service pipes following special requirements shall also be met:
- 1.17.1 All carbon steel pipes having wall thickness 9.53 mm (0.375") and above shall be normalised. Cold drawn pipes shall be normalised after the final cold draw pass for all thicknesses.
- 1.17.2 All alloy steel (Cr-Mo) pipes shall be normalised and tempered. The normalising and tempering shall be a separate heating operation and not a part of the hot forming operation. The maximum room temperature tensile strength shall be 100,000 psig.
- 1.17.3 For carbon steel Pipes, hardness of weld and HAZ shall be 200 BHN (max.). For alloy steel Pipes, hardness of weld and HAZ shall be 225 BHN (max.).
- 1.17.4 For all austenitic stainless steels, the weld deposit shall be checked for ferrite content. A Ferrite No.(FN) not less than 3% and not more than 10% is required to avoid sigma phase embrittlement during heat treatment. FN shall be determined by Ferritescope prior to post weld heat treatment.
- 1.17.5 For all Carbon steel and Alloy steel pipes with wall thickness over 20mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 for weld metal and base metal from the thickest item per heat of material and per heat treating batch. Impact test specimen shall be in complete heat treated condition and accordance with ASTM A370. Impact energies at 0°Celsius shall average greater than 27J (20 ft-lb) per set of three specimens, with a minimum of 19J (15 ft-lb).
- 1.18** For dual grades of SS where specified, chemical composition and mechanical properties of both grades specified shall be ensured.

2.0 IBR PIPES

2.1 IBR Documentation

- 2.1.1 Pipes under purview of IBR shall be accompanied with IBR certificate original in Form III-A or Form III-D [for well known pipe manufacturers as per IBR], duly approved and countersigned by IBR authority/local authority empowered by the Central Boiler Board of India. Photocopy of the original certificate duly attested by the local boiler inspector where the supplier is located is the minimum requirement for acceptance. Well known pipe manufacturers, as recognized by IBR, shall submit a duly attested copy of Form XVI-G along with Form III-D.
- 2.1.2 For materials 1¼Cr - ½Mo (ASTM A335 Gr.P11 / A691 Gr.1¼Cr), 2¼Cr - 1Mo (ASTM A335 Gr.P22 / A691 Gr.2¼Cr) & 9Cr -1Mo-V (A335 Gr.P91/A691 Gr.91), Form III-A approved by IBR shall include the tabulation of Et, Sc & Sr values for the entire temperature range given below. Et, Sc & Sr values shall be such that throughout the temperature range

$$\begin{array}{l} E_t / 1.5 \geq \\ S_r / 1.5 \geq \\ S_c \geq \end{array} \quad \left| \quad S_A \right.$$

where ,

- S_A : Allowable stress at the working metal temperature.
 E_t : Yield point (0.2% proof stress at the working metal temperature)
 S_c : The average stress to produce elongation of 1%(creep) in 100000 hrs at the working metal temperature.
 S_r : The average stress to produce rupture in 100000 hrs at the working metal temperature and in no case more than 1.33 times the lowest stress to produce rupture at this temperature.

S_A (psi)												
Temp(°F) Material	500	600	650	700	750	800	850	900	950	1000	1050	1100
A335 Gr.P11	17200	16700	16200	15600	15200	15000	14500	12800	9300	6300	4200	2800
A691 Gr.1¼Cr	18900	18300	18000	17600	17300	16800	16300	15000	9900	6300	4200	2800
A335 Gr.P22 / A691 Gr.2¼Cr	17900	17900	17900	17900	17900	17800	14500	12800	10800	7800	5100	3200
A335 Gr.P91/ A691 Gr.91	28100	27700	27300	26700	25900	24900	23700	22300	20700	18000	14000	10300

Note : S_A values shall be as per the latest edition prevailing.

2.2 For carbon steel pipes under IBR the chemical composition shall conform to the following:

- Carbon (max) : 0.25%
 Others (S, P, Mn) : As prescribed in IBR.

The chemical composition as indicated in this clause is not applicable for pipes other than IBR services.

3.0 ACCEPTABLE DEVIATIONS

- 3.1** Pipes to IS 3589 Gr.410 are acceptable in place of IS 3589 Gr.330.
3.2 Pipes of Grades SS317 of corresponding material are acceptable in place of Grades SS316 or SS316(2.5 Mo min.).
3.3 Pipes of Grades SS317L of corresponding material are acceptable in place of Grades SS316L or SS316L(2.5Mo min.).
3.4 Seamless pipes are acceptable in place of welded pipes except in the case of welded SS321/SS321H pipes with nominal thickness greater than 9.53mm.

4.0 HYDROSTATIC TEST

- 4.1** All pipes shall be hydrostatically tested.

4.2 The mill test pressure shall be as follows:

4.2.1 Seamless, E.R.W. & Spiral Welded

a) Carbon Steel

Material Std.	Test Pressure Std.
ASTM A106 Gr.B	ASTM A530
API 5L Gr.B, Seamless	API 5L
API 5L, E.R.W.	API 5L
API 5L, Spiral	API 5L
ASTM A333 Gr.3 & 6, Seamless	ASTM A530
ASTM A333 Gr.3 & 6, E.R.W.	ASTM A530

b) Seamless Alloy Steel

Material Std.	Test Pressure Std.
ASTM A335 Gr.P1, P12, P11, P22, P5, P9	ASTM A530
ASTM A268 TP 405, TP410	ASTM A530

c) Seamless Stainless Steel

Material Std.	Test Pressure Std.
ASTM A312 Gr.TP 304, 304L, 304H, 316, 316L, 316H, 321, 347	ASTM A999

d) Seamless Nickel Alloy

Material Std.	Test Pressure Std.
ASTM B161 UNS No. 2200	ASTM B161
ASTM B165 UNS No. 4400	ASTM B165
ASTM B167 UNS No. 6600	ASTM B167
ASTM B407 UNS No. 8800	ASTM B407

e) Welded Nickel Alloy

Material Std.	Test Pressure Std.
ASTM B725 UNS No. 2200,4400	ASTM B725
ASTM B517 UNS No. 6600	ASTM B517
ASTM B514 UNS No. 8800	ASTM B514

4.2.2 Electric Fusion Welded

a) Carbon Steel & Alloy Steel E.F.S.W (16" & above)

Material Std.	Test Pressure Std.
API 5L Gr.B ASTM A671 Gr.CC65, 70 (Cl.32) ASTM A672 Gr.C60, 65, 70 (Cl.12,22) ASTM A671 Gr.CF60, 65, 66, 70 (Cl.32) ASTM A691 Gr.½Cr, 1Cr, 1¼Cr, 2¼Cr, 5Cr, 9Cr (Cl.42)	P = 2ST/D S = 90% of SMYS Except for API 5L Gr.B S = 85% of SMYS For API 5L Gr.B T = Nominal Wall Thickness D = O.D of Pipe

b) Stainless Steel E.F.S.W (2" to 6")

The hydrostatic test pressure in kg/cm² for the following materials shall be as given below :

Material Gr.1 :ASTM A312 TP 304 / 304H / 316 / 316H / 321 / 347 welded.

Material Gr.2 :ASTM A312 TP 304L / 316L welded.

Size	Pipe Schedule : 10S		Pipe Schedule : 40S		Pipe Schedule : 80S	
	Material Gr. 1	Material Gr.2	Material Gr.1	Material Gr.2	Material Gr.1	Material Gr.2
2"	100	80	155	130	230	190
3"	80	60	155	130	230	190
4"	80	50	155	130	230	190
6"	65	35	90	75	155	130

c) Stainless Steel E.F.S.W (8" and above).

Material Std.	Test Pressure Std.
ASTM A358 TP 304L, 304, 304H, 316L, 316, 316H, 321, 347 (Classes 1, 3 & 4)	P = 2ST/D S = 85% of SMYS T = Nominal Wall Thickness D = O.D of Pipe
ASTM A358 TP 304L, 304, 304H, 316L, 316, 316H, 321, 347 (Classes 2 & 5)	P = 2ST/D S = 72% of SMYS T = Nominal Wall Thickness D = O.D of Pipe

4.2.3 Carbon Steel Pipes to BIS Standards

Material Std.	Test Pressure Std.
IS 1239	IS 1239
IS 3589	IS 3589

5.0 MARKING AND DESPATCH

- 5.1 All pipes shall be marked in accordance with the applicable codes, standards and specifications. In addition the purchase order number, the item code & special conditions like "IBR", "CRYO", "NACE", "H2" etc. shall also be marked.
- 5.2 Pipes under "IBR", "CRYO", "NACE" & "H2" shall be painted in red stripes, light purple brown stripes, canary yellow & sea green stripes respectively longitudinally throughout the length (25mm width) for easy identification. Marking of Pipes circumferentially for sizes 1" and below at one metre interval along the length of pipes is also acceptable.
- 5.3 Paint or ink for marking shall not contain any harmful metal or metallic salts such as zinc, lead or copper which cause corrosive attack on heating.
- 5.4 Pipes shall be dry, clean and free from moisture, dirt and loose foreign materials of any kind.
- 5.5 Pipes shall be protected from rust & corrosion.
- 5.6 Rust preventive used on machined surfaces to be welded shall be easily removable with a petroleum solvent and the same shall not be harmful to welding.
- 5.7 Both ends of the pipe shall be protected with the following material:
- | | | |
|--------------|---|-------------------------------|
| Plain end | : | Plastic cap |
| Bevel end | : | Wood, Metal or plastic cover |
| Threaded end | : | Metal or plastic threaded cap |
- 5.8 Pipes may be provided with plastic push-fit type end caps/ steel caps without belt wire.
- 5.9 Steel end protectors to be used on galvanized pipes shall be galvanized. Plastic caps can also be used as end protectors for galvanised pipe ends.

6.0 REFERENCES

- 6.1 6-81-0001: Specification for Positive Material Identification (PMI) at Supplier's Works.
- 6.2 6-81-0002: Inspection & test plan for welded pipes.
- 6.3 6-81-0003: Inspection & test plan for seamless pipes.
- 6.4 6-79-0013: Material requirements for carbon steel components used in sour service for petroleum refinery environments

फ्लैजों, स्पैक्टेकल ब्लाइंडों एवं ड्रिप रिंगों के लिए तकनीकी टिप्पणियाँ

TECHNICAL NOTES FOR FLANGES, SPECTACLE BLINDS AND DRIP RINGS

5	31.12.13	REVISED & ISSUED AS STD SPECIFICATION	UK	SH	AK	RN	AP	SC
4	04.07.08	REVISED & ISSUED AS STD SPECIFICATION	RN	SC	DM	VC		
3	01.11.00	REVISED & ISSUED AS STD SPECIFICATION	RN	BRB	NS	MI		
2	04.04.94	I.G.C. TEST CLAUSE REVISED	AKG	BPV	GRR	AS		
1	31.05.92	ISSUED AS GENERAL REVISION	MSD	NS	SLG	RNS		
0	01.03.90	ISSUED AS STANDARD SPECIFICATION	RKJ		GRR	RCPC		
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman	Approved by	

Abbreviations:

AARH	:	Arithmetic Average Roughness Height
ANSI	:	American National Standards Institute
API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing & Materials
AWWA	:	American Water Works Association
BHN	:	Brinell Hardness Number
HIC	:	Hydrogen Induced Cracking
IBR	:	Indian Boiler Regulations
IGC	:	Inter Granular Corrosion
IS	:	Indian Standard
MR	:	Material Requisition
MSS	:	Manufacturer's Standardization Society
NACE MR	:	National Association of Corrosion Engineers : Material Requirement
PMI	:	Positive Material Identification

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CONTENTS

1.0	GENERAL	4
2.0	IBR REQUIREMENTS	6
3.0	ACCEPTABLE DEVIATIONS.....	6
4.0	MARKING AND DESPATCH	7
5.0	REFERENCES.....	7

1.0 GENERAL

1.1 All items, their dimensions, tolerances, chemical composition, physical properties, heat treatment and testing etc. shall conform to the latest codes and standards specified in the requisition. Supplier shall strictly comply with MR/PR stipulations and no deviations shall be permitted. Post Order Waiver/ Deviation format 5-0000-0180-F1 as mentioned in Cl. 5.18 of Specification for Quality Management System Requirements from Bidders (6-78-0001) is not applicable.

1.2 Testing

1.2.1 Test reports shall be supplied for all mandatory tests as per the relevant material specifications. Test reports shall also be furnished for any supplementary tests as specified in the requisition & Clauses 1.11, 1.12 & 1.15.

1.2.2 Material test certificates (physical property, chemical composition & heat treatment report) shall also be furnished for the flanges supplied.

1.2.3 Positive Material Identification (PMI) shall be performed as per the scope and procedures as defined in the 'Specification for Positive Material Identification (PMI) at Supplier's Works' (No. 6-81-0001).

1.2.4 Refer to specification no. 6-81-0006 for Inspection and Test plans for flanges, spectacle blinds & drip rings.

1.3 Ends of weld neck flanges shall be beveled to suit the schedule / thickness of matching pipe, as specified in the requisition.

1.4 Bevel end details for welding neck flanges shall be as per ASME B16.25. Contour of bevel end shall be as follows:

Material	Wall Thickness	Weld Contour
Carbon Steel (Except Low Temp. Carbon Steel)	Upto 22 mm	Figure 2 Type A
	> 22 mm	Figure 3 Type A
Alloy Steel, Stainless Steel & Low Temp. Carbon Steel	Upto 10 mm	Figure 4
	> 10 mm & Upto 25 mm	Figure 5 Type A
	> 25 mm	Figure 6 Type A

1.5 Bore of socket weld flanges & reducing blind flanges shall suit the outside diameter and schedule / thickness of matching pipe.

1.6 Bore of slip on flanges shall suit the outside diameter of matching pipe.

1.7 Flange face finish shall be normally specified in the requisition as serrated finish, 125 AARH etc. The interpretation for range of face finish shall be as follows:

Stock Finish	:	1000 μ in AARH max.
Serrated Finish/125 AARH	:	Serrations with 125 to 250 μ in AARH
63 AARH	:	32 TO 63 μ in AARH

- 1.8 Galvanized flanges shall be coated with zinc by hot dip process conforming to IS 4736 / ASTM A153.
- 1.9 Ends of screwed flanges unless otherwise specified shall have taper threads as per ASME/ANSI B1.20.1 (upto 1.5" NB) & IS 554 (for 2" to 6" NB).
- 1.10 For ring joint flanges, blinds and spacers the hardness shall be as follows:

Flange Material	Min. Hardness of Groove (BHN)
Carbon Steel	140
1% Cr to 5%, 9% Cr	150
Type 304, 316, 321, 347	160
Type 304L, 316L	140

- 1.11 For ring joint flanges, blinds and spacers, the hardness shall be recorded in the test report.

1.12 NACE/HIC Requirements

- 1.12.1 Flanges, blinds, drip rings under "NACE" category and those designated as "HIC1" shall meet the requirements given in NACE MR-0103 unless otherwise specified.
- 1.12.2 Flanges, blinds, drip rings made from plates and designated as "HIC1" shall meet the HIC requirements of EIL Specification 6-79-0013 unless otherwise specified.

- 1.13 All austenitic stainless steel flanges shall be supplied in solution annealed condition.

1.14 I.G.C. Test for Stainless Steels:

- 1.14.1 For all austenitic stainless steel flanges, blinds, drip rings & Fig.8 flanges intergranular corrosion test shall have to be conducted as per following:

ASTM A262 Practice 'B' with acceptance criteria of "60 mils/year (max.)".

OR

ASTM A262 Practice 'E' with acceptance criteria of "No cracks as observed from 20X magnification" & "Microscopic structure to be observed from 250X magnification".

- 1.14.2 When specifically asked for in requisition for high temperature application of some grades of austenitic stainless steel (like SS309, 310, 316, 316H etc.) ASTM A262 Practice 'C' with acceptance criteria of "15 mils/year" shall have to be conducted. When testing is conducted as per Practice 'E', photograph of microscopic structure shall be submitted for record.
- 1.14.3 For the IGC test as described in 1.14.1 & 1.14.2 two sets of samples shall be drawn from each solution treatment lot; one set corresponding to highest carbon content and the other corresponding to the highest rating / thickness.
- 1.15 All types of 321 or 347 stainless steel flanges shall be in a stabilized heat treated condition. Stabilising heat treatment shall be carried out subsequent to the normal solution annealing. Soaking temperature and holding time for stabilizing heat treatment shall be 900 C and 4 hours respectively.

- 1.16 For dual grades of SS where specified, chemical composition and mechanical properties of both grades specified shall be ensured.
- 1.17 AWWA C207 flanges shall be hub type.
- 1.18 Dimensions for handle projection for Spacers & Blinds shall be as specified in EIL Std. 7-44-0166.
- 1.19 Flanges of 22" size shall be as per MSS-SP44 unless otherwise specified
- 1.20 All 1Cr-½Mo and 1¼Cr-½Mo flanges shall be normalised and tempered.
- 1.21 Ring Joint Fig-8 Flanges, Spacers & Blinds shall be female type only.
- 1.22 The handle for spacers & blinds for classes 900# & above shall be designed by the vendor. The handle may be integral or attached to the line blank / spacer by welding. In case of attachment by welding heat treatment & welding shall be in accordance with B31.3.
- 1.23 For Hydrogen service following special requirements shall also be met:
- All carbon steel flanges having wall thickness 9.53 mm and above shall be normalised. The normalising heat treatment shall be a separate heat treatment operation and not a part of the hot forming operation.
 - All alloy steel (Cr-Mo) flanges shall be normalised and tempered. The normalising and tempering shall be a separate heat treatment operation and not a part of the hot forming operation.
 - For all carbon steels and alloy steels with wall thickness over 20mm, Charpy-V Notch impact testing shall be carried out in accordance with paragraph UG-84 of ASME Section VIII, Div-1 per heat of material and per heat treating batch. Impact test specimen shall be in accordance with ASTM A370. Impact energies at 0 C shall average greater than 27J (20 ft-lb) per set of 3 specimens, with a minimum of 19J (15ft-lb).

2.0 IBR REQUIREMENTS

2.1 IBR Documentation

- 2.1.1 Flanges coming under the purview of IBR (Indian Boiler Regulations) shall be accompanied with IBR Certificate original in Form III C duly approved and countersigned by IBR authority/ local authority empowered by Central Boiler Board of India. Photocopy of original certificate duly attested by the local boiler inspector where the supplier is located is the minimum requirement for acceptance.

- 2.2 For carbon steel pipes under IBR the chemical composition shall conform to the following:

Carbon (max)	:	0.25%
Others (S, P, Mn)	:	As prescribed in IBR.

The chemical composition as indicated in this clause is not applicable for pipes other than IBR services.

3.0 ACCEPTABLE DEVIATIONS

- 3.1 Blind Flanges and Spacers & Blinds if specified as plate materials are acceptable in forging materials also in the corresponding material grades.

3.2 Flanges/Spectacle Blinds/Drip rings of Grades SS317 of corresponding material are acceptable in place of Grades SS316 or SS316(2.5Mo min.).

3.3 Flanges/Spectacle Blinds/Drip rings of Grades SS317L of corresponding material are acceptable in place of Grades SS316L or SS316L(2.5Mo min.).

4.0 MARKING AND DESPATCH

4.1 All items shall be legibly and conspicuously stamped in accordance with the requirements of applicable ASME, API and MSS Standards. In addition, EIL item code, purchase order number & special conditions like "IBR", "CRYO", "NACE" "H2" etc. shall also be stamped.

4.2 All items coming under the purview of "IBR", "CRYO", "NACE" & "H2"(hydrogen) shall be painted in red stripes, light purple stripes, canary yellow stripes & sea green stripes (25 mm width) respectively for easy identification.

4.3 Paint or ink for marking shall not contain any harmful metal or metal salts such as zinc, lead or copper which cause corrosive attack on heating.

4.4 All items shall be dry, clean and free from moisture, dirt and loose foreign materials of any kind.

4.5 All items shall be protected from rust, corrosion and mechanical damage during transportation, shipment and storage.

4.6 Rust preventive on machined surfaces to be welded shall be easily removable with a petroleum solvent and the same shall not be harmful to welding.

4.7 Each end of flange shall be protected with the following materials:

Flange face	:	Wood, metal or plastic cover
Bevelled end	:	Wood, metal or plastic cover
Threaded end	:	Plastic plug
Socket welding end	:	Plastic cover or plug

4.8 Each size of flanges, blinds, etc. shall be supplied in separate packagings marked with the purchase order number, item code number, material specification, size and rating.

5.0 REFERENCES

6-81-0001	:	Specification for Positive Material Identification (PMI) at Supplier's Works.
6-81-0006	:	Inspection & test plan for flanges, spectacle blinds & drip rings
6-79-0013	:	Material requirements for carbon steel components used in sour service for petroleum refinery environments
7-44-0162	:	Standard for Spacers & Blinds $\geq 26''$ (150CL, 300CL & 600CL FF)
7-44-0164	:	Standard for Spacers & Blinds $\geq 26''$ (For AWWA Flanges)
7-44-0166	:	Dimensions for Handle projection for Spacers & Blinds $\geq \frac{1}{2}''$ -24"

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

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

1	26.05.2008	Revised & Reissued	PG	KPS	AA	VC
0	15.05.2003	Issued for Implementation	PG	KPS	VC	SKG
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	

Abbreviations:

API	:	American Petroleum Institute
ASME	:	American Society of Mechanical Engineers
SS	:	Stainless Steel

General Engg. Standards Committee

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CONTENTS

1.0	PURPOSE	4
2.0	SCOPE	4
3.0	REFERENCES	4
4.0	DEFINITIONS	4
5.0	METHODOLOGY AND CONTROL	4
6.0	RESPONSIBILITIES / APPROVALS	9
7.0	DOCUMENTATION	9
	TABLE-1	11
	ANNEXURE-I	27
	ANNEXURE-II	28

1.0 PURPOSE

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

2.0 SCOPE

This specification covers ASME B16.5 flange joints wherein both the flanges are of same material and are prepared by means of either hydraulic bolt tensioning or calibrated torque wrenches.

3.0 REFERENCES

- | | |
|------------------------------------|---|
| EIL Spec no. 6-44-0005 | - Standard Piping Material Specification |
| ASME B16.5 | - Pipe Flanges and Flanged Fittings |
| ASME B31.3 | - Process Piping |
| BP RP 42-2 | - British Petroleum Recommended Practice: Bolting for flange joints |
| ASME Section VIII Div. 1/
Div.2 | - Boiler and Pressure Vessel Code |

4.0 DEFINITIONS

None.

5.0 METHODOLOGIES AND CONTROL

5.1 Identification of Joints for Controlled Bolt Tightening

Controlled bolt tightening can be done either by application of calculated bolt tension with hydraulic tensioner or by application of calculated bolt torque with calibrated torque wrenches.

5.1.1 Hydraulic Bolt tensioning

Hydraulic bolt tensioning shall be applied for all joints where the bolt sizes match following criteria:

Nominal Bolt dia	Condition	Remarks
All	When specified by Process licensor/ vendor / project specifications	
50 mm and over	All joints except joint under Category 'D' fluid services	Category 'D' service is defined in ASME B31.3
38 mm to 50 mm	Class 600 and above	
	Hydrogen service	(See Note-1 below)
	Category 'M' fluid services	Refer ASME B31.3
	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)
25mm to 38mm	Joints with leakage potential	(See Note-2 below)
	Critical joints with equipments	(See Note-3 below)

Note-1: Hydrogen Service

Hydrogen service is defined as service in contact with hydrogen or gaseous mixtures containing hydrogen in which the partial pressure of hydrogen is 7 Kg/cm² (100 psi) or more as per industrial practice. However the actual partial pressure will be as per the job specification.

Note-2: Joints with leakage potential shall include

- Joints involving tapped holes.
- Item not subjected to hydrotest e.g. joints for equipment manholes, equipment mounted temperature, pressure and level instruments, line mounted temperature connections, on line instrument joints like control valves and safety valves, compressor volume bottles.
- Items involving two sets of gaskets with one set of bolt e.g. orifice flange joint, joints with spectacle blind, spacer, flangeless wafer check valve, wafer type butterfly valves.
- Tie-in joints with other contractors and package vendors.
- High temperature (above 370°C) joints in hydrocarbon services.

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

5.1.2 Application of torque

Controlled bolt torque, with calculated torque values, shall be applied using calibrated torque wrench. Such torque should be applied for the following joints. Joints those qualify for hydraulic tensioning per 5.1(a) shall not be considered for torque application.

Service	Classes
Hydrogen service	All classes
Category 'M' services	All classes
Other services	Class 600 and above

5.2 Pre-Bolting Operations

5.2.1 Design

- Flange connection with bolting of nominal diameter 25mm and above shall have sufficient clearances and access to allow the use of hydraulic tensioning equipment (wherever hydraulic bolt tensioning is being used).
- Stud bolts shall be longer by one diameter to suit the bolt tensioners for hydraulic bolt tensioning. Excess threads shall be protected by a threaded cap. On bolts at ambient temperature duty the cap should have a grease nipple.
- All flanges on hydrogen service must be left exposed unless otherwise agreed.
- Interface joints shall be system pressure tested as per relevant code to ensure their integrity.

5.2.2 General

- Use of right type of Gasket, Fasteners etc. conforming to the specifications as per Design and Drawings should be ensured.
- The ring joint gaskets should have 30 to 40 Vickers hardness less than that of the mating face of the flange.

- c) All non-ring joint gaskets shall be replaced with new ones whenever an opened joint is to be re-closed during construction and commissioning stage. Ring joint gaskets normally can be re-used provided they are inspected and are free from any damage
- d) Flange joints once tested at shop should not be disturbed at site. In case the joint is opened, Contractor shall be responsible for final hook-up joints including bolt tensioning if applicable.

5.2.3 Visual inspection

- a) Condition of flange faces should be checked. These shall be free from dirt, scale, remnant gasket, and protrusions. Faces with pitting, indentations or radial tool marks, or scratches are not desirable. Surface finish should conform to specifications.
- b) Flanges should be aligned properly. Flange faces shall be parallel and boltholes shall match so that studs can be inserted freely.
- c) Visual examination of gaskets should be carried out prior to installation to ensure that these are free of any defects such as bends, crease or loose spiral windings etc.
- d) Gasket position should be checked.
- e) Studs and nuts shall be free from dirt, nicks, burrs and chips. Studs shall be straight and nuts shall turn freely on the stud.
- f) No external load shall be used to align the flanges.

5.2.4 Corrective measures

- a) Faces with pitting, indentations or radial tool marks, or scratches that form leakage paths or with the surface finish not in accordance with design requirements shall be replaced or re-machined to specified surface finish.
- b) If necessary, gasket-seating face should be cleaned using wire brush (SS bristles on alloy components) and/or suitable solvent.
- c) Damaged gaskets shall be replaced.
- d) If holding gasket in place after installation is a problem, a thin adhesive tape should be used along the outside edge of gasket.

5.2.5 Lubrication/anti-seize compound

- a) Threads and nuts to flange contact face should be lubricated with suitable lubricant. Thread compound or lubricant may be used suitable for line temperature.
- b) Gaskets should not be lubricated.
- c) Lubricant shall not be applied on bolts, used in oxygen services.
- d) Some of the types of lubricants used are as follows:
 - Molybdenum lead oxide (graphite based)
 - Molykote G-n plus
 - Molykote P37

- Molykote HSC Plus / Never Seez nickel special
- API SA2
- Molykote 1000
- Machine oil
- Graphite grease

5.2.6 Assembly

- a) Suitable lubricant (refer cl. 5.2.5) to be applied to the threads and the face of the nut that contacts the flange.
- b) Four studs should be placed in positions 1, 2, 3 and 4 according to “Stud Tightening Pattern” in Fig.1, as centring guides for the gasket.
- c) Balance studs should be inserted next.
- d) Nuts should be run down by hand in such a way that an equal number of threads project at each end.

5.2.7 Torque/tension calculation

- a) EIL software FLTRQ16.5 is used for calculation. The analysis part of this software primarily follows the procedure outlined in ASME Section VIII Division 1/ Division 2.
- b) Basic formulae used for torque calculation takes care of friction between bolt threads and nut threads as well as that between nut and back face of flange.
- c) A frictional co-efficient of 0.15 is assumed for calculation of torque values for the lubricant - graphite grease. When a lubricant with different co-efficient of friction (μ) is used, the calculated values get multiplied by the ratio $\mu/0.15$. The approximate μ values of some of the lubricants are as follows:

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

* However, it is advisable to reconfirm the value of co-efficient of friction (μ) from the manufacturer.

5.2.8 Torque/tension values

TABLE-1 contains the tension and torque values to be used for bolt tightening using hydraulic bolt tensioner and torque wrench respectively. These values are listed specification and size wise. The tension values specified are the target load per bolt intended after the bolt tensioning operation is complete. This means any allowance inherent in bolt tensioning equipment (viz. backlash etc.) as recommended by the equipment manufacturer shall also be taken care of.

For D1K class, the listed values apply only if the line temperature is above 150°C. Below this temperature the listed values are not suited.

Recalculation of torque/tension values should be carried out if the pipe wall thickness calculation pressure falls below 80% of the class rating pressure.

5.3 Bolting Operation

5.3.1 General

- Categorisation of joints for tension or torque application shall be as per cl. 5.1
- Bolt tightening tension or torque value shall be as per cl. 5.2.8.
- Guidelines and safety requirements provided by the manufacturer of bolt tightening equipment should be followed.

5.3.2 Hydraulic bolt tension application

- Hydraulic pressure adequate to get the target bolt load can be calculated dividing the bolt load by the load cell hydraulic seal area. This pressure should be applied simultaneously to all load cells.
- 4 load cells equally spaced should be used.
- Nuts should be run down to flange surface manually.
- Load cells should be shifted following the Criss-cross Pattern shown in Fig. 1 but in-groups of 4 bolts each (i.e. 1-2-3-4, 5-6-7-8, 9-10-11-12 etc.) and the tensioning of all bolts should be completed.
- Tensioning operations should be repeated once again applying the same pressure.

5.3.3 Stud bolt torque application

- Bolt torque application sequence shall be in accordance with "Criss-cross Stud Tightening Pattern"(Fig. 1).
- Properly calibrated torque wrenches should be used.
- Torque wrench should be held perpendicular to the axis of the bolt and if hydraulic wrench is used, ensure that it reacts against a rigid support parallel to the axis of bolt.
- Torque should be applied using a minimum of following five steps:

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

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

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

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

- iii. Tightening to 60% of the final torque value (Criss-cross Pattern – Fig.1).
Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).
- iv. Tightening to the final torque value (Criss-cross Pattern – Fig. 1).

Flange should be bearing uniformly on the gasket (Distance between mating flanges shall be uniform).
- v. Tightening should be continued with the final torque in a clockwise manner (bolt to bolt) until no further rotation is observed.
- e) In the event of nut seizure, the nut should be backed off and additional lubricant should be applied or the nut or/and bolt should be replaced, if necessary.

5.3.4 Testing of joints

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

6.0 RESPONSIBILITIES / APPROVALS

- 6.1 All procedures/documents to be used during Construction should be submitted by the Contractor to Engineer-in-charge at site in advance.
- 6.2 The equipment supplier shall be subjected to EIL/Owner approval.
- 6.3 The details of hydraulic tensioner equipment to be used for tightening shall be intimated to Engineer-in-charge before application.
- 6.4 Boxing up and tightening of flange joints shall be done by skilled technicians, qualified and approved by Contractor and EIL/Owner.
- 6.5 Any conflict between the requirements of this standard and related codes, standards, data sheets, drawings, requisitions etc. shall be referred to client / consultant. Agency carrying out bolt tightening shall list and describe all the deviations from this specification and the related codes

7.0 DOCUMENTATION

- 7.1 History sheet for flange joints shall be maintained as per Annexure-I.
- 7.2 Sequence of activities involved for reopening/ making/ blinding/ deblinding/ wedge opening of flange joints shall be as per Annexure-II.
- 7.3 All joints shall be boxed-up and record shall be maintained of salient points and names of the persons involved in execution/inspection of boxing-up operation.
- 7.4 All critical joints shall be boxed-up under the supervision of the Contractor's representative and EIL's Engineer-in-charge or his representative and separate records shall be maintained for such joints.
- 7.5 Box up records of interface joints and on-line instrument joints, like control valves, safety valves, turbine flow meters etc., which are not subjected to hydrotest shall be maintained separately.
- 7.6 If mentioned in project specification, complete set of bolt Tensioning Equipment/ Torque Wrenches shall be supplied by Contractor to the Owner after commissioning of the plant, as mandatory spares.

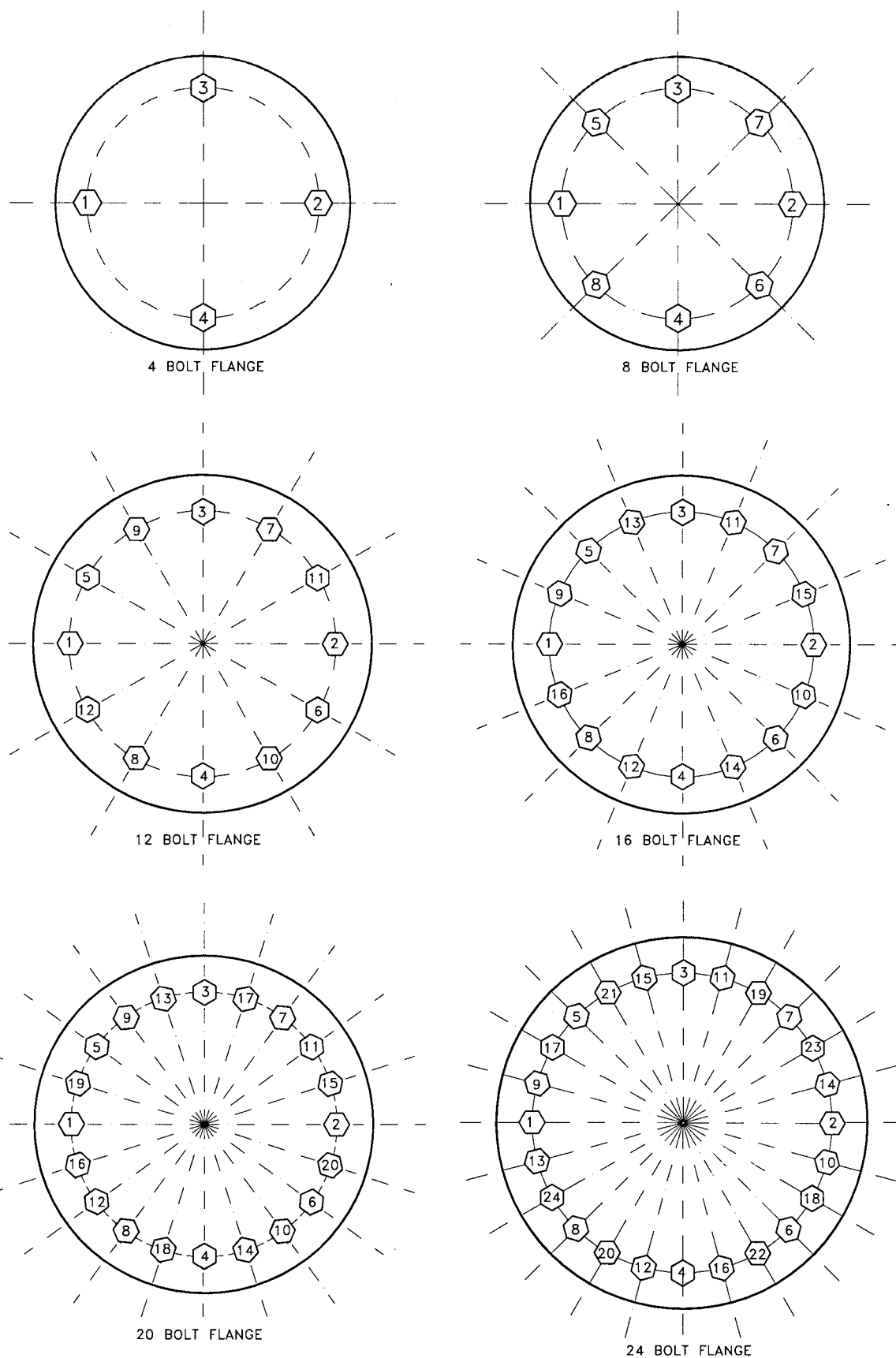


Figure 1 Typical "Criss-cross" Bolt tightening/Torque application pattern

TABLE 1 BOLT TENSION AND TORQUE VALUES

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
1	A1A	0.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	684	2.1	12.0
2	A1A	0.75	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	855	2.6	15.0
3	A1A	1.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	1027	3.1	18.0
4	A1A	1.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	1597	4.9	28.0
5	A1A	2.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	2566	9.8	28.0
6	A1A	3.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	3025	11.6	33.0
7	A1A	4.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	8	2475	9.5	27.0
8	A1A	6.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	3974	17.9	29.0
9	A1A	8.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	4933	22.2	36.0
10	A1A	10.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	5133	26.7	27.0
11	A1A	12.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	5323	27.6	28.0
12	A1A	14.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	12	5875	34.7	23.5
13	A1A	16.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1	16	5750	34.0	23.0
14	A1A	18.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	16	8588	56.5	26.0
15	A1A	20.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8588	56.5	26.0
16	A1A	24.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10959	79.3	26.0
17	A1K	0.50	150	7.73	371	30.05	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1/2	4	570	1.7	10.0
18	A1K	0.75	150	7.73	371	30.05	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1/2	4	798	2.4	14.0
19	A1K	1.00	150	7.73	371	30.05	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1/2	4	913	2.8	16.0
20	A1K	1.50	150	7.73	371	30.05	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1/2	4	1426	4.3	25.0
21	A1K	2.00	150	7.73	371	30.05	A105	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	5/8	4	2291	8.8	25.0
22	A1K	3.00	150	7.73	371	30.05	A105	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	5/8	4	3025	11.6	33.0

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

STANDARD SPECIFICATION No.
6-76-0002 Rev. 1

Page 12 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
23	A1K	4.00	150	7.73	371	30.05	A105	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	5/8	8	2475	9.5	27.0
24	A1K	6.00	150	7.73	371	30.05	A105	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	3/4	8	4111	18.5	30.0
25	A1K	8.00	150	7.73	371	30.05	A105	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	3/4	8	5070	22.8	37.0
26	A1K	10.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	7/8	12	5133	26.7	27.0
27	A1K	12.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	7/8	12	5513	28.6	29.0
28	A1K	14.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	1	12	6750	39.9	27.0
29	A1K	16.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	1	16	5750	34.0	23.0
30	A1K	18.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	1-1/8	16	8588	56.5	26.0
31	A1K	20.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8588	56.5	26.0
32	A1K	24.00	150	7.73	371	30.05	A105	A358 Gr. TP304 Cl. 1	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10959	79.3	26.0
33	A5A	0.50	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	684	2.1	12.0
34	A5A	0.75	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	855	2.6	15.0
35	A5A	1.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	1027	3.1	18.0
36	A5A	1.50	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	1597	4.9	28.0
37	A5A	2.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	2566	9.8	28.0
38	A5A	3.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	3025	11.6	33.0
39	A5A	4.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	8	2475	9.5	27.0
40	A5A	6.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	3974	17.9	29.0
41	A5A	8.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	4933	22.2	36.0
42	A5A	10.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	7/8	12	5133	26.7	27.0
43	A5A	12.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	7/8	12	5323	27.6	28.0
44	A5A	14.00	150	11.95	260	30.05	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1	12	5875	34.7	23.5
45	A5A	16.00	150	11.95	260	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1	16	5750	34.0	23.0
46	A5A	18.00	150	11.95	260	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	16	8588	56.5	26.0
47	A5A	20.00	150	11.95	260	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8588	56.5	26.0
48	A5A	24.00	150	11.95	260	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10959	79.3	26.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 13 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
49	A9A	0.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	684	2.1	12.0
50	A9A	0.75	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	855	2.6	15.0
51	A9A	1.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	1027	3.1	18.0
52	A9A	1.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	1597	4.9	28.0
53	A9A	2.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	2566	9.8	28.0
54	A9A	3.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	3025	11.6	33.0
55	A9A	4.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	8	2475	9.5	27.0
56	A9A	6.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	3974	17.9	29.0
57	A9A	8.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	4933	22.2	36.0
58	A9A	10.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	5133	26.7	27.0
59	A9A	12.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	5323	27.6	28.0
60	A9A	14.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	12	5875	34.7	23.5
61	A9A	16.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1	16	5750	34.0	23.0
62	A9A	18.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	16	8588	56.5	26.0
63	A9A	20.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8588	56.5	26.0
64	A9A	24.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10959	79.3	26.0
65	A11A	0.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	684	2.1	12.0
66	A11A	0.75	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	855	2.6	15.0
67	A11A	1.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	1027	3.1	18.0
68	A11A	1.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	1597	4.9	28.0
69	A11A	2.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	2566	9.8	28.0
70	A11A	3.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	3025	11.6	33.0
71	A11A	4.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	8	2475	9.5	27.0
72	A11A	6.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	3974	17.9	29.0
73	A11A	8.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	4933	22.2	36.0
74	A11A	10.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	5133	26.7	27.0

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

STANDARD SPECIFICATION No.
6-76-0002 Rev. 1
Page 14 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
75	A11A	12.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	5323	27.6	28.0
76	A11A	14.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	12	5875	34.7	23.5
77	A11A	16.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1	16	5750	34.0	23.0
78	A11A	18.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	16	8588	56.5	26.0
79	A11A	20.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8588	56.5	26.0
80	A11A	24.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10959	79.3	26.0
81	A16A	0.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	1/2	4	684	2.1	12.0
82	A16A	0.75	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	1/2	4	855	2.6	15.0
83	A16A	1.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	1/2	4	1027	3.1	18.0
84	A16A	1.50	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	1/2	4	1597	4.9	28.0
85	A16A	2.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	5/8	4	2566	9.8	28.0
86	A16A	3.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	5/8	4	3025	11.6	33.0
87	A16A	4.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	5/8	8	2475	9.5	27.0
88	A16A	6.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	3/4	8	3974	17.9	29.0
89	A16A	8.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	3/4	8	4933	22.2	36.0
90	A16A	10.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	7/8	12	5133	26.7	27.0
91	A16A	12.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	7/8	12	5323	27.6	28.0
92	A16A	14.00	150	7.73	371	30.05	A105	A106 Gr.B	A193 Gr. B7M	SW SS316+CAF	1	12	5875	34.7	23.5
93	A16A	16.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7M	SW SS316+CAF	1	16	5750	34.0	23.0
94	A16A	18.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7M	SW SS316+CAF	1-1/8	16	8588	56.5	26.0
95	A16A	20.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7M	SW SS316+CAF	1-1/8	20	8588	56.5	26.0
96	A16A	24.00	150	7.73	371	30.05	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7M	SW SS316+CAF	1-1/4	20	10959	79.3	26.0
97	B1A	0.50	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	741	2.3	13.0
98	B1A	0.75	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	1008	3.9	11.0
99	B1A	1.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
100	B1A	1.50	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	4	2192	9.9	16.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 15 of 28

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				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
101	B1A	2.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	8	1650	6.3	18.0
102	B1A	3.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	3700	16.7	27.0
103	B1A	4.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	4796	21.6	35.0
104	B1A	6.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	12	5207	23.5	38.0
105	B1A	8.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	7604	39.5	40.0
106	B1A	10.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	16	8750	51.7	35.0
107	B1A	12.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	16	10900	71.7	33.0
108	B1A	14.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8258	54.3	25.0
109	B1A	16.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10538	76.3	25.0
110	B1A	18.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	11381	82.4	27.0
111	B1A	20.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	24	18487	158.2	29.0
112	B1A	24.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	741	2.3	13.0
113	B2A	0.50	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	1008	3.9	11.0
114	B2A	0.75	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
115	B2A	1.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	4	2192	9.9	16.0
116	B2A	1.50	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	8	1650	6.3	18.0
117	B2A	2.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	3700	16.7	27.0
118	B2A	3.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	4796	21.6	35.0
119	B2A	4.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	12	5207	23.5	38.0
120	B2A	6.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	7604	39.5	40.0
121	B2A	8.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	16	8750	51.7	35.0
122	B2A	10.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	16	10900	71.7	33.0
123	B2A	12.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8258	54.3	25.0
124	B2A	14.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10538	76.3	25.0
125	B2A	16.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	11381	82.4	27.0
126	B2A	18.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	11381	82.4	27.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 16 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
127	B2A	20.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	13488	97.6	32.0
128	B2A	24.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	24	18487	158.2	29.0
129	B3A	0.50	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	741	2.3	13.0
130	B3A	0.75	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1008	3.9	11.0
131	B3A	1.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
132	B3A	1.50	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	4	2192	9.9	16.0
133	B3A	2.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	8	1650	6.3	18.0
134	B3A	3.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	3700	16.7	27.0
135	B3A	4.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	4796	21.6	35.0
136	B3A	6.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	12	4522	20.4	33.0
137	B3A	8.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	7/8	12	6274	32.6	33.0
138	B3A	10.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1	16	8250	48.7	33.0
139	B3A	12.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1-1/8	16	10900	71.7	33.0
140	B3A	14.00	300	43.50	230	78.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8258	54.3	25.0
141	B3A	16.00	300	43.50	230	78.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10538	76.3	25.0
142	B3A	18.00	300	43.50	230	78.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	11381	82.4	27.0
143	B3A	20.00	300	43.50	230	78.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	13488	97.6	32.0
144	B3A	24.00	300	43.50	230	78.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	24	15937	136.4	25.0
145	B9A	0.50	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	741	2.3	13.0
146	B9A	0.75	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1008	3.9	11.0
147	B9A	1.00	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
148	B9A	1.50	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	4	2192	9.9	16.0
149	B9A	2.00	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	8	1650	6.3	18.0
150	B9A	3.00	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	3700	16.7	27.0
151	B9A	4.00	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	4796	21.6	35.0
152	B9A	6.00	300	28.82	427	82.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	12	5207	23.5	38.0

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

STANDARD SPECIFICATION No.
6-76-0002 Rev. 1

Page 17 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
153	B9A	8.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	12	7604	39.5	40.0
154	B9A	10.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	16	8750	51.7	35.0
155	B9A	12.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	16	10900	71.7	33.0
156	B9A	14.00	300	28.82	427	82.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	20	8258	54.3	25.0
157	B9A	16.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10538	76.3	25.0
158	B9A	18.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	11381	82.4	27.0
159	B9A	20.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/4	24	13488	97.6	32.0
160	B9A	24.00	300	28.82	427	82.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	24	18487	158.2	29.0
161	B5D	0.50	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1/2	4	627	1.9	11.0
162	B5D	0.75	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	5/8	4	1008	3.9	11.0
163	B5D	1.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	5/8	4	1375	5.3	15.0
164	B5D	1.50	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	3/4	4	2466	11.1	18.0
165	B5D	2.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	5/8	8	1741	6.7	19.0
166	B5D	3.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	3/4	8	4385	19.8	32.0
167	B5D	4.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	3/4	8	5070	22.8	37.0
168	B5D	6.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	3/4	12	5207	23.5	38.0
169	B5D	8.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	7/8	12	7224	37.5	38.0
170	B5D	10.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1	16	9500	56.1	38.0
171	B5D	12.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1-1/8	16	11891	78.2	36.0
172	B5D	14.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-1/8	20	9249	60.8	28.0
173	B5D	16.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-1/4	20	11802	85.4	28.0
174	B5D	18.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-1/4	24	11802	85.4	28.0
175	B5D	20.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-1/4	24	14753	106.8	35.0
176	B5D	24.00	300	22.49	510	85.00	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-1/2	24	19124	163.6	30.0
177	B3M	0.50	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr.660 Cl.A	SW SS321+Grafil	1/2	4	570	1.7	10.0
178	B3M	0.75	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr.660 Cl.A	SW SS321+Grafil	5/8	4	917	3.5	10.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 18 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press. kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
179	B3M	1.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	5/8	4	1375	5.3	15.0
180	B3M	1.50	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	3/4	4	2055	9.3	15.0
181	B3M	2.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	5/8	8	1375	5.3	15.0
182	B3M	3.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	3/4	8	2466	11.1	18.0
183	B3M	4.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	3/4	8	3837	17.3	28.0
184	B3M	6.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	3/4	12	3974	17.9	29.0
185	B3M	8.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	7/8	12	5703	29.6	30.0
186	B3M	10.00	300	27.06	510	76.00	A182 Gr. F321	A312 Gr. TP321	A453 Gr. 660 Cl.A	SW SS321+Grafil	1	16	6500	38.4	26.0
187	B3M	12.00	300	27.06	510	76.00	A182 Gr. F321	A358 Gr. TP321 Cl.1	A453 Gr. 660 Cl.A	SW SS321+Grafil	1-1/8	16	7927	52.2	24.0
188	B3M	14.00	300	27.06	510	76.00	A182 Gr. F321	A358 Gr. TP321 Cl.1	A453 Gr. 660 Cl.A	SW SS321+Grafil	1-1/8	20	7597	50.0	23.0
189	B3M	16.00	300	27.06	510	76.00	A182 Gr. F321	A358 Gr. TP321 Cl.1	A453 Gr. 660 Cl.A	SW SS321+Grafil	1-1/4	20	9695	70.2	23.0
190	B3M	18.00	300	27.06	510	76.00	A182 Gr. F321	A358 Gr. TP321 Cl.1	A453 Gr. 660 Cl.A	SW SS321+Grafil	1-1/4	24	10327	74.8	24.5
191	B3M	20.00	300	27.06	510	76.00	A182 Gr. F321	A358 Gr. TP321 Cl.1	A453 Gr. 660 Cl.A	SW SS321+Grafil	1-1/4	24	11802	85.4	28.0
192	B3M	24.00	300	27.06	510	76.00	A182 Gr. F321	A358 Gr. TP321 Cl.1	A453 Gr. 660 Cl.A	SW SS321+Grafil	1-1/2	24	16256	139.1	25.5
193	D1A	0.50	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1/2	4	970	3.0	17.0
194	D1A	0.75	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
195	D1A	1.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	4	1925	7.4	21.0
196	D1A	1.50	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	4	4248	19.1	31.0
197	D1A	2.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	5/8	8	2933	11.2	32.0
198	D1A	3.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	3/4	8	5207	23.5	38.0
199	D1A	4.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	8	7224	37.5	38.0
200	D1A	6.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	12	8750	51.7	35.0
201	D1A	8.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	12	12882	84.8	39.0
202	D1A	10.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/4	16	13910	100.7	33.0
203	D1A	12.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/4	20	14753	106.8	35.0
204	D1A	14.00	600	58.00	427	164.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-3/8	20	17294	136.6	33.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 19 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press. kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
205	D1A	16.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	20	21037	180.0	33.0
206	D1A	18.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-5/8	20	26679	245.8	35.0
207	D1A	20.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-5/8	24	25154	231.7	33.0
208	D1A	24.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-7/8	24	34437	362.8	33.0
209	D2A	0.50	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	970	3.0	17.0
210	D2A	0.75	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
211	D2A	1.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1925	7.4	21.0
212	D2A	1.50	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	4	4248	19.1	31.0
213	D2A	2.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	8	2933	11.2	32.0
214	D2A	3.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	5207	23.5	38.0
215	D2A	4.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	7/8	8	7224	37.5	38.0
216	D2A	6.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1	12	8750	51.7	35.0
217	D2A	8.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1-1/8	12	12882	84.8	39.0
218	D2A	10.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1-1/4	16	13910	100.7	33.0
219	D2A	12.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1-1/4	20	14753	106.8	35.0
220	D2A	14.00	600	58.00	427	164.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1-3/8	20	17294	136.6	33.0
221	D2A	16.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	20	21037	180.0	33.0
222	D2A	18.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-5/8	20	26679	245.8	35.0
223	D2A	20.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-5/8	24	25154	231.7	33.0
224	D2A	24.00	600	58.00	427	164.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-7/8	24	34437	362.8	33.0
225	D5A	0.50	600	87.00	230	156.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	1/2	4	970	3.0	17.0
226	D5A	0.75	600	87.00	230	156.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1375	5.3	15.0
227	D5A	1.00	600	87.00	230	156.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	4	1925	7.4	21.0
228	D5A	1.50	600	87.00	230	156.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	4	4248	19.1	31.0
229	D5A	2.00	600	87.00	230	156.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	5/8	8	2933	11.2	32.0
230	D5A	3.00	600	87.00	230	156.00	A105	A106 Gr. B	A193 Gr. B7	SW SS316+CAF	3/4	8	5207	23.5	38.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 20 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
231	D5A	4.00	600	87.00	230	156.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	7/8	8	7224	37.5	38.0
232	D5A	6.00	600	87.00	230	156.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1	12	8750	51.7	35.0
233	D5A	8.00	600	87.00	230	156.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/8	12	12882	84.8	39.0
234	D5A	10.00	600	87.00	230	156.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/4	16	13910	100.7	33.0
235	D5A	12.00	600	87.00	230	156.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-1/4	20	14753	106.8	35.0
236	D5A	14.00	600	87.00	230	156.00	A105	A106 Gr.B	A193 Gr. B7	SW SS316+CAF	1-3/8	20	17294	136.6	33.0
237	D5A	16.00	600	87.00	230	156.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-1/2	20	21037	180.0	33.0
238	D5A	18.00	600	87.00	230	156.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-5/8	20	26679	245.8	35.0
239	D5A	20.00	600	87.00	230	156.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-5/8	24	25154	231.7	33.0
240	D5A	24.00	600	87.00	230	156.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	SW SS316+CAF	1-7/8	24	34437	362.8	33.0
241	D5D	0.50	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1/2	4	970	3.0	17.0
242	D5D	0.75	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	5/8	4	1375	5.3	15.0
243	D5D	1.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	5/8	4	2108	8.1	23.0
244	D5D	1.50	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	3/4	4	4796	21.6	35.0
245	D5D	2.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	5/8	8	3299	12.6	36.0
246	D5D	3.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	3/4	8	5344	24.1	39.0
247	D5D	4.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	7/8	8	7794	40.5	41.0
248	D5D	6.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1	12	9250	54.6	37.0
249	D5D	8.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1-1/8	12	13543	89.1	41.0
250	D5D	10.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1-1/4	16	16017	116.0	38.0
251	D5D	12.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1-1/4	20	15174	109.8	36.0
252	D5D	14.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	SW SS316+CAF	1-3/8	20	17818	140.8	34.0
253	D5D	16.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A691 Gr. I.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-1/2	20	21674	185.5	34.0
254	D5D	18.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A691 Gr. I.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-5/8	20	28203	259.8	37.0
255	D5D	20.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A691 Gr. I.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-5/8	24	26679	245.8	35.0
256	D5D	24.00	600	30.23	538	169.33	A182 Gr. F11 Cl. 2	A691 Gr. I.25Cr Cl.42	A193 Gr. B16	SW SS316+CAF	1-7/8	24	36525	384.8	35.0

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

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**
Page 21 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press. kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
257	DIK	0.50	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1/2	4	627	1.9	11.0
258	DIK	0.75	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	5/8	4	917	3.5	10.0
259	DIK	1.00	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	5/8	4	1283	4.9	14.0
260	DIK	1.50	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	3/4	4	2329	10.5	17.0
261	DIK	2.00	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	5/8	8	1650	6.3	18.0
262	DIK	3.00	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	3/4	8	3015	13.6	22.0
263	DIK	4.00	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	7/8	8	4943	25.7	26.0
264	DIK	6.00	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1	12	6000	35.4	24.0
265	DIK	8.00	600	55.54	454	114.00	A182 Gr. F304	A312 Gr. TP304	A193 Gr. B7	SW SS316+CAF	1-1/8	12	8918	58.7	27.0
266	DIK	10.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-1/4	16	9273	67.1	22.0
267	DIK	12.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-1/4	20	10116	73.2	24.0
268	DIK	14.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-3/8	20	11529	91.1	22.0
269	DIK	16.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-1/2	20	14662	125.5	23.0
270	DIK	18.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-5/8	20	18294	168.5	24.0
271	DIK	20.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-5/8	24	18294	168.5	24.0
272	DIK	24.00	600	55.54	454	114.00	A182 Gr. F304	A358 Gr. TP304 Cl.1	A193 Gr. B7	SW SS316+CAF	1-7/8	24	25045	263.9	24.0
273	EIA	0.50	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	2877	12.4	21.0
274	EIA	0.75	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3700	15.9	27.0
275	EIA	1.00	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	4	4563	22.7	24.0
276	EIA	1.50	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1	4	7000	39.5	28.0
277	EIA	2.00	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	5133	25.5	27.0
278	EIA	3.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	6844	34.0	36.0
279	EIA	4.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	8	8258	52.0	25.0
280	EIA	6.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	12	9909	62.4	30.0
281	EIA	8.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	12	15197	114.8	29.0
282	EIA	10.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	16	16245	122.8	31.0

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

STANDARD SPECIFICATION No.
6-76-0002 Rev. 1

Page 22 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
283	E1A	12.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	20	17294	130.7	33.0
284	E1A	14.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/2	20	21674	177.4	34.0
285	E1A	16.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	1-5/8	20	26679	235.1	35.0
286	E1A	18.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	1-7/8	20	34959	352.3	33.5
287	E1A	20.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2	20	40880	437.7	34.0
288	E1A	24.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-1/2	20	60340	798.1	31.0
289	E2A	0.50	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	2877	12.4	21.0
290	E2A	0.75	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3700	15.9	27.0
291	E2A	1.00	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	4	4563	22.7	24.0
292	E2A	1.50	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1	4	7000	39.5	28.0
293	E2A	2.00	1500	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	5133	25.5	27.0
294	E2A	3.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	6844	34.0	36.0
295	E2A	4.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	8	8258	52.0	25.0
296	E2A	6.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	12	9909	62.4	30.0
297	E2A	8.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	12	15197	114.8	29.0
298	E2A	10.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	16	16245	122.8	31.0
299	E2A	12.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	20	17294	130.7	33.0
300	E2A	14.00	900	156.00	427	245.15	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/2	20	21674	177.4	34.0
301	E2A	16.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	1-5/8	20	26679	235.1	35.0
302	E2A	18.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	1-7/8	20	34959	352.3	33.5
303	E2A	20.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2	20	40880	437.7	34.0
304	E2A	24.00	900	156.00	427	245.15	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-1/2	20	60340	798.1	31.0
305	E5A	0.50	1500	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	2877	12.4	21.0
306	E5A	0.75	1500	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3700	15.9	27.0
307	E5A	1.00	1500	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	4	4563	22.7	24.0
308	E5A	1.50	1500	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1	4	7000	39.5	28.0

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

STANDARD SPECIFICATION No.
6-76-0002 Rev. 1
Page 23 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
309	E5A	2.00	1500	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	5133	25.5	27.0
310	E5A	3.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	6844	34.0	36.0
311	E5A	4.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	8	8258	52.0	25.0
312	E5A	6.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	12	9909	62.4	30.0
313	E5A	8.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	12	15197	114.8	29.0
314	E5A	10.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	16	16245	122.8	31.0
315	E5A	12.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	20	17294	130.7	33.0
316	E5A	14.00	900	156.00	230	235.00	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/2	20	21674	177.4	34.0
317	E5A	16.00	900	156.00	230	235.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	1-5/8	20	26679	235.1	35.0
318	E5A	18.00	900	156.00	230	235.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	1-7/8	20	34959	352.3	33.5
319	E5A	20.00	900	156.00	230	235.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2	20	40880	437.7	34.0
320	E5A	24.00	900	156.00	230	235.00	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-1/2	20	60340	798.1	31.0
321	E5E	0.50	1500	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	3/4	4	3152	13.6	23.0
322	E5E	0.75	1500	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	3/4	4	3700	15.9	27.0
323	E5E	1.00	1500	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	7/8	4	5133	25.5	27.0
324	E5E	1.50	1500	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1	4	7250	40.9	29.0
325	E5E	2.00	1500	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	7/8	8	6464	32.1	34.0
326	E5E	3.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	7/8	8	6464	32.1	34.0
327	E5E	4.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-1/8	8	10240	64.4	31.0
328	E5E	6.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-1/8	12	10900	68.6	33.0
329	E5E	8.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-3/8	12	16245	122.8	31.0
330	E5E	10.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-3/8	16	16770	126.7	32.0
331	E5E	12.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-3/8	20	18080	136.6	34.5
332	E5E	14.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A335 Gr. P22	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-1/2	20	22949	187.8	36.0
333	E5E	16.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A691 Gr. 2.25Cr Cl.42	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-5/8	20	28203	248.5	37.0
334	E5E	18.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A691 Gr. 2.25Cr Cl.42	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	1-7/8	20	36525	368.1	35.0

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

STANDARD SPECIFICATION No.

6-76-0002 Rev. 1

Page 24 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
335	ESE	20.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A691 Gr. 2.25Cr Cl. 42	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	2	20	43886	469.9	36.5
336	ESE	24.00	900	158.20	538	256.00	A182 Gr. F22 Cl. 3	A691 Gr. 2.25Cr Cl. 42	A193 Gr. B7	RTJ 4-6Cr-1/2Mo	2-1/2	20	70073	926.8	36.0
337	FIA	0.50	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3015	13.0	22.0
338	FIA	0.75	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3974	17.1	29.0
339	FIA	1.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	7/8	4	4943	24.5	26.0
340	FIA	1.50	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1	4	7500	42.4	30.0
341	FIA	2.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	6464	32.1	34.0
342	FIA	3.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	8	11891	74.8	36.0
343	FIA	4.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-1/4	8	15596	108.0	37.0
344	FIA	6.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	12	19390	146.5	37.0
345	FIA	8.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-5/8	12	28203	248.5	37.0
346	FIA	10.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-7/8	12	40699	410.1	39.0
347	FIA	12.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	2	16	46892	502.1	39.0
348	FIA	14.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	2-1/4	16	55862	668.4	36.0
349	FIA	16.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-1/2	16	66180	875.3	34.0
350	FIA	18.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-3/4	16	85917	1244.5	36.0
351	FIA	20.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	3	16	108966	1715.2	38.0
352	FIA	24.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	3-1/2	16	142922	2609.6	36.0
353	F2A	0.50	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3015	13.0	22.0
354	F2A	0.75	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3974	17.1	29.0
355	F2A	1.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	7/8	4	4943	24.5	26.0
356	F2A	1.50	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1	4	7500	42.4	30.0
357	F2A	2.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	6464	32.1	34.0
358	F2A	3.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	8	11891	74.8	36.0
359	F2A	4.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-1/4	8	15596	108.0	37.0
360	F2A	6.00	1500	260.50	427	409.20	A105	A106 Gr. B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	12	19390	146.5	37.0

**STANDARD SPECIFICATION FOR
APPLICATION OF TORQUE AND
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STANDARD SPECIFICATION No.
6-76-0002 Rev. 1

Page 25 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
361	F2A	8.00	1500	260.50	427	409.20	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-5/8	12	28203	248.5	37.0
362	F2A	10.00	1500	260.50	427	409.20	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-7/8	12	40699	410.1	39.0
363	F2A	12.00	1500	260.50	427	409.20	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	2	16	46892	502.1	39.0
364	F2A	14.00	1500	260.50	427	409.20	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	2-1/4	16	55862	668.4	36.0
365	F2A	16.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-1/2	16	66180	875.3	34.0
366	F2A	18.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	2-3/4	16	85917	1244.5	36.0
367	F2A	20.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	3	16	108966	1715.2	38.0
368	F2A	24.00	1500	260.50	427	409.20	A105	A672 Gr. B60 Cl. 12	A193 Gr. B7	RTJ SOFT IRON	3-1/2	16	142922	2609.6	36.0
369	F2D	0.50	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	3/4	4	3700	15.9	27.0
370	F2D	0.75	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	3/4	4	4796	20.7	35.0
371	F2D	1.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	7/8	4	6274	31.2	33.0
372	F2D	1.50	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	1	4	8750	49.4	35.0
373	F2D	2.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	7/8	8	7034	34.9	37.0
374	F2D	3.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	1-1/8	8	12882	81.1	39.0
375	F2D	4.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	1-1/4	8	16017	110.9	38.0
376	F2D	6.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	1-3/8	12	19390	146.5	37.0
377	F2D	8.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	1-5/8	12	29728	262.0	39.0
378	F2D	10.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	1-7/8	12	40699	410.1	39.0
379	F2D	12.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	2	16	43285	463.5	36.0
380	F2D	14.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A335 Gr. P11	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	2-1/4	16	52759	631.3	34.0
381	F2D	16.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	2-1/2	16	68126	901.0	35.0
382	F2D	18.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	2-3/4	16	83530	1209.9	35.0
383	F2D	20.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	3	16	100363	1579.8	35.0
384	F2D	24.00	1500	263.65	538	423.04	A182 Gr. F11 Cl. 2	A691 Gr. 1.25Cr Cl.42	A193 Gr. B16	RTJ 4-6Cr-1/2Mo	3-1/2	16	134982	2464.7	34.0
385	F5A	0.50	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3015	13.0	22.0
386	F5A	0.75	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	3/4	4	3974	17.1	29.0

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APPLICATION OF TORQUE AND
HYDRAULIC BOLT TENSION FOR
FLANGE JOINTS**

**STANDARD SPECIFICATION No.
6-76-0002 Rev. 1**

Page 26 of 28

Sl. No	Line Spec	Size (in)	Flange rating	Design		Test press., kg/cm ²	Materials			Gasket type/material	Bolt size	No. of bolts	Bolt tension, kg	Bolt torque, kg-m	Basic Bolt stress, ksi
				Press., kg/cm ²	Temp., °C		Flange	Pipe	Bolt						
387	F5A	1.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	4	4943	24.5	26.0
388	F5A	1.50	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1	4	7500	42.4	30.0
389	F5A	2.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	7/8	8	6464	32.1	34.0
390	F5A	3.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/8	8	11891	74.8	36.0
391	F5A	4.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-1/4	8	15596	108.0	37.0
392	F5A	6.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-3/8	12	19390	146.5	37.0
393	F5A	8.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-5/8	12	28203	248.5	37.0
394	F5A	10.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	1-7/8	12	40699	410.1	39.0
395	F5A	12.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	2	16	46892	502.1	39.0
396	F5A	14.00	1500	260.50	230	390.73	A105	A106 Gr.B	A193 Gr. B7	RTJ SOFT IRON	2-1/4	16	55862	668.4	36.0
397	F5A	16.00	1500	260.50	230	390.73	A105	A672 Gr. B60 Cl. 22	A193 Gr. B7	RTJ SOFT IRON	2-1/2	16	66180	875.3	34.0
398	F5A	18.00	1500	260.50	230	390.73	A105	A672 Gr. B60 Cl. 22	A193 Gr. B7	RTJ SOFT IRON	2-3/4	16	85917	1244.5	36.0
399	F5A	20.00	1500	260.50	230	390.73	A105	A672 Gr. B60 Cl. 22	A193 Gr. B7	RTJ SOFT IRON	3	16	108966	1715.2	38.0
400	F5A	24.00	1500	260.50	230	390.73	A105	A672 Gr. B60 Cl. 22	A193 Gr. B7	RTJ SOFT IRON	3-1/2	16	142922	2609.6	36.0

ANNEXURE - I

Test loop No.:

ISO Drawing No.:

Connected P & ID

Connected P & ID No.:

[illegible]

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

Acceptance by Licensor/Owner.

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

Annexure – II

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

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

ACCEPTANCE BY

OWNER / EIL

पाइपिंग फेब्रिकेशन के लिए वेल्डिंग विनिर्देश

WELDING SPECIFICATION FOR FABRICATION OF PIPING

<i>P Chowdhary</i> <i>S Ghosal</i> <i>P P Lahiri</i> <i>S Chanda</i>						
4	8/07/14	REVISED & REISSUED AS STANDARD SPECIFICATION	P CHOWDHARY	S GHOSAL	P P LAHIRI	S CHANDA
3	28/12/07	REVISED & REISSUED AS STANDARD SPECIFICATION	MPJ	VRK	VRK	VC
2	08/02/02	REVISED TO INCLUDE CHECK RADIOGRAPHY	GC	RN	TVD	
1	15/05/98	REVISED & REISSUED AS STANDARD SPECIFICATION	MPJ	TVD	JRP	AS
0	31/07/87	ISSUED AS STANDARD SPECIFICATION	TVD	TVD	JRP	AK
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

ABBREVIATIONS

ASME	:	American Society of Mechanical Engineers
ASNT	:	American Society for Nondestructive Testing
AWS	:	American Welding Society
AUT	:	Automated Ultrasonic Testing
BPVC	:	Boiler & Pressure Vessel Code
CFH	:	Cubic Feet per Hour
DWDI	:	Double Wall Double Image
DWSI	:	Double Wall Single Image
GTA	:	Gas Tungsten Arc
GTAW	:	Gas Tungsten Arc Welding
IBR	:	Indian Boiler Regulations
IQI	:	Image Quality Indicator
NDT	:	Non Destructive Testing
PQR	:	Procedure Qualification Record
RT	:	Radiographic Testing
SMAW	:	Shielded Metal Arc Welding
SWSI	:	Single Wall Single Image
UTS	:	Ultimate Tensile Strength

Welding Standards Committee

Convenor : Mr. P. P. Lahiri (SMMS)

Members : Mr. R.Nanda(Piping)
Mr. S.Ghosal (SMMS)
Mr. K. Anjaneyulu (SED)
Mr. D. Jana (Construction)
Mr. R.K. Singh (Inspection)
Mr. Raj Kishore (Pipeline)

CONTENTS

1.0	GENERAL	4
2.0	APPLICABLE CODES & STANDARDS.....	4
3.0	BASE METAL	5
4.0	WELDING CONSUMABLES.....	5
5.0	SHIELDING & PURGING GAS	5
6.0	EQUIPMENTS & ACCESSORIES	6
7.0	WELDING PROCESS	6
8.0	EDGE PREPARATION.....	6
9.0	ALIGNMENT & SPACING	7
10.0	WEATHER CONDITIONS	7
11.0	WELDING TECHNIQUE	7
12.0	HEAT TREATMENT	8
13.0	CLEANING OF THE WELD JOINT	10
14.0	INSPECTION AND TESTING	10
15.0	REPAIRS OF WELDS.....	14
16.0	DOCUMENTS TO BE SUBMITTED BY CONTRACTOR (4 COPIES EACH)	14
	EXHIBIT – A: ELECTRODE QUALIFICATION TEST RECORD	16
	EXHIBIT – B: STRESS RELIEF HEAT TREATMENT PROCEDURE SPECIFICATION.....	20
	EXHIBIT-D: FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR).....	24
	EXHIBIT – E: FORMAT FOR MANUFACTURER’S RECORD FOR WELDER OR WELDING OPERATOR QUALIFICATION TESTS	27
	EXHIBIT – F: RADIOGRAPHIC PROCEDURE QUALIFICATION RECORD FOR PIPE WELDING	29
	EXHIBIT – G: WELDER’S IDENTIFICATION CARD.....	30
	EXHIBIT – H: TYPE OF SOURCE AND FILMS TO BE USED FOR RADIOGRAPHY	31
	EXHIBIT – I: AUTOMATED ULTRASONIC TESTING.....	32

1.0 GENERAL

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

The welded pipe joints shall include the following:

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

Any approval granted by the Engineer-in-Charge or Owner's inspector, shall not relieve the Contractor of his responsibilities and guarantee.

This specification shall not be applicable for welding of pipelines for transportation of liquid petroleum, gas and other similar products in on shore and off shore.

2.0 APPLICABLE CODES & STANDARDS

All welding work, equipments for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the following accepted standards and procedures unless otherwise specified in the Welding Specification Chart and the Technical Notes attached thereof. In the case of conflicting requirements, the requirements mentioned in Welding Specification Chart/Technical Notes shall be applicable.

- i) ASME B31.3: Process Piping, ASME Code for Pressure Piping, B31
- ii) ASME Boiler & Pressure Vessel Code, Sec II Part C: Specifications for Welding Rods, Electrodes and Filler metals.
- iii) ASME Boiler & Pressure Vessel Code, Section V: Non destructive examination.
- iv) ASME Boiler & Pressure Vessel Code, Section IX: Welding and Brazing Qualifications.
- v) The Indian Boiler Regulations - I.B.R.
- vi) 6-44-0016: Standard Specification for Non-Destructive Examination Requirements of Piping.
- vii) 6-77-0005: Welding Specification charts for Piping Classes.
- viii) API 582: Welding Guidelines for the Chemical, Oil, and Gas Industries.

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

3.0 BASE METAL

- 3.1** In general, use of carbon steel, alloy steel and stainless steel is envisaged. The details of the material specifications are given in the Welding Specification Chart.
- 3.2** The Contractor shall provide the manufacturer's test certificates for every batch of the materials supplied by him.

4.0 WELDING CONSUMABLES

- 4.1** The Contractor shall provide, at his own expense, all the welding consumables necessary for the execution of the job such as electrodes, filler wires, argon etc. and these should bear the approval of the Engineer-in-Charge.
- 4.2** The welding electrodes and filler wires supplied by the Contractor shall conform to the class specified in the Welding Specification Chart. The materials shall be of the make approved by the Engineer-in-Charge.
- 4.3** Electrode qualification test records should be submitted as per the Exhibit-A (attached) in respect of the electrodes tested by the Contractor, for obtaining the approval of the Engineer-in-Charge. It shall record the minimum test results required for classification of welding consumables as per ASME Section II part C.
- 4.4** The Contractor shall submit batch test certificates from the electrode manufacturers.
- 4.5** All electrodes shall be purchased in sealed containers and stored properly to prevent deterioration. The electrodes removed from the containers shall be kept in baking ovens at temperatures recommended by the electrode manufacturer. "Out of the oven time" of electrodes, before they are consumed, shall not exceed the limits recommended by the electrode manufacturer. The electrodes shall be handled with care to avoid any damage to the flux covering.
- 4.6** All low hydrogen type of electrodes and others, shall be baked as per manufacturers recommendation and stored in holding ovens at temperature recommended by the manufacturer.
- 4.7** The electrodes, filler wires and flux used shall be free from rust, oil, grease, earth and other foreign matter which affect the quality of welding.

5.0 SHIELDING & PURGING GAS

- 5.1** Argon gas used in GTA welding for shielding purposes shall be minimum 99.995% pure. The purity of the gas shall be certified by the manufacturer. The rate of flow for shielding purposes shall be established through procedure qualification tests.
- 5.2** Argon gas with a purity level of minimum 99.995% shall be used for purging.
- 5.3** When GTAW process alone or a combination of GTAW and SMAW processes is recommended for the production of a particular joint, the purging shall be maintained during the root pass and for the first filling pass to minimize oxidation on the inner side of the pipe, unless otherwise specified in Welding Specification Chart.
- 5.4** Initial purging shall be maintained for sufficient period of time so that at least 4-5 times the volume between the dams is displaced, in order to completely remove the entrapped air. In no case should the initial purging period be less than 10 minutes. High gas pressure should be avoided.

- 5.5 After initial purging, the flow of the backing gas should be reduced to a point where only a slight positive pressure prevails.
- 5.6 Gas backing (purging) is not required for socket type of welded joints.
- 5.7 Dams, used for conserving inert gas during purging, shall be removed after completion of the welding, and shall be accounted for. Wherever, removal of dams is not possible after welding, use of water-soluble dams should be made.

6.0 EQUIPMENTS & ACCESSORIES

- 6.1 All the equipment for performing the heat treatment, including transformers, thermocouples, pyro-meters, automatic temperature recorders (with suitable calibration arrangement etc.) shall be provided by the Contractor at his own expense along with certificate traceable to national /international standard.
- 6.2 Contractor shall make necessary arrangements at his own expense, for providing the radiographic equipments, radiographic films, processing equipment all other darkroom facilities and all the equipments/materials required for carrying out the dye-penetrant/magnetic particle test/ultrasonic testing.

7.0 WELDING PROCESS

- 7.1 The welding processes to be employed are given in the Welding Specification Chart.
- 7.2 In addition to Shielded Metal Arc Welding Process (SMAW) and Gas Tungsten Arc Welding Process (GTAW), Welding of various materials under this specification may be carried out using one or more of the following processes with the approval of the Engineer-in-Charge.
- Gas Metal Arc Welding (GMAW)
 - Flux Cored Arc Welding (FCAW)
 - Submerged Arc Welding (SAW)

- 7.3 The Welding procedure could be employed for a particular joint only after duly qualifying the welding procedure to be adopted.

8.0 EDGE PREPARATION

8.1 General

The edges to be welded shall be prepared to meet the joint design requirements by any of the following methods recommended:

- (a) Carbon Steel
Gas cutting, machining or grinding methods shall be used. After gas cutting, oxides shall be removed by chipping or grinding.
- (b) Low Alloy Steels (containing up to 5% Chromium).
Gas cutting, machining or grinding methods shall be used. After gas cutting, machining or grinding shall be carried out on the cut surface.
- (c) High alloy steel (> 5% Chromium) and stainless steels, nickel alloys:
Plasma cutting, machining or grinding methods shall be used. After plasma cutting, cut surfaces shall be machined or ground smooth.

8.2 Cleaning

- (a) The ends to be welded shall be properly cleaned to remove paint, oil, grease, rust, oxides, sand, earth and other foreign matter. The ends shall be completely dry before the welding commences.
- (b) On completion of each run, craters, welding irregularities, slag etc., shall be removed by grinding and chiseling. Wire brushes used for cleaning stainless steel joints shall have stainless steel wires and the grinding wheels used for grinding stainless steel shall be of a suitable type. Separate grinding wheels and wire brushes should be used for carbon steels and stainless steels.

9.0 ALIGNMENT & SPACING

- 9.1** Components to be welded shall be aligned and spaced as per the requirements laid down in applicable code. Special care must be taken to ensure proper fitting and alignment when the welding is performed by GTAW process. Flame heating for adjustment and correction of ends is not permitted unless specifically approved by the Engineer-in-Charge.
- 9.2** A wire spacer of suitable diameter may be used for maintaining the weld root opening while tacking, but it must be removed after tack welding and before laying the root bead.
- 9.3** For pipes of wall thickness 5 mm and above, the ends to be welded shall be secured in position with the aid of couplers, yokes and 'C' clamps, to maintain perfect alignment. Yokes shall be detached after the completion of weld, without causing any surface irregularity. Any irregularity caused on the pipe surface must be suitably repaired to the satisfaction of the Engineer-in-Charge.
- 9.4** Tack welds, for maintaining the alignment, of pipe joints shall be made only by qualified welders using approved WPS. Since the tack welds become part of the final weldment they shall be executed carefully and shall be free from defects. Defective tack welds must be removed prior to the actual welding of the joints.
- 9.5** Tacks should be equally spaced. Minimum number of tacks shall be:
 - 3 tacks - for 2 1/2" and smaller dia. pipes.
 - 4 tacks - for 3" to 12" dia. pipes.
 - 6 tacks - for 14" and larger dia. pipes.

- 9.6** Welding shall commence only after approval of fit-up by the Engineer-In-Charge.

10.0 WEATHER CONDITIONS

- 10.1** The parts being welded and the welding personnel should be adequately protected from rain and strong winds. In the absence of such a protection no welding shall be carried out.
- 10.2** During field welding using GTAW process, particular care shall be exercised to prevent any air current affecting the welding process.

11.0 WELDING TECHNIQUE

11.1 Root Pass

- (a) Root pass shall be made with electrodes/filler wires recommended in the welding specification chart. For fillet welding, root welding shall be done with consumables recommended for filler passes. The preferred size of the electrodes is 2.5 mm diameter (12 SWG) but in any case not greater than 3.25 mm (10 SWG).

- (b) Upward technique shall be adopted for welding pipe held fixed with its axis horizontal.
- (c) The root pass of butt joints should be executed so as to achieve full penetration with complete fusion of the root edges. Weld projection inside the pipe shall be as per applicable code. It shall be limited 3mm max. when the applicable code does not place any restriction.
- (d) Any deviation desired from the recommended welding technique and electrodes indicated in the welding specification chart should be adopted only after obtaining express approval of the Engineer-in-Charge.
- (e) Welding shall be uninterrupted.
- (f) While the welding is in progress care should be taken to avoid any kind of movement of the components, shocks, vibrations and stresses to prevent occurrence of weld cracks.
- (g) Peening shall not be used.

11.2 Joint Completion

- (a) Joint shall be completed using the class of electrodes, recommended in the Welding Specification Chart. Size of the electrode shall not exceed 4 mm in diameter for stainless steels and alloy steels used for low temperature applications.
- (b) Two weld beads shall not be started at the same point in different layers.
- (c) Butt joints shall be completed with a cover layer that would affect good fusion at the joint edges and a gradual notch free surface.
- (d) Each weld joint shall have a workmanship like finish. Weld identification work shall be stamped clearly at each joint, just adjacent to the weld. Metal stamping shall not be used on thin pipe having wall thickness less than 3.5mm. Suitable paint shall be used on thin wall pipes for identification.
- (e) Rust preventive/protective painting shall be done after the weld joint has been approved.

11.3 Dissimilar Welds

Where welds are to be produced between carbon steels and alloy steels, preheat and post weld heat treatment requirements shall be those specified for corresponding alloy steels and filler wire/electrodes shall correspond to ER70S-2 or E-7016/7018 type. For welds between two dissimilar Cr-Mo low alloy steels, preheat and post weld heat treatments shall be those specified for higher alloy steel and electrodes used shall correspond to those specified for steel of lower alloy content. For carbon steel or alloy steel to stainless welds, use of filler wire/electrodes E/ER-309/ERNiCr-3/E Ni Cr Fe-3/ENiCrMo-3 shall be made. The welding procedure, electrodes/filler wires to be used shall be approved by the Engineer-in-Charge.

12.0 HEAT TREATMENT

12.1 Preheating

- (a) No welding shall be performed without preheating the joint to 10°C (50°F) when the ambient temperature is below 10 degree.

- (b) Preheating requirements for the various materials shall be as per the Welding Specification Chart attached.
- (c) Preheating shall be performed using resistance or induction heating methods. Preheating by gas burners, utilizing oxy-acetylene or oxy-propane gas mixtures, with neutral flame may also be carried when permitted by the Engineer-in-Charge.
- (d) Preheating shall extend uniformly to at least three times the thickness of the joint, but not less than 25 mm, on each sides of the weld.
- (e) Preheating temperature shall be maintained over the whole length of the joint during welding. Temperature recorders shall be provided by the Contractor to record the temperature during alloy steel welding. For carbon steel piping, preheat temperature shall be ensured by use of temperature indicating crayons, pyrometers or other suitable means.

12.2 Post Heating

In case of alloy steel materials such as Cr-Mo steels, if the post weld heat treatment is not performed immediately after welding, the weld joint and adjacent portion of pipe, at least 50 mm on either side of weld, shall be uniformly heated to 300°C. This temperature shall be maintained for half an hour minimum, and then wrapped with mineral wool before allowing it to cool to room temperature. If the Post Heating temperature specified in the Welding Specification Charts exceeds 300°C, the same shall be followed. Similarly, if the welding specification chart specifies post-heat time, the same shall be applicable. Post weld heat treatment as specified in the Welding Specification Chart shall be carried out later on.

12.3 Post Weld Heat Treatment (PWHT)

- (a) Post weld heat treatment, wherever required for joints between pipes, pipes and fittings, pipe body and supports shall be carried out as per the welding specification chart, applicable codes standards and the instructions of the Engineer-in-Charge. In this regard procedure qualification to be done before carrying out PWHT in production welds
- (b) The Contractor shall submit for the approval of the Engineer-in-Charge, well before carrying out actual heat treatment, the details of the post weld heat treatment procedure as per Exhibit B attached, that he proposes to adopt for each of the materials/assembly/part involved.
- (c) Post weld heat treatment shall be done in a furnace or by using an electric resistance or induction-heating equipment, as decided by the Engineer-in-Charge.
- (d) While carrying out local post weld heat treatment, technique of application of heat must ensure uniform temperature attainment at all points of the portion being heat-treated. Care shall be taken to ensure that width of heated band over which specified post weld heat treatment temperature attained is at least that specified in the relevant applicable standards/codes. Control of temperature shall be done using microprocessor/computer controlled system. The desired time-temperature cycle shall be entered into the microprocessor/computer.
- (e) Throughout the cycle of heat treatment, the portion outside the heated band shall be suitably wrapped under insulation so as to avoid any harmful temperature gradient at the exposed surface of pipe. For this purpose temperature at the exposed surface should not be allowed to exceed 50% of the peak temperature.

- (f) The temperature attained by the portion under heat treatment shall be recorded by means of thermocouple pyrometers. Adequate number of thermocouples should be attached to the pipe directly at equally spaced location along the periphery of the pipe joint. The minimum number of thermocouples attached per joint shall be 1 up to 6" dia., 2 up to 10" dia. and 3 for 12" dia. and above. However, the Engineer-in-Charge can increase the required number of thermocouples to be attached if found necessary.
- (g) Automatic temperature recorders, which have been suitably calibrated, shall be employed for measuring & recording temperature. The time-temp graph shall be submitted to Engineer-in-Charge immediately on completion of Stress Relieving Cycle. The calibration record of each recorder should be submitted to the Engineer-in-Charge prior to starting the heat treatment operations and his approval should be obtained.
- (h) Manufacturer's test certificate shall be submitted for the thermocouples materials and record shall be maintained by the Contractor.
- (i) Immediately on completion of the Heat Treatment, the Post Weld Heat Treatment charts/records along with the hardness test results on the weld points, wherever required as per the Welding Specification Chart, shall be submitted to Engineer-in-Charge for his approval.
- (j) Each weld joint shall bear a unique identification number, which shall be maintained in the piping sketch to be prepared by the Contractor. The weld joint identification number should appear on the corresponding post weld heat treatment charts. The chart containing the identification numbers and piping sketch shall be submitted to the Engineer-in-Charge in suitable folders.

13.0 CLEANING OF THE WELD JOINT

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

14.0 INSPECTION AND TESTING

14.1 General

- (a) The Owner's inspector shall have free access to all concerned areas, where the actual work is being performed. The contractor shall also accord the Owner's Inspector all means and facilities necessary to carry out inspection.
- (b) The Owner is entitled to depute his own inspector to the shop or field where prefabrication and erection of pipe lines is in progress for (but not limited to) the following objectives:
 - i) To check the conformance to relevant standards and suitability of various welding equipments and the welding performance.
 - ii) To witness the welding procedure qualification.
 - iii) To witness the welder performance qualification.
 - iv) To check whether shop/field welding being executed is in conformity with the relevant specifications and codes of practice followed in piping construction.

- (c) Contractor shall intimate sufficiently in advance the commencement of qualification tests, welding works and acceptance tests, to enable the Owner's inspector to be present to supervise them, as decided by the Engineer-In-Charge.

14.2 Welding Procedure Qualification

Welding procedure qualification shall be carried out in accordance with the applicable requirements of ASME Sec. IX latest edition and/or other applicable codes and the job requirements. The contractor shall submit the welding procedure specification in format as per Exhibit-C (attached) immediately after the receipt of the order. Owner's inspector will review, check and approve the welding procedure submitted and shall release the procedure for qualification tests. The procedure qualification test shall be carried out by the Contractor at his own expense. A complete set of test results in the format as per Exhibit-D (attached) shall be submitted to the Owner's inspector for his approval immediately after completing the procedure qualification test and at least 2 weeks before the commencement of actual work. Standard test as specified in the code shall be carried out in all cases. In addition to these tests, other tests like macro/micro examination, hardness tests, dye penetrant examination, charpy V-notch, Corrosion tests, impact tests etc. shall be carried out on specimens depending upon the type of base material, operating conditions and requirements laid down in the detailed drawings and specifications. It shall be the responsibility of the Contractor to carry out all the tests required to the satisfaction of the Owner's inspector.

14.3 Welder's Qualification

- (a) Welders shall be qualified in accordance with the ASME Section-IX or other applicable codes. The Owners inspector reserves the right to witness the test and certify/approve the qualification of each welder separately. Only those welders who have been approved by the Owner's Inspector shall be employed for welding. Contractor shall submit the welder qualification test reports in the format as per Exhibit-E (attached) and obtain express approval before commencement of work. It shall be the responsibility of Contractor to carry out qualification tests of welders. For welding of the steam piping, falling under the purview of Indian Boiler Regulations, only those welders with IBR Certification, qualified by Boiler Inspectorate, and acceptable to the local Boiler Inspector authority shall be employed.
- (b) The welders shall always have in their possession, an identification card containing information contained in Exhibit-G and shall produce it on demand by the Engineer-In-Charge or his representative. It shall be the responsibility of the Contractor to issue the identify cards after it has been duly certified by the, owner's Inspector.
- (c) No welder shall be permitted to work without the possession of the identify card.
- (d) If a welder is found to perform a type of welding or in a position for which he is not qualified, he shall be debarred from doing any further work. All welds performed by an unqualified welder shall be cut and redone by a qualified welder at the expense of the Contractor

14.4 Visual Examination

Visual Examination of all welds shall be carried out as per the latest editions of the applicable codes and specifications. All finished welds shall be visually inspected for parallel and axial alignment of the work, excessive reinforcement, concavity of welds, shrinkage cracks, inadequate penetration, unrepaired burn-through, under cuts, dimensions of the weld, surface porosity and other surface defects. Undercutting adjacent to the completed weld shall not exceed the limits specified in the applicable standard/code.

14.5 Radiographic Examination

- (a) The Radiographic Examination procedures to be adopted shall be submitted by the contractor as per Exhibit-F and shall be got approved from the Owner's Inspector prior to employment. A person qualified to ASNT Level-II or ASNT Level-III in Radiographic testing shall prepare the procedure. The Radiography Procedure shall be established to demonstrate that the required sensitivity can be consistently achieved under the most unfavorable parameters (e.g. source to film distance, geometric unsharpness, thickness etc.). The radiographic technique and procedure adopted shall conform of the requirements mentioned in Article 2 as well as Article 22 of ASME Sec.V. The IQI sensitivity obtained shall be equal to or better than the requirements mentioned in Article 2 of ASME Sec.V. Source side penetrameter shall be used in establishing radiographic procedure/ technique. The acceptance criteria shall be as per the relevant codes of Fabrication and over riding requirements if mentioned else where in the technical specifications of the contract. The Contractor shall be responsible for carrying out Radiography; rectification of defects and re-radiography of welds repaired/rectified at his cost.
- (b) The extent of Radiography shall be as per specifications to be supplied to the Contractor. For welds between dissimilar materials, the extent of Radiographic Examination shall be the more stringent of the two recommended for the materials being welded. Wherever random Radiography is called for, in a particular piping class, the dissimilar materials weld joints shall essentially be included.
- (c) Type of Radiation source and film to be used shall be as per Exhibit-H for carrying out radiographic examination. However if specifications (as given else where in the contract) for some critical material require usage of X-Radiation, then Radiography shall be done using X-Rays only.
- (d) The Contractor shall fulfill all the statutory and owner's safety requirements while handling X-ray and Gamma-ray equipments.
- (e) In case of random radiography, the joints for Radiography shall be selected by the Owner's Inspector and the Radiography shall be performed in his presence, if he instructs the contractor to do so. The contractor shall furnish all the radiographs, to the Owner's Inspector immediately after processing along with evaluation by a person qualified to ASNT Level-II in Radiographic testing, inline with Article 2 of ASME Sec.V. The certificate of ASNT/ISNT Level II qualification of the NDT personnel shall be submitted to owner's inspector for his approval prior to start of job.
- (f) The Contractor shall provide the Owner's Inspector, all the necessary facilities at site such as a dark room with controlled temperature, illuminator (viewer) suitable for varying densities, a duly calibrated electronic densitometer with batteries, magnifying glass, tracing papers, ruler, marking pencils etc. to enable him to review the radiographs.
- (g) Where random radiography is specified, the first weld of each welder shall be completely radiographed. In the case of pipe of size 6" and below, the first two welds shall be completely radiographed.
- (h) For each weld performed by a welder found unacceptable, two additional checks shall be carried out on welds performed by the same welder. This operation is iterative and the of two additional welds for each weld deemed unsatisfactory shall be continued till such time that two consecutive welds of satisfactory quality are found for every defective weld.
- (i) The Contractor shall carry out these additional radiographic testing at his own expense. To avoid the possibility of too many defective welds by a single welder

remaining undetected for a long period to time, the Contractor shall promptly arrange for Radiographic Examination so that there is no accumulation of defective joints.

- (j) Contractor shall quote rates for X-ray as well as Gamma Ray for joints indicated to be radiographed by X-ray in Table of Exhibit-H.

14.5.1 Check shots

- (a) Owner / Engineer- in- charge or his representative shall select 5% of the total joints radiographed on a day for check shots. Contractor shall carry out check shots as directed.
- (b) Weld profiles of check shots shall be compared with weld profile observed in the earlier Radiographs. In the event of any one variation in the check shots and earlier Radiographs, contractor shall re-shoot the entire lot of joints radiographed by particular Radiography agency on the particular date. All the re-shot films shall be compared with the originally submitted films.

14.6 Liquid Penetrant and Magnetic Particle Examination

- (a) Whenever such tests are specified, the tests shall be carried out on joints chosen by the Owner's inspector, as per ASME Section V article 6 and 7 respectively. The tests are to be performed by a person possessing a valid ASNT/ISNT Level-II qualification in the method being used.
- (b) For austenitic stainless steels and other nonmagnetic materials, liquid (dye) penetrant test shall be carried out. For carrying out this test, the materials shall be brought within a temperature limit of 15⁰ to 50⁰C.

14.7 Automated Ultrasonic examination (AUT)

- (a) Automated ultrasonic testing (AUT) can be used in substitution of radiographic examination when permitted by ASME B31.3 code case 181 shall require prior approval of Engineer-in-charge as detailed in EXHIBIT-I.
- (b) The automated ultrasonic testing (AUT) procedure to be adopted shall be submitted by the CONTRACTOR as per EXHIBIT-I and get it approved from EIL/OWNER.
- (c) The CONTRACTOR shall make all the arrangements for the Automated Ultrasonic Testing of work at his expense. The CONTRACTOR shall furnish all the reports to the EIL/OWNER, immediately after examination together with the corresponding interpretation reports on the approved format. The details of the AUT reports along with the joint identification number shall be duly entered in a register and signed by the CONTRACTOR and submitted to the EIL/OWNER for approval. The EIL/OWNER will review all the Automatic Ultrasonic Testing records of welds and inform the CONTRACTOR to those welds, which are unacceptable. The decision of the COMPANY shall be final and binding in this regard.
- (d) In addition, Radiography examination shall be carried out when in the opinion of EIL/OWNER, Radiography inspection is required to confirm or clarify defects indicated by Automated Ultrasonic examination. Repaired welds and transition spool piece weld joints shall be additionally examined by radiography if it is examined by automated ultrasonic testing.
- (e) The automated ultrasonic testing system used for inspecting welds shall be approved by EIL/OWNER.

14.8 Hardness Test

Hardness requirements for welds shall be as per the Welding Specification Chart/Non Destructive Examination Specification attached elsewhere in the contract. Hardness testing shall be carried out by Vickers Hardness Tester during welding procedure qualification and shall be cross sectional. For production welds, hardness testing shall be carried out by portable digital hardness testers. Poldi hardness tester shall not be permitted. Contractor shall produce documentary evidence/calibration certificate to the Owner's Inspector and obtain approval of the hardness testing equipment.

14.9 Proof Tests

Hydrostatic and pneumatic tests shall be performed as per the requirements laid down by respective flushing and Testing specification/applicable codes to demonstrate the soundness of the welds. The tests shall be conducted after fulfilling the requirement of visual examinations radiography etc., and after the entire work has been certified by the Owner's inspector to be fit for being subjected to such tests.

15.0 REPAIRS OF WELDS

- (a) No repair shall be carried out without prior permission of the Owner's inspector.
- (b) Repairs and/or work of defective welds shall be done in time to avoid difficulties in meeting the construction schedules.
- (c) Defects ascertained through the inspection methods, which are beyond acceptable limits shall be removed after the joint is completely radiographed by the process of chipping and grinding. The repaired welds shall be subjected, as a minimum requirement to the same testing and inspection requirements as the original weld.
- (d) The number of times repair welding can be permitted for the same weld shall be governed by the standard specification, 6-44-0016.
- (e) When the entire joint is judged unacceptable, the welding shall be completely cut and edges suitably prepared as per required alignment tolerances. The rewelded joint shall again be examined following standard practices.

16.0 DOCUMENTS TO BE SUBMITTED BY CONTRACTOR (4 COPIES EACH)

- (a) Electrode and Welding Consumable Qualification Records as per Exhibit-A, for the Welding Consumables tested and approved for the work.
- (b) Batch Test Certificates, for the Electrodes used, obtained from the Electrode Manufacturers.
- (c) Proposed Heat Treatment Procedure as per Exhibit-B.
- (d) Heat Treatment Charts.
- (e) Weld joint hardness test results.
- (f) Welding Procedure Specifications as per Exhibit-C immediately after receipt of the order.
- (g) Welding Procedure Qualification records as per Exhibit-D.

-
- (h) Welder Performance Qualification records as per Exhibit-E immediately after conducting Welder Qualification Tests.
 - (i) Radiography Procedure as per Exhibit-F and other NDT procedures.
 - (j) Radiographic test Report along with Radiographs and other NDT reports.
 - (k) Piping Sketch (Isometric) giving all the details regarding the pipe specifications, welded joints, joints radiographed magnetic particle, tested, ultrasonic tested, penetrant tested, joints heat treated, WPS used, welders identification number, etc.

EXHIBIT – A: ELECTRODE QUALIFICATION TEST RECORD

Date:

Test started on:

Test completed on:

A: DETAILS

CONTRACTOR

Tested at (Site name)

Code of Reference (used for testing) :

Special Requirements (if any) :

Sl. No.	Classification of electrode	Size of electrode	Batch no.	Manufacturer name/brand/date of manufacture	Intended for welding in position	Remarks

B: All-weld Tensile Test

Base Material used :

Buttering used : Yes/No

Pre-heat temperature :

Inter-pass temperature :

Post weld heat treatment details :

Visual examination .:

Radiographic examination results :

Tensile test results :

Sl.No.	Batch no./ identification no.	Size of electrode	Current & polarity	UTS		YS		% elongation		Remarks
				As per code	Actual	As per code	Actual	As per code	Actual	

C. Impact Test Results

Test Temperature : Notch in :

Type of Specimens (Charpy) : Size of Specimens :

Sl.No.	Batch no./ identification no.	Size of electrode	Current & polarity	Impact value						Remarks
				As per code, max./avg.	1	2	3	4	5	

D. Chemical Analysis Results

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

E. Fillet Weld Test Results :

Base Materials :

Sl. No.	Batch no./ identification no.	Size of electrode	Current & polarity	Welding position	Visual	Macro	Fracture	Remarks
				Horizontal				
				Vertical				
				Overhead				
				Horizontal				
				Vertical				
				Overhead				

F. Other Test Results :

1. Transverse tensile test :

In combination with :

Base material used :

Position of welding :

Preheat temperature :

Post weld heat treatment :

Radiography :

Identification No. U.T.S. Fracture in Remarks

2. Guided Bend Test :

Position	Identification No.	Root, Face or Side Bend	Remarks
	1		
	2		
	3		
	4		
	5		

G. Any other tests :

H. Conclusions :

PREPARED BY
(CONTRACTOR)

REVIEWED BY
(CONTRACTOR)

APPROVED BY
(EIL/OWNER)

EXHIBIT – B: STRESS RELIEF HEAT TREATMENT PROCEDURE SPECIFICATION

LSTK CONTRACTOR : _____

Name of the Heat treater : _____

Name of the Project : _____

Specification /Reference No. : _____

Line no./Joint No. _____

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

3. Heat Treatment Cycle Details

Charging Temp °C _____

Rate of heating °C /Hr. _____

Soaking Temperature, °C _____

Soaking Time, Hrs. _____

Rate of Cooling °C /Hr. _____

Method of Cooling _____

4. Other details, if any _____

EXHIBIT – C: FORMAT FOR WELDING PROCEDURE SPECIFICATION (WPS)

Company Name _____ By _____

Welding Procedure Specification No. _____ Date _____ Supporting PQR No. (S) _____

Revision No. _____ Date _____

Welding Process (es) _____ Type (s) _____
(Automatic, Manual, Machines or Semi Auto)

JOINTS

Joint Design _____

Backing (Yes) _____ (No) _____

Backing Material (Type) _____

Sketches Production Drawings. Weld Symbols Written

Description should show the general arrangement of the parts to be welded. Where applicable, the root spacing and the details of weld groove may be specified.

(At the option of the Manufacturer sketches may be attached to illustrate joint design weld layers and bead sequence e.g. for notch toughness procedures, for multiple process procedures, etc.)

BASE METALS

P.No. _____ Group No. _____ to P. No. _____ Group No. _____

OR

Specification type and grade _____
to Specification type and grade _____

OR

Chem. Analysis and Mech. Prop. _____
to Chem. Analysis and Mech. Prop. _____

Thickness Range :

Base Metal : Groove _____ Fillet _____

Deposited Weld Metal : Groove _____ Fillet _____

Pipe Dia Range : Groove : _____ Fillet _____

Other _____

FILLER METALS

F.No. _____ Other _____
A.No. _____ Other _____
Spec. No. (SFA) _____
AWS No. (Class) _____
Size of filler metals _____

(Electrodes, Cold Wire, Hot Wire etc.)

Electrode-Flux (Class) _____
Flux Trade Name _____
Consumable Inset _____

Each base metal/filler metal combination should be recorded individually.

WPS NO. _____ Rev. _____

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

ELECTRICAL CHARACTERISTICS

Current AC or DC _____ Polarity _____
Amps (Range) _____ Volts (Range) _____
(Amps and volts range should be recorded for each electrode size, position, and thickness, etc. This information may be listed in a tabular form similar to that shown below).

Tungsten Electrode Size and Type _____
(Pure Tungsten, 2% Ceriated, etc)

Mode of Metal Transfer for GMAW _____
(Spray arc, short circuiting arc, etc.)

Electrode Wire feed speed range _____

TECHNIQUE

String or Weave Bead _____

Orifice or Gas Cup Size _____

Initial and Interpass Cleaning (Brushing, Grinding, etc.) _____

Method of Back Gouging _____

Oscillation _____

Contact Tube to Work Distance _____

Multiple or Single Pass (per side) _____

Multiple or Single Electrodes _____

Travel Speed (Range) _____

Peening _____

Other _____

Weld Layer(s)	Process	Filler Metal		Current		Volt Range	Travel Speed Range	Others
		Class.	Dia.	Type Polarity	Amp. Range			
								e.g. Remarks, Comments, Hot wire Addition, Technique Torch Angle, etc.

EXHIBIT-D: FORMAT FOR PROCEDURE QUALIFICATION RECORD (PQR)
RECORD OF ACTUAL CONDITIONS USED TO WELD TEST COUPON

Company Name _____
Procedure Qualification Record No. _____ Date _____
WPS No. _____

Welding Process (es) _____
Types (Manual, Automatic, Semi-Auto) _____

JOINTS

Groove Design of Test Coupon

(For combination qualification the deposited weld metal thickness shall be recorded for each Filler metal or process weld)

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

TENSILE TEST

Specimen No.	Width	Thickness	Area	Ultimate total force, kgf	Ultimate tensile stress, Kgf/mm ²	Type & location of failure

GUIDED BEND TESTS

Type of Figure No.	Result

TOUGHNESS TESTS

Specimen No.	Notch Location	Notch Type	Test Temp.	Impact Value	Lateral Exp.		Drop Weight	
					% Shear	Mils	Break	No Break

FILLET WELD TEST

Result - Satisfactory : Yes _____ No _____ Penetration into Parent Metal : Yes ____ No. ____

Marco - Results _____

OTHER TESTS

Type of Test _____

Deposit Analysis _____

Other _____

Welder's Name _____ Clock No. _____ Stamp No. _____

Test Conducted by _____ Laboratory Test No. _____

We certify that the statements in this record are correct and test welds were prepared, welded and tested in accordance with the requirements of Section IX of the ASME Code.

Date _____

Manufacturer _____

By _____

(Detail of record of tests are illustrative only and may be moulded to conform to the type and number of tests required by codes and specifications).

**EXHIBIT – E: FORMAT FOR MANUFACTURER’S RECORD FOR WELDER OR
WELDING OPERATOR QUALIFICATION TESTS**

Welder Name _____ Check No. _____ Stamp. No. _____

Using WPS No. _____ Rev. _____

The above welder is qualified for the following ranges

<u>Variable</u>	<u>Record Actual Values Used in Qualification</u>	<u>Qualification Range</u>
Process	_____	_____
Process Type	_____	_____
Backing (metal, Weld metal, flux, etc)	_____	_____
Material Spec.	_____ to _____	_____ to _____
Thickness		
Groove	_____	_____
Fillet	_____	_____
Diameter		
Groove	_____	_____
Fillet	_____	_____
Filler Metal		
Spec. No.	_____	_____
Class	_____	_____
F. No.	_____	_____
Position	_____	_____
Weld Progression	_____	_____
Gas Type	_____	_____
Electrical Characteristics		
Current	_____	_____
Polarity	_____	_____

Guided Bend Test Results

Type and Fig. No.	Result

Radiographic Test Results

For alternative qualification of groove welds by radiography

Radiographic Results _____

Fillet Weld Test Results

Fracture Test (Describe the location, nature and size of any crack or tearing of the specimen) _____

Length and Per Cent of Defects _____ inches _____ %

Macro Test - Fusion _____

Appearance - Fillet Size (ing) _____ x _____ Convexity or Concavity _____

Test Conducted by _____ Laboratory - Test No. _____

We certify that the statements in this record are correct and that the test welds were prepared.
Welded and tested in accordance with the requirements of Section IX of the ASME Code.

Date _____

Organization _____

By _____

(Details of record tests are illustrative only and may be modified to conformation to the type & number of tests required by the Code).

Note: Any essential variables in addition to those above shall be recorded.

EXHIBIT – F: RADIOGRAPHIC PROCEDURE QUALIFICATION
RECORD FOR PIPE WELDING

1. Location
2. Date of Testing
3. Name of the LSTK CONTRACTOR/Agency
4. Material: Carbon steel/Alloy Steel/Stainless Steel
- 4 A. Technique: DWSI/SWSI/DWDI
5. Diameter & Thickness:
6. Type of Weld Joint:
7. Radiation Source:
8. Intensifying Screens/Lead Screens:
9. Geometric Relationship:
10. Limit of Film Coverage:
11. Film Type and Make:
12. Exposure Time:
13. Processing:
14. Density:
15. Sensitivity:
- 16.* Type of penetrameter:
(Source side)
- 17.* Type of penetrameter:
(Film side)

Signature of LSTK CONTRACTOR/Agency with Seal

Approval of OWNER/ PMC's Inspector

- * Ref. Para regarding recommended practice on placement of penetrameters Article 22, SE 142, ASME Sec. V.
- * For "Random Radiography" lines placement of penetrameters as per Article 2, ASME, Sec. V is permitted.

EXHIBIT – G: WELDER'S IDENTIFICATION CARD

1. Name:
2. Identification:
3. Date of Testing:
4. Process
5. Thickness range
6. Diameter range
7. P. No.
8. Date of approval of welding
9. Position(s)

Photograph

Approved by:

Employer's Signature with Seal

EXHIBIT – H: Type of Source and Films to be used for RADIOGRAPHY

NOMINAL WALL THICKNESS (T) IN mm		SHOP WELDED JOINTS		IN-SITU WELDS	
		SOURCE	FILM : CEN Class	SOURCE	FILM : CEN Class
$T \geq 19$	All Materials	Gamma Ray	C 5	Gamma Ray	C 5
$8 \leq T < 19$	Carbon Steel	Gamma Ray	C 4	Gamma Ray	C 4
	All other materials	Gamma Ray	C3	Gamma Ray	C 3
< 8	Carbon Steel Other than Inspection Class IV *	Gamma Ray	C 3	Gamma Ray	C3/C1
	All other materials and Carbon Steel of Inspection Class IV *	X-Ray	C 4	X-ray with C4 or Equivalent to be used. Gamma Ray (Se 75 Source only) with C3/C2 Equivalent may be allowed only if in the assessment of the owner's inspector, Joints are inaccessible for X-ray equipment and radiographic sensitivity is achieved.	

Note: Integral to above table

- 1) Films slower than the above may have to be used, if required radiographic sensitivity is not achieved consistently.

* Piping classes where 100% RT is specified. Refer Std. Spec. No. 6-44-0016

COMPARISON OF FILMS FROM DIFFERENT MANUFACTURERS

CEN Classification	KODAK	AGFA	FUJI
---	CX	D8	---
C5	AA400	D7	IX100
C4	T200	D5	IX80
C3	MX125	D4	IX50
C2	M100	D3	---
C1	DR50	D2	IX25
---	SR**	---	---

** Special films, extremely fine grain & very high resolution

EXHIBIT – I: AUTOMATED ULTRASONIC TESTING (AUT)

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

1.0 INTRODUCTION

The specification shall be applicable for Automated Ultrasonic Testing (AUT) system or Semi-Automated Ultrasonic Testing suitable for full penetration butt welds of piping. The system shall incorporate Phased array probes and Time of Flight Diffraction (TOFD) probes plus pulse echo probes. The procedure shall evaluate the performance of Phased Array Ultrasonic examination instruments and system. This specification is intended to be used on thickness of 13.0 mm and greater. Lesser thicknesses may be tested using the standard practice if the technique can be demonstrated to provide adequate protection on mockups of the same wall thickness and geometry.

2.0 REFERENCE DOCUMENTS

The latest edition with addendum of the following standards shall be referred here:

- a) ASME B31.3 – Process piping
- b) ASME B31 Case 181-2. 2012 Use of alternative Ultrasonic Examination Acceptance Criteria in ASME B31.3
- c) ASME Section V- Non Destructive Examination (Latest edition)
- d) ASNT SNT-TC-1A - Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing

3.0 AUT SYSTEM

3.1 Instrument Requirement

The ultrasonic examination shall be performed using a system employing automated/ semi-automated scanning with computer based data and analysis abilities.

The instrument shall be capable of real-time sectorial scan (also called an S-scan) image during scanning to assure that proper data has been collected, generating and displaying sectorial-scan image, which can be stored and recall for subsequent review.

The system shall provide an adequate number of examination channels to ensure the complete volumetric examination of the weld through the thickness in one circumferential scan.

The evaluation zones should be of maximum 2.0mm height. The instrument linearity should be such that the accuracy is within 5%.

Each examination channel should be selective for pulse-echo or through transmission mode gate position and length for a minimum of two gates and gain.

TOFD techniques & B-scan mapping should be available to improve characterization. Recording thresholds should be selectable to display signals between 0 and 100% of full screen height for simple amplitude and transit time recording and it should be from 0 to 100% for B-scan or mapping type recording of data. Two recordable signals output per gate should be available being either analog or digital and representative of signal height and time of flight. Measuring distance accuracy of circumferential weld shall be within 1.0 cm from zero (0) position.

Electronic noise shall be lower than acoustical noise in all channels for the probes and sensitivities to be used during inspection. The signal to noise ratio for each channel during examination shall be at least ≥ 20 dB for shear waved probes.

The Contractor shall provide the detail information of the equipment like model, trade name, software used to the OWNER/EIL.

3.2 Probes

The phased array search unit frequency shall be between 1 MHz and 10 MHz depending on material type and thickness. The Contractor shall provide the detail information of the probe frequency, no. of elements, size, pitch etc. to the OWNER/EIL.

3.3 Wedge

Phased array wedges shall be of a design to accommodate phased array search unit. Nominal refracted-wedge angles shall be possible from 35 to 75 degrees to ensure 100 % coverage of the weld and heat affected zone. The Contractor shall provide the detail information of the wedge to the OWNER/EIL.

3.4 Encoder

The encoder shall be capable of permitting a scan resolution of 1.0mm as minimum.

4.0 COUPLANT

The couplant shall be obtained by using a medium suitable for the purpose. It shall be suitable for the temperature used. The couplant, including additives, shall not be detrimental to the material being examined. Couplants used on nickel base alloys shall not contain more than 250 ppm of sulfur. Couplants used on austenitic stainless steel shall not contain more than 50 ppm of halides (chlorides plus fluorides). A method should be employed to determine that constant coupling is achieved during examination. An examination of the test piece with its surface wiped dry should produce a record showing an absence of the couplant recording signal.

The same couplant shall be used during calibration and examination.

5.0 CALIBRATION/DEMONSTRATION BLOCK

5.1 Calibration/Demonstration Block Material

5.1.1 Material selection

The material from which the qualification and calibration blocks are fabricated shall be of the same product form and material specification or equivalent P-number grouping as one of the materials being examined.

5.1.2 Heat treatment

The calibration and qualification blocks shall receive at least the minimum tempering treatment required by the material specification for the type and grade. If the calibration and qualification blocks contains welds other than cladding, and the component weld at the time of the examination has been heat treated, the block shall receive the same heat treatment.

5.1.3 Reflectors

- a) Calibration blocks reflectors: Side drilled holes shall be used to confirm adequate sensitivity settings.
- b) Demonstration blocks reflectors: Surface and sub-surface notches

5.1.4 Quality of calibration and demonstration blocks

Prior to fabrication, the block material shall be completely examined with a straight beam search unit. Areas that contain an indication exceeding the remaining back-wall reflection shall be excluded from the beam paths required to reach the various calibration reflectors.

5.1.5 Cladding

When the component material is clad, the block shall be clad by the same welding procedure as the production part. It is desirable to have component materials, which have been clad before the dropouts, or prolongations are removed. When the cladding is deposited using an automatic welding process, and, if due to block size, the automatic welding process is impractical, deposition of clad may be by the manual method.

5.1.6 Surface roughness of calibration and demonstration blocks

The roughness of the Demonstration and calibration surfaces of the blocks shall be representative for the scanning surface of the components to be examined.

5.2 Calibration Blocks

5.2.1 Standard block

IIW V1 calibration block or V2 or equivalent calibration block are a recognized test reference for sweep range scale, index point of shear wave transducer, and refracting angle.

5.2.2 Calibration reference block

Reference block shall be made with notch and side-drilled hole as per ASME Section V article 4, Fig.T-434.2.1 and Fig.T-434.3 and shall be used for gain calibration and construction of reference curves. The reference calibration block shall be a section of pipe of the same nominal and schedule and normally be manufactured from the actual material examined and have approved dimensions.

5.2.3 Non-piping Calibration block

The basic calibration block configuration and reflectors shall be as shown in ASME Section V article 4, Fig.T-434.2.1. The block size and reflector locations shall be adequate to perform calibrations for the beam angles used.

5.2.4 Piping Calibration block

The basic calibration block configuration and reflectors shall be as shown in ASME Section V article 4, Fig.T-434.3. The block size and reflector locations shall be adequate to perform calibration for the beam angles used.

5.2.5 Block Curvature

The block curvature shall be as per ASME Section V article 4.

5.3 Demonstration Block

5.3.1 Preparation

A demonstration block shall be prepared by welding or, provided the acoustic properties are similar, the hot isotactic process (HIP) may be used.

5.3.2 Thickness

The demonstration block shall be within 25% of the thickness to be examined. For welds joining two different thickness of material, demonstration block thickness shall be based on the thinner of the two materials.

5.3.3 Weld joint configuration

The demonstration blocks weld joint geometry shall be representative of the production joints details.

5.3.4 Flaw location

Unless specified otherwise by the referencing Code Section, the demonstration block which three EDM notches oriented and major groove faces. The flaws shall be located at or adjacent to the blocks groove faces as follows:

- (a) One surface flaw on the side of the block representing the component O.D. surface
- (b) One surface flaw on the side of the block representing the component I.D. surface
- (c) One subsurface flaw

When the scan plan to be utilized subdivides a weld into multiple examination zones, a minimum of one flaw per zone is required.

5.3.5 Flaw Size

Demonstration block flaw sizes shall be based on the demonstration block thickness and shall be no larger than that specified by the referencing Code Section.

- (a) Maximum acceptable flaw height for material less than 1 in. (25 mm) thickness, or
- (b) 0.25 aspect ratio acceptable flaw for material equal to or greater than 1 in. (25 mm) thickness based on the demonstration block

5.3.6 Single I.D. / O.D. flaw alternative

When the demonstration block can be scanned from both major surfaces during the qualification scan [e.g., joint I.D. and O.D. have a similar detail, diameter of curvature is greater than 20 in. (500 mm), no cladding or weld overlay present, etc.], then only one surface flaw is required.

5.3.7 One-sided exams

When, due to obstructions, the weld examination can only be performed from one side of the weld axis, the demonstration block shall contain two sets of flaws, one set on each side of the weld axis. When the demonstration block can be scanned from both sides of the weld axis during the qualification scan (e.g., similar joint detail and no obstructions), then only one set of flaws is required.

6.0 CALIBRATION

6.1 General Calibration Requirements

1) Ultrasonic system: Calibration

Calibration shall be performed for complete ultrasonic system and shall be done prior to examination in the desired thickness range.

- 2) The surface condition of the calibration block shall be similar to that on which production test will be performed with respect to the surface geometry and cladding.
- 3) Same couplant shall be used for calibration as well as production testing.
- 4) Contact wedges, if used, shall be same for the calibration as well as for the production testing.
- 5) Any control, which affects instrument linearity (e. g. Filters, reject, or clipping), shall be in the same position for calibration, calibration checks, instrument linearity checks and examination.
- 6) Focal-Law: The focal law to be used during the examination shall be used for calibration.
- 7) Beam Calibration

All individual beams used in the examination shall be calibrated to provide measurement of distance and amplitude correction over the sound path employed in the examination. This shall include applicable compensation for wedge sound path variations and wedge attenuation effects.

- 8) The maximum temperature difference between test blocks and examination surface shall not exceed 14°C.

6.2 PA Instrument Linearity

The following requirements shall be met at intervals not to exceed one year or prior to first use thereafter.

- 1) Screen height linearity: The PAUT equipment's screen height linearity shall be evaluated in accordance with Mandatory Appendix I of ASME Sect. V, Art.4.

- 2) Amplitude control linearity: The PAUT equipment's amplitude control linearity shall be evaluated in accordance with Mandatory Appendix II of ASME Sect. V, Art.4 for each pulse-receiver circuit

- 3) Equipment linearity shall be such that accuracy of indicated amplitude or time is $\pm 5\%$ of actual full scale amplitude or time.

6.3 Phased array system calibration

Calibration shall be performed from the surface of the calibration block which corresponds to the component surface to be examined. System calibration shall include the complete ultrasonic system. Screen distance calibration shall be at least 1-1/2 "veepaths"(also known as skip) for the minimum angle that will be used during the examination.

The system shall be calibrated for velocity and wedge delay calibration, sensitivity calibration, Time Corrected Gain (TCG) calibration. Encoder calibration and confirmation of sensitivity.

The system shall require re-calibration due any of the following conditions:

- 1) Search unit transducer or wedge change.
- 2) Search unit cable or length change.
- 3) Ultrasonic instrument change.
- 4) Change in examination personnel.
- 5) Change in type of power source.

7.0 PROCEDURE

7.1 Safety

At first, safety supervisor or technician should be confirmed regarding safety matters before starting examination. Those are included mainly of scaffolding, ladder, lighting, electric conditions and personnel safety equipments have been checked by themselves as followed Project Safety Regulation. If there is not clear for safety questions for personnel, equipment and examination, the technician has right to stop his job whenever.

- 7.2 A detailed Automated Ultrasonic examination procedure shall be prepared and qualified for each wall thickness and joint geometry to be examined prior to the start of any NDT work. Repair procedure shall be separately qualified for each joint geometry. The procedure as a minimum shall include the following:

Scope; equipment; probe type and details; surface preparation, cleaning and couplant; technique sheet for each technique specified (number of techniques to be sufficient to cover all type of joints to be covered by the procedures scope); material; weld material (if different); sketch showing joint configuration, beam coverage; extent of scan; scanning pattern; material thickness and curvature; calibrations and frequency; means of setting and scanning sensitivity levels and DAC curves; flaw location and size evaluation; acceptance criteria; reporting format; operator qualifications.

7.3 Lamination Check

A-UT shall be performed using a device employing automatic computer based data acquisition. The straight beam material examination (T-472 of Section V, Article 4) for reflectors that could interfere with the angle beam examination shall be performed:

- a) Manually,
- b) As part of a previous manufacturing process, or
- c) During the A-UT examination provided detection of these reflectors is demonstrated.
- d) The coverage shall be included minimum 100mm from centerline of welding.

7.4 Examination Coverage

The required volume of the weld and base material to be examined shall be scanned using a linear scanning technique with an encoder. Each linear scan shall be parallel to the weld axis at a constant standoff distance with the beam oriented perpendicular to the weld axis.

The ultrasonic examination area shall include the volume of the weld, plus the lesser of 25mm (1 in.) or "t" on each side of the weld.

A documented examination strategy or scan plan shall be provided, showing transducer placement, movement, and component coverage, that provides a standardized and repeatable methodology for weld acceptance. The scan plan shall also include ultrasonic beam angle used, beam directions with respect to weld centerline, and pipe volume examined for each weld. The documentation shall be made available to the owner's Inspector.

7.5 Examination side

Basically shall be examined on the both sides of welding line axis but can be examined from one side in case of another side is not available access under full coverage volume condition.

7.6 Surface condition

The contact surface shall be cleaned of weld spatter, dirt, pitting, rust and/or any other impurities or roughness that will interfere with the free movement of the ultrasonic transducers or would prevent adequate transmission of ultrasound. Prior to inspection the NDT technician shall judge the suitability of the surface and when required remedial action shall be taken.

7.7 Scanning

- 1) The search unit shall be maintained at a fixed distance from the weld axis by a fixed guide or mechanical means.
- 2) The examination angle(s) for E-scan and range of angles for S-scan shall be appropriate for the joint to be examined.
- 3) Scanning speed shall be such that data drop-out is less than 2 data lines per inch (25mm) of the linear scan length and that there are no adjacent data line skips.
- 4) For E-scan techniques, overlap between adjacent active apertures (i.e., aperture incremental change) shall be a minimum of 50% of the effective aperture height.
- 5) For S-scan techniques, the angular sweep incremental change shall be a maximum of 1 deg or sufficient to assure 50% beam overlap.
- 6) When multiple linear scan are required to cover the required volume of weld and base material, overlap between adjacent linear scans shall be a minimum of 10% of the effective aperture height for E-scan or beam width for S-scan
- 7) Each scan shall have an overlap of minimum 1 in. (25 mm) - (in case of re-acquisition of missing or poor data line etc.)
- 8) TOFD channel
The TOFD gate start will be set 1 μ Sec before the arrival of the lateral wave and should extend up to the first back wall echo to achieve full cover of wall thickness.

7.8 Data Recording

A-scan data shall be recorded in an unprocessed form with on threshold, at a minimum digitization rate of five times the examination frequency, and recording increments of a maximum of

- a) 0.04 in. (1 mm) for material < 3 in. (75 mm) thick
- b) 0.08 in. (2 mm) for material $\geq$ 3 in. (75 mm) thick

7.9 Reflectors Transverse to the Weld Seam

As an alternate to line scanning, a manual angle beam examination may be performed for reflectors transverse to the weld axis. Manual angle beam UT shall be accordance with manual ultrasonic examination procedure based on (T-472 of Article 4, ASME Sec V).

7.10 Re-examination

- 1) Re-examination for repaired welds shall follow the same condition (same examination method, same acceptance criteria) as for the original weld.
- 2) The additional testing shall be extent a length at least equal to 1 in.(25 mm) from the both end of repaired area.
- 3) Additional NDT methods of UT and MT shall be carried out to make ensure for the repaired area

8.0 TRAINING AND QUALIFICATION

All Inspectors of the EIL/OWNER (EIL/OWNER) shall be imparted training at the CONTRACTOR's cost. The inspector shall be provided complete awareness and knowledge regarding the equipment, limitations, capabilities complete range, method of operation, calibration, scanning, including development of suitable procedure, training on variables effecting the system performance and interpretation of results.

The Ultrasonic lead operator performing the examination shall be qualified in accordance with the EIL/OWNER's written practice, ASNT-TC-1A, ASME B31 Case 181-1. The minimum qualification of AUT operator who analyze and interpret the collected data shall be a ASNT Level II or III.

Only qualified UT personnel trained in the use of the equipment and who have demonstrated the ability to properly acquire examination data, shall conduct production scan.

Scanner technician, Band setter, scribe line technician shall have sufficient experience and capabilities to perform their duties to the satisfaction of AUT operator.

9.0 EVALUATION AND ACCEPTANCE CRITERIA

9.1 Evaluation

9.1.1 Data analysis criteria

Reflectors exceeding the limits in either a) or b) below, as applicable, shall be investigated to determine whether the indications originates from a flaw or is a geometric indication in accordance with Para. 9.1.3 (Flaw sizing) below.

- a) For amplitude-based techniques, the location, amplitude, and extent of all reflectors that produce response greater than 20% of the reference level shall be investigated.
- b) For non amplitude-based techniques, the location and extent of all images that have an indicated length greater than the limits, as applicable, shall be investigated.

9.1.2 Geometric

Ultrasonic indications of geometric and metallurgical origin shall be classified as follows:

1) Indications that are determined to originate from the surface configurations(such as weld reinforcement or root geometry) or variations in metallurgical structure of materials (such as cladding to base metal interface) may be classified as geometric indications, and

- a) Need not be characterized or sized.
- b) Need not be compared
- c) Location shall be recorded

2) The following steps shall be taken to classify an indication as geometric:

- a) Interpret the area containing the indication;
- b) Plot and verify the indication coordinate, provide a cross-sectional display showing the indication position and surface discontinuity such as root or counter bore; and
- c) Review fabrication or weld preparation drawings.

3) Alternatively other NDE methods or techniques may be applied to classify an indication as geometric (e.g. alternative UT beam angles, radiography, ID and/or OD profiling).

9.1.3 Flaw sizing

The dimensions of the flaw shall be determined by the rectangle that fully contains the area of the flaw.

Flaw Sizing - Reflectors determined to be flaws shall be sized in accordance with a procedure demonstrated to size similar flaws at similar material depths. A flaw may be sized by manually analysis the data using sizing techniques that have been demonstrated on the calibration block. The dimension of the flaw shall be determined by the size of the rectangle that fully contains the area of the flaw.

9.1.4 Flaw evaluation

Flaws shall be evaluated for acceptance using the applicable criteria of ASME B31 Case 181-2.

9.2 Acceptance criteria

Weld quality shall be judged on the basis of the acceptability criteria mentioned in ASME B31 Case 181-2.

INSPECTION AND TEST PLAN
FOR
WELDED PIPES

STANDARD SPECIFICATION NO.

6-81-0002 Rev. 4

Page 1 of 6

वैल्डेड पाइपों के लिये
निरीक्षण एवं परीक्षण योजना

INSPECTION AND TEST PLAN
FOR
WELDED PIPES

4	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
3	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
2	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND
1	28.09.2007	REVISED AND RE-ISSUED	PD	RB	MVKK	VC
0	23.04.2002	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	SB
Rev. No.	Date	Purpose	Prepared By	Checked By	Standards Committee Convenor	Standards Bureau Chairman
						Approved by

INSPECTION AND TEST PLAN FOR WELDED PIPES

STANDARD SPECIFICATION NO.

6-81-0002 Rev. 4

Page 2 of 6

Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. S C Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr. Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

INSPECTION AND TEST PLAN FOR WELDED PIPES

STANDARD SPECIFICATION NO.

6-81-0002 Rev. 4

Page 3 of 6

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements for Welded Pipes.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	Procedure						
1.1	Hydrostatic Test, Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS,PQR & WPQ	-	H	W- New R- Existing
2.0	Material Inspection						
2.1	Raw Material Inspection	Chemical & Mechanical Properties	100%	Test Certificates	-	H	R
3.0	In Process Inspection						
3.1	Welding	Welding Parameters as per WPS / PQR	100%	Inspection Reports	-	H	-

**INSPECTION AND TEST PLAN
FOR
WELDED PIPES**

STANDARD SPECIFICATION NO.

6-81-0002 Rev. 4

Page 4 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.2	Heat Treatment	Stress Relieving, Normalising, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart	-	H	R
3.3	Ferrite Check Of SS Pipes (If Applicable)	% Ferrite Check	Random On Weld	Inspection Report	-	H	R
3.4	UT / RT As applicable	Surface & Internal Imperfections	PR / Purchase Specification	RT Films, Reports, & UT Reports	-	H	R
3.5	Identification of Test Samples	Product Chemical, Mechanical, Impact, IGC and Other test as applicable	PR / Purchase Specification	Test Reports	-	H	H (Note – 1)
3.6	Product Analysis	Chemical Composition	PR / Purchase Specification	Test Reports	-	H	R
3.7	Destructive Testing	Mechanical, Impact, IGC and Other test as applicable	PR / Purchase Specification	Test Reports	-	H	H (Note – 1)
3.8	Galvanizing (If Applicable)	Integrity Of Galvanised Coating	100%	Inspection Report	-	H	R
4.0	Final Inspection						

**INSPECTION AND TEST PLAN
FOR
WELDED PIPES**

STANDARD SPECIFICATION NO.

6-81-0002 Rev. 4

Page 5 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.1	Hydrostatic Testing	Leak Check	100%	Test Report	-	H	RW (Note-1)
4.2	Visual and Dimensional Inspection (VDI)	Surface Condition, Straightness, End Finish, Bevel Angle, Root Face, Outer Dia, Profile Thickness, Length, End Finish, Marking etc	100%	Inspection Report	-	H	RW (Note-1)
4.3	Weight Checking as applicable	Weight	100%	Inspection Report	-	H	-
4.4	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.5	Final Stamping	Stamping Of Accepted Pipes	Stamping of Pipes which are witnessed by EIL/TPIA.	Inspection Report	-	H	H
5.0	Painting						
5.1	Rust Preventive Coating & Color Coding (As applicable)	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-

**INSPECTION AND TEST PLAN
FOR
WELDED PIPES**

STANDARD SPECIFICATION NO.

6-81-0002 Rev. 4

Page 6 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
6.0	Documentation & IC						
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Manufacturer TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

- For Non NACE & Non Hydrogen service Carbon Steel Pipes up to size 12” will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by EIL/TPIA.
- This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable.(Unless otherwise agreed upon)
- Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
- For orders placed on stockist, items shall be accepted based on manufacturer’s TC with EN10204 type 3.2 certification from EIL approved suppliers.

वाल्वों के लिये निरीक्षण व परीक्षण योजना

INSPECTION AND TEST PLAN FOR VALVES

5.	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
4	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
3	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND
2	31.01.2008	REVISED AND RE-ISSUED	CS	SS	MVKK	VC
1	05.10.2005	QUANTUM OF CHECK & SCOPE OF INSPECTION REVISED	SS	MVKK	SY	VJN
Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	

INSPECTION AND TEST PLAN FOR VALVES

STANDARD SPECIFICATION NO.

6-81-0004 Rev. 5

Page 2 of 7

Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. S C Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr. Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

INSPECTION AND TEST PLAN FOR VALVES

STANDARD SPECIFICATION NO.

6-81-0004 Rev. 5

Page 3 of 7

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Valves.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	Procedure						
1.1	Hydrostatic Test, Heat Treatment, NDT, Helium Leak Test And Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS,PQR &WPQ	-	H	W- New R- Existing
1.3	Pre-Qualification Tests	Fire safe, Cryogenic & Other Test as applicable	As per PR / Purchase Specification	Acceptance Report	-	H	H (If new)

INSPECTION AND TEST PLAN FOR VALVES

STANDARD SPECIFICATION NO.

6-81-0004 Rev. 5

Page 4 of 7

SL NO	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
2.0	Material Inspection						
2.1.	Castings & Forgings (Body, Bonnet, Disc, Stem, Body ring)	Chemical ,Mechanical , Heat Treatment, NDT,IGC & Other Properties as applicable	100%	Test Certificates	H	R	R
2.2	Castings & Forgings (Body, Bonnet, Disc, Stem, Body ring)	Visual & Dimension	100%	Inspection Report	H	H	-
2.3.	Body and Bonnet Castings	Radiography Examination	As per PR / Purchase Specification	Films and report	H	R	R
2.4	Bars for Trim material	Chemical Analysis	Each Heat	Test Certificates& Lab Report	H	R	-
2.5	Gaskets, Gear units, Fasteners, Gland, Packings, etc.	Physical / Chemical Properties	100%	Test Certificates& Lab Report	H	R	-
2.6	Actuators as applicable	Performance , Statutory Certificates as applicable	100%	Test Certificates , Inspection report	H	H	R

INSPECTION AND TEST PLAN FOR VALVES

STANDARD SPECIFICATION NO.

6-81-0004 Rev. 5

Page 5 of 7

SL NO	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	In Process Inspection						
3.1	Welding	Welding Parameters as per WPS / PQR	100%	Inspection Reports	-	H	-
3.2	Machining of components	Visual / Dimension	100%	Inspection Reports	-	H	-
4.0	Final Inspection						
4.1	Hydrostatic / Pneumatic Test and Helium Leak test as applicable	Leak Check	As per PR / Purchase Specification	Test Report	-	H	RW (Note 1)
4.2	Visual / Dimension	Surface & Dimension Check	100%	Test Report	-	H	RW (Note 1)
4.3	Functional Test for Actuator Operated Valves	Satisfactory Performance	100%	Test Report	-	H	RW

INSPECTION AND TEST PLAN FOR VALVES

STANDARD SPECIFICATION NO.

6-81-0004 Rev. 5

Page 6 of 7

SL NO	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.4	PMI Check	Chemical	As per EIL Spec. 6-81-0001	Inspection Report	-	H	RW
4.5	Strip Check(As applicable)	Verify Components & Differential hardness if applicable	As per PR / Purchase Specification	Inspection Report	-	H	RW (Note-1)
4.6	Final Stamping	Stamping Of Accepted Valves	Stamping of Valves which are witnessed by EIL/TPIA.	Inspection Report	-	H	H (Note-1)
5.0	Painting						
5.1	Painting and Color coding as applicable	Visual / DFT Check	100%	Inspection Report	-	H	-
6.0	Documentation & IC						
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

**INSPECTION AND TEST PLAN
FOR
VALVES**

STANDARD SPECIFICATION NO.

6-81-0004 Rev. 5

Page 7 of 7

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

1. For Non NACE & Non Hydrogen service Carbon Steel Valves up to size 12” will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by EIL/TPIA.
2. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable.(Unless otherwise agreed upon)
3. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.

INSPECTION AND TEST PLAN
FOR
FORGED, SEAMLESS & WELDED FITTINGS

STANDARD SPECIFICATION No.

6-81-0005 Rev. 5

Page 1 of 6

फोर्ज्ड, सीमलेस एंड वैल्डेड फिटिंगों के लिये
निरीक्षण व परीक्षण योजना
INSPECTION AND TEST PLAN
FOR
FORGED, SEAMLESS & WELDED FITTINGS

5.	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
4	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
3	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND
2	31.01.2008	REVISED AND RE-ISSUED	CS	SS	MVKK	VC
1	30.06.2004	REVISED AND ISSUED FOR IMPLEMENTATION	MS	SPS	SY	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
						Approved by

INSPECTION AND TEST PLAN FOR FORGED, SEAMLESS & WELDED FITTINGS

STANDARD SPECIFICATION No.

6-81-0005 Rev. 5

Page 2 of 6

Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. S C Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr. Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

INSPECTION AND TEST PLAN FOR FORGED, SEAMLESS & WELDED FITTINGS

STANDARD SPECIFICATION No.

6-81-0005 Rev. 5

Page 3 of 6

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Forged, Seamless & Welded Fittings.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	Procedure						
1.1	Heat Treatment / NDT	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification	100%	WPS,PQR & WPQ	-	H	W- New R- Existing
2.0	Material Inspection						
2.1	Raw Material Identification (Billets, Rounds, Pipes, Coil, Plates, etc.)	Chemical and Mechanical Properties	100%	Mill test certificate, Supplier's Inspection Report	-	H	R

INSPECTION AND TEST PLAN
FOR
FORGED, SEAMLESS & WELDED FITTINGS

STANDARD SPECIFICATION No.

6-81-0005 Rev. 5

Page 4 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	In Process Inspection						
3.1	Forming & Welding	Forming & Welding Parameters	100%	Supplier's records	-	H	-
3.2	Ferrite Check Of SS Welds (If Applicable)	% Ferrite Check	100%	Inspection Report	-	H	R
3.3	Heat Treatment	Stress Reliving, Normalising, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart / Report	-	H	R
3.4	NDT As Applicable	Surface & Internal Imperfections	As per PR/Purchase Specification	NDT Reports	-	H	R
3.5	Identification of Test Samples	Product Chemical, Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	H (Note-1)
3.6	Product Analysis	Chemical Composition	As per PR/Purchase Specification	Test Reports	-	H	R
3.7	Destructive Testing	Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	H (Note-1)

INSPECTION AND TEST PLAN
FOR
FORGED, SEAMLESS & WELDED FITTINGS

STANDARD SPECIFICATION No.

6-81-0005 Rev. 5

Page 5 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.8	Galvanizing (If Applicable)	Integrity Of Galvanised Coating	100%	Inspection Report	-	H	-
4.0	Final Inspection						
4.1	Visual and Dimension	Size, Thickness / Schedule, Dimensions, Surface quality, Marking, etc.	100%	Inspection Report	-	H	RW (Note-1)
4.2	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.3	Final Stamping	Stamping Of Accepted Fittings	Stamping of Fittings which are witnessed by EIL/TPIA.	Inspection Report	-	H	H (Note-1)
5.0	Painting						
5.1	Rust Preventive Coating & Color Coding	Visual & Color Coding as applicable	100%	Inspection Report	-	W	-
6.0	Documentation & IC						

INSPECTION AND TEST PLAN
FOR
FORGED, SEAMLESS & WELDED FITTINGS

STANDARD SPECIFICATION No.

6-81-0005 Rev. 5

Page 6 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

- For Non NACE & Non Hydrogen service Carbon Steel Fittings up to size 14" will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by EIL/TPIA.
- This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable.(unless otherwise agreed upon)
- Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.
- For orders placed on stockist, items shall be accepted based on manufacturer's TC with EN10204 type 3.2 certification from EIL approved suppliers.

फ्लैंजों, स्पैक्टैकल ब्लांडों एवं ड्रिप रिंगों के लिये
निरीक्षण व परीक्षण योजना
INSPECTION AND TEST PLAN
FOR
FLANGES, SPECTACLE BLINDS & DRIP RINGS

4.	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
3	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
2	30.06.2010	REVISED AND RE-ISSUED	RKB	VKJ	SKP	ND
1	28.09.2007	REVISED AND RE-ISSUED	PD	RB	MVKK	VC
0	23.04.2002	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	SB
Rev. No.	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
					Approved by	

INSPECTION AND TEST PLAN FOR FLANGES, SPECTACLE BLINDS & DRIP RINGS

STANDARD SPECIFICATION No.

6-81-0006 Rev. 4

Page 2 of 6

Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. S C Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr. Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

INSPECTION AND TEST PLAN FOR FLANGES, SPECTACLE BLINDS & DRIP RINGS

STANDARD SPECIFICATION No.

6-81-0006 Rev. 4

Page 3 of 6

1.0 SCOPE

This Inspection and Test Plan covers the minimum testing requirements of Flanges, Spectacle Blinds & Drip Rings.

2.0 REFERENCE DOCUMENTS

PO/PR/Standards referred therein/ Job specifications /Approved documents.

3.0 INSPECTION AND TEST REQUIREMENTS

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	Procedure						
1.1	Heat Treatment, NDT and Other Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
1.2	WPS,PQR & WPQ	Welding Parameters & Qualification Record	100%	WPS,PQR & WPQ	-	H	W- New R- Existing
2.0	Material Inspection						
2.1	Raw Material Inspection	Chemical & Mechanical Properties	100%	Test Certificates	-	H	R
3.0	In Process Inspection						

**INSPECTION AND TEST PLAN
FOR
FLANGES, SPECTACLE BLINDS & DRIP RINGS**

STANDARD SPECIFICATION No.

6-81-0006 Rev. 4

Page 4 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.1	Welding / Forging	Forging /Welding Parameters	100%	Inspection Reports	-	H	-
3.2	Heat Treatment	Stress Relieving, Normalising, Tempering, Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	HT chart	-	H	R
3.3	Identification of Test Samples	Product Chemical, Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	H (Note-1)
3.4	Product Analysis (As applicable)	Chemical Composition	As per PR/Purchase Specification	Test Reports	-	H	R
3.5	Destructive Testing	Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	H (Note-1)
3.6	NDT as applicable	Surface & Internal Imperfections	As per PR/Purchase Specification	NDT Reports	-	H	R
3.7	Galvanizing (If Applicable)	Integrity Of Galvanised Coating	100%	Inspection Report	-	H	-
4.0	Final Inspection						

**INSPECTION AND TEST PLAN
FOR
FLANGES, SPECTACLE BLINDS & DRIP RINGS**

STANDARD SPECIFICATION No.

6-81-0006 Rev. 4

Page 5 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.1.	Final Inspection	1.Visual 2. Dimensions 3.Hardness 4. Marking etc	100%	Inspection Report	-	H	H (Note-1)
4.2	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	RW
4.3	Final Stamping	Stamping Of Accepted Items	Stamping of Items which are witnessed by EIL/TPIA.	Inspection Report	-	H	H (Note – 1)
5.0	Painting						
5.1	Rust Preventive Coating & Color Coding	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	Documentation & IC						

**INSPECTION AND TEST PLAN
FOR
FLANGES, SPECTACLE BLINDS & DRIP RINGS**

STANDARD SPECIFICATION No.

6-81-0006 Rev. 4

Page 6 of 6

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

NOTES (As applicable):

- For Non NACE & Non Hydrogen service Carbon Steel Flanges, Spectacle Blinds & Drip Rings up to size 24"-300ANSI Class Will be accepted on review of Supplier Test Certificates. Supplier Test Certificate to be reviewed by EIL/TPIA.
- This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable.(unless otherwise agreed upon)
- Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.

INSPECTION AND TEST PLAN
FOR
BOLTING MATERIAL

STANDARD SPECIFICATION No.

6-81-0007 Rev. 3

Page 1 of 5

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INSPECTION AND TEST PLAN
FOR
BOLTING MATERIAL

3	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
1	28.09.2007	REVISED AND RE-ISSUED	PD	RB	MVKK	VC
0	23.04.02	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	SB
Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
Approved by						

INSPECTION AND TEST PLAN FOR BOLTING MATERIAL

STANDARD SPECIFICATION No.

6-81-0007 Rev.3

Page 2 of 5

Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. S C Gupta

Members:

Mr. R.K. Singh	Mr. Rajeev Kumar	Mr. Himangshu Pal
Mr. Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

INSPECTION AND TEST PLAN FOR BOLTING MATERIAL

STANDARD SPECIFICATION No.

6-81-0007 Rev.3

Page 3 of 5

1.0 SCOPE:

This Inspection and Test Plan covers the minimum testing requirements of Bolting Material.

2.0 REFERENCE DOCUMENTS:

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

3.0 INSPECTION AND TEST REQUIREMENTS:

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	Procedure						
1.1	Heat Treatment & NDT Procedures	Documented Procedures	100%	Procedure Documents	-	H	R
2.0	Material Inspection						
2.1	Raw Material Inspection	Chemical, Macro Etch & Mechanical Properties	100%	Test Certificates	H	H	R
3.0	In Process Inspection						
3.1	Thread Rolling, Forging Of Nuts, Machining	Process Parameters	100%	Inspection Report	-	H	-

**INSPECTION AND TEST PLAN
FOR
BOLTING MATERIAL**

STANDARD SPECIFICATION No.

6-81-0007 Rev.3

Page 4 of 5

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.2	Heat Treatment	Normalising & Tempering, Quenching & Tempering Solution Annealing, Stabilization Heat Treatment etc. as applicable	100%	Inspection Report	-	H	R
3.3	NDT	Defects	100%	Test Reports	-	H	R
3.4	Identification of Test Samples	Product Chemical, Proof Load Test , Stress Rupture, Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	-
3.5	Destructive Testing	Product Chemical, Proof Load Test , Stress Rupture, Mechanical, Impact, IGC and Other test as applicable	100%	Test Reports	-	H	R
3.6	Galvanizing (If Applicable)	Integrity Of Galvanised Coating	100%	Inspection Report	-	H	-
4.0	Final Inspection						
4.1	Visual & Dimension	Visual Marking & Dimensions	100%	Inspection Report	-	H	-

INSPECTION AND TEST PLAN FOR BOLTING MATERIAL

STANDARD SPECIFICATION No.

6-81-0007 Rev.3

Page 5 of 5

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.2	Final Stamping	Stamping Of Accepted Bolting Material	100%	Inspection Report	-	H	-
4.3	PMI Check	Chemical Check	As Per EIL Spec. 6-81-0001	Inspection report	-	H	R
5.0	Painting						
5.1	Rust Preventive & Color Coding	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	Documentation & IC						
6.1	Documentation & Inspection Certificate(IC)	Review of Stage Inspection Reports / Test Reports & Issue of IC	100%	Supplier TC & IC	-	H	H

Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

Notes (as applicable):

1. This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable.(unless otherwise agreed upon)
2. Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.

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INSPECTION AND TEST PLAN
FOR
GASKETS

3.	17.06.2013	REVISED AND RE-ISSUED	TKK	RKS	SCG	DM
2	15.07.2011	REVISED AND RE-ISSUED	TKK	SCG	AKC	DM
1	02.01.08	REVISED AND RE-ISSUED	AM	SS	MVKK	VC
0	23.04.02	ISSUED FOR IMPLEMENTATION	NKN	SPS	AKB	SB
Rev. No.	Date	Purpose	Prepared by	Checked by	Convenor Standards Committee	Chairman Standards Bureau
Approved by						

INSPECTION AND TEST PLAN FOR GASKETS

STANDARD SPECIFICATION No.

6-81-0008 Rev3

Page 2 of 5

Abbreviations:

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

Inspection Standards Committee

Convenor : Mr. S C Gupta

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Mr. Neeraj Mathur	Mr. T Kamalakannan	Mr. Deepak Gupta (Project)
Mr. Mayank Jain		

INSPECTION AND TEST PLAN FOR GASKETS

STANDARD SPECIFICATION No.

6-81-0008 Rev3

Page 3 of 5

1.0 SCOPE:

This Inspection and Test Plan covers the minimum testing requirements of Gaskets.

2.0 REFERENCE DOCUMENTS:

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

3.0 INSPECTION AND TEST REQUIREMENTS:

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
1.0	Procedure						
1.1	HT & Test Procedure	Documented Procedures	100%	Procedure Documents	-	H	R
2.0	Material Inspection						
2.1	Raw Material Inspection	Chemical , Physical and other properties as per applicable material specification	100%	Test Certificates	H	H	-

INSPECTION AND TEST PLAN FOR GASKETS

STANDARD SPECIFICATION No.

6-81-0008 Rev3

Page 4 of 5

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
3.0	In Process Inspection						
3.1	Punching & Finishing	Finish & Dimension	100%	Inspection Report	-	H	-
3.2	Heat Treatment for RTJ Gaskets (As applicable)	Time & Temperature	100%	HT Chart		H	R
4.0	Final Inspection						
4.1	Final Visual , Dimension & Testing	Compressibility, Recovery, Seal ability ,Groove Hardness for Ring & Tongue Joint etc as applicable and Visual / Dimension	100%	Inspection Report	-	H	-
4.2	Final Stamping	Stamping Of Accepted Gaskets	100%	Inspection Report	-	H	-

INSPECTION AND TEST PLAN FOR GASKETS

STANDARD SPECIFICATION No.

6-81-0008 Rev3

Page 5 of 5

SL NO.	STAGE/ ACTIVITY	CHARACTERISTICS	QUANTUM OF CHECK	RECORD	SCOPE OF INSPECTION		
					SUB SUPPLIER	SUPPLIER	EIL/TPIA
4.3	PMI Check	Chemical Check	As per EIL Spec: 6-81-001	Inspection Report	-	H	R
5.0	Painting						
5.1	Rust Preventive & Color Coding as applicable	Visual & Color Coding as applicable	100%	Inspection Report	-	H	-
6.0	Documentation & IC						
6.1	Documentation & IC	Review of test reports, Inspection documents & Issue of IC	100%	Supplier Records / IC	-	H	H

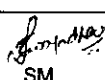
Legend: H- Hold (Do not proceed without approval), P-Perform, RW - Random Witness (As specified or 10% (min.1 no. of each size and type of Bulk item)), R-Review, W-Witness (Give due notice, work may proceed after scheduled date).

Notes (as applicable):

- This document describes the generic test requirements. Any additional test or Inspection scope if specified in contract documents shall also be applicable.(unless otherwise agreed upon)
- Acceptance Norms for all the activities shall be as per PO/PR/STANDARDS referred there in /Job Specification /Approved Documents.

निर्माण स्थलों पर सकारात्मक सामग्री पहचान के लिए मानक विनिर्देश

STANDARD SPECIFICATION FOR POSITIVE MATERIAL IDENTIFICATION AT CONSTRUCTION SITES

2	14/11/2011	Revised and updated	 SM	 SM	 MKG	 DM
1	02/01/2007	Revised and updated	AS	MPJ	VNP	VC
0	22/07/2002	Issued as Standard Specification	MPJ	MPJ	RSG	GRR
Rev. No	Date	Purpose	Prepared by	Checked by	Standards Committee Convenor	Standards Bureau Chairman
Approved by						

Abbreviations:

API	:	American Petroleum Institute
ASM	:	American Society for Metals
ASME	:	American Society of Mechanical Engineers
ASTM	:	American Society for Testing and Materials
BV	:	Bureau Veritas
CEIL	:	Certification Engineers International Limited
DNV	:	Det Norske Veritas
EIL	:	Engineers India Limited
ITP	:	Inspection Test Plan
PMI	:	Positive Material Identification
RTJ	:	Ring Type Jacket
TPI/TPIA	:	Third Party Inspection /Third Party Inspection Agency

Construction Standards Committee

Convenor : Sh. MK Garg, DGM (Construction)

Members : Sh. SK Kaul, DGM (C&P)
Sh. M.P. Jain, DGM (Projects)
Sh. Rakesh Nanda, DGM (Piping)
Sh. S Mukherjee, AGM (Construction)
Sh. B Chakraborty, AGM (Construction)

CONTENTS

1.0	SCOPE	4
2.0	DEFINITIONS	4
3.0	SPECIFIC APPLICABILITY	4
4.0	REFERENCES	5
5.0	GENERAL REQUIREMENTS	5
6.0	EXTENT OF PMI	6
7.0	PMI OF PIPING AND HEATER COIL COMPONENTS	6
8.0	TESTING METHODOLOGY	6
9.0	CHARACTERISTIC ELEMENTS	7
10.0	CALIBRATION	7
11.0	SITE VERIFICATION OF ANALYZER	8
12.0	PERSONNEL QUALIFICATION	8
13.0	ACCEPTANCE CRITERIA	8
14.0	REJECTION CRITERIA	8
15.0	DOCUMENTATION	9

ATTACHMENT (REPORTING FORMAT)

FORMAT FOR PMI TEST REPORT - 6-82-0002-F1 (1 SHEET)

1.0 SCOPE

- 1.1** This specification applies to metallic alloy materials as well as carbon steel materials as defined in this document used in piping, heater coils, storage tanks, vessels etc. at construction sites. Positive Material Identification (PMI) is to be carried out on Owner supplied material as well on materials purchased by the contractor.
- 1.2** Any deviation from this specification must be approved by Owner/EIL in the prescribed format.

2.0 DEFINITIONS

2.1 Positive Material Identification (PMI)

The term Positive Material Identification (PMI) refers primarily to determination/verification of alloy type or its composition using portable or mobile spectrometer/alloy analyzer. For the purpose of this specification, some carbon steel materials as defined in this document are also included for PMI checking to avoid mix up with Alloy steel during installation.

Chemical spot checking, resistivity testing, eddy current testing, electromagnetic alloy sorting, thermoelectric testing shall not be considered as PMI for the purpose of this specification.

3.0 SPECIFIC APPLICABILITY

- 3.1** The following items require PMI unless specifically exempted through a Concession/ Deviation permit by Owner/EIL.
- 3.1.1** All pressure containing piping components including, thermowells instrument manifolds, RTJ gaskets, fasteners etc..
- 3.1.2** Tubular products used in the fabrication of heaters.
- 3.1.3** Pressure - containing instrument housings (e.g. gauge glass housings, orifice meter tubes).
- 3.1.4** Internal metallic linings/cladding, and weld overlay, done at site, used for protection against corrosive environments.
- 3.1.5** Tubing
- 3.1.6** Stud, bolts and nuts
- 3.1.7** Plates
- 3.1.8** All pressure containing welds.
- 3.1.9** a) Carbon steel piping components of rating 900# and above
b) Carbon steel piping items under H₂ and NACE service.
- 3.1.10** any other components or materials specifically designated for PMI on the purchase order/contract.

3.2 Exclusions

The following items are exempted unless specifically designated for PMI in the purchase order/contract:

- 3.2.1 Gaskets (spiral wound or carbon steel only).
- 3.2.2 Internal instrument parts.
- 3.2.3 Internal machinery parts.
- 3.2.4 Internal non pressure - containing baffles, trays, tray clips, supports, pall-rings, support rings, etc.
- 3.2.5 Electrical components.
- 3.2.6 Internal valve components.
- 3.2.7 Compression-type ferrules and fittings for use with 3/4 inch (19mm) outside diameter and smaller tubing.
- 3.2.8 All carbon steel piping components (including carbon steel pipe supports) other than those specified at 3.1.9.
- 3.2.9 All carbon steel Studs/bolts/nuts.

4.0 REFERENCES

American Society of Mechanical Engineers (ASME) BPV Code Section-II Part A, B, C and D

ASME B 31.3

American Society for Testing and Materials (ASTM): As applicable

Material Verification Program for New and Existing Alloy Piping Systems: API RP 578

Any other material specification referenced by the Purchase Order/Contract.

IS 1239, IS 3589 and other relevant BIS codes.

5.0 GENERAL REQUIREMENTS

- 5.1 The test methods outlined in this specification are intended to identify the nominal composition of alloy/Carbon steel materials. These test methods are not intended to establish the conformance of a material to a particular specification.
- 5.2 PMI shall not be considered as a substitute for required mill test reports listing chemical composition. In addition, mill test reports shall not be considered as confirming alloy/composition verification.
- 5.3 The PMI activity shall be included in the overall quality plan and Inspection & Test Plan for fabrication/erection. The contractor shall submit to EIL/Owner, a procedure for PMI to comply with the requirements of this specification. Approval of PMI procedure shall be obtained from Owner/EIL prior to commencement of fabrication/erection as the case may be.
- 5.4 Contractor shall engage reputed TPIA (BV, Lloyds, CEIL, DNV) with prior approval to witness inspection at site prior to hydrotesting, and accordingly submit ITP for review of owner/EIL.
- 5.5 A copy of daily PMI records shall be submitted to Owner/EIL.

- 5.6 After installation, but prior to hydrostatic testing/painting/insulation, the contractor shall examine all components requiring PMI for proper compliance to this specification. A record of this final check duly endorsed by TPIA, as specified below, shall be submitted to EIL/Owner and made part of the permanent inspection records.

5.6.1 Owner Supplied Material

Records signed by contractor and duly certified by TPIA (engaged by contractor)/ and reviewed by EIL/ Owner at Contractor's warehouse as part of the receiving inspection at warehouse.

5.6.2 Contractor Supplied Material

Records signed by contractor and certified by an approved third party inspection agency.

- 5.7 After acceptance, all components shall be marked with a suitable paint mark. Markings must be permanent and readily visible. These markings are in addition to markings required by other codes/specifications/Technical Notes.

- 5.8 Controls shall be established to keep the non conforming items identified till proper resolution of non conformity.

- 5.9 EIL/Owner shall have the right to witness the performance of any PMI test.

6.0 EXTENT OF PMI

PMI shall be done on each component (100 percent PMI inspection) including welds, unless specifically exempted by Owner/EIL.

PMI shall be done on pipe supports (welded/bolted) such as pads, saddles, dummy pipes etc. (100 percent PMI inspection) in all piping systems of alloy material

PMI shall be done on all bolts and nuts (100 percent PMI inspection) of flange joints in all piping systems of alloy material.

7.0 PMI OF PIPING AND HEATER COIL COMPONENTS

PMI testing (irrespective of PMI done at earlier stages) shall be carried out when piping loops/heater coils have been cleared for hydrostatic testing by EIL/Owner. Hydrostatic Testing shall be carried out only when non conforming components have been replaced with conforming components and subsequent Non Destructive Testing, Post Weld Heat-Treatment, Hardness checking etc., as required by specifications have been completed. PMI records shall form a part of piping/heater inspection records. Contractor shall demonstrate to EIL that each & every component of the piping system and heater coils has been subjected to PMI by providing line wise records of PMI duly endorsed by TPIA .

8.0 TESTING METHODOLOGY

- 8.1 The method used for PMI examination shall provide a quantitative determination of the alloying elements like chromium, nickel, molybdenum or vanadium in alloy steel items for the characteristic elements specified in clause 9.0

- 8.2 Instruments or methods used for PMI examination shall be able to provide quantitative, recordable, elemental composition results for positive identification of elements.
- 8.3 The acceptable instruments for alloy analyzer shall be either "portable X-ray Fluorescence" or "optical Emission type each capable of verifying the percentage of elements within specified range .The instruments must have the printout facility and sensitivity to detect the elements in the specified range.
- 8.4 Chemical spot testing, magnets, alloy sorters and other methods using eddy current or triboelectric testing methods are not acceptable for PMI examination.
- 8.5 All PMI instruments shall have been serviced within a 6 month period of the time of use to verify the suitability of batteries, sources,etc, and the date of the last service shall be stated on the PMI report form.
- 8.6 The surfaces to be examined shall be prepared and cleaned by suitable means before PMI so that surface be free from grease, oil, paint or oxides. Testing shall be done after proper surface cleaning and other requirements as outlined by the manufacturer of the portable alloy analyzer. Modification, if any, of these procedures must be approved by Owner/EIL.
- 8.7 Alloy steel ring type joint gaskets shall be inspected by using portable X-ray fluorescence instrument.

9.0 CHARACTERISTIC ELEMENTS

Material Specification		Characteristic Elements
ASTM A 335	Gr P11	Cr, Mo
	Gr P5	
	Gr P22	
	Gr P9	
ASTM A 312	Type 304	Cr, Ni
	Type 316	Cr, Ni, Mo
	Type 321	Cr, Ni, Ti
	Type 347	Cr, Ni, Columbium, Tantalum

- 9.1 Carbon Steel materials shall be checked for Cr, Ni, Mo, Cu and Va as per clause no: 13 .3.
- 9.2 Characteristic elements for materials not listed above shall be proposed by the contractor for approval of the Owner/EIL

10.0 CALIBRATION

- 10.1 Instruments used for PMI shall have the sensitivity to detect the alloying elements in the specified ranges. Instruments or methods used for examination shall be of the type that will provide quantitative, recordable, elemental composition results for positive identification of the alloy elements present.
- 10.2 Each alloy analyzer shall be calibrated using known alloy standards for intended materials to be checked by PMI. A calibration certification from the Manufacturer or his authorized agency shall be submitted to EIL/Owner for records.

- 10.3** EIL/Owner shall review the procedure and qualification and witness sample alloy/carbon steel materials verification tests to confirm that the procedures, equipment and personnel are capable of providing consistent and accurate results. Certified samples, with full traceability, of a known alloy materials/carbon steel materials shall be available for use as a random spot checking on instrument calibration.

11.0 SITE VERIFICATION OF ANALYZER

Verification using Standard samples supplied by institutes such as ASM (American Society of Metals) for the intended materials type and grade shall be performed each day before using the analyzer. Such verification shall be done again if PMI test is to be performed on different grade or type of material.

12.0 PERSONNEL QUALIFICATION

The persons performing the PMI test should be knowledgeable about properties of material, all aspects of operation of PMI equipment including the method of testing. Qualification/experience documents of the person performing the PMI test including his training and experience shall be submitted to EIL/Owner for review and approval.

13.0 ACCEPTANCE CRITERIA

13.1 Base Metal

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

13.2 Deposited Weld Metal

For deposited weld metal between base metals of the same specification using matching consumables, the recorded presence of characteristic elements upto 12.5% less than the minimum specified value in the welding consumables specification and upto 12.5% more than the maximum specified value in the welding consumable specification shall be acceptable.

13.3 Carbon Steel Material

The cumulative percentage of chemical composition of Cr, Ni, Mo, Cu and Va shall maximum be 1% for acceptance of material.

14.0 REJECTION CRITERIA

- 14.1** If the PMI test results fall outside the acceptable range as given in 13.0 above, the contractor shall obtain a quantitative check analysis performed by a laboratory acceptable to EIL/Owner for a complete chemical analysis. Results of this analysis shall be submitted to EIL/Owner, with contractor's recommendation, for final decision.

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

- 14.2** If any material component or weld is found unacceptable, all other represented materials (e.g. in case of fasteners, supports) or welds shall be considered suspect. In such cases, the contractor has the following options:

- 14.2.1** Scrapping all those represented materials or components and replacing with new components or welds.

14.2.2 Performing 100% examination of the remainder of the represented materials/ components and replacing each item that fails the PMI check.

14.2.3 If the performance of any verification activity is unacceptable to EIL/Owner or if any material has been incorrectly identified, all further tests shall be subject to EIL/Owner approval until the problem is corrected.

15.0 DOCUMENTATION

15.1 Print out from alloy analyzer, in original, duly certified by the contractor/ PMI agency.

15.2 PMI report as per format No. 6-82-0002-F1

15.3 Basis and action for resolving and documenting PMI non conformances.

15.4 Contractor shall demonstrate to EIL/Owner that all components requiring PMI have been subjected to PMI testing and accepted.

REPORT NO: _____

Contractor _____

Date of PMI _____

Project _____

Inspection Agency _____

Location _____

PMI Agency _____

Job No. _____

PMI Equipment Model _____

Line No. /ISO Drg. No. _____
/Heater No./Drawing No

Make & Serial No. _____

Sr. No.	Part Identification	Material As per Drg./spec	Material as per PMI	Result (Accepted/Rejected/ Retest)

(PMI AGENCY)

(CONTRACTOR)

(TPI AGENCY)

(EIL/OWNER *)

*When material is supplied by Owner

3	29.06.09	REAFFIRMED & ISSUED AS STANDARD	<i>h</i> PK	<i>ph</i> RN	<i>h</i> SC	<i>h</i> ND
2	15.07.04	REVISED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman

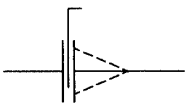
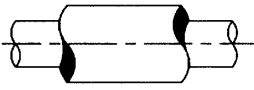
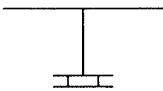
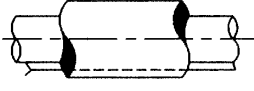
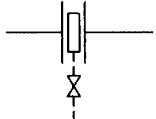
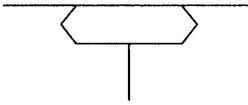
DESCRIPTION	FLANGED	SCREWED	WELDED (NOTE)	SOCKET WELD
GATE VALVE (PLAN)				
GATE VALVE (ELEVATION)				
GLOBE VALVE (PLAN)				
GLOBE VALVE (ELEVATION)				
ANGLE VALVE (PLAN)				
ANGLE VALVE (ELEVATION)				
CHECK VALVE (PLAN OR ELEVATION)				
ANGLE STOP CHECK VALVE (PLAN)				
ANGLE STOP CHECK VALVE (ELEVATION)				
PLUG VALVE (PLAN)				
PLUG VALVE (ELEVATION)				
BALL VALVE (PLAN)				
BALL VALVE (ELEVATION)				
NEEDLE VALVE (PLAN OR ELEVATION)				
RELIEF VALVE (PLAN)				
RELIEF VALVE (ELEVATION)				
CONTROL VALVE GLOBE TYPE (PLAN)				
CONTROL VALVE GLOBE TYPE (ELEV)				
CONTROL VALVE BUTTERFLY TYPE (PLAN)				
CONTROL VALVE BUTTERFLY TYPE (ELEV)				
SOLENOID OPERATED VALVE (PLAN OR ELEV)				
BUTTERFLY VALVE (PLAN OR ELEVATION)				

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DESCRIPTION	FLANGED	SCREWED	WELDED (NOTE-1)	SOCKET WELD
DIAPHRAGM VALVE (PLAN OR ELEVATION)				
3-WAY PLUG VALVE (PLAN OR ELEVATION)				
4-WAY PLUG VALVE (PLAN OR ELEVATION)				
EXPANSION JOINT				
ANGLE CONTROL VALVE				
CHAIN OPERATING VALVE (TYP)				
GEAR OPERATED VALVE (BEVEL GEAR) PLAN	 1-4 INDICATES BEVEL PINION LOCATION			
GEAR OPERATED VALVE (SPUR GEAR) PLAN	 1-4 INDICATES PINION LOCATION			
MOTOR OPERATING VALVE				
STEAM TRAP				
Y-STRAINER				

DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL
SLIP-ON FLANGE		STUB - IN (WITH OR WITHOUT REINF)	
WELDNECK FLANGE			
SCREWED FLANGE		STUB - IN (SADDLE REINF)	
SOCKET WELD FLANGE			
SPACER		STUB - IN WITH REINF (IN PLAN)	 R.P.
SPACER BLIND			
SPECTACLE FIG. 8 (BLIND)		INSULATED (LINES 12" AND BELOW)	
SPECTACLE FIG. 8 (OPEN)			

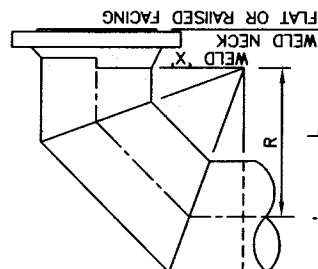
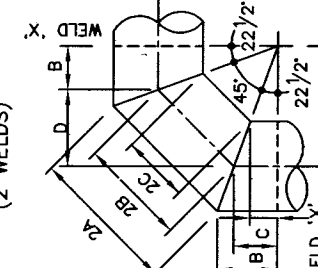
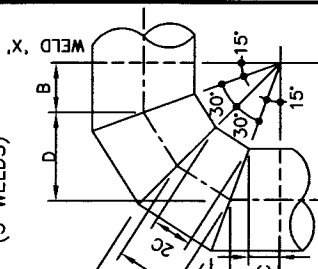
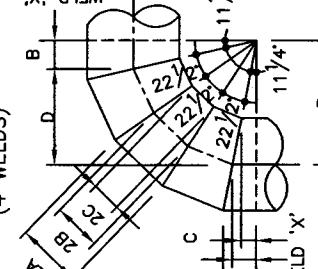
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DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL
CONICAL STRAINER		INSULATED (LINES 14" & ABOVE)	
T-TYPE STRAINER	 T-STRAINER	STEAM TRACED	
DRIP-RING		WELDOLET	

NOTES :

1. WELD DOTS NOT TO BE SHOWN ON PIPING G.A.Ds.
2. FOR SYMBOLS/LEGENDS RELATED TO CIVIL ENGINEERING/UNDERGROUND PIPING WORK, REFER CIVIL ENGINEERING STANDARD 7-65-0001.

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FLANGED MITERED 90° ELBOW (TYPE - I SHOWN)				TYPE - I 3PIECE 90° MITERED ELBOW (2 WELDS)				TYPE - II 4PIECE 90° MITERED ELBOW (3 WELDS)				TYPE - III 5PIECE 90° MITERED ELBOW (4 WELDS)				PIPE SIZE			
																			
DIMENSION 'L' IDENTICAL FOR TYPE I, II, III ELBOWS				R															
PIPE SIZE	FLAT/RAISED FACE/GROOVE /FEMALE		RING JOINT		TONGUE / MALE		IDENTICAL FOR ALL TYPES												
	150#	300#	150#	300#	150#	300#													
6"	318	328	324	335	324	334	229												
8"	407	416	413	424	413	423	305												
10"	483	498	489	506	489	504	381												
12"	571	587	578	595	578	593	457												
14"	660	676	666	684	666	682	533												
16"	737	756	743	764	743	762	610												
18"	826	845	832	853	832	851	686												
20"	907	924	913	934	913	930	762												
22"	987	1003	—	1017	—	—	838												
24"	1066	1082	1073	1093	1073	1088	914												
26"	1080	1136	—	1148	—	—	991												
28"	1162	1216	—	1229	—	—	1067												
30"	1243	1301	—	1314	—	—	1143												
32"	1327	1387	—	1401	—	—	1219												
34"	1405	1468	—	1482	—	—	1295												
36"	1489	1553	—	1567	—	—	1372												

NOTES:-

- MITERED ELBOWS WITH LESS THAN 90° DEFLECTION MAY BE ADOPTED FROM THE DETAILS SHOWN. A TWO PIECE (ONE WELD) 45° MITERED ELBOW SHOULD BE SIMILAR TO TYPE - I, A THREE PIECE (TWO WELDS) 45° MITERED ELBOW WOULD BE SIMILAR TO TYPE - II IN ANY CASE. THE TABULATED DIMENSIONS FOR 'A', 'B', 'C', 'D', & 'R' SHOULD BE MAINTAINED.
- ALL DIMENSIONS ARE IN mm CALCULATED AND ROUNDED OFF TO THE NEAREST 1 mm
- DIMENSION 'L' COMBINES ELBOW DIMENSION 'R' WITH LENGTH OF WELDNCK FLANGES ESTABLISHED BY ASME B16.5 EXCEPT SIZE 22" WHERE LENGTH OF WELD NECK FLANGE IS IN ACCORDANCE WITH MSS-SP-44. FOR SIZES 26" & ABOVE LENGTH OF WELD NECK FLANGES IS AS ESTABLISHED BY ASME B16.47B
- WELD 'X' SHALL BE OMITTED EXCEPT WHEN FITTING OR FLANGE ARE USED WITH THE MITERED ELBOW OR IF THE JOINT MUST BE FIELD WELDED.
- WHEN WELD 'X' IS A FIELD WELDED JOINT, THE END OF THE MITERED ELBOW SHALL BE BEVELED BY SHOP.

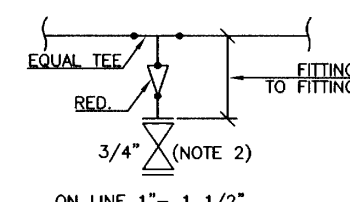
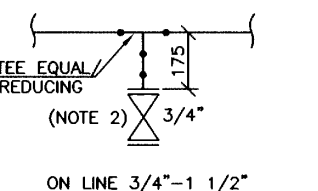
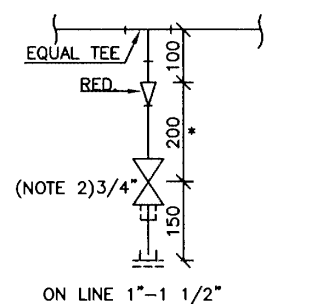
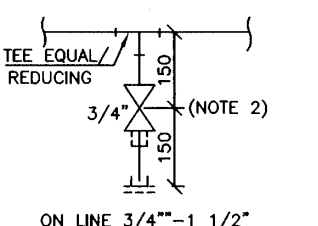
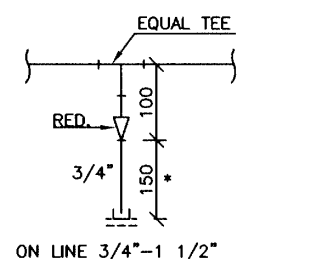
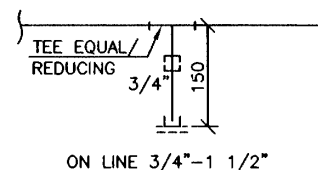
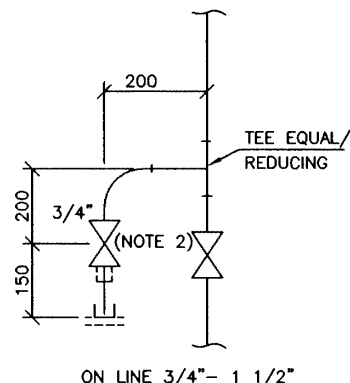
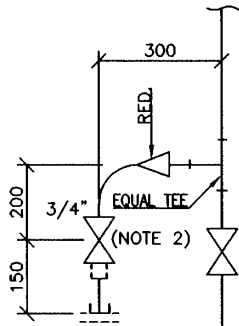
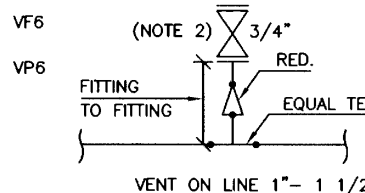
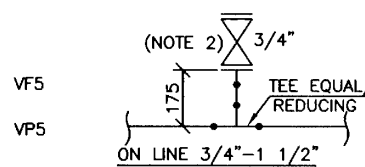
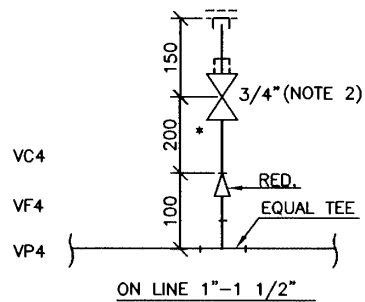
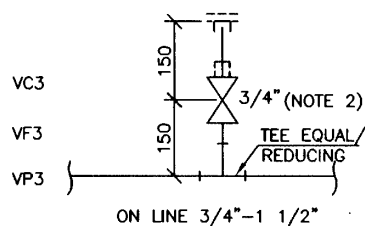
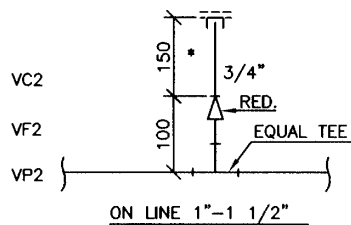
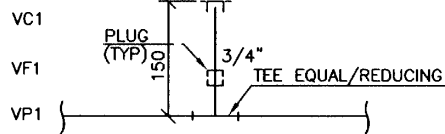
4	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
3	24.03.06	REAFFIRMED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convener	Stds. Bureau Chairman	Approved by

FOR FIGURES
REF.EIL STANDARD NO.7-44-0033(SHT.1 OF 2)

PIPE SIZE	'L' FOR FF OR RF		'R' IDENTICAL FOR ALL TYPES	TYPE-I				TYPE-II				TYPE-III				PIPE SIZE
	150#	300#		A	B	C	D	A	B	C	D	A	B	C	D	
38"	1572	1640	1448	800	600	400	848	517	388	259	1060	384	288	192	1160	38"
40"	1653	1722	1524	842	631	421	893	544	408	273	1116	404	303	202	1221	40"
42"	1733	1805	1600	884	663	442	937	572	429	286	1171	424	318	213	1282	42"
44"	1813	1890	1676	926	694	463	982	599	449	299	1227	445	333	222	1343	44"
46"	1898	1975	1753	968	726	484	1027	626	470	313	1283	465	349	233	1404	46"
48"	1978	2053	1829	1010	758	505	1071	653	490	327	1339	485	363	243	1465	48"
50"	2059	2140	1905	1052	789	526	1116	681	510	340	1395	505	379	253	1526	50"
52"	2138	2224	1981	1094	821	547	1160	708	531	354	1450	525	394	263	1587	52"
54"	2219	2297	2057	1136	852	568	1205	735	551	367	1506	546	409	273	1648	54"
56"	2301	2402	2134	1178	884	589	1250	762	572	381	1562	566	424	283	1710	56"
58"	2385	2485	2210	1220	915	610	1295	790	592	395	1618	586	440	293	1770	58"
60"	2465	2558	2286	1263	947	631	1339	817	613	408	1673	606	455	303	1831	60"

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TYPE



TYPE

DC1
DF1
DP1

DC2
DF2
DP2

DC3
DF3
DP3

DC4
DF4
DP4

DC5
DF5

DC6
DF6

NOTES :

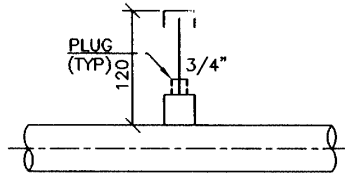
- DIMENSIONS INDICATED ARE VALID FOR 50mm(MAX) INSULATION. FOR HIGHER INSULATION THICKNESS, INCREASE DIMENSIONS AS REQUIRED. DIMENSIONS MARKED '*' ARE MAXIMUM AND MAY BE REDUCED TO SUIT.
- VALVES TO BE PROVIDED SHALL BE SIMILAR TO LINE ISOLATION VALVE (GATE, BALL OR PLUG VALVE ETC., WITH FLGD, S.W. OR SCR'D ENDS) UNLESS OTHERWISE SPECIFIED IN PMS, BRANCH-OFFS LIKE TEES(EQUAL OR REDUCING)/HALF COUPLINGS S.W. OR SCR'D)/SOCKLETS/WELDOLETS AND END CONNECTIONS LIKE CAP/PLUG/FLANGE & BLIND FLANGE SHALL BE AS PER PIPING MATERIAL SPECIFICATION.
- LEGEND : V = VENT; D = DRAIN; C = CAP; F = FLANGE; RED. = REDUCER, COUPLING OR SWAGE; P = PLUG.
- PLUGGED END OF VALVE OR FITTING SHALL BE THREADED.

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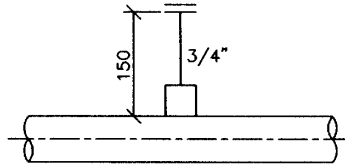
TYPE

VENT

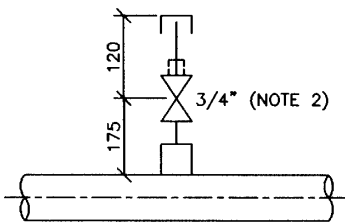
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VP1



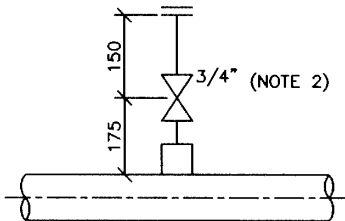
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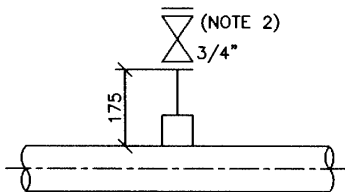
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V4



V5



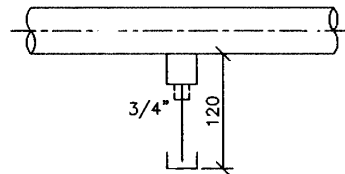
NOTES :

- DIMENSIONS INDICATED ARE VALID FOR 75mm (MAX) INSULN. THICKNESS. FOR HIGHER INSULATION THICKNESS INCREASE DIMENSION AS REQUIRED
- VALVES TO BE PROVIDED SHALL BE SIMILAR TO LINE ISOLATION VALVE (GATE, BALL OR PLUG VALVE ETC., WITH FLGD, SW OR SCR'D ENDS) UNLESS OTHERWISE SPECIFIED IN PMS. BRANCH-OFFS LIKE HALF CPLG(SW OR SCR'D)/SOCKOLET/WELDOLET & END CONNECTIONS LIKE CAP/PLUG/FLANGE & BLIND FLANGE SHALL BE AS PER PIPING MATERIAL SPECIFICATIONS.
- VENTS/DRAINS CAN BE PROVIDED ON FLAT SIDE OF ECCENTRIC REDUCER ON SIZES 4" & ABOVE
- LEGEND V=VENT, D=DRAIN, C=CAP, F=FLANGE, P=PLUG
- PLUGGED END OF VALVE OR FITTING SHALL BE THREADED

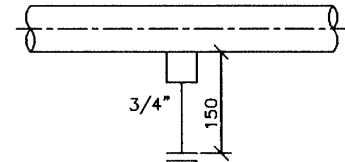
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TYPE

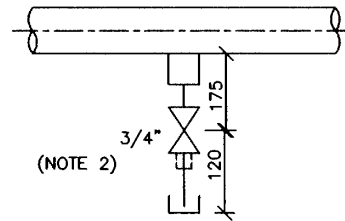
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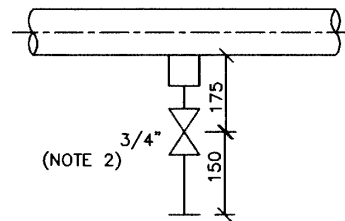
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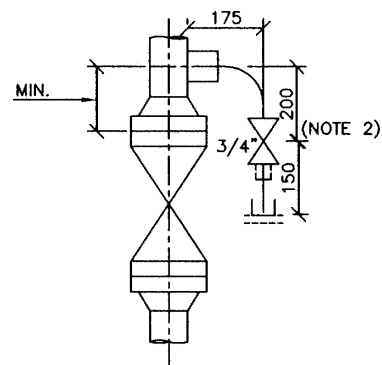
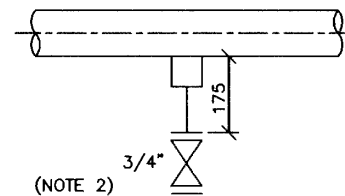
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DP3



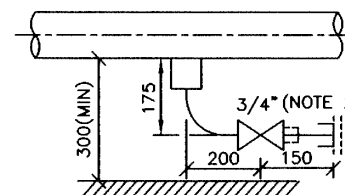
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D5



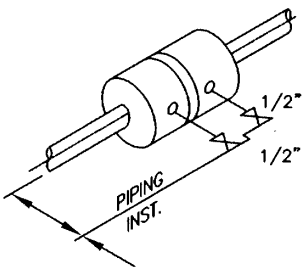
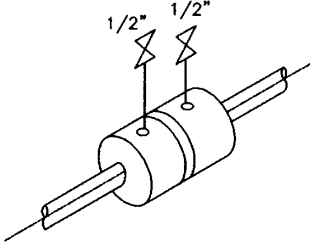
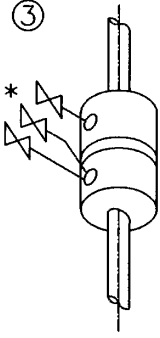
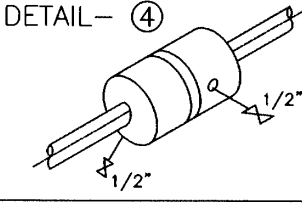
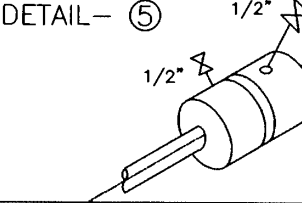
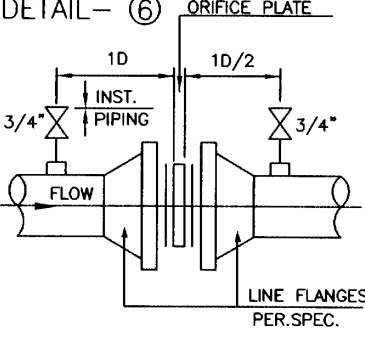
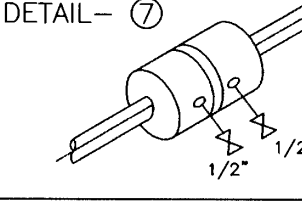
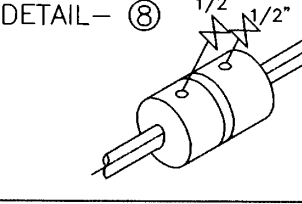
DC9
DF9
DP9



DC10
DF10
DP10

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FOR LIQUID OR STEAM LINES	FOR GAS LINES	FOR VERTICAL LINES
DETAIL- ① 	DETAIL- ② 	DETAIL- ③  * FOR STEAM & CONDENSIBLES, LOWER BLOCK VALVE SHALL BE RAISED TO THE LEVEL OF THE UPPER BLOCK VALVE
FOR LIQUID LINES ON PIPE RACK	FOR STEAM & GAS LINES ON PIPE RACK	FOR TAPS ON PIPE RACK
DETAIL- ④ NOTE-6 	DETAIL- ⑤ NOTES-6 	DETAIL- ⑥ ORIFICE PLATE  ORIENTATION OF TAPS SHALL BE LIQUID: 45° FROM VERTICAL DOWNWARDS STEAM & GAS: 45° FROM VERTICAL UPWARDS
DETAIL- ⑦ 	DETAIL- ⑧ 	

INSTRUMENT SCOPE

- ORIFICE FLANGES ASSEMBLY WITH BOLTS/NUTS AND GASKETS
- IMPULSE LINE STARTING AFTER THE TAPPING VALVE

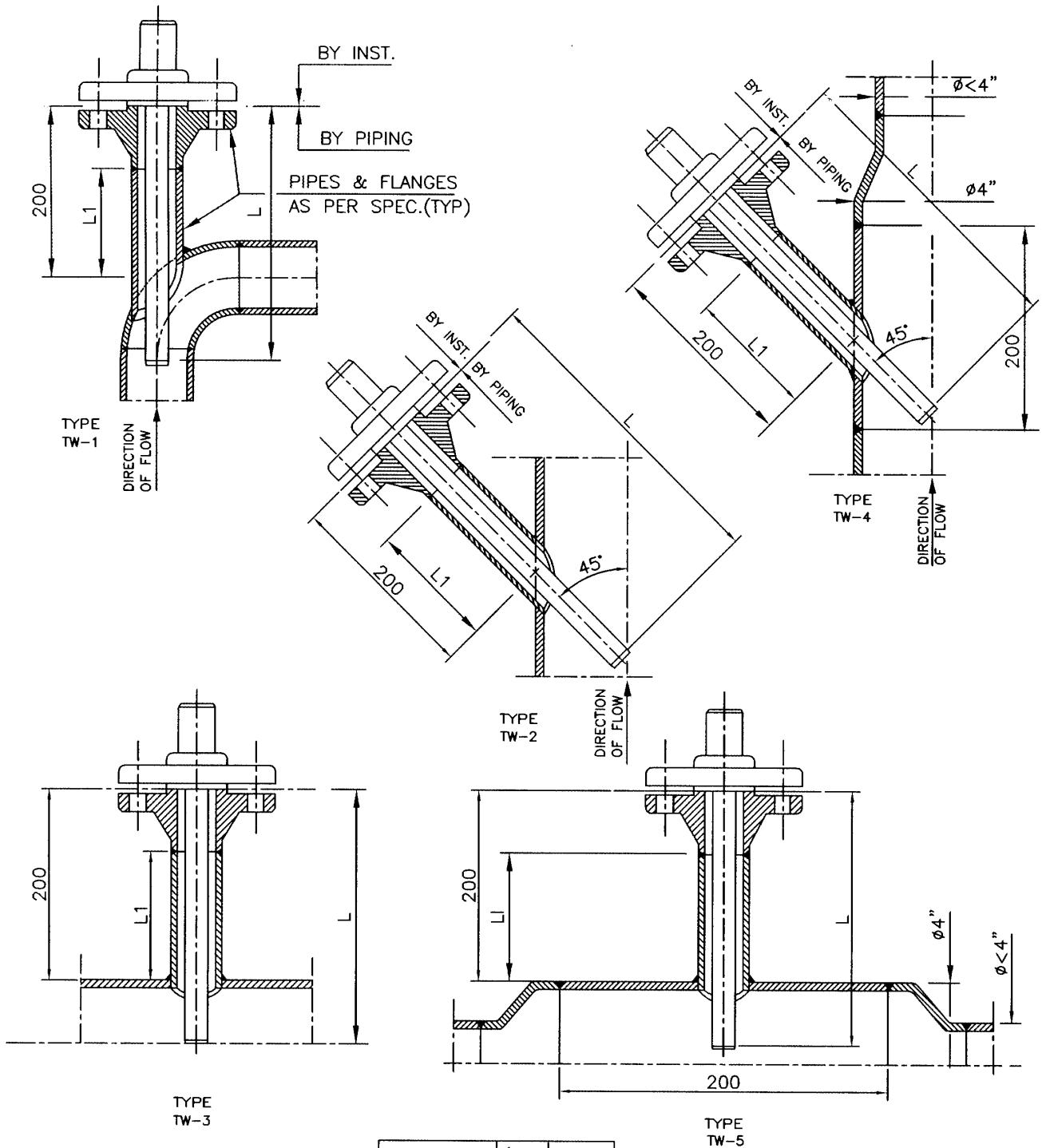
PIPING SCOPE

- TAPPING NIPPLE, COUPLINGS AND VALVES

NOTES :

- ORIFICE FLANGES IN HORIZONTAL LINES SHALL BE PREFERRED.
- TAPS SHALL BE ORIENTED TO SUIT LOCATION OF INSTRUMENT.
- SIZE OF TAPS ON ORIFICE FLANGES SHALL BE 1/2" WHILE SIZE OF TAPS ON PIPE LINES (DETAIL-6) SHALL BE 3/4".
- IN CASE OF VERTICAL LINES FLOW SHALL BE UPWARDS FOR LIQUIDS CONTAINING VAPOUR & DOWNWARDS FOR WET GASES & STEAM.
- TAPS ON PIPE LINES INSTEAD OF ORIFICE FLANGES SHALL BE GENERALLY USED FOR 16" & ABOVE (DETAIL-6) UNLESS OTHERWISE SPECIFIED. IN WHICH CASE FLANGES SHALL BE SAME AS LINE FLANGES.
- THE ORIENTATION OF TAPPING IN CASE OF DETAILS 4 & 5 SHALL BE AS FOLLOWS:
FOR LIQUID LINE : 4,8 & 16 BOLT FLANGE - AT 45° TO VERTICAL POINTING DOWNWARDS
12 BOLT FLANGE - AT 60° TO VERTICAL POINTING DOWNWARDS
20 BOLT FLANGE - AT 54° TO VERTICAL POINTING DOWNWARDS.
FOR STEAM LINE: 4,8 & 16 BOLT FLANGE - AT 45° TO VERTICAL POINTING UPWARDS,
12 BOLT FLANGE - AT 60° TO VERTICAL POINTING UPWARDS
20 BOLT FLANGE - AT 54° TO VERTICAL POINTING UPWARDS.
FOR GAS LINE : 4,8 & 16 BOLT FLANGE - AT 45° TO VERTICAL POINTING UPWARDS,
12 BOLT FLANGE - AT 60° TO VERTICAL POINTING UPWARDS
20 BOLT FLANGE - AT 54° TO VERTICAL POINTING UPWARDS.
- FOR CLEARANCE REQUIREMENT AROUND ORIFICE FLANGE REF.EIL STD: 7-44-0504

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NOTES:-

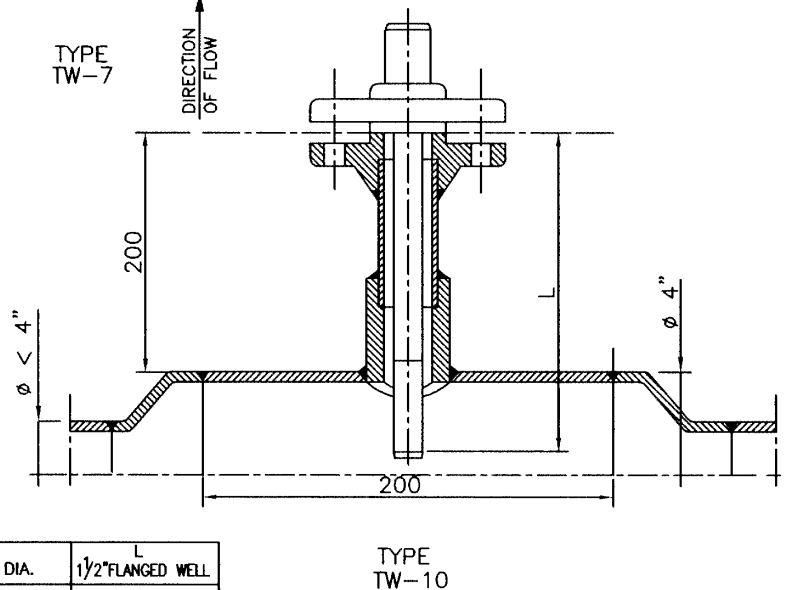
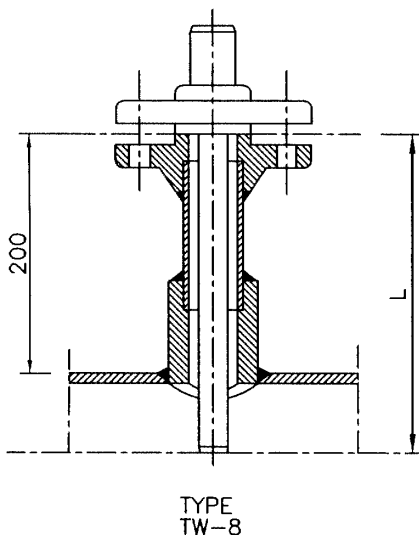
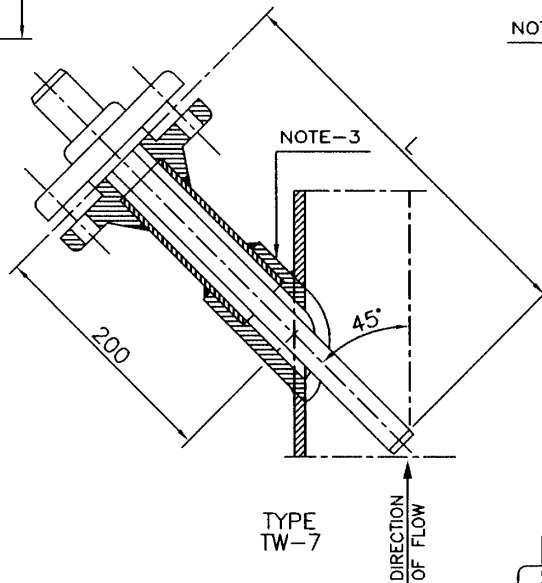
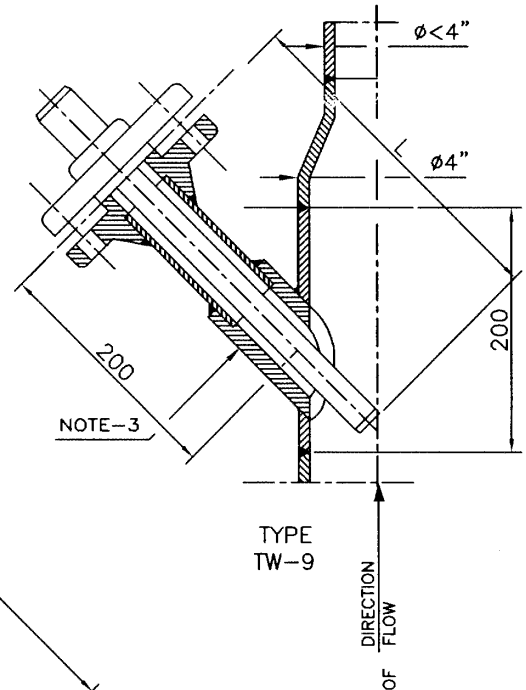
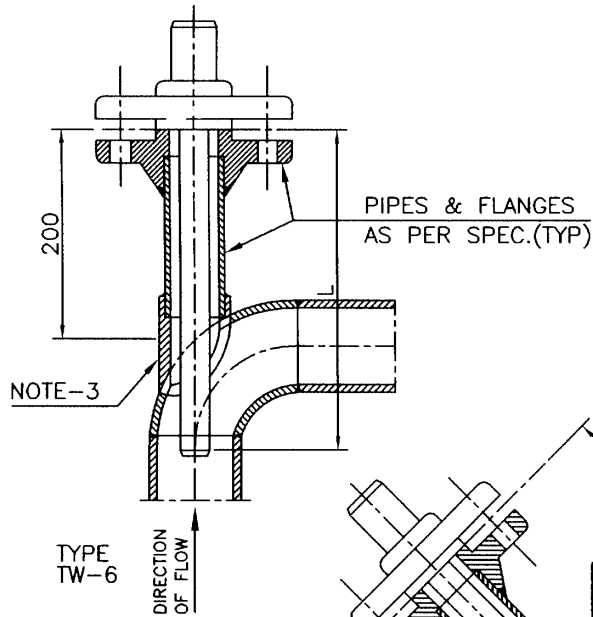
- 1 BOLTS, NUTS AND GASKETS BY PIPING.
- 2 MIN. CLEARANCE FOR REMOVAL L+350.
- 3 L1 - DIMENSIONS ARE CALCULATED FOR WN, R.F. FLANGE ONLY.
- 4 IN CASE ANY DEVIATION IS REQUIRED FOR INSTALLING T.W. TAPS FROM THIS STANDARD INST. DEPTT. TO BE CONSULTED.

LINE DIA.	L 1½" FLANGED WELL
4"	280
6"	300
8"	300
10"	350
12"	350
14"	350
16"	400
18"	400
20" AND LARGER	500
VESSELS	AS REQUIRED

LINE Ø	L1				
	150 #	300 #	600 #	900 #	1500 #
4"	138	132	124	111	111

- TYPE TW-1 : ELBOW MIN. 4" Ø OR LARGER
 TYPE TW-2 : VERTICAL LINE 4" Ø OR LARGER
 TYPE TW-3 : HORIZONTAL LINE 4" Ø OR LARGER
 TYPE TW-4 : VERTICAL LINE DIA. LESS THAN 4"
 TYPE TW-5 : HORIZONTAL LINE DIA. LESS THAN 4"

3	29.06.09	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	ND
2	15.07.04	REAFFIRMED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman



LINE DIA.	L 1½" FLANGED WELL
4"	280
6"	300
8"	300
10"	350
12"	350
14"	350
16"	400
18"	400
20" AND LARGER VESSELS	500 AS REQUIRED

NOTES:-

- 1 BOLTS, NUTS AND GASKETS BY PIPING.
- 2 MIN CLEARANCE FOR REMOVAL L+350
- 3 COUPLING TO BE SPECIAL LENGTH.

TYPE TW-6 : ELBOW MIN. 4" DIA. OR LARGER

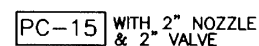
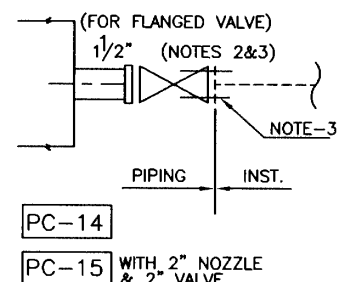
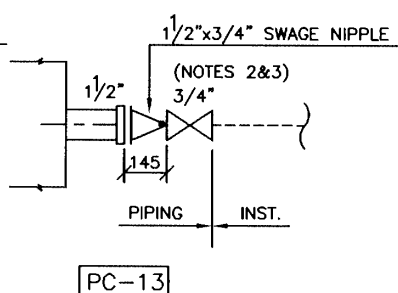
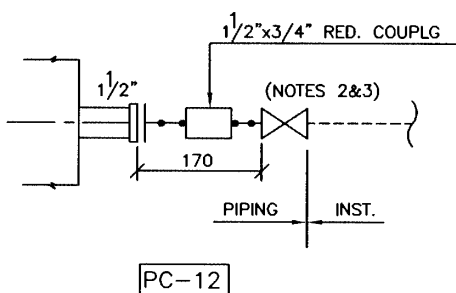
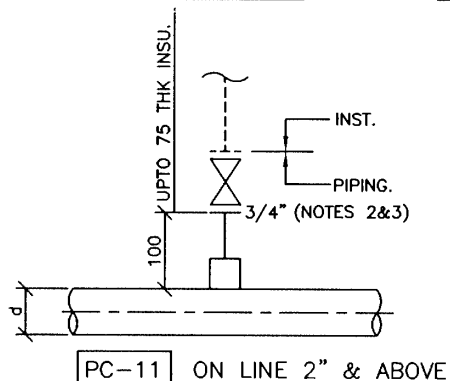
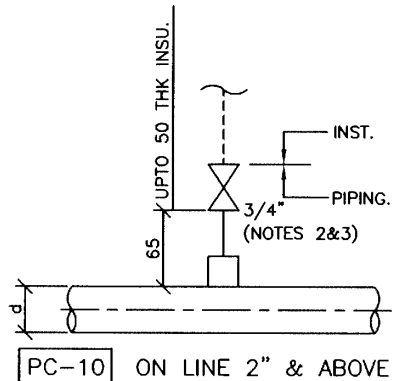
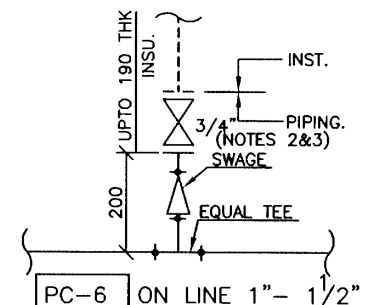
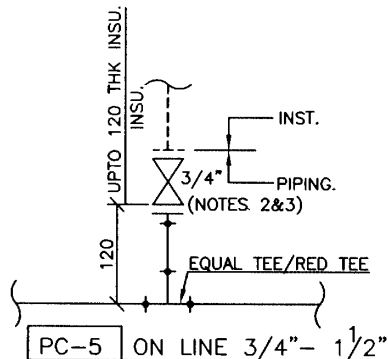
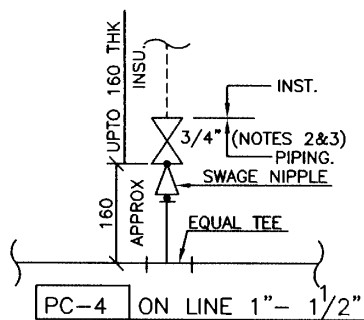
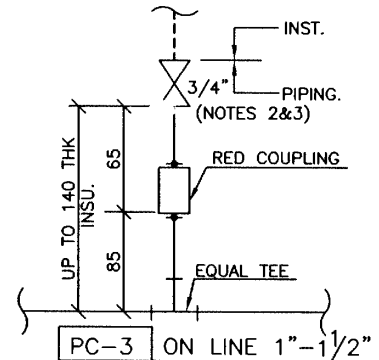
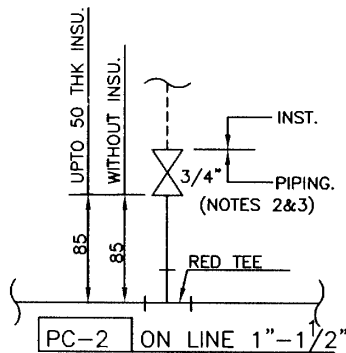
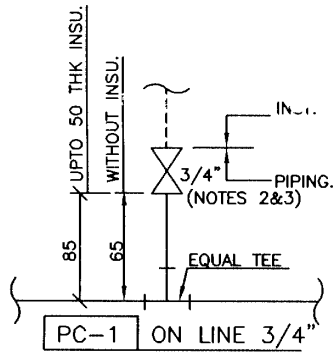
TYPE TW-7 : VERTICAL LINE 4" DIA. OR LARGER

TYPE TW-8 : HORIZONTAL LINE 4" DIA. OR LARGER

TYPE TW-9 : VERTICAL LINE DIA. LESS THAN 4"

TYPE TW-10: HORIZONTAL LINE DIA. LESS THAN 4"

3	29.06.09	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	ND
2	15.07.04	REAFFIRMED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman

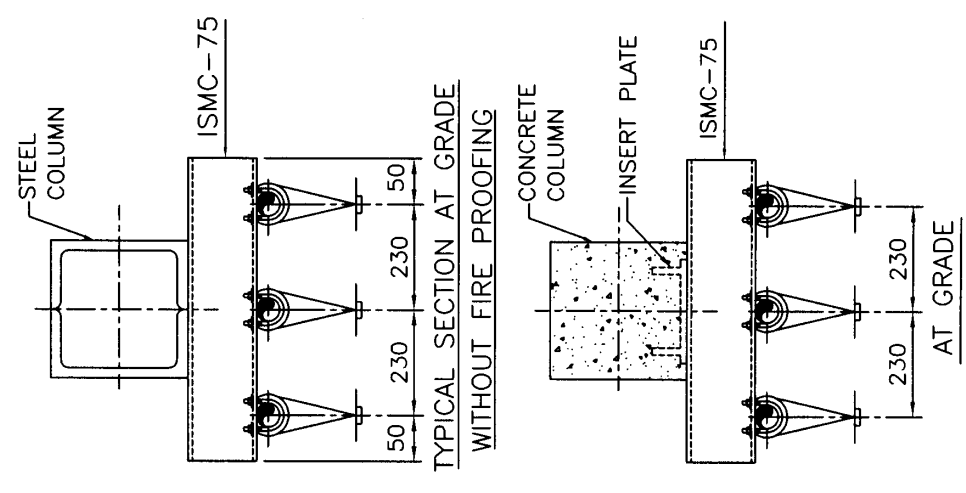
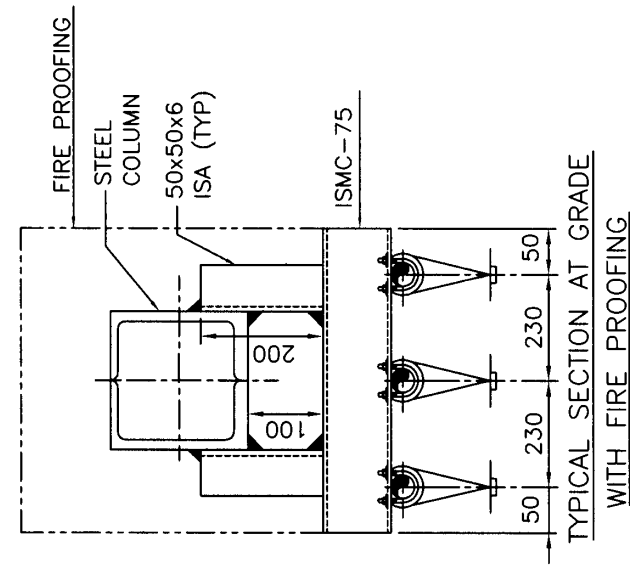
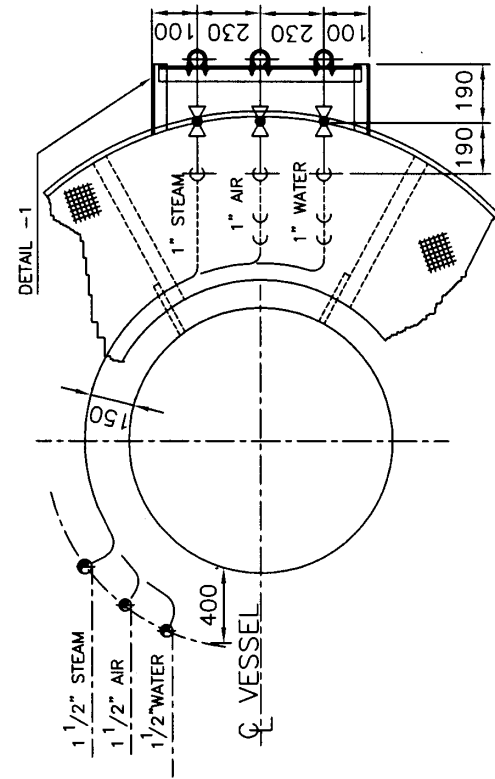
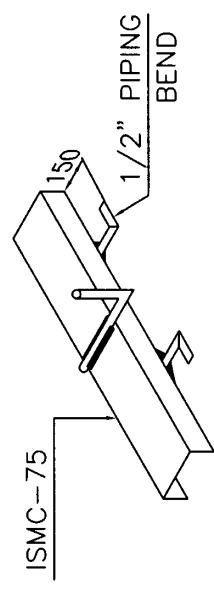
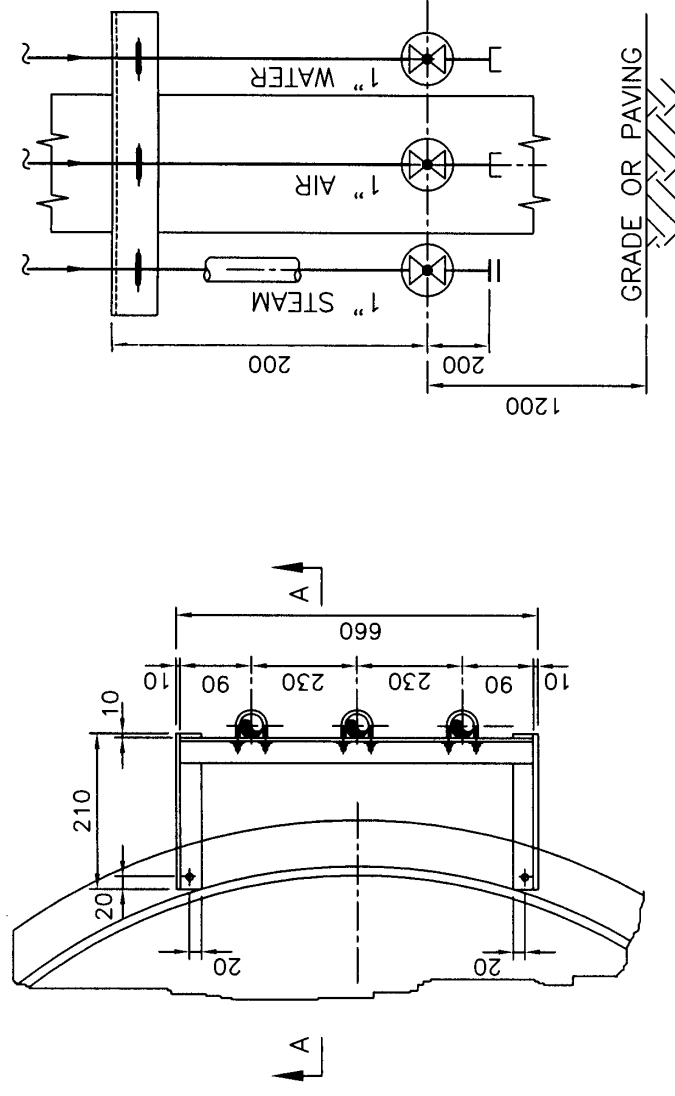


ON VESSELS / COLUMNS

NOTES :

1. THE INDICATED DIMENSIONS ARE MINIMUM WHICH ALSO COVER INSULATION TO THE EXTENT SHOWN ABOVE. IN CASE OF HIGHER THICKNESS OF INSULATION THAN INDICATED THE DIFFERENCE SHALL BE ADDED IN THE DIMENSIONS SHOWN ABOVE.
2. PRESSURE TAPPING SHALL BE PROVIDED WITH VALVE SIMILAR TO LINE ISOLATION VALVE (GATE, BALL OR PLUG VALVE ETC., WITH FLGD, S.W. OR SCR'D ENDS) UNLESS OTHERWISE SPECIFIED IN PMS, TEE(EQUAL OR REDUCING)/HALF COUPLING(S.W. OR SCR'D)/STUB IN/SOCKOLET/WELDOLET SHALL BE AS PER PIPING MATERIAL SPECS.
3. IN CASE OF FLGD VALVES BOLTING & GASKET ON BOTH SIDES OF VALVE SHALL BE IN PIPING SCOPE
4. IN CASE OF TAPPING PROVIDED OTHER THAN INDICATED IN THIS STD FOR LAYOUT REASONS DETAILED DIMENSIONS WILL BE CALLED OUT.

3	29.06.09	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	ND
2	15.07.04	REVISED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman

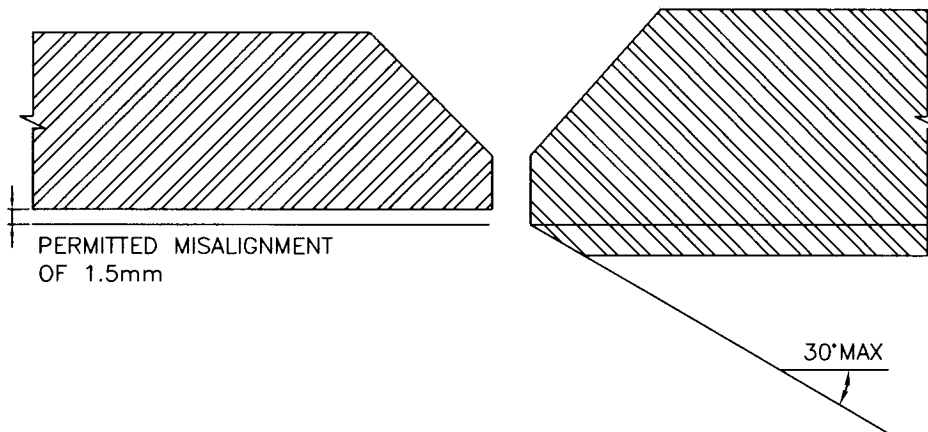


UTILITY HOSE STATION ON VESSEL PLATFORM

THE HOSE SUPPORT WHEN
REQD. SHALL BE MOUNTED
AS CLOSE AS POSSIBLE.
HOSE STATION ORIENTATION
AND POSITION SHALL BE
DECIDED CASE BY CASE.

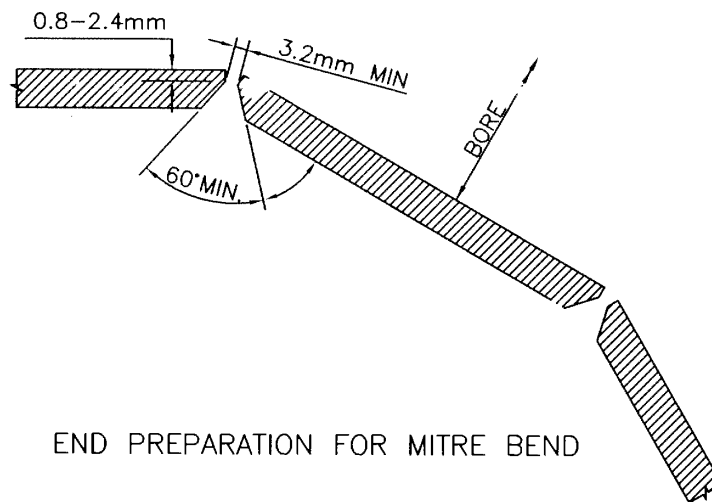
- NOTES:
1. HOSE STATIONS AT GRADE SHALL BE SO LOCATED THAT AREAS TO BE SERVED CAN BE REACHED WITH A 15M HOSE.
 2. SERVICE POINTS SHALL ALWAYS BE GROUPED STEAM, AIR & WATER IN THAT ORDER FROM LEFT TO RIGHT.
 3. THE SIZE OF LINES SHALL BE AS GIVEN IN THIS STD. UNLESS OTHERWISE SPECIFIED ON P&ID.
 4. STEAM CONNECTION SHALL ALWAYS BE PROVIDED WITH HEADER TAKE OFF VALVE. AIR AND WATER CONNECTION SHALL BE PROVIDED WITH HEADER TAKE OFF VALVES ONLY FOR HOSE STATION ON VESSELS.

[illegible]

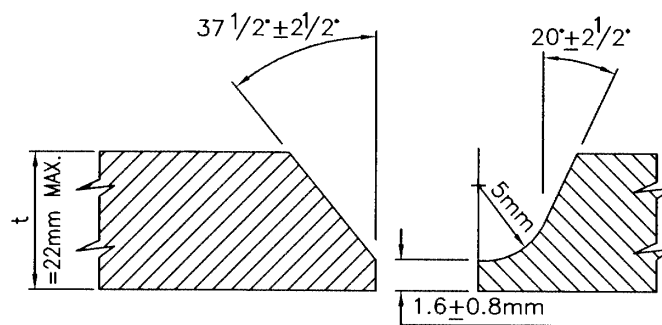


THICKER PIPE TAPER BORED TO ALIGN
(AS PER ASME B31.3)

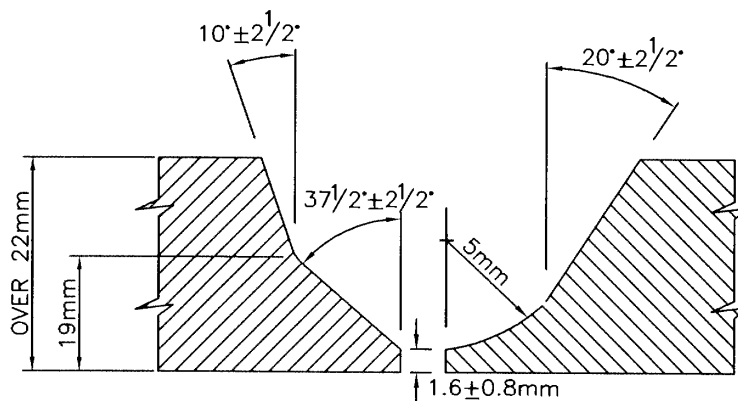
4	31.07.13	REAFFIRMED & ISSUED AS STANDARD	UK	SH	RN	ATD	DM
3	15.11.08	REAFFIRMED & ISSUED AS STANDARD	AC	RN	DM	VC	
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman	Approved by



END PREPARATION FOR MITRE BEND



(A) WALL THICKNESS 5-22mm INCLUSIVE
(AS PER ASME B31.3)

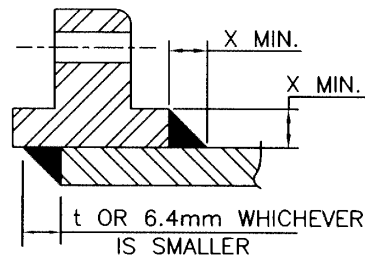


(B) WALL THICKNESS OVER 22mm
(AS PER ASME B31.3)

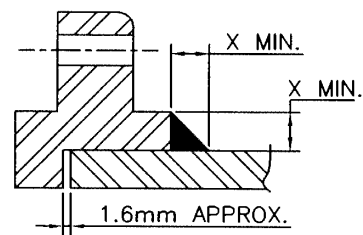
NOTES :

1. SQUARE ENDS MAY BE USED FOR WALL THICKNESS LESS THAN 5mm
2. PIPE ENDS SUPPLIED WITH BEVEL ANGLE OF $30^{\circ} \pm \frac{5^{\circ}}{0}$ NEED NOT BE BEVELED FURTHER.

3	29.06.09	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	ND
2	15.07.04	REAFFIRMED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
Approved by						



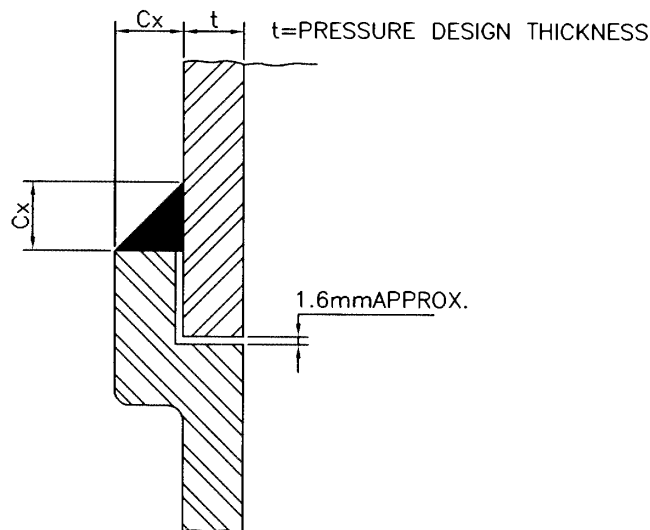
SLIP ON FLANGE



SOCKET WELDED FLANGE

$X \text{ MIN.} = 1.4t \text{ OR THE THICKNESS OF HUB, WHICHEVER IS SMALLER.}$

t = PRESSURE DESIGN THICKNESS.(NOT CONSIDERING CORROSION ALLOWANCE AND MANUFACTURING TOLERANCE.)

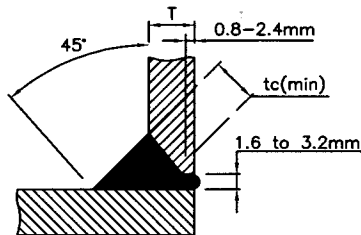
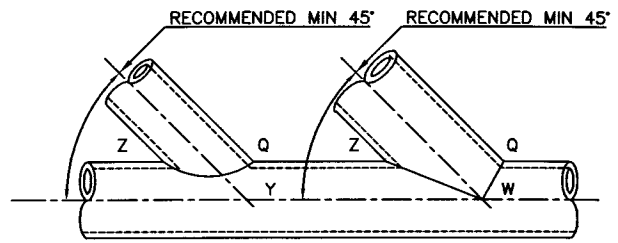
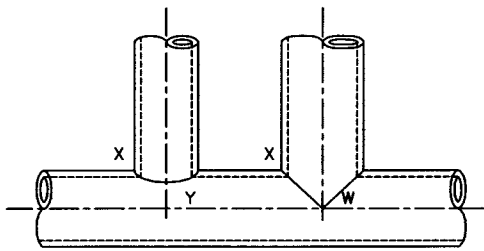


SOCKET WELDING FITTINGS

$Cx \text{ (MIN)} = 1.25t \text{ BUT NOT LESS THAN } 3.2\text{mm}$

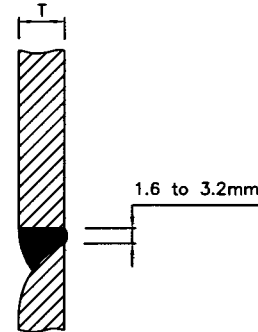
FILLET WELD DETAILS
(AS PER ASME B31.3)

3	29.06.09	REAFFIRMED & ISSUED AS STANDARD	<i>Per PK</i>	<i>put</i> RN	<i>SC</i>	<i>ND</i>
2	15.07.04	REAFFIRMED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman
Approved by						

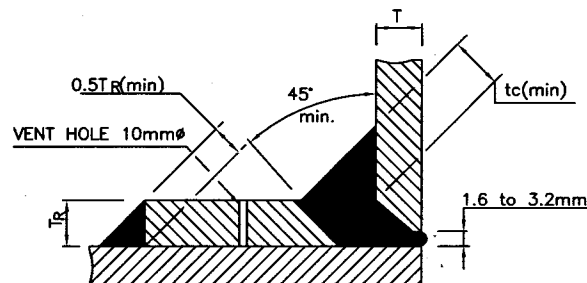


tc: MINIMUM OF 0.7T & 6.4mm

SECTION X AT CROTCH OF
RIGHT ANGLE BRANCH

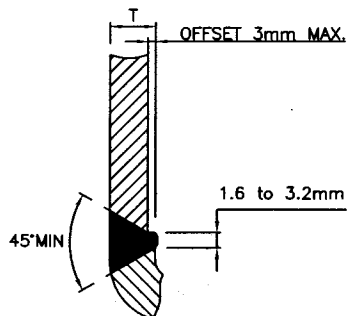


SECTION Y AT FLANK

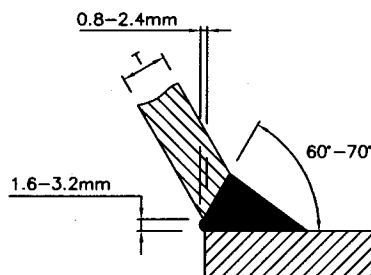


tc: MINIMUM OF 0.7T & 6.4mm

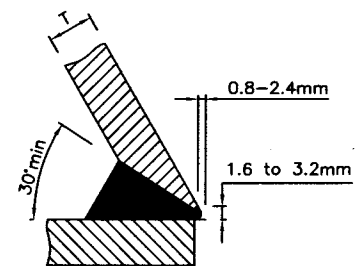
DETAIL FOR REINFORCED BRANCH



SECTION W AT FLANK OF
EQUAL BRANCH



SECTION Q AT BACK OF
SLOPING BRANCH

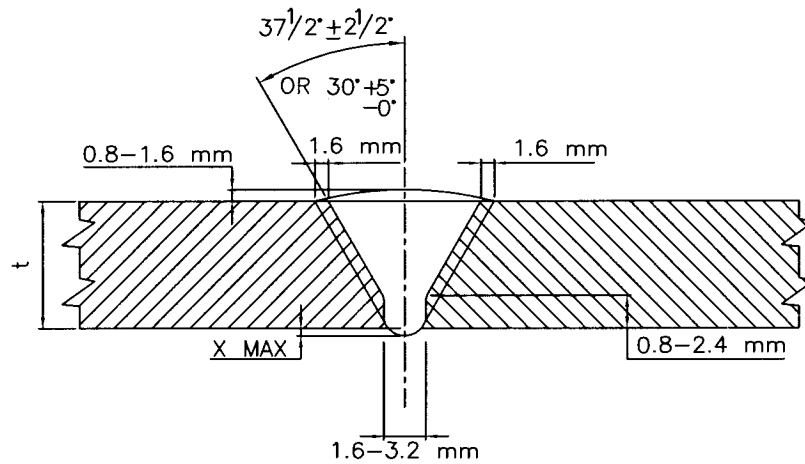


SECTION Z AT CROTCH OF
SLOPING BRANCH

NOTES :-

1. THIS TYPE IS TO BE USED WHEN BRANCH IS EQUAL TO OR ONE SIZE SMALLER THAN MAIN PIPE.
2. REFER STANDARD 7-44-0484 FOR DIMENSIONAL DETAILS.

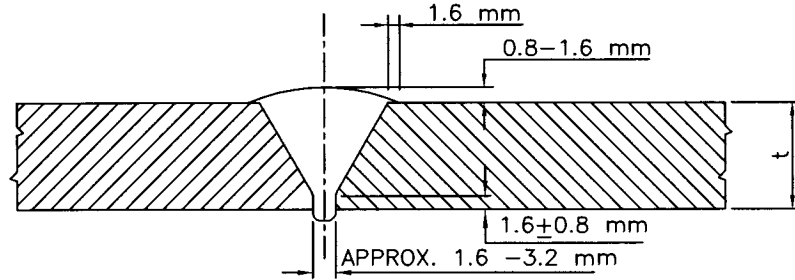
3	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
2	24.03.06	REVISED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman	Approved by



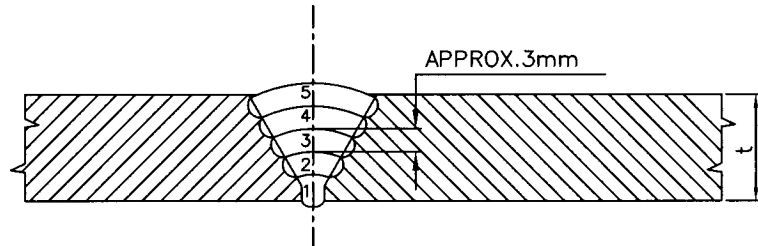
$$4.8 \text{ mm} \leq t \leq 19.1 \text{ mm}$$

X MAX = 1.5 mm FOR PIPES 2" AND BELOW
3.0 mm FOR PIPES ABOVE 2"

4	31.07.13	REAFFIRMED & ISSUED AS STANDARD	UK	SH	RN	ATD	DM
3	15.11.08	REAFFIRMED & ISSUED AS STANDARD	AC	RN	DM	VC	
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman	Approved by



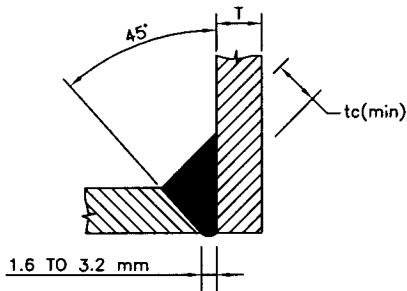
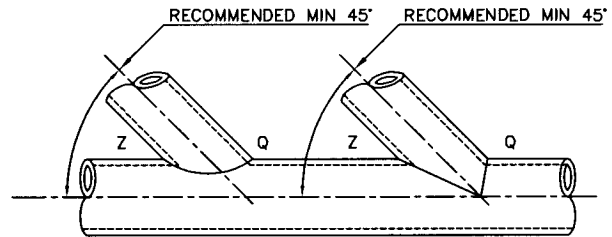
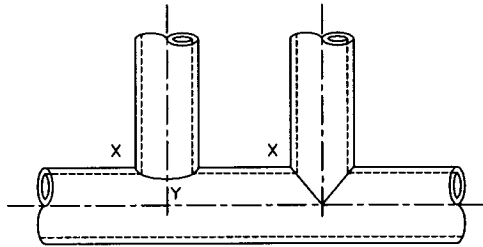
STANDARD 'V' BEVEL
BUTT JOINT



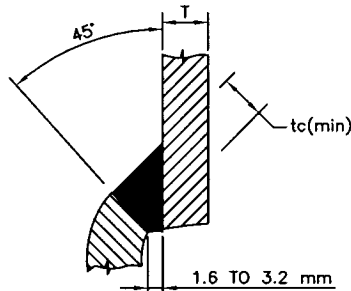
SEQUENCE OF WELDS

$$4.8 \text{ mm} \leq t \leq 19.1 \text{ mm}$$

4	31.12.13	REAFFIRMED & ISSUED AS STANDARD	<i>[Signature]</i> UK	<i>[Signature]</i> SH	<i>[Signature]</i> RN	<i>[Signature]</i> SC
3	15.11.08	REAFFIRMED & ISSUED AS STANDARD	AC	RN	DM	VC
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
Approved by						



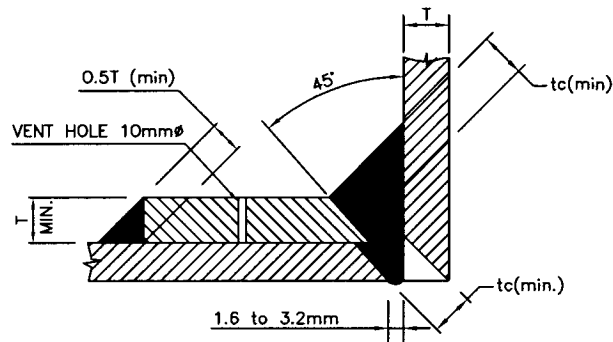
SECTION X AT CROTCH OF RIGHT
ANGLE BRANCH



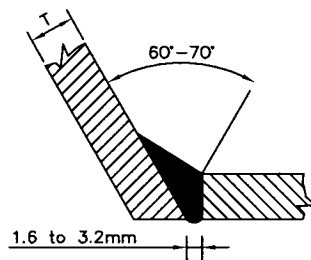
SECTION Y AT FLANK

NOTES :

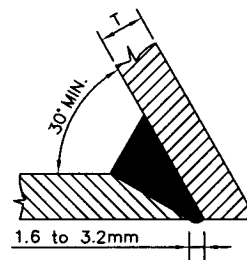
1. THIS TYPE IS TO BE USED WHEN BRANCH IS MORE THAN ONE SIZE SMALLER OF MAIN PIPE.
2. FOR LINES COMING UNDER THE PURVIEW OF IBR RECOMMENDED MIN. ANGLE SHALL BE 60°).



$tc = \text{MIN OF } 0.7t \text{ \& } 6.4\text{mm}$

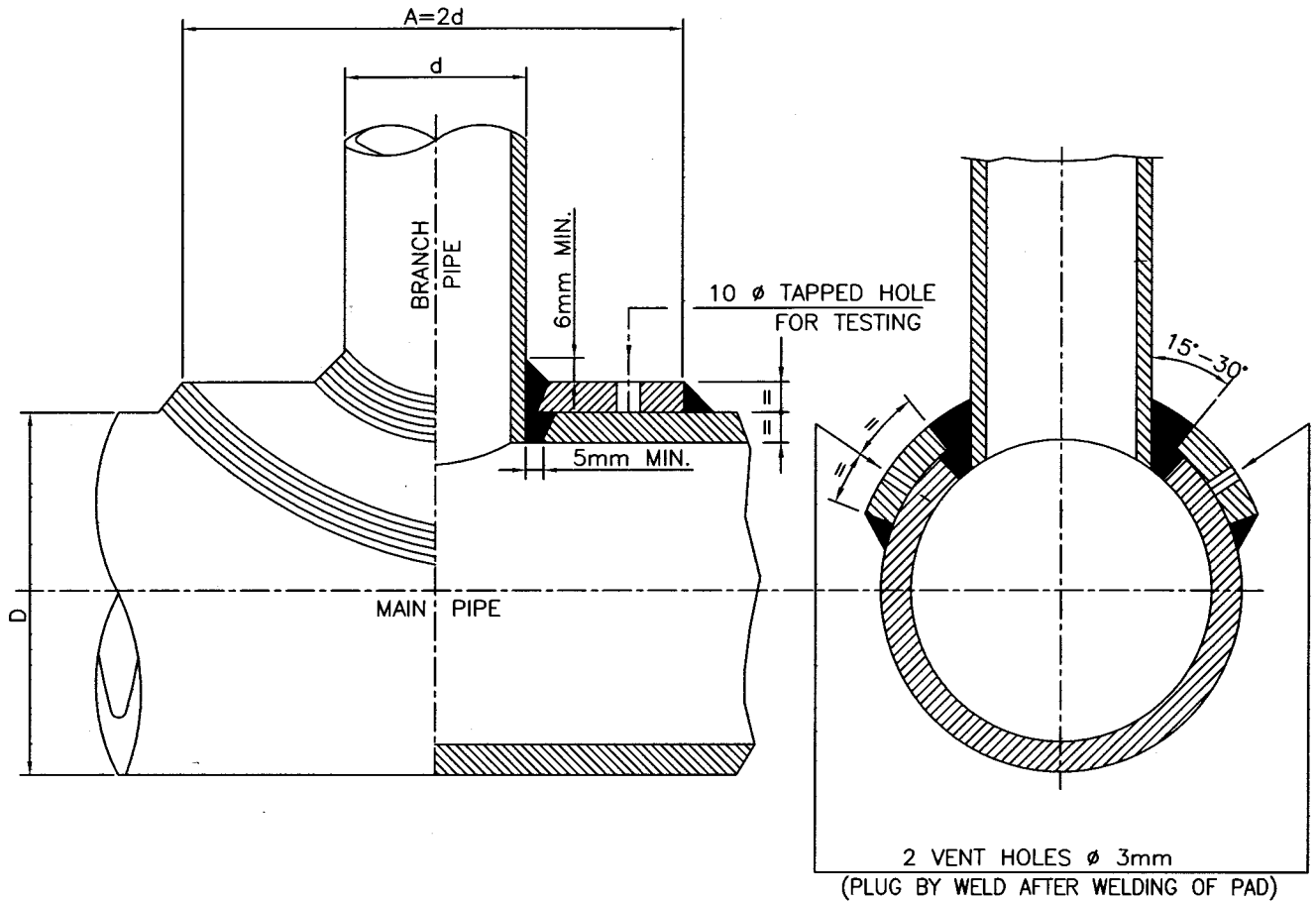


SECTION Q AT BACK OF
SLOPING BRANCH

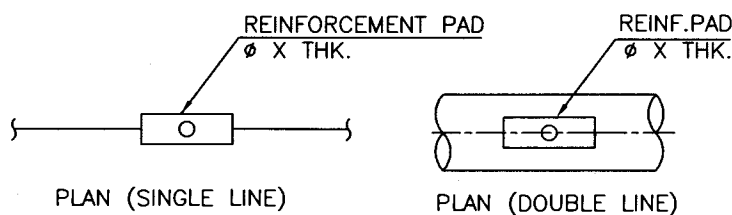


SECTION Z AT CROTCH OF
SLOPING BRANCH

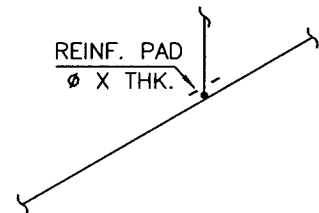
4	31.12.13	REAFFIRMED & ISSUED AS STANDARD	UK	SH	AK	RN	SC
3	15.11.08	REAFFIRMED & ISSUED AS STANDARD	AC	RN	DM	VC	
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman	Approved by



SYMBOL ON GADS



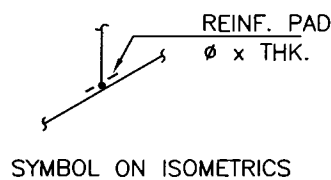
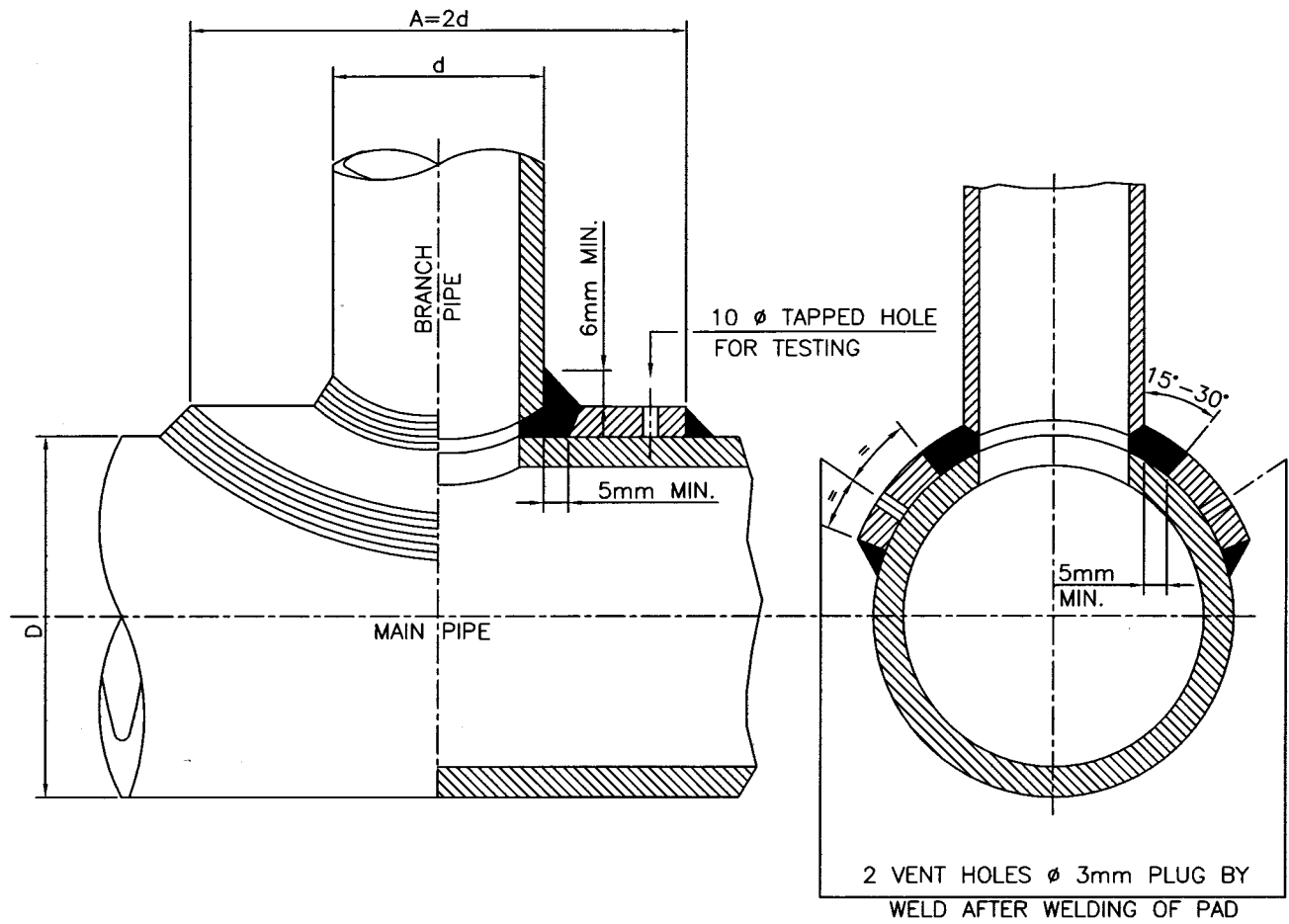
SYMBOL ON ISOMETRICS



NOTES :-

1. THIS TYPE IS TO BE USED WHEN BRANCH IS MORE THAN ONE SIZE SMALLER THAN MAIN PIPE
2. THE REINFORCING PLATE SHALL BE OBTAINED FROM PIPE SPOOL OF THE SAME SCHEDULE AND DIAMETER OF MAIN PIPE UNLESS OTHERWISE STATED
3. THE REINFORCEMENT PAD CALCULATIONS SHALL BE MADE IN ACCORDANCE WITH ASME B31.3 OR IBR AS APPLICABLE
4. ALSO SEE STANDARD 7-44-0484
5. REFER STANDARD 7-44-0482 FOR WELDING DETAILS.

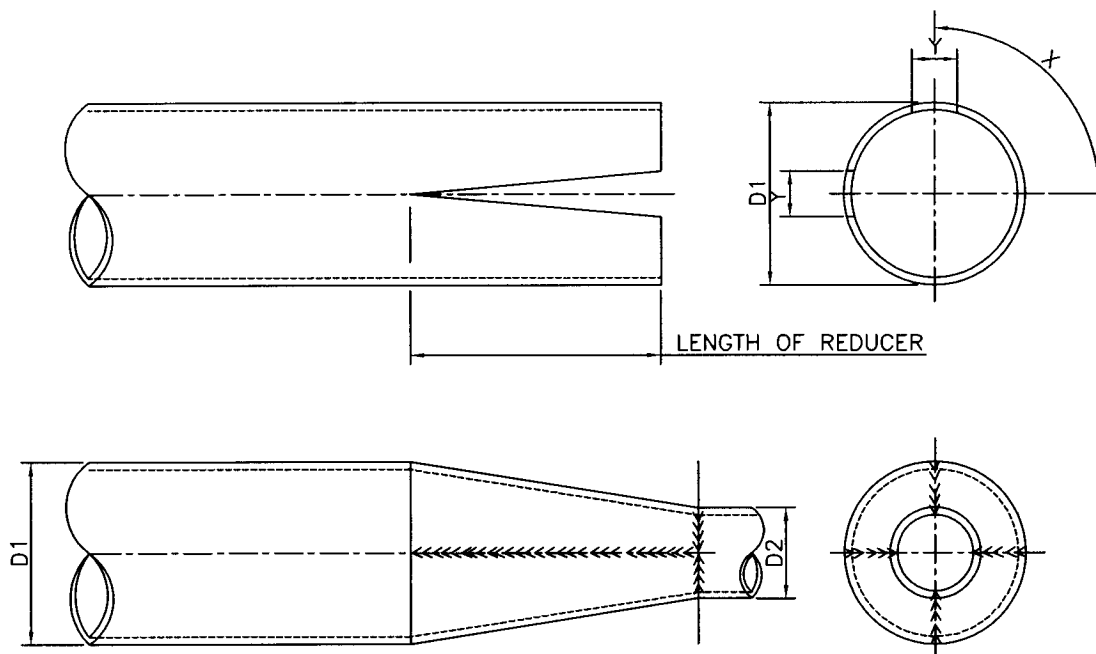
3	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
2	24.03.06	REVISED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman	Approved by



NOTES :

1. THIS TYPE IS TO BE USED WHEN BRANCH IS EQUAL TO OR ONE SIZE SMALLER THAN MAIN PIPE
2. THE REINFORCEMENT PAD SHALL BE OBTAINED FROM PIPE SPOOL OF THE SAME SCHEDULE AND DIAMETER AS MAIN PIPE UNLESS OTHERWISE STATED.
3. THE REINFORCEMENT PAD CALCULATION SHALL BE MADE IN ACCORDANCE WITH ASME B31.3 OR IBR AS APPLICABLE.
4. ALSO SEE STANDARD 7-44-0483
5. REFER STANDARD 7-44-0479 FOR WELDING DETAILS.

3	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
2	24.03.06	REAFFIRMED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman	Approved by

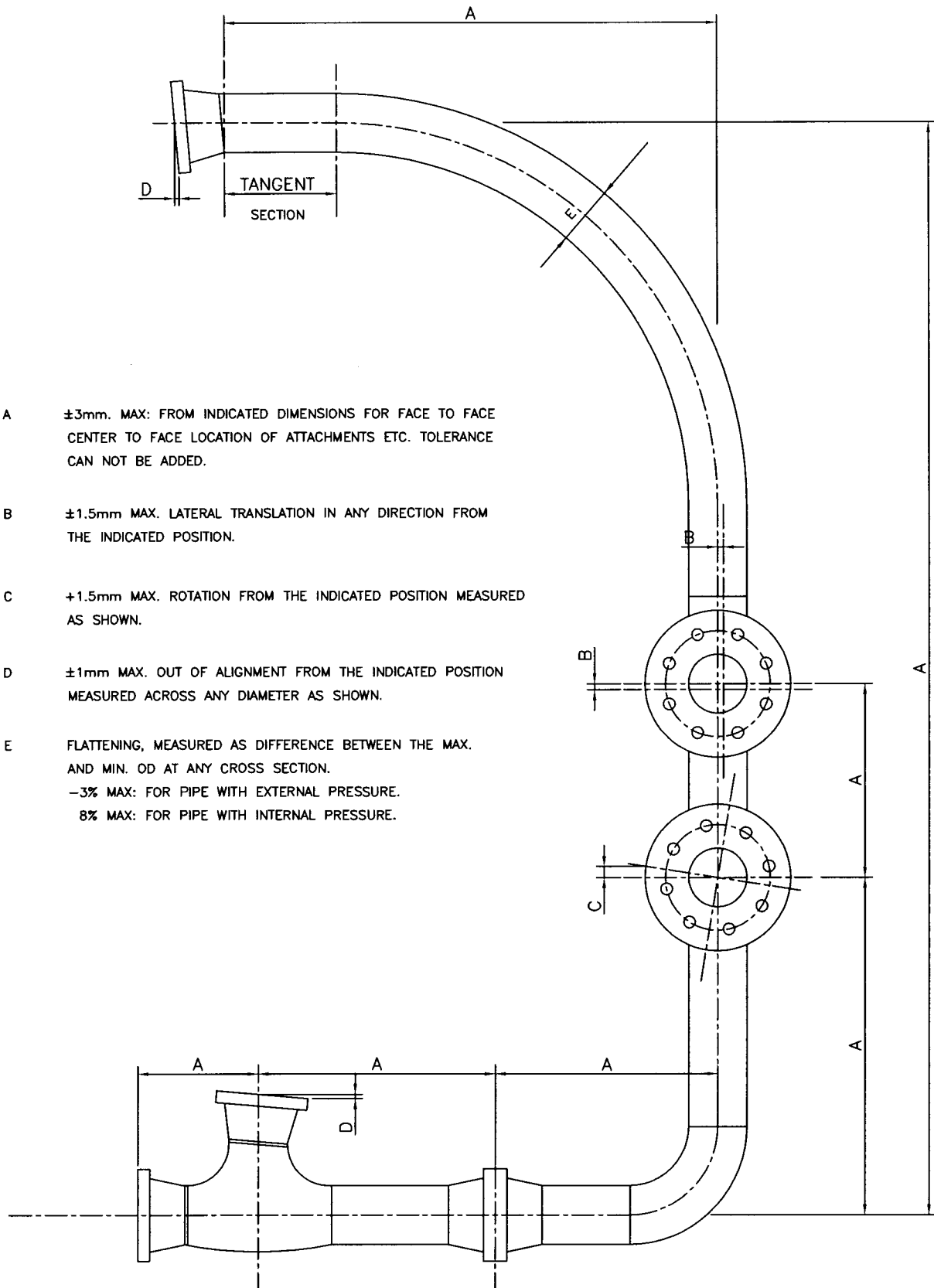


DIFFERENCE IN DIAMETER D1 - D2	NUMBER OF PIECES TO BE CUT OUT	ANGLE BETWEEN CUT OUTS X	SIZE OF CUT OUT Y	LENGTH OF REDUCER	CIRCUMFERENCE OF D1 MINUS CIRCUMFERENCE OF D2.
1"	2	180°	1 1/2"	D1	3 1/8"
2"	3	120°	2 1/4"	D1	6 1/4"
3"	3	120°	3"	D1	9 1/2"
4"	4	90°	3"	D1	12 1/2"
5"	4	90°	4"	D1	15 3/4"
6"	4	90°	4 3/4"	D1	18 3/4"
7"	6	60°	3 3/4"	D1	22"
8"	6	60°	4 1/4"	1.1XD1	25"
9"	6	60°	4 3/4"	1.1XD1	28 1/4"
10"	8	45°	4"	1.1XD1	31 1/2"
12"	8	45°	4 3/4"	1.1XD1	37 3/4"
14"	10	36°	4 1/2"	1.1XD1	44"
16"	12	30°	4 1/4"	1.1XD1	50 1/4"
18"	12	30°	4 3/4"	1.1XD1	56 1/2"
20"	12	30°	5 1/4"	1.1XD1	62 3/4"

NOTES:-

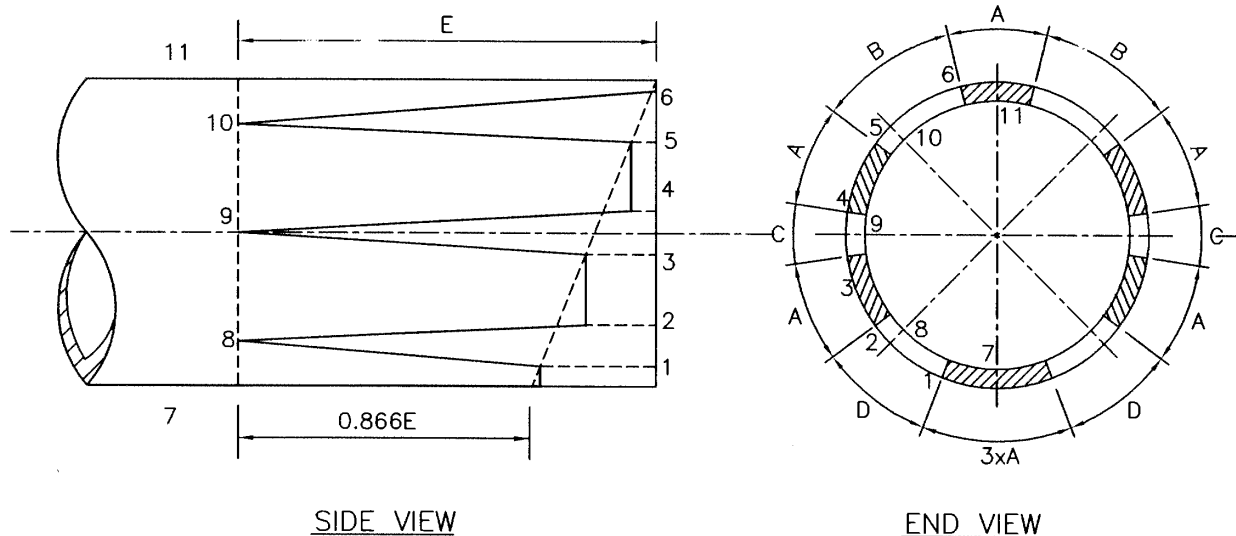
- CUT OUT REQUIRED NUMBER OF PIECES IN ACCORDANCE WITH TABLE. HEAT & BEND ENDS OF PIPE TO CONFORM WITH DIAMETER D2. WELD ALL AROUND.
- RADIOGRAPHY SHALL BE PERFORMED IN ACCORDANCE WITH REQUIREMENTS OF INDIVIDUAL PIPING CLASSES.

4	31.12.13	REAFFIRMED & ISSUED AS STANDARD	UK	SH	AK	RN	SC
3	15.11.08	REAFFIRMED & ISSUED AS STANDARD	AC	RN	DM	VC	
Rev. No.	Date	Purpose	Prepared by	Std. Committee Convenor	Std. Bureau Chairman	Approved by	



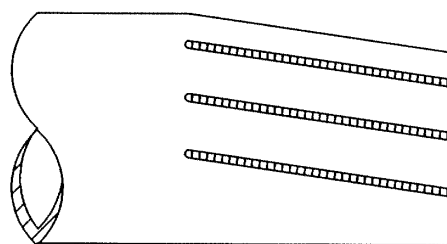
- A $\pm 3\text{mm}$ MAX. FROM INDICATED DIMENSIONS FOR FACE TO FACE CENTER TO FACE LOCATION OF ATTACHMENTS ETC. TOLERANCE CAN NOT BE ADDED.
- B $\pm 1.5\text{mm}$ MAX. LATERAL TRANSLATION IN ANY DIRECTION FROM THE INDICATED POSITION.
- C $+1.5\text{mm}$ MAX. ROTATION FROM THE INDICATED POSITION MEASURED AS SHOWN.
- D $\pm 1\text{mm}$ MAX. OUT OF ALIGNMENT FROM THE INDICATED POSITION MEASURED ACROSS ANY DIAMETER AS SHOWN.
- E FLATTENING, MEASURED AS DIFFERENCE BETWEEN THE MAX. AND MIN. OD AT ANY CROSS SECTION.
 -3% MAX: FOR PIPE WITH EXTERNAL PRESSURE.
 8% MAX: FOR PIPE WITH INTERNAL PRESSURE.

4	31.12.13	REAFFIRMED & ISSUED AS STANDARD	UK	SH	RN	SC
3	15.11.08	REAFFIRMED & ISSUED AS STANDARD	AC	RN	DM	VC
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman
Approved by						



SIDE VIEW

END VIEW



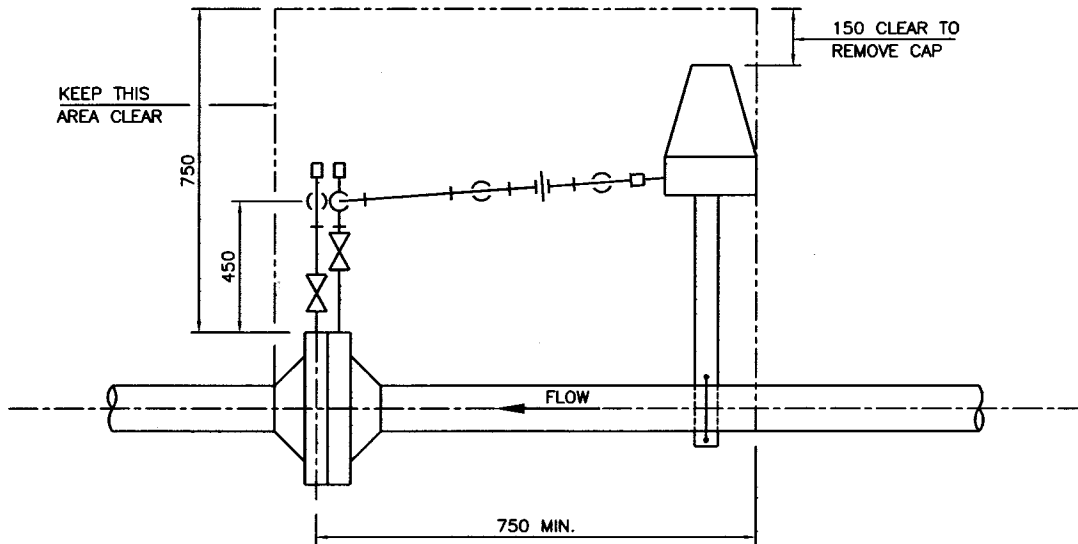
COMPLETED REDUCER

- A = $1/8$ OF SMALL PIPE CIRCUMFERENCE.
B = $3/12$ DIFFERENCE BETWEEN CIRCUMFERENCES.
C = $2/12$ DIFFERENCE BETWEEN CIRCUMFERENCES.
D = $1/12$ DIFFERENCE BETWEEN CIRCUMFERENCES.
E = $1.5 \times \text{O.D. OF LARGER PIPE.}$

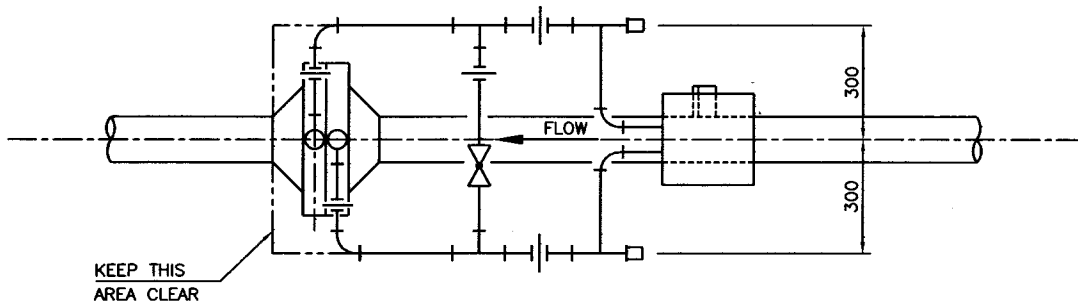
NOTES :-

- REDUCER SHALL BE FABRICATED OUT OF LINE PIPE.
- ALL WELDS SHALL BE RADIOGRAPHED AS PER THE PIPING CLASS NDT REQUIREMENTS.

4	29.06.09	REAFFIRMED & ISSUED AS STANDARD	MPK	RN	SC	ND
3	15.07.04	REAFFIRMED & ISSUED AS STANDARD	RN	SC	MRC	SKG
Rev. No.	Date	Purpose	Prepared by	Checked by	Stds. Committee Convenor	Stds. Bureau Chairman



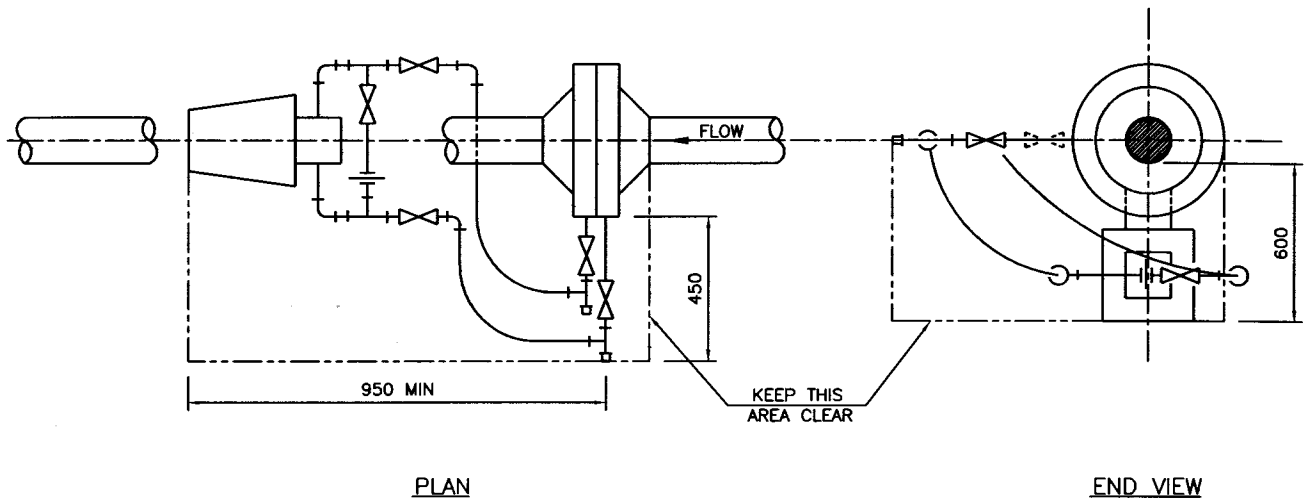
ELEVATION



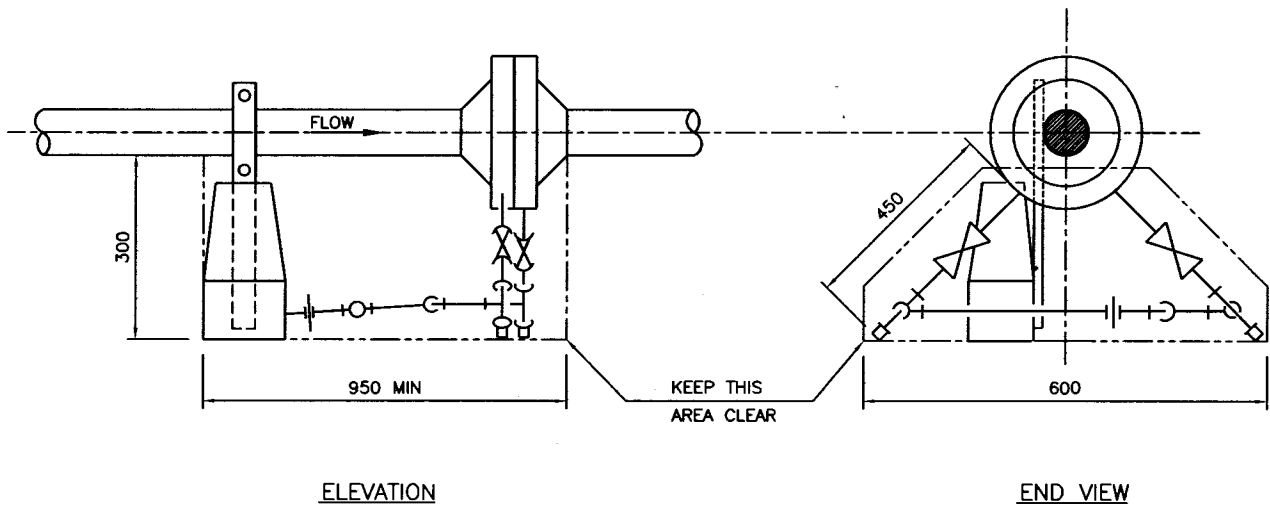
PLAN

90° TOP TAPS – DRY GAS SERVICE / HF ACID

2	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
1	24.03.06	REAFFIRMED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman	Approved by

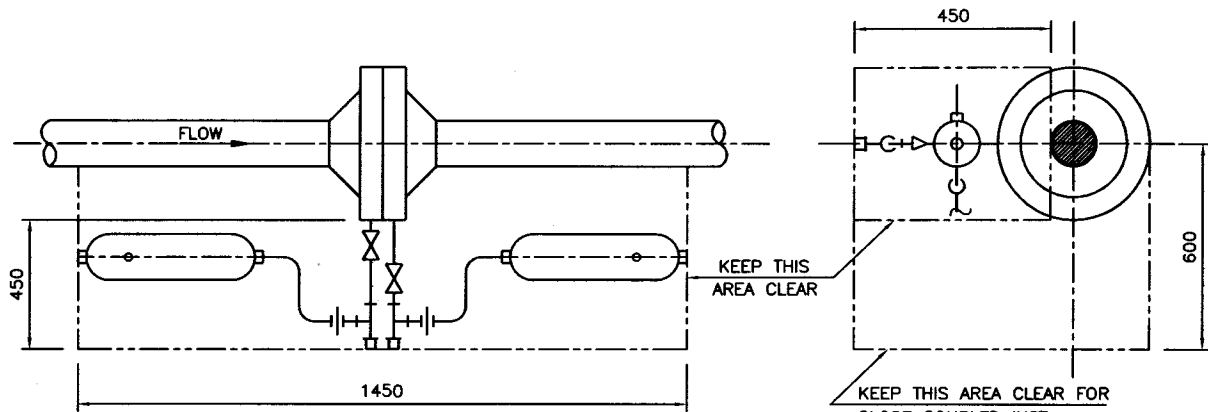


90° HORIZONTAL TAPS – LIQUID OR STEAM SERVICE



45° BOTTOM TAPS – HORIZONTAL LIQUID SERVICE

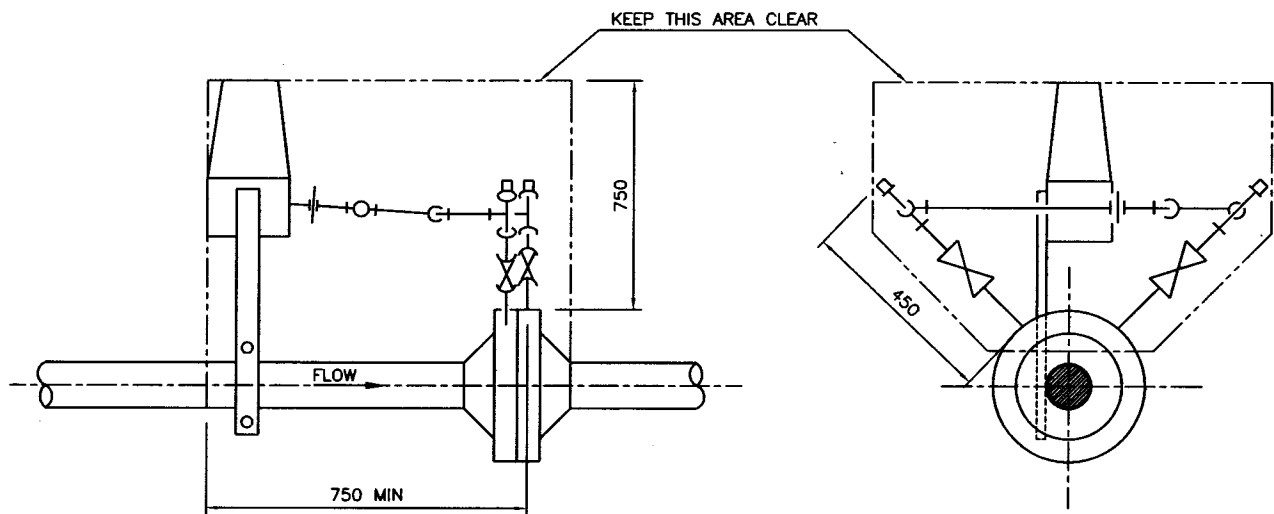
2	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
1	24.03.06	REAFFIRMED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman	Approved by



PLAN

END VIEW

90° HORIZONTAL TAPS STEAM SERVICE W/CONDENSATE POTS



ELEVATION

END VIEW

45° TOP TAPS – HORIZONTAL GAS SERVICE

2	10.07.10	REAFFIRMED & ISSUED AS STANDARD	PK	RN	SC	DM	ND
1	24.03.06	REAFFIRMED & ISSUED AS STANDARD	RN	DM	MRC	VJN	
Rev. No.	Date	Purpose	Prepared by	Checked by	Std. Committee Convenor	Std. Bureau Chairman	Approved by