

WELDING SPECIFICATION FOR PIPING CLASSES

PROJECT : GANDHAR COMPRESSOR PROJECT

CLIENT : GAIL (INDIA) LIMITED

JOB NO. : B240

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1.0 SCOPE

The requirements stated herein shall be followed for the fabrication of all types of welded joints of Carbon Steel piping.

The welded pipe joints shall include the following:

- a) Circumferential butt-welded.
- b) Attachments of castings, forgings, flanges and other supports to pipes.
- c) Welded manifold headers and other sub-assemblies.
- d) Welded branch connections.
- 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 CLIENT shall not relieve the CONTRACTOR of his responsibilities and guarantees.

1.1 Abbreviations

ANSI: American National Standards Institute

API: American Petroleum Institute

ASME: American Society of Mechanical Engineers

BS: British Standard

CRT: Cathode Ray Tube

GMAW: Gas Metal Arc Welding

GTAW: Gas Tungsten Arc Welding

HAZ: Heat Affected Zone

HV: Vickers Hardness

IIW: International Institute of Welding

IQI: Image Quality Indicator

ISO: International Organization for Standardisation

MPI: Magnetic Particle Inspection

PQR: Procedure Qualification Record

SMAW: Shielded Metal Arc Welding

UT: Ultrasonic Testing

UTS: Ultimate Tensile Strength

WPS: Welding Procedure Specification

1.2 Applicable Codes, Standards and Specifications

All welding work, equipment for welding, heat treatment, other auxiliary functions and the welding personnel shall meet the requirements of the latest editions of the codes, standards and specifications listed below:

- a) Code for Gas Transmission and Distribution Piping Systems, ANSI B 31.8.
- b) Standard for welding of Pipelines and Related Facilities, API 1104-2013
- c) Specification for welding Electrodes and Filler Materials ASME Sec. II Part C.
- d) Non Destructive examination, ASME Sec. V.
- e) Welding Specification Charts for Piping classes, B240-000-02-42-WSC-0001.

Welding Specification Charts specified anywhere in this document refer to B240-000-02-42-WSC-0001.

2.0 BASE MATERIAL

In general carbon steel and Stainless steels are used in this specification. The details of material specifications are given in the Welding Specification Charts attached along with other project data sheets. The CONTRACTOR will arrange and maintain the record of test certificates of all the materials for the reference of the welding engineer.

3.0 WELDING PROCESSES

- 3.1 Welding process is specified in the Welding Specification Charts. Any other welding processes may be used after obtaining approval of the Client/Engineer-in-charge.

4.0 WELDING CONSUMABLES

- a) The CONTRACTOR shall provide at his own expense all the welding consumables necessary for the execution of the job such as electrodes, oxygen, acetylene etc. and these shall bear the approval of the CLIENT.
- b) The welding electrodes / filler wires supplied by the CONTRACTOR shall conform to the class specified in the welding specification chart attached along with other project data sheets. The materials shall be of the make approved by the CLIENT.
- c) The electrode shall be suitable for the welding process recommended and the base metal used. Physical properties of the welds produced by an electrode recommended for the welding of a particular base metal shall not be lower than the minimum values specified for the base metal unless otherwise specified in the Welding Specification Chart and shall correspond to the physical properties of the class of electrode adopted. The choice of electrode shall be made after conducting the required tests on

the electrodes as per relevant standards, and shall be the sole prerogative of the CLIENT.

- d) The CONTRACTOR shall submit batch test certificates from each electrode manufacturers giving details of physical and chemical tests carried out by them for each batch of electrodes to be used.
- e) Electrode Qualification test records shall be submitted as per the Exhibit–A (attached) in respect of the electrodes tested by the CONTRACTOR for obtaining the approval of the CLIENT.
- f) All electrodes shall be purchased in sealed containers and stored properly to prevent deterioration. The electrodes removed from the containers (except cellulosic coated electrodes) shall be kept in the holding ovens, at the temperature recommended by the electrode manufacturer. Ovens shall be used for the low hydrogen electrodes only. 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.

Different grades of electrodes shall be stored separately. Cellulosic electrodes used shall however be used as per the specific recommendations of manufacturer.

- g) Manufacturer's recommendation for baking of low hydrogen electrodes shall be followed. All low hydrogen electrodes shall be used within four hours of issue. If low hydrogen electrodes are not used within four hours of issue or exposed to atmospheric conditions, shall be baked again in accordance with the manufacturer's recommendation. Electrodes are permitted to bake twice maximum. If these electrodes after the second baking are not used within four hours, they shall be discarded.
- h) Diffusible hydrogen in any of the weld shall be limited to a maximum of 8 ml per 100 g of weld metal irrespective of the type of consumables or welding method. The method of determination shall be as per AWS A4.3 as indicated in AWS A5.1 or ISO 3690:2012.
- h) The electrodes used shall be free from rust, oil, grease, earth and other foreign matter, which affect the quality of welding.

i) Shielding Gas

The composition and the purity of shielding gas when required by the welding processes other than shielded metal arc welding, when permitted by the CLIENT shall bear the approval of the CLIENT. Where appropriate, gases or gas mixture of the following quality shall be used.

1. Argon gas complying with BS 4365.
2. Carbon dioxide gas complying with type 1 specified in BS 4105

3. Gas mixtures that have been proved to be satisfactory as a result of procedure approval tests.

When a gas mixture is used, which has specified additions, e.g. 2% O₂, 5% CO₂ the variation of such addition shall not exceed $\pm 10\%$ of that stated. Moisture content shall correspond to a dew point of -30°C or lower. All shielding gas containers shall have clear identification labels which include the gas type.

- j) The quality management system followed by the CONTRACTOR and Manufacturer/Agency shall be approved by the CLIENT to ensure that each batches of welding consumables used during welding can be traced whenever required.

5.0 EQUIPMENT & ACCESSORIES

- 5.1 The CONTRACTOR shall have sufficient number of welding and cutting equipment, auxiliaries and accessories of sufficient capacities to meet the target schedules.
- 5.2 All the equipment for performing the heat treatment, including transformers, thermocouples, pyrometers, automatic temperature recorders with suitable calibration arrangements, etc. shall be provided by the CONTRACTOR, at his own expense and these shall bear the approval of the CLIENT. Adequate means of measuring current and voltage shall be available.
- 5.3 Redoing of any work necessitated by faulty equipment or operation used by the CONTRACTOR, will be done at his own expense.

6.0 BEVEL CLEANING / BEVEL INSPECTION

Before welding, all the rust and the foreign matter shall be removed from the bevelled ends by power operated tools. This shall be effected inside and outside and for a minimum distance of 25 mm from the edge of the weld bevel. The bevels shall be thoroughly inspected at this stage. If any of the ends of the pipe joints are damaged to the extent that, in the opinion of the CLIENT, satisfactory weld spacing cannot be obtained and local repair by grinding cannot be successfully done, the damaged ends shall be cut and bevelled to the satisfaction of the CLIENT, with an approved bevelling machine. Manual cutting and weld repairs of bevels is not allowed. Should laminations, split ends or inherent manufacturing defects in the pipe be discovered, the lengths of pipe containing such defects shall be removed from the line to the satisfaction of CLIENT. On pipes, which have been cut back, a zone extending 25 mm back from the new field bevel, shall be ultrasonically tested to the requirement of the line pipe specification to ensure freedom from laminations. The new bevel shall be 100% visual and 100% dye penetrant/MPI tested. A report shall be written for all the testing and records kept.

7.0 ALIGNMENT AND SPACING

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.

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.

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.

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.

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.

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

8.0 WEATHER CONDITIONS

The parts being welded and the welding personnel shall be adequately protected from rain and strong winds. In the absence of such a protection no welding shall be carried out. The completed welds shall be suitably protected in case of bad weather conditions.

9.0 WELDING

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 charts 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.

Joint Completion

- (a) Joint shall be completed using the class of electrodes recommended in the Welding Specification Chart.
- (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.

10.0 HEAT TREATMENT

10.1 Preheating

- a) Preheating requirements for the various materials shall be as per the welding specification chart attached along with other project data sheets.
- b) Preheating shall be performed using resistance or induction heating methods.
Pre-heating for tie-in welds, repair welds or welds at point spreads may be done using a propane gas burner ring with prior approval from CLIENT. The contractor may be asked to demonstrate the effectiveness of the arrangement.
- c) Preheating shall extend uniformly to at least three times the thickness of the joint, but not less than 50 mm, on both sides of the weld.

- d) Preheating temperature shall be maintained over the whole length of the joint during welding. Temperature indicating crayons or other temperature indicating devices shall be provided by the CONTRACTOR to check the temperature.

10.2 Post Weld Heat Treatment

- a) Post weld heat treatment, wherever required for joints between pipes and fittings, pipe body and supports shall be carried out by the CONTRACTOR at his expense as per the relevant specifications, applicable standards and the instructions of the CLIENT.
- b) The heat treatment of welded joints shall be carried out as per the requirements laid down in ANSI B31.8 and other special requirements mentioned in welding specification chart.
- c) The CONTRACTOR shall submit for the approval of the CLIENT, well before carrying out actual heat treatments 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.
- d) Post weld heat treatment shall be done in a furnace or by using an electric resistance or induction heating equipment, as decided by the CLIENT.
- e) 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 is attained is at least as that specified in the relevant applicable standards/codes.
- f) The width of the heated band centered on the weld shall at least be equal to the width of weld plus 2" (50 mm). The temperature gradient shall be such that the length of the material on each side of the weld, at a temperature exceeding half the heat treatment temperature, is at least $2.5 \text{ } r t$ where r is the bore radius and t is the pipe thickness at the weld.
- g) Throughout the cycle of heat treatment, the portion outside the heat 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 of the pipe shall not be allowed to exceed 400°C .
- h) The temperature attained by the portion under heat treatment shall be recorded by means of thermocouple pyrometers. Adequate number of thermocouples shall be attached to the pipe directly at equally spaced locations along the periphery of the pipe joint. The minimum number of thermocouples attached per joint shall be 2 up to

10" dia and 3 for 12" dia and above. However, the CLIENT can increase the required minimum number of thermocouples to be attached if found necessary.

- i) Automatic temperature recorders, which have been suitably calibrated, shall be employed. The calibration chart of each recorder shall be submitted to the CLIENT prior to starting the heat treatment operation and its approval shall be obtained.
- j) Immediately on completion of the heat treatment, the post weld heat treatment charts/records along with the hardness test results on the weld joints (whenever required as per the welding specification chart) shall be submitted to CLIENT for its approval.
- k) Each joint shall bear an identification number, which shall be maintained in the piping sketch to be prepared by the CONTRACTOR. The joint identification number shall appear on the corresponding post weld heat treatment charts. The same identification numbers shall also be followed for identification of corresponding radiographic films. The chart containing the identification number and the piping sketch shall be submitted to the CLIENT in suitable folders.
- l) Vickers hardness/Brinell hardness of the heat affected zone as well as of the weld metal, after heat treatment shall be measured using a suitable hardness tester and shall not exceed the maximum hardness specified in the welding specification chart. The weld joint shall be subjected to reheat treatment, when hardness measured exceeds the specified limit, at the CONTRACTOR'S own expense.
- m) The CONTRACTOR shall arrange for the hardness testing and shall maintain the records of all the joints tested. These records shall be checked by the plant CLIENT'S inspector.

11.0 WELDING QUALIFICATIONS

11.1 General

- a) The CLIENT'S Inspector shall have free access to all the concerned areas, where the actual work is being performed. The CONTRACTOR shall also provide the CLIENT'S inspector all means and facilities necessary to carry out inspection.
- b) The CLIENT is entitled to depute its own inspector to the shop or field where pre-fabrication and erection of pipelines are being done, with (but not limited to) the following objectives:
 - i) To check the conformance to relevant standards and suitability of various welding equipment and the welding performance.
 - ii) To supervise the welding procedure qualification.
 - iii) To supervise the welders performance qualification.

- iv) To check whether shop/field welding being executed is in conformity with the relevant specifications and codes of practice followed in pipeline construction.
- c) CONTRACTOR shall intimate sufficiently in advance the commencement of the qualification tests, welding works and acceptance tests, to enable the CLIENT'S inspector to be present to supervise them.

11.2 Welding Procedure Qualification

- a) Welding procedure qualification shall be carried out in accordance with the relevant requirements of API 1104 latest edition or other applicable codes and other job requirements by the CONTRACTOR at his expense. The CONTRACTOR shall submit the welding procedure specifications in format as per Exhibit-C (attached) immediately after the receipt of the order.
- b) CLIENT'S inspector will review, check and approve the welding procedure submitted and shall release the procedure for procedure qualification tests. The procedure qualification tests shall be carried out by the CONTRACTOR under field conditions at his own expense. A complete set of the test results in format as per Exhibit-C (attached) shall be submitted to the CLIENT'S Inspector for approval immediately after completing the procedure qualification test and at least 2 weeks before the commencement of actual work. Standard tests as specified in the code shall be carried out in all cases. In addition to these tests, other tests like radiography, macro/micro examination, hardness test, dye penetrant examination, charpy v-notch etc. shall be carried out on the specimens. It shall be the responsibility of the CONTRACTOR to carry out all the tests required to the satisfaction of the CLIENT'S Inspector. The destructive testing of welded joints shall be as per Annexure – 1.

11.3 Welder's Qualification

- a) Welders shall be qualified in accordance with the API 1104 or other applicable specifications by the CONTRACTOR at his expense. The butt weld test pieces of the qualification test shall meet the radiographic test requirements specified in Clause 12.3 and Annexure-4 of this specification for Manual and Semiautomatic welding process. Weld test samples prepared by Automatic welding process shall be inspected by Automated ultrasonic examination as per Annexure-3. The CLIENT'S inspector shall witness the test and certify the qualification of each welder/welding operator separately. Only those welders/welding operator who have been approved by the CLIENT'S inspector shall be employed for welding. CONTRACTOR shall submit the welder qualification test reports in the standard format as shown in Exhibit-D and obtain express approval, before commencement of the work. It shall be the responsibility of CONTRACTOR to carry out qualification tests of welders.

- b) The welders shall always have in their possession the identification card as shown in Exhibit-E and shall produce it on demand by the CLIENT'S Inspector. It shall be the responsibility of the CONTRACTOR to issue the identity cards after the CLIENT has duly certified it.
- c) No welder shall be permitted to work without the possession of identity 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.

12.0 PRODUCTION WELD INSPECTIONS AND TESTING

12.1 Visual Inspection

CLIENT shall carry out inspection of all welds 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, shrinkage, cracks, under-cuts, dimensions, surface porosity and other surface defects. The acceptance criteria shall be as given in Doc. No. 6-44-0016. Undercutting adjacent to the completed weld shall not exceed the limits specified in API 1104.

12.2 NDT Examinations

Radiography: All Butt welds, 100%. (as per Annexure 3)

Magnetic Particle Testing: All Socket Welds, 100%.

Dye penetrant test/ Magnetic Particle Testing: All fillet welds.

All butt welded golden joints shall be inspected by Ultrasonic Testing (as per Annexure 2), 100%.

Weld joints shall comply with all other NDT requirements specified in EIL Standard specification, 6-44-0016.

12.3 NDT Acceptance Criteria

The NDT acceptance criteria for Station/Terminal Piping weld joints shall be as per ASME B31.3 latest edition.

12.4 Destructive Testing

The CLIENT has the authority to order the cutting of up to 0.1% of the total number of welds completed for subjecting to destructive tests at no extra cost to CLIENT. The destructive testing of weld joints shall be made as per Annexure – 1.

In addition, welds already cut out for defects for any reason may also be subjected to destructive testing. The sampling and the re-execution of welds shall be carried out by the CONTRACTOR at his own expense. If the results are unsatisfactory, welding

operations shall be suspended and may not be restarted until the causes have been identified and the CONTRACTOR has adopted measures, which guarantee acceptable results. If it is necessary in the CLIENT's opinion the procedure shall be re-qualified. The weld joint represented by unsatisfactory welds shall stand rejected unless investigation proves otherwise.

13.0 REPAIRS OF WELDS

13.1 Repair weld procedure

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

A separate welding procedure specification sheet shall be formulated and qualified by CONTRACTOR for repair welds simulating the proposed repair to be carried out. Separate procedures are required to be qualified for

- (a) through thickness repair,
- (b) external repair and
- (c) internal repair.

Welders shall be qualified in advance for repairs. The root pass, for repairs opening the root, shall be replaced by the vertical uphill technique. The procedure shall be proven by satisfactory procedure test to API-1104 including the special requirements of the specification, and shall also be subjected to metallographic examination, hardness surveys and Charpy tests to determine the effects of repair welding on the associated structure.

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

The repair shall be subjected, as a minimum requirement to the same testing and inspection requirements as the original weld. After the repair of the circumferential weld, re-radiography of the full joint shall be carried out. A 100% ultrasonic test shall be done at the repaired area externally. Any repaired area that is wide, irregular or rough shall be rejected and a full cut out shall be done.

Repairs are limited to a maximum of 30% of the weld length. Not more than two repairs are permitted on the same location. All repairs shall be carried out the day after initial radiography/AUT or earlier. A full report of all repairs made shall be submitted every day to the CLIENT.

13.2 Weld Rejected by Accumulation of Defects

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

ANNEXURE – 1: DESTRUCTIVE TESTING OF WELDED JOINT - BUTT WELDS

1.0 Destructive Testing Of Welded Joint - Butt Welds

1.1 Preparation

Having passed the visual and the nondestructive inspection, the test weld shall be subjected to mechanical tests.

After satisfactory completion of all visual and non-destructive testing the procedure test weld shall be set-aside for a period not less than 24 hours. No further work on the test weld and no cutting of test specimens from the weld shall be performed until a period of at least 24 hours has expired.

Weld specimens shall be taken from the positions indicated in Figure1 & 1A of this specification from areas as free from defects as possible; for this reason it is necessary to take the previous nondestructive tests result into account. The minimum number of tests to be carried out is given in Table - 1 of this specification.

The test shall be carried out at laboratories approved by the CLIENT. The specimens shall be prepared in accordance with the figures given in the paragraphs that refer to the individual test.

1.2 Tensile Strength

Specimens shall be taken from the position indicated in Figure1 & 1A of this specification. Two ISO type specimens and two API-type specimens shall be taken.

The ISO test specimens are shown in fig.2 of this specification.

1.2.1 Method

The test shall be carried out in accordance with BS EN ISO 6892-1:2009.

TABLE 1

PIPE SIZE, OUT SIDE DIAMETER INCHES	NUMBER OF SPECIMENS									
	TENSILE API	TENSILE ISO	NICK BREAK	ROOT BEND	FACE BEND	SIDE BEND	MACRO	HARDNESS	IMPACT	TOTAL
	WALL THICKNESS ½ INCH (12.7 mm) AND UNDER									
UNDER 2	0	0	2	2	0	0	0	0	0	4
2 TO 4½ INCLUDING	0	0	2	2	0	0	0	0	0	4
OVER 4½ LESS THAN 12¾	2	0	2	2	2	0	2	2	12	24
12¾ AND OVER	2	2	4	4	4	0	2	2	24	44
	WALL THICKNESS OVER ½ INCH (12.7 mm)									
4½ AND SMALLER	0	2	0	0	0	2	0	0	0	4
OVER 4½ LESS THAN 12¾	2	0	2	2	2	0	2	2	12	24
12¾ AND OVER	2	2	4	0	0	8	2	2	24	44

1.3 Nick-Break Test

1.3.1 Preparation

Specification for nick-break test with notches thus worked can break in the base metal, instead of in the fusion zone; therefore an alternative test piece may be used after authorization by the CLIENT with a notch cut in the reinforcement of outside weld bead to a maximum depth of 1.5mm, measured from the surface of the weld bead.

1.4 Macroscopic Inspection

1.4.1 Preparation

Specimens shall be taken from the positions indicated in Fig.1 of this specification and shall be prepared in accordance with ASTM E3-11.

The width of the macro section has to be at least three times the width of the weld. The section is to be prepared by grinding and polishing and etched to clearly reveal the weld metal and heat affected zone.

1.4.2 Method

Specimens shall be carefully examined under the microscope, with a magnification of at least 25 times (25:1). The CLIENT may ask for a macrograph with 5 times (5:1) magnification, for DOCUMENTATION purposes.

1.4.3 Requirements

Under macroscopic examination, the welded joints shall show good penetration and fusion, without any defect exceeding the limits stated in the evaluation criteria of the nick-break test.

1.5 Hardness Test

1.5.1 Preparation

The prepared macro section is to be used for hardness testing using the vickers method with 10 kg load indentations are to be made along traverses each approximately 1 mm below the surface at both side of the weld.

In the weld metal a minimum of 6 indentations equally spaced along the traverses are to be made. The HAZ indentations are to be made along the traverses for approximately 0.5 mm each into unaffected material, and starting as close to the fusion line as possible.

One indentation at each side of the weld along each traverse has to be made on parent metal. Reference is made to Fig. 3 of this specification. The indentations are to be made in the adjacent region as well as on the opposite side of the macro section along the specified traverses.

1.5.2 Method

The test shall be carried out in accordance with recommendation ISO 6507-1:2005, Vickers hardness, using a laboratory type machine controlled as pre-recommendation ISO 6507-2:2005 and using a diamond pyramid penetrator set at 2.37 rad (136") with a load of 10 kg.

1.5.3 Requirements

Hardness value shall not exceed the limit specified in welding specification charts. In case of a single reading strictly (+10HV) higher than the specified limit, further indentations shall be made to check if the high value was an isolated case.

All the hardness values obtained from the heat-affected zone shall not exceed 100 HV with respect to the average hardness of the values obtained for the base metal. If these additional tests give hardness within the specification limit the slightly higher value may be accepted.

1.6 Charpy V-Notch Impact Test

- 1.6.1 Specimens shall be taken from the position indicated in Fig. 1 of this specification. The test specimens will be prepared in accordance with BS EN ISO 148-1:2009. Charpy V-Notch specimens shall have dimensions as given in Fig. 4 of the specification. Three test specimens shall be taken from each sample and they shall be cut and worked so that their length is transverse and perpendicular to the weld bead with the notch position as shown in Fig. 4 of this specification. The notch shall be perpendicular to the roller surface. The test specimen width shall depend upon the pipe wall nominal thickness as per the following table:

Nominal wall thickness (mm)	Test specimen width (mm)
Over 12	10
Over 9.5 and up to 12	7.5
From 7 up to 9.5	5
Less than 7	2.5

1.6.2 Test Method

The test shall be carried out as indicated in BS EN ISO 148-1:2009 or ASTM A 370-12a.

Test pieces shall be immersed in a thermostatic bath and maintained at the test temperature for at least 15 minutes. They shall then be placed in the testing machine and broken within 5 seconds of their removal from the bath. The test temperature shall be as mentioned in welding specification charts.

1.6.3 Requirements (Note 1)

The impact energy shall be as per the values given in the Welding Specification Charts for full-size test pieces. If subsize test pieces are used, the required minimum average (set of three test pieces) absorbed energy values shall be the required values for full-size test pieces times the ratio of the specified width of the subsize test piece to the specified width of the full-size test piece, with such derived values rounded to the nearest joule.

Note :

- (1) These values are specified for resistance to brittle fracture only. Where additional requirements are specified in project data sheet (Ex. pipeline materials with arrest properties i.e. a higher upper shelf charpy V energy for resistance against propagating ductile fractures) the same shall be followed.
- (2) Only one value is permitted to be lower than average value upto the value specified.

1.7 Bend Test Requirements

The Bend test Specimens shall be made and tested as per the requirements of API 1104 latest edition. The acceptance criteria shall however be as per para 5.6.4.3 and 5.6.5.3 of API 1104. However, the dimensions of the Jig for guided bend test in Figure 8 (of API 1104) shall be modified as specified below:

Radius of the Plunger 'A' = $2t$

Radius of the die. 'B' = $3t + 1.6 \text{ mm}$

Width of the die. 'C' = 50.8

where t = thickness of specimen

ANNEXURE – 2: ULTRASONIC TESTING

1.0 ULTRASONIC INSPECTION

In addition to the Radiography inspection, only mechanized UT which provides a permanent registration of the results (hard copy) shall be used. This section concerns manual Ultrasonic inspection. However Ultrasonic inspection by automatic equipment may be used if approved by the CLIENT.

1.1 GENERAL

The CONTRACTOR who carries out the Ultrasonic inspections shall have sufficient number of qualified personnel, equipment and instruments at his disposal to be able to effect the tests without hindering or delaying the pipeline assembly operations.

The CONTRACTOR appointed shall supply all the requisite instruments to carry out Ultrasonic inspection at site.

1.2 SPECIFICATION FOR ULTRASONIC TESTING PROCEDURE

The CONTRACTOR shall present a Specification describing the proposed Ultrasonic testing procedure qualification.

This specification shall state the following information including all the parameters described in API 1104 (latest edition):

- a) Type of Ultrasonic testing equipment to be used
- b) Type and dimensions of transducers
- c) Frequency range
- d) Details for calibration
- e) Coupling medium
- f) Inspection technique
- g) Reference to the welding procedure where it is intended to adopt the specification
- h) Temperature range of the joints to be inspected
- i) Record details.

1.3 QUALIFICATION OF ULTRASONIC TESTING PROCEDURE

Before the actual inspection begins, the CLIENT shall require the qualification test of the Ultrasonic testing procedure. The qualification test shall be conducted under normal operating conditions on some weld made by the CONTRACTOR according to the same production procedure, where there are typical defects are intended to be detected. The qualification test shall be conducted in the presence of the CLIENT's representative. The Ultrasonic inspection procedure shall be approved by the CLIENT.

1.4 TEST PROCEDURE

Circumferential welds shall be inspected from both sides using angle probes.

The surface with which the probe comes into contact shall be free of metal spatter, dirt, iron oxide, and scales of any type. Therefore, it shall be necessary to clean a strip at least 50 mm wide on both sides of the weld with steel-wire brushes. The cleaned strip must be at least wide enough to allow one and a half skip examination.

If echoes of doubtful origin appear during the test, it shall be necessary to inspect a convenient area on the pipe surface close to the weld, with a straight beam transducer in order to check whether any manufacturing defects are interfering with the ultrasonic beam.

The equipment shall include but not be limited to the following:

- a) Ultrasonic equipment and coupling medium
- b) Sample sections for calibration of instruments
- c) Equipment for cleaning of surface to be examined
- d) Rules calibrated in centimeters for exact location of the position of defects.

The characteristics of the above listed instruments and equipment shall guarantee:

- a) The required standards of the inspection procedure previously established and approved by the CLIENT are satisfied
- b) Continuous operation.

All the instruments and equipment shall be approved by the CLIENT before being used. The CLIENT has the authority to reject any item that is considered unsuitable. The decision of the CLIENT is final. The Agency/ CONTRACTOR appointed to carry out Ultrasonic inspections shall also ensure the operational efficiency and maintenance of the instruments and equipment, and shall immediately substitute any item rejected by the CLIENT.

All the instruments and equipment necessary for carrying out Ultrasonic inspection on site shall satisfy the requirements laid down by the public boards of institutions that regulate 'safety at work'.

1.5 ULTRASONIC INSTRUMENTS

The Ultrasonic instruments shall have the following:

- a) Pulse-echo type; able to generate, receive and display on the screen of a Cathode Ray Tube (CRT); pulse at frequencies between 1 and 6 MHz. The useful part of the CRT screen shall be at least 70mm wide and at least 50mm high.

Variable amplification, with steps of 1 or 2 dB over a range of at least 60 dB.

- b) The regulation control shall be accurate to within ± 1 dB and this accuracy shall be certified by the instrument manufacturer.
- c) May be powered by a battery or an electric generator. In the first case, the autonomy of operation (endurance) of the instrument shall be sufficient to carry out work without frequent interruptions, and the instrument shall be equipped with an automatic switch, which switches off when the battery runs down. In the second case, there must be a voltage stabilizing device with a tolerance of ± 2 volts.

1.6 PROBES

The probes used shall have dimensions, frequencies, and a refraction angle suited to the type of steel, the diameter, and the thickness of the pipeline and to the joint design.

1.7 REFERENCE SAMPLE PIECES

The efficiency of the equipment, the effective refraction angle of the probe, and the beam output point shall be checked using a V_1 and V_2 sample block, IIW type or the calibration block ASTM E428-08.

For manual Ultrasonic testing and automated Ultrasonic testing, the reference sample pieces shall be as described in API 1104 (latest edition).

1.8 CALIBRATION

The calibration, qualification of the testing procedure shall be done as provided in API 1104 (latest edition).

1.9 REGULATION OF AMPLIFICATION DURING PRODUCTION TESTING

Scanning sensitivity shall be as provided in API 1104 (latest edition).

1.10 QUALIFICATION OF ULTRASONIC TESTING OPERATORS

Before the actual inspection begins, the CLIENT shall require a qualification test for the ultrasonic equipment operators.

The operators shall be fully qualified as per a recognized standard (ASME Sec V or equivalent) and they shall have as minimum level II as described in para 11.4.3, API 1104 (21st edition) with addendum in place. The operators shall be able to:

- a) Calibrate the equipment
- b) Perform an operational test under production conditions
- c) Interpret the screen picture
- d) Evaluate the size and location of reflectors
- e) Interpret the type of defects detected.

The CLIENT has the option of checking the ability of personnel employed for Ultrasonic testing by means of qualification tests.

1.11 EVALUATION OF INDICATIONS GIVEN BY ULTRASONIC TESTING

Each time that echoes from the weld bead appear during production testing, the instrument amplification shall be altered to coincide with the reference amplifications and the probe shall be moved until maximum response is obtained, paying attention all the time to the probe-tube coupling.

If, under these conditions, the height of the defect echo is equal to or greater than that of the reference echo, the defect shall be evaluated according to the clause 12.3 of this specification. If the defect has also been detected by the Radiography and/or Visual examination, the dimensions shall be judged according to the type of examination that detects the greater defect. Returns that are less than 50% of the reference echo will not be considered. If returns are above 50% but lower than 100% of the reference echo, and if the operator has good reasons to suspect that the returns are caused by unfavorably oriented cracks, he shall inform the CLIENT. Moreover, when there is a defect to be repaired, such defect shall be removed for a length corresponding to the one where no more return echo is given.

1.12 OTHER EQUIPMENT

The use of rules calibrated in centimeters, attached to the probe is recommended for the precise location of the position of welding defects. Defect location is effected by measuring the projection distance between the probe output and the reflecting surface.

The operators carrying out the tests may require other equipment besides the probing instrument, tools for cleaning the pipe surface viz. files, brushes etc., and coupling liquid or paste appropriate for the temperature of the section to be examined.

ANNEXURE-3: RADIOGRAPHY

1.0 SCOPE

This annexure covers the radiographic inspection of all types of welded joints of the main pipeline.

The welded joints shall include the following:

- i) Full girth welds on the mainline construction including double jointing of pipe, if adopted.
- ii) Welds for installation of block valves, insulating joints and other appurtenances and tie-ins.
- iii) Welds at scraper launching and receiving barrels.
- iv) Terminal Piping

2.0 APPLICABLE STANDARDS

This specification shall apply in conjunction with the following (all latest edition):

- i) API 1104, Standard for welding Pipelines and Related Facilities
- ii) ANSI B 31.8, Code for Gas Transmission and Distribution Piping Systems.
- iii) ANSI B 31.4, Code for Transportation System for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia and Alcohols.
- iv) ASTM E94 - 04(2010) Standard Guide for Radiographic Examination
- v) The American Society for Nondestructive Testing. Recommended Practice No. SNT-TC-1A Supplement A.
- iv) DIN EN 462-1:1994-03: Non-destructive testing-Image quality of Radiographs-Part 1: Image quality Indicators (wire type)- Determination of image quality value.

3.0 PROCEDURE

- 3.1 The radiographic examination procedure to be adopted shall be submitted by the CONTRACTOR as per Exhibit-F.
- 3.2 The procedure of radiographic examination shall be qualified to the entire satisfaction of CLIENT prior to use. It shall include but not be limited to the following requirements:
 - i) Lead foil intensifying screens, at the rear of the film shall be used for all exposures.
 - ii) Type 2 and 3 films as per ASTM E94-04(2010) shall be used.
 - iii) A densitometer shall be used to determine film density. The transmitted film density shall be between 2.0 and 3.5 throughout the weld. The unexposed base density of the film shall not exceed 0.30.
 - iv) Radiographic identification system and documentation for radiographic interpretation reports and their recording system.
- 3.3 The CONTRACTOR shall qualify each procedure in the presence of the CLIENT prior to use.
- 3.4 The procedure of radiographic examination shall produce radiographs of sufficient density, clarity and contrast so that defects in the weld or in the pipe adjacent to the weld, are clearly discernible.
- 3.5 One Check shot of the full joint on main line welds shall be taken per 100 circumferential welds or one per day of the production whichever is more for cross checking the correctness of the radiographs of weld joints executed by the contractors. For taking

check shots on completed/accepted sections, contractor has to separately mobilize either internal crawler/external X-ray unit, as appropriate.

- 3.6 All the girth welds of mainline shall be subjected to 100% radiographic examination. The CONTRACTOR shall furnish all the radiographs to the CLIENT, immediately after processing them, together with the corresponding interpretation reports on approved format. The details of the radiographs along with the joint identification number shall be duly entered in a register and signed by the CONTRACTOR and submitted to the CLIENT for approval.
- 3.7 When the radiation source and the film are both on the outside of the weld and located diametrically opposite each other, the maximum acceptable length of film for each exposure shall not exceed the values given. The minimum film overlap, in such cases, shall be 40mm. The ellipse exposure technique may be used on nominal pipe sizes of 2 inch and smaller provided that the source of film distance used is a minimum of 12 inch.
- 3.8 Three copies of each acceptable radiographic procedure (as per Exhibit-F) and three copies of radiographic qualification records, shall be supplied to CLIENT. One set of the qualifying radiographs on the job shall be kept by the CONTRACTOR's authorized representative to be used as a standard for the quality of production radiographic during the job. The other two sets shall be retained by CLIENT for its permanent record.
- 3.9 Three copies of the exposure charts relating to material thickness, kilo voltage, source of film distance and exposure time shall also be made available to CLIENT by the CONTRACTOR.
- 3.10 The CONTRACTOR shall, on a daily basis, record for each radiograph (1) radiograph's number, (2) approximate chainage of weld location, (3) whether or not the welds meet the specified acceptance standards and (4) the nature and approximate location of unacceptable defects observed. It must be possible to relate back to a particular butt weld and welder on piping drawing and pipeline alignment drawing.
- 3.11 Each day's production of processed radiographs shall be properly packaged separately, identified by at least the (1) date, (2) radiographic unit, (3) job locations, (4) starting and ending progress survey stations and (5) shall include original and three copies of the daily radiographic record. The package shall be submitted to the CLIENT daily when possible, but in no event later than noon of the following day.
- 3.12 The CONTRACTOR shall provide all the necessary facilities at site, such as a dark room with controlled temperature, film viewer etc. to enable the CLIENT to examine the radiographs.
- 3.13 The CONTRACTOR, if found necessary, may modify the procedure of radiographic examination suiting to the local conditions prevailing. This shall, however, be subject to the approval of the CLIENT.
- 3.14 CLIENT shall have free access to all the CONTRACTOR's work facilities in the field.
- 3.15 Any approval granted by the CLIENT shall not relieve the CONTRACTOR of his responsibilities and guarantees.

4.0 RADIATION SOURCE

- 4.1 Radiographic examination shall be carried out using X-radiations; radiographic examination by Gamma rays using slow speed films may be allowed, at the discretion of the CLIENT, in case of inaccessible joints. Radiography by Gamma ray for tie-in-joints shall be acceptable provided Type I of ASTM E1815-08 film or equivalent is used and the required sensitivity obtained.

- 4.2 Whenever possible, pipeline welds will be inspected by placing the radiation source inside the pipe, on the pipeline axis, with a radiation of 6.28 red. (360).

If it is impossible to place the radiation source inside the pipe, the weld will be inspected with the source on the outside. An overlap of at least 40 mm at the ends of each film shall be required to ensure that the first and last location increment numbers are common to successive films and to establish that no part of a weld has been omitted.

5.0 LEVEL OF QUALITY

The quality level of Radiographic sensitivity required for radiographic inspection shall be at least equivalent to the values in Figure-5.

6.0 PENETRAMETERS

The Image Quality Indicator (IQI) shall be used for the qualification of the welding procedure and during normal line production. Radiography sensitivity shall be measured with the wire image quality indicator (Penetrameter). The Penetrameter shall be selected according to DIN EN 462-1:1994-03 or ISO 19232-1:2004. For radiographs made with the source on the outside, a Penetrameter shall be placed on each side of the film with the smaller wire of the Penetrameter turned towards the end of the film itself. When a complete weld is radiographed in a single exposure using a source inside the piping, four penetrameters approximately equally spaced around the circumference shall be used. During the procedure qualification, IQI shall be placed both on the source side and on the film side. The sensitivity obtained with IQI on the source side shall not be less than the values shown in Figure 5 of this specification.

The sensitivity limit may be considered to have been reached when the outline of the IQI, its identification number and the wire of the required diameter show up clearly on the radiograph.

The CLIENT may authorize use of types of IQI other than those planned, provided that they conform with recognized standards and only if the CONTRACTOR is able to demonstrate that the minimum sensitivity level required is obtained. For this demonstration, a test shall be carried out comparing the IQI specified and the CONTRACTOR's to show up the identification number and other details of the proposed IQI, which must be visible in the test radiograph.

7.0 FILM IDENTIFICATION MARKERS

All films shall be clearly identified by lead numbers, letters, and/or markers. The image of the markers shall appear on the films, without interfering with the interpretation. These markers positions shall also be marked on the part to be radiographed and shall be maintained during radiography.

8.0 PROTECTION AND CARE OF FILM

- 8.1 All unexposed films shall be protected and stored properly as per the requirements of API 1104 standard and ASTM E94-04(2010).
- 8.2 The exposed and unexposed film shall be protected from heat, light, dust and moisture. Sufficient shielding shall be supplied to prevent exposure of film to damaging radiation prior to and following the use of the film for radiographic exposure.

9.0 RE-RADIOGRAPHY

- 9.1 The weld joints shall be re-radiographed in case of unsatisfactory quality of the radiographs, at the expense of the CONTRACTOR.
- 9.2 All the repaired weld joints shall be re-radiographed at no extra cost to the CLIENT in the same manner as that followed for the original welds. In addition, the repaired weld

areas shall be identified with the original identification number plus the letter R to indicate the repair.

- 9.3 When evaluating repair film, radiographers shall compare each section (exposure) of the weld with the original film to assure repair was correctly marked and original defect removed.
- 9.4 The CLIENT will review prior to any repair of welds, all the radiographs of welds that contain, according to the CONTRACTOR's interpretation, unacceptable defects. The final disposition of all unacceptable welds shall be decided by the CLIENT.

10.0 QUALIFICATION OF RADIOGRAPHERS

- 10.1 Pipeline radiographers shall be qualified in accordance with the requirement of API 1104 and to the full satisfaction of CLIENT.
- 10.2 Certification of all the radiographers, qualified as per 10.1 above, shall be furnished by the CONTRACTOR to the CLIENT before a radiographer will be permitted to perform production radiography. The certificate record shall include:
- i) Background and Experience Record
 - ii) Training Course Record
 - iii) Technical Examination Record
 - iv) Doctor's report on radiographer's Jacque 0-1 acuity eye test
 - v) Date of qualification
- 10.3 The radiographers shall be required to qualify with each radiographic procedure they use, prior to performing the work assigned to him in accordance with the specification.

11.0 PRESERVATION OF RADIOGRAPHS

- 11.1 The radiographs shall be processed to allow storage of films without any discoloration for at least three years. All the radiographs shall be presented in suitable folders for preservation along with necessary documentation.
- 11.2 All radiographs shall become property of the CLIENT.

12.0 EQUIPMENT AND ACCESSORIES

- 12.1 CONTRACTOR shall make necessary arrangements at his own expense, for providing the radiographic equipment, radiographic films and all the accessories for carrying out the radiographic examination for satisfactory and timely completion of the job.
- 12.2 For carrying out the mainline radiographic examination the CONTRACTOR shall be equipped with suitable mobile/stationary type dark rooms.

These shall have all the required facilities for film processing. Film viewer used shall be equipped with the film illuminator that has a light source of sufficient intensity and suitably controlled to allow viewing film densities up to 4.0 without damaging the film.

13.0 RADIATION PROTECTION

- 13.1 CONTRACTOR shall be responsible for the protection and personnel monitoring of every man with or near radiation sources.
- 13.2 The protection and monitoring shall comply with local regulations.
- 13.3 In view of visual hazards in the handling of Radioactive source of material, CONTRACTOR shall be solely responsible for complying with all rules and regulations set forth by Atomic Energy Commission or any other Government agencies of India in this regard and CLIENT shall not be responsible and shall be kept indemnified by the CONTRACTOR for default (s) of whatever nature by the CONTRACTOR. Safety equipment as considered adequate by the CLIENT for all necessary personnel shall be

made available for use and maintained for immediate and proper use by the CONTRACTOR.

14.0 DISPLAY OF SAFETY INSTRUCTIONS

- 14.1 The safety provisions shall be brought to the notice of all concerned by display on a notice board at prominent place at the work spot. The person responsible for the "Safety" shall be named by the CONTRACTOR.

15.0 ENFORCEMENT OF SAFETY REGULATIONS

- 15.1 To ensure effective enforcement of the rules and regulations relating to safety precautions, the arrangement made by the CONTRACTOR shall be open to inspection by CLIENT or its representatives.

16.0 FIRST AID AND INDUSTRIAL INJURIES

- 16.1 CONTRACTOR shall maintain first aid facilities for its employees and those of sub-contractors.
- 16.2 CONTRACTOR shall make outside arrangements for ambulance service and for treatment of industrial injuries. Names of those providing these services shall be furnished to CLIENT prior to start of work and their telephone no. Shall be posted prominently in CONTRACTOR'S field office.
- 16.3 All critical industrial injuries shall be reported promptly to the CLIENT and a copy of CONTRACTOR's report covering each personal injury requiring the attention of physician shall be furnished to the CLIENT.

17.0 NO EXEMPTION

Notwithstanding the above there is nothing in these to exempt the CONTRACTOR from the operation of any other act or rules in force.

EXHIBIT - A

Sheet 1 of 3

ELECTRODE QUALIFICATION TEST RECORD

A. Tested at (Site name) Date:

Manufacturer's Name :

Brand Name:

Batch Number & Size tested :

Classification & Code :

Intended for welding in position :

In combination with (if any) :

Code of Reference (used for testing) :

Special Requirements (if any) :

B. All-weld Tensile Test

Base Material used :

Pre-heat temperature :

Post weld heat treatment details :

Visual examination :

Radiographic examination results :

Tensile test results :

Identification No.	U.T.S.	Yield Point	Elongation	Remarks
1.				
2.				

EXHIBIT - A

Sheet 2 of 3

C. Impact Test Results

Test Temperature : Notch in :
Type of Specimens (Charpy) : Size of Specimens :

Specimen No.	Impact Value	Average
1		
2		
3		
4		
5		

D. Chemical Analysis Results

Electrode Size Result :
Batch No. :

% C	%S	% P	% Si	% Mn	% Cr	%Ni	%Mo	Other

E. Fillet Weld Test Results :

Welding Positions :
Base Materials :
Size of electrode used :
Visual Inspection Results :
1)
2)
3)

EXHIBIT - A

Sheet 3 of 3

Macro Test Results :

Fracture Test Results

Remarks :

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
(CLIENT)

EXHIBIT - B

Sheet 1 of 1

STRESS RELIEF HEAT TREATMENT PROCEDURE SPECIFICATION

Name of the Heat-treater :

Name of the Project :

Specification Reference No.

1. General Detail:

Name of the Equipment:
Gas/Oil/Elect.

Name of the Assembly/Part:
:

Drawing No:

Material:

2. Furnace Details

Type of Heating :

Res./Induction Type of Heating

Capacity (Size) :

Maximum Temp.(C) :

Method of temp. Measurement

Atmosphere Control :

3. Heat Treatment Cycle Details :

Charging Temp. C

Rate of heating, C/Hr

Soaking Temp. C

Soaking Time, hrs.

Rate of Cooling, C/Hr.

Mode of Cooling

4. Other Details, if any :

Notes:

The following documents shall be furnished along with the specifications:

- i) Material test certificates
- ii) Assembly/Part Drawing.

PREPARED BY
(CONTRACTOR)

REVIEWED BY
(CONTRACTOR)

APPROVED BY
(CLIENT)

EXHIBIT - C

Sheet 1 of 3

Example of record form for welding procedure qualification test

Project/ Contract	Contractor			
Pipe and fitting material				
Process				
Outside diameter				
Pipe thickness				
Joint design (Sketch attached)				
	Make and type of filler metal	Diameter	Current	Voltage
Root				
Second run				
Other runs				
Other characteristics	electrical	a.c/d.c	Electrode negative/Positive	
Shielding gas				
Type of mixture				
Flow				
Shielding flux				
Position				
Direction of welding	:			
Root	:	Vertical up*/ Vertical down		
Second run	:	Vertical up*/ Vertical down		
Other runs	:	Vertical up*/ Vertical down		
Number of welders	:			
Root				
Second run				
Other runs				

EXHIBIT - C

Sheet 2 of 3

Time lapse between commencement of second
run and commencement of other runs

Minimum number of runs before joint allowed
to cool

Maximum time between commencement and
completion of weld

Type of line-up clamp

Removal of clamp after run

Lowering off after run

Cleaning

Preheating

Minimum temperature C Ambient
temperature C

Type of heater to be used

Interpass temperature

Minimum C Maximum C

Post weld heat treatment

Speed of travel

Test Results

State acceptable 'non-acceptable (with
reasons) or give numerical results

Non-destructive tests

Visual

Radiograph

EXHIBIT – C

Sheet 3 of 3

Destructive tests	1	2	3	4
Transverse tensile				
Tensile strength (with units)				
Fracture location				
Test temperature				
Macro-examination				
Fillet weld fracture				
Hardness survey :				
Type				
Hardness range :				
Parent metal				
Heat affected zone				
weld				
Charpy V-notch impact tests				
Specimen location and size				
Notch location				
Test temperature				
Results (with units)				

Additional test(s) and results. e.g. chemical analysis, micro-examination, CTOD tests, Bend tests, Nick Break test.

The statements in this record are correct. The test joints were prepared, welded and tested in accordance with the requirements of specification.

Contractor

Inspector

Position

Witnessed by

Date

Date

EXHIBIT - D

Sheet 1 of 1

Example of record form for welder qualification test

Welder test certificate	Test no.
Project/Contract	Date
Contractor	Inspector
Welder's name	
Address	
Pipe material	
Pipe thickness	
Pipe outside diameter	
Welding process	Root
	Fill and cap
Electrode/wire	
Root Current	Voltage
Second run	Current Voltage
Fill and cap	Current Voltage
Direction of travel	Root : Vertical up*/ Vertical down
down	Fill and cap : Vertical up*/ Vertical
Reason for failure	
Visual	
Non-destructive testing	
Butt joint	
Fillet weld	
`Number of attempts	
Comments	
Accepted date/Time	Signed by Contractor
	Signed by Inspector

*Delete as necessary

EXHIBIT - E

Welder's Identification Card

Name	:	
Identification	:	Photograph
Date of Testing	:	
Valid till	:	
Approval of Welding	:	
Welding Position	:	
Material	:	
Diameter	:	
Diameter range approved	:	
Wall thickness	:	
Thickness range approved	:	
Type of welding consumables	:	

Approved by :
with seal

Employers' Signature

EXHIBIT - F

Sheet 1 of 1

Radiographic Procedure for Pipe Welding

1. Location
2. Date of Testing
3. Name of Supervised Contractor
4. Material
5. Dia & Thickness
6. Type of weld joint
7. Radiation Source (X-ray, iridium)
8. Type of equipment (External/Internal)
9. Intensifying screens and material
10. Filter type and placement mask, Diaphragm Lead screen etc. adjacent to radiation source or specimen.
11. Exposure Geometry (Source focal spot size, object to film distance, radiation angle with respect to weld and film).
12. Limit of film coverage
13. Film type and make
14. Exposure Conditions (ma, KV, time)
15. Processing (time temperature for development stop bath or rinse, fixation, washing, drying etc.)
16. Density
17. Sensitivity
18. Type of penetrameter
19. Essential wire to be seen on source side:
20. Essential wire accepted for film side viewing:

Approval of the CLIENT

Signature of CONTRACTOR with
seal

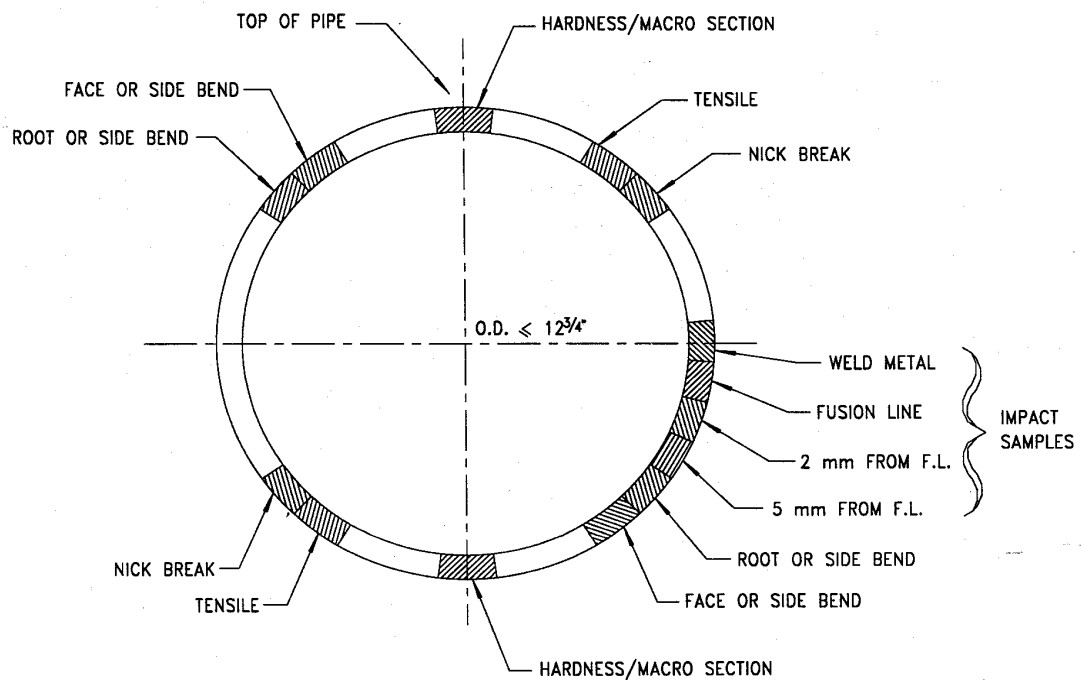


FIGURE 1. LOCATION OF SPECIMENS FOR WELD PROCEDURE
QUALIFICATION FOR PIPE DIA. $\leq 12\frac{3}{4}$ "

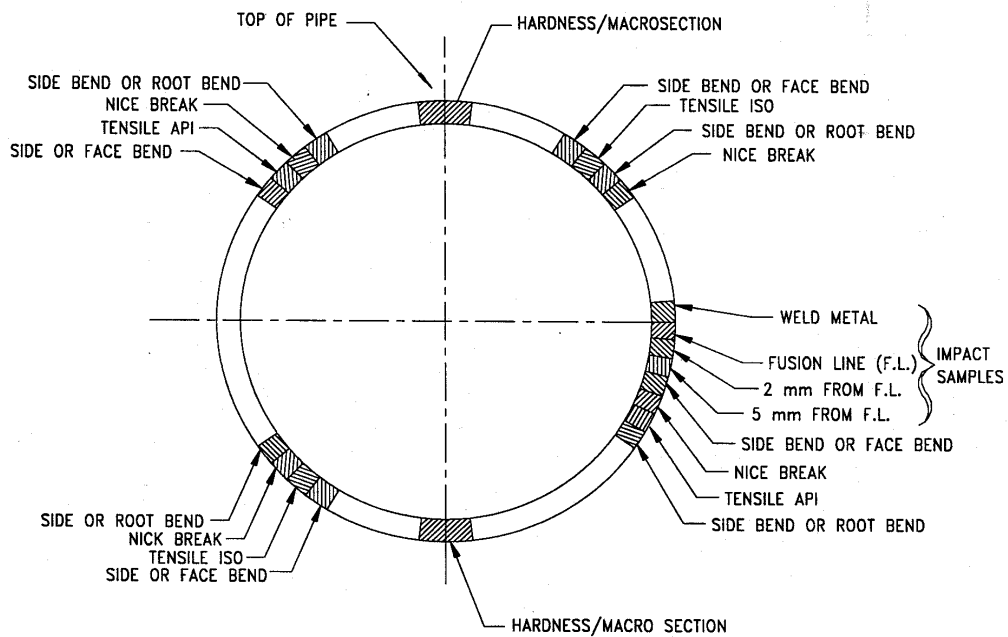


FIGURE 1A. LOCATION OF SPECIMENS FOR WELD PROCEDURE
QUALIFICATION FOR PIPE DIA. $\geq 12\frac{3}{4}$ "

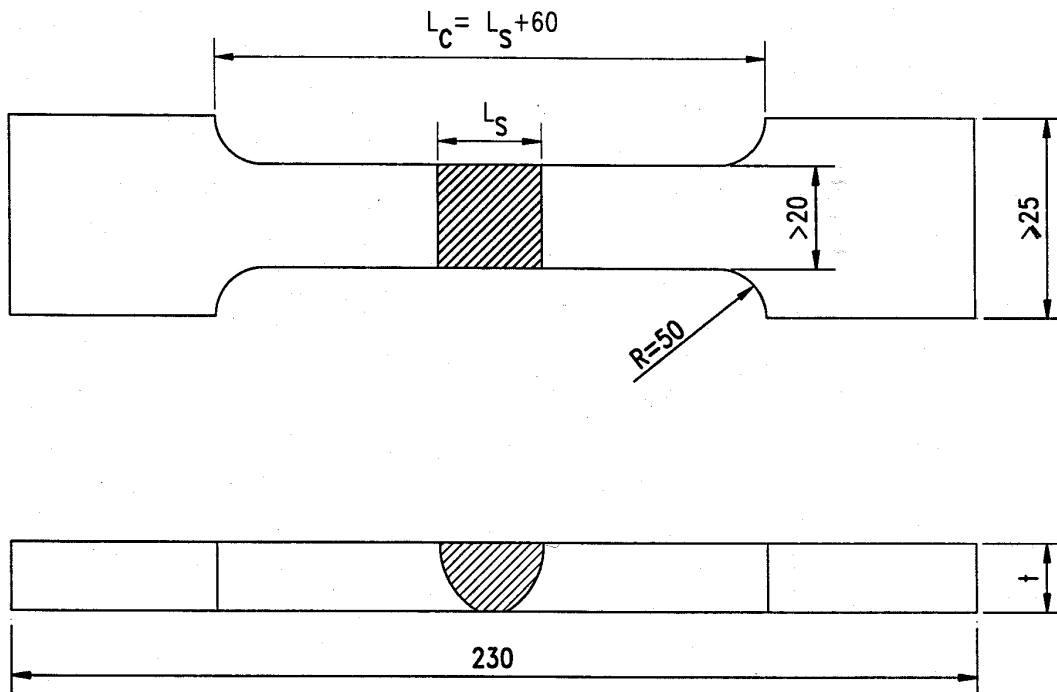


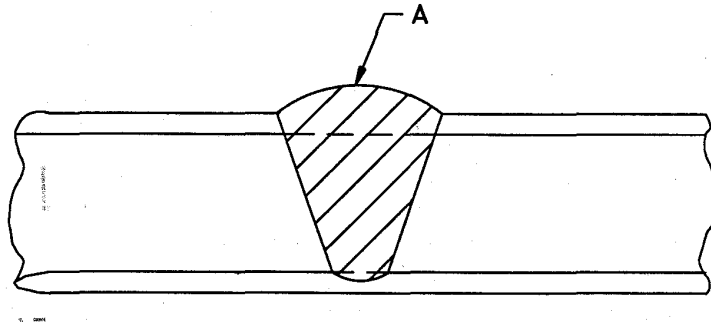
FIGURE 2. ISO TENSILE TEST SPECIMEN

LEGEND

t = PIPE WALL THICKNESS

L_S = WELD WIDTH AFTER LEVELLING

L_C = LENGTH OF PARALLEL EDGES



HARDNESS TESTING – BUTT WELDS

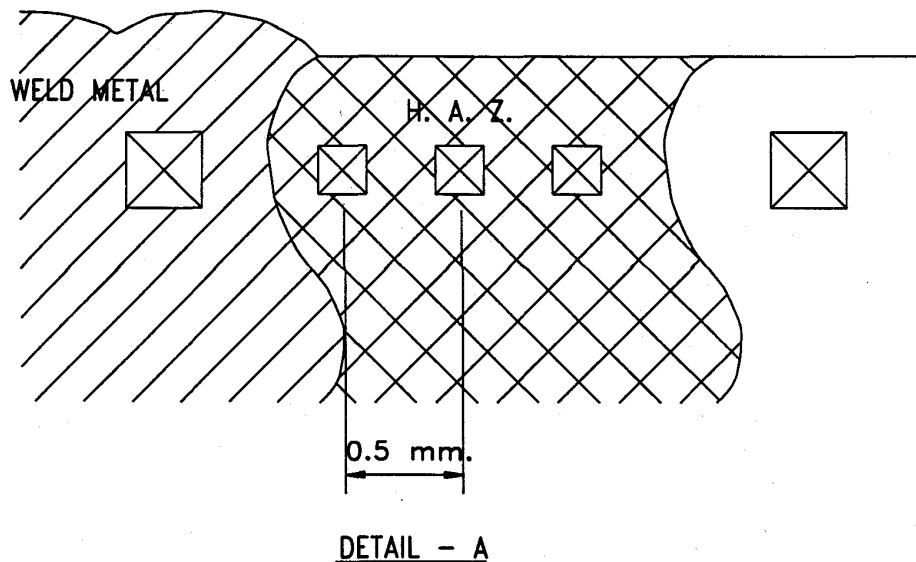
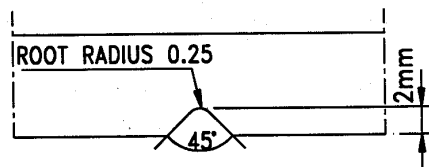
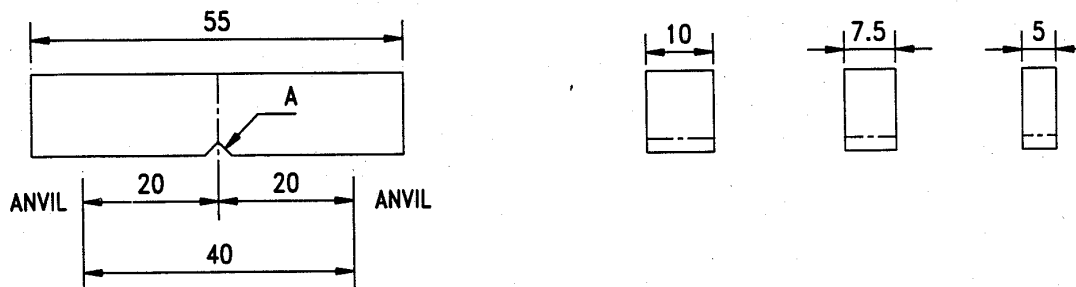
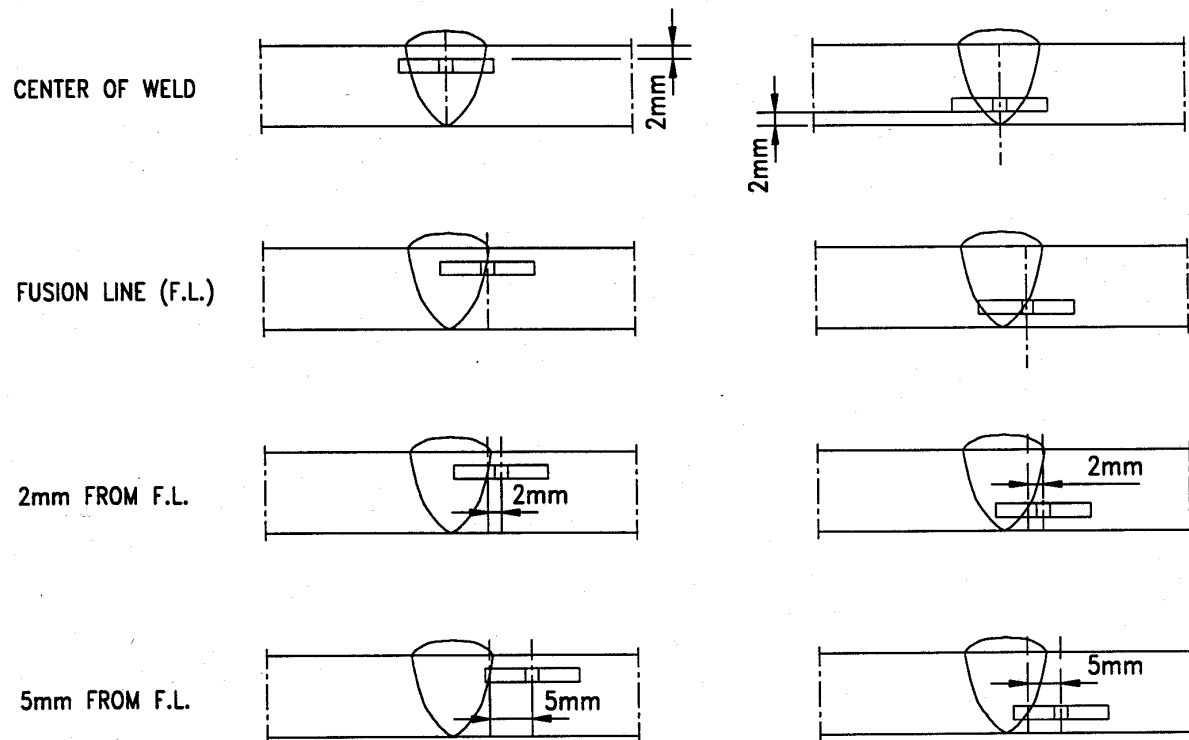


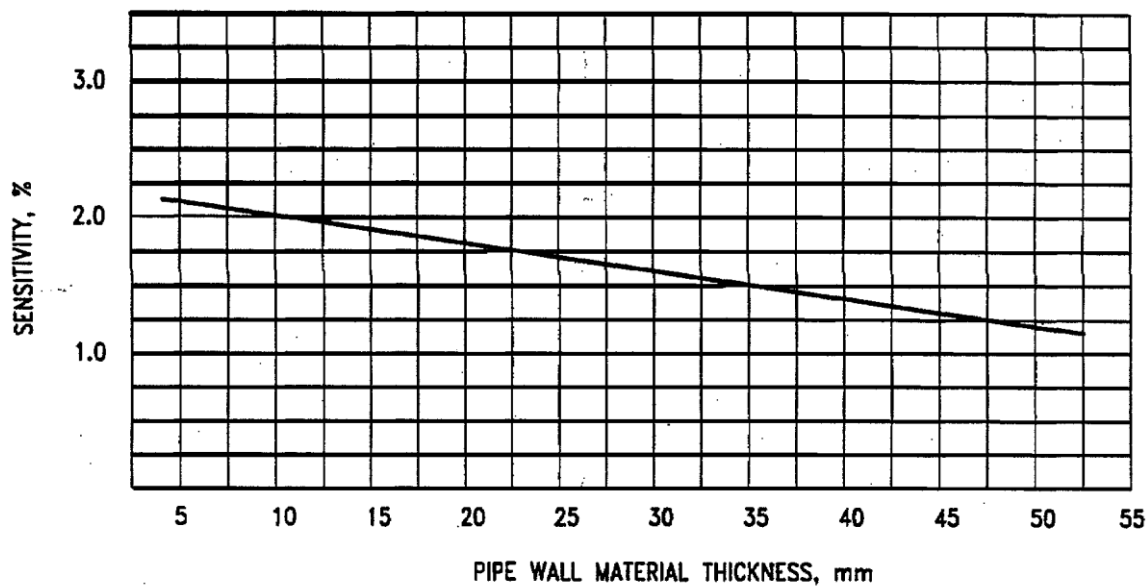
FIGURE 3. HARDNESS TESTING OF WELD JOINTS – SCHEMATIC

NOTCH POSITIONS



DETAIL-A

FIG.4. CHARPY V – NOTCH TEST SPECIMEN



NOTE

FOR PRODUCTION RADIOGRAPHY, SENSITIVITY READINGS BASED ON FILM SIDE PENETRAMETERS ARE TO BE JUDGED AS PER RESULTS FROM THE PROCEDURE QUALIFICATION WITH PENETRAMETER PLACED ON THE SOURCE SIDE.

Figure 5