



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 421

**Site welding of carbon steel pipelines to API 1104
(Intermediate and Severe Sour Service)**

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1. Scope

This specification defines the COMPANY general requirements for the field welding and inspection of transmission pipelines operating in Intermediate or Severe Sour Service as defined in specification **GS COR 170**.

It applies to butt welding (including tie-ins), fillet welding and socket welding of line pipes, bends, flanges, branch outlet fittings and other fittings in carbon steel and low alloy steel, with a minimum specified yield strength not exceeding 65,000 psi (448 MPa), during onshore or offshore installation of the said pipelines.

Branches made of pipes directly welded to main pipeline are not normally used and shall be subject to special agreement of COMPANY (see § 10.9 of this specification).

Due to the presence of sour effluent, all welds shall have a good resistance to any kinds of H₂S embrittlement.

This specification shall be used in conjunction with a Project Particular Specification (PPS) to be made for purpose detailing the additional tests and requirements or the possible modifications to the present specification, based on the special design conditions of the pipeline project.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

The work shall satisfy the requirements of **ANSI B 31.4** or **B 31.8**, where applicable.

Welding shall be carried-out to **API 1104** and the amendments contained in this specification.

Should omissions or ambiguity or incorrect information exist, they shall be notified as soon as possible by CONTRACTOR to COMPANY, and COMPANY shall have the right of final decision.

All codes, specifications, standards and other documents which are referenced in this specification are listed hereafter.

The order of precedence of the applicable documents shall be:

- The Contract
- The Project Particular Specification (PPS)
- The present General Specification
- The codes and standards in reference.

Unless otherwise specifically indicated in writing by the COMPANY, the CONTRACTOR shall work in accordance with the requirements specified herein and the applicable requirements of the latest editions at date of contract award of the referenced Codes and Standards, whenever requested in the present specification.

Note: The specification **GS COR 170** is mentioned herein only as a background to the definition of the types of sour services (i.e. Intermediate Sour Service or Severe Sour Service) and corresponding “areas” on graph of the said specification (i.e. area 2 or 3).

Standards

Reference	Title
ISO 1027	Radiographic image quality indicators for non-destructive testing
ISO 1106-1/2/3	Recommended practice for radiographic examination of welded joints
ISO 2504	Radiography of welds and viewing conditions for films
ISO 5579	Radiographic testing of metallic materials by X and gamma-rays
ISO 7539	Corrosion of Metals and Alloys – Stress Corrosion Testing
ASTM E 384	Test Method for Micro hardness of Materials
ASTM E 709	Magnetic particle Examination
ASTM A 578	Straight Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Application
ASTM E 23	Notched Bar Impact Testing of Metallic Materials
ASTM A 370	Mechanical Testing of Steel Products
ASTM G 39	Practice for Preparation and Use of Bent-Beam Stress Corrosion Test Specimens
BS 4365	Industrial Argon
BS 4105	Liquid Carbon Dioxide: Industrial
BS 7448	Fracture mechanics toughness tests
EN 473	General principles for qualification and certification of NDT personnel
EN 10204	Types of inspection documents

Professional Documents

Reference	Title
API 1104	Standard for Welding Pipelines and Related Facilities
NACE TM 01-77	Laboratory Testing of Metals in H ₂ S Environments
EFC Publication n° 16	Guidelines on material requirements for carbon and low alloy steels for H ₂ S containing environments in oil and gas production
NACE TM0284	Evaluation of Pipeline and Pressure Vessel Steel for Resistance to Hydrogen-Induced Cracking
NACE MR0175	Sulfide Stress Cracking Resistant Metallic Material for Oilfield Equipment

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
B 31.4	Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols
B 31.8	Gas Transmission and Distribution Piping Systems
AWS/ASME Section II, Part C	Boiler and Pressure Vessel Code

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS COR 170	Materials for sour service (Upstream Applications). Specification for design
GS PLR 211	Fabrication of seamless pipes for pipelines (Intermediate and Severe Sour Service)
GS PLR 212	Fabrication of longitudinally submerged arc welded pipes for pipelines (Intermediate and Severe Sour Service)
GS PLR 231	Induction bends for pipelines (Intermediate and Severe Sour Service)
GS PLR 232	Carbon steel flanges and branch outlet fittings for pipelines (Intermediate and Severe Sour Service)
GS PLR 233	Carbon steel tees for pipelines (Intermediate and Severe Sour Service)

3. General

3.1 Definitions

Definition of terms are those stated in [API Std 1104](#), with additions and modifications given in the following.

- **Inspector** COMPANY'S authorized representatives or members from COMPANY elected inspection agencies for the time being or from time to time duly appointed in writing by the COMPANY to act as its representative for the purpose of the contract shall be referred to herein as the "INSPECTOR".
- **PPS** This designates the Project Particular Specification as defined in section 1 above.
- **Site** This term designates the sites, workshops, worksites, barges, ships or other locations where the prefabrication, welding and installation of the pipeline is performed complete or in part.
- **Approval** Authorisation in writing given by COMPANY to CONTRACTOR to proceed with the performance of a specific part of the work without releasing in any way CONTRACTOR from its obligations and liabilities under the contract or at law. Approve, Approved and Approval shall be construed accordingly.

3.2 Project Particular Specification (PPS)

The following information shall be provided in the PPS:

1. Clarification on the details of end bevels of free issued products (e.g. when they are different from those stated in General Specifications or related PPS) (refer to section 5).
2. Materials ordered with a simulated PWHT (if any) (refer to section 5).
3. Impact test temperature(s) and impact test absorbed energy requirement for WT above 20 mm (where needed) (refer to § 8.4.2.8).
4. CTOD test temperature (when required) (refer to § 8.4.2.9).
5. The sour service severity and pipeline effluent to clarify the H₂S test conditions (refer to § 8.4.2.12 and Appendix 10).

The PPS shall include the pipeline Data Sheet, if it is not included elsewhere in any other Project specification.

4. Quality Control/Quality Assurance

4.1 Quality Control

Responsibility for quality control shall rest with the CONTRACTOR aided by such staff as may be required.

Four weeks prior to commencement of any work the CONTRACTOR shall prepare and submit a Quality Control Plan which describes the systematic control of the construction, inspection and testing, as dictated by the overall contract quality programme. The Quality Control Plan shall set forth "witness", "hold", "review" and "monitor" points.

Regarding inspection, the Quality Control Plan shall include:

- A flowchart illustrating each inspection point and its relative location in the procedure cycle, where conformance of characteristics is verified

- The characteristics to be inspected at each inspection point, the procedures and acceptance criteria to be used. The procedures shall be provided to the COMPANY, as requested
- Copies of specific forms used by CONTRACTOR to record the results of each inspection.

The CONTRACTOR shall maintain quality records as documentary evidence of compliance with quality requirements. Quality records shall be available to the Inspector for analysis and review.

All CONTRACTOR inspection systems shall be subject to evaluation and checks by the Inspector to ensure that the system is effectively applied and meets the requirements of this specification.

The CONTRACTOR shall employ competent supervisors to ensure that both the standard of workmanship and the quality of materials used comply with the requirements of this specification.

4.2 Quality Assurance

The CONTRACTOR shall operate a Quality Assurance system in accordance with [ISO 9002 Std](#), or equivalent, approved by a COMPANY recognised authority. The Quality assurance Manual shall be submitted prior the start of work.

5. Base materials

Pipes and fittings supplied by COMPANY are defined in COMPANY General Specifications listed in section 2 of this specification, and in related PPS.

Unless otherwise stated in the PPS, pipes and fittings supplied by COMPANY will be finished with ends bevelled (refer to line pipe specifications of the order). If the CONTRACTOR elects to weld the pipes using a bevel design different from the one supplied, then rebeveling shall be made by CONTRACTOR.

When Post Weld Heat Treatment (PWHT) is to be applied to certain weldments, the related welded materials must have been previously tested (e.g. at time of materials order) for tensile and toughness properties after performance of the said PWHT.

6. General welding requirements

6.1 Standards

Welding requirements shall be in accordance with the requirements of [API Std 1104](#) as modified by the present specification.

The requirements of this specification shall prevail over those of [API Std 1104](#) and where this specification states no overriding requirements, those of [API Std 1104](#) apply in full.

6.2 Electrodes, filler wires and fluxes

1. All welding consumables shall conform to ASME/AWS, Section II, Part C or approved equivalent standard.
2. SAW flux procurement, packing, storage and use shall comply to the requirements of the relevant appendix attached to the present specification.

3. Each heat, lot (or so called batch herein) of consumables shall be subject to inspection and approval by the Inspector. 3.1.b (according to EN 10204 Std) Mill test certificates from consumables manufacturers showing test results actually obtained on the said lot shall be submitted to the Inspector.

The lot and the level of testing are specified as per AWS A5.01-93 as follows:

- covered electrodes: class C5
- bare solid electrodes and rods: class S3
- flux cored electrodes and metal cored electrodes and rods: class T3
- flux for submerged arc welding: class F2

The level of testing shall be schedule I as a minimum.

In addition, for SAW flux, testing of granulometry and testing of diffusible hydrogen and / or moisture, shall be required

4. All welding consumables shall be supplied in sealed, dirt and moisture proof containers. Unopened containers shall be stored in a dry location where a temperature of 20°C and humidity of less than 40% are maintained.
5. The nickel content in consumables shall not exceed 1.0 percent. The use of C-0.5 Mo consumables is not permitted.
6. All welding consumables shall, as a minimum, be stored and handled in accordance with the written manufacturer's recommendations. CONTRACTOR's procedure relative to storing handling, drying, recycling and traceability of consumables shall be approved by the Inspector before commencement of production welding.
7. Each tin or packet of electrodes, or reel of filler wire and bag of flux shall be clearly marked with the respective batch no. In the event of consumables being unmarked or showing signs of deterioration or other damage, they shall be discarded.
8. Each batch of welding consumables shall be subject to welding tests. Test procedure (namely, weld preparation, chemical analysis, mechanical tests, etc.) shall be proposed by CONTRACTOR and approved by Inspector. On special occasions, this requirement may be waived if further impact tests from the qualification test weld still meet the required absorbed energies specified values when tested 10°C below the specified routine test temperature. All batch testing shall be completed prior to the start of field welding. No retests shall be permitted unless an explanation for the failure is accepted by the COMPANY.

For automatic welding processes, impact tests for each batch of consumables shall be performed under the same conditions and with the same equipment as used for the relevant approved welding procedure.

9. The weld deposits obtained from these consumables shall satisfy the impact toughness, CTOD (when required) and hardness requirements of this specification and shall have a tensile strength that does not overmatch that of actual line pipes or fittings of the job by more than 30%, with YS to TS ratio of weld metal not exceeding 0.90.

All these properties shall be verified during the welding procedure qualification tests or batch testing.

10. Cellulosic coated electrodes shall not be permitted when the required impact test temperature is lower than -20°C.

6.3 Shielding gas

The requirements of **API 1104** shall apply.

6.4 Welding process

1. Gas Tungsten Arc Welding (GTAW) and Shielded Metal Arc Welding (SMAW) processes are approved for use.
2. Automatic and semi-automatic welding systems may be offered where the CONTRACTOR can give evidence of long and successful practice of the system on similar jobs and requirements, to the satisfaction of COMPANY. Otherwise, the COMPANY will specify special welding and NDT trials, to be completed successfully, before the proposed technique can be approved to proceed for the qualification testing.
3. FCAW process shall be thoroughly controlled at all times by CONTRACTOR to avoid any excessive scatters in the mechanical properties (and specially impact properties) of weld deposits. In that view, mechanical test results of qualification test welds shall show sufficient safety margins against requirements of this specification. The COMPANY reserves the right to reject such a process when its reliability is not satisfactory.
4. Only Gas Tungsten Arc Welding process (GTAW) shall be used for pipe diameters less than 2" 3/8 (60 mm).
5. Basic coated low hydrogen electrodes shall be used for all fillet welds.
6. In each case where a semi-automatic and/or automatic welding process or system is approved for use, a manual welding procedure shall be qualified as back up. This requirement may be waived for automatic welding only when CONTRACTOR can give evidence of successful past experience and when so specially agreed with COMPANY at the bid stage.
7. Welding processes for anode connecting welds or any other welds to electrically connect attachments (see § 8.6) shall have prior approval of COMPANY.
8. On steel grade X60 and above, cellulosic-coated electrodes shall be permitted only for the first pass (penetration pass). Moreover, whatever the steel grade, the electrode type shall be limited to AWS A 5.1 6010. However, cellulosic-coated electrodes shall not be permitted for repairs, even for the first pass of a through thickness repair.
9. Only basic coated low shall be used for welding repairs. The coated electrodes shall be of the extra low hydrogen type (i.e. maximum specified hydrogen content of 5 ml per 100 grams of Weld Metal). The electrodes shall be supplied in vacuum packing. Moreover, they shall be guaranteed against moisture absorption for 8 hours after pack opening.

7. Welding Procedure Specifications (WPS)

7.1 General

The WPS for both the main welding procedures and weld repair procedures shall be submitted to COMPANY one month minimum before the start of qualification tests. The WPS shall be accompanied by a summary table showing: process, consumables, direction of welding, type of weld, WPS no., test weld wall thickness and scope of qualification. The welding procedure qualification tests shall not be undertaken until the Inspector has given his approval of the principle on the said WPS.

The WPS shall include, as a minimum, all items listed in clause 5.3.2 or 12.4 (when applicable) of **API 1104** and the additional details noted hereafter:

- Manufacturer and trade name of consumables
- Minimum and maximum preheating temperature
- Interpass temperature (minimum and maximum)
- Time lapse between end of root pass and start of hot pass, and end of hot pass and start of 3rd pass
- Minimum number of runs before joint is allowed to cool down
- Time at which removal of line-up clamp is allowed
- Nozzle diameter for automatic welding (if applicable)
- Fit-up tolerances and bevel dimensional tolerances
- Oscillation width, dwell and frequency for automatic welding (if applicable).
- Electrode stick-out length (if applicable).
- Scope of qualification in terms of material sourcing, steel grade, O.D. and W.T. groups, CE, Pcm and C%.

All WPS shall conform to **API 1104** together with amendments stated in § 7.2 hereafter and essential variables of § 8.2.

7.2 Welding procedure specification information

7.2.1 Pipe and fitting materials

Pipe, valves, flanges and fittings from different chemical compositions or grades, or made from material from different sources, or in different supply conditions shall be treated separately and shall require separate procedure qualification. Identical welding procedures qualified on pipes from different sources will also qualify joints between pipes from the two sources.

7.2.2 Diameter group - Wall thickness group

Different wall thicknesses and outside diameters shall be qualified separately as shown in § 8.2.

When grouping of wall thicknesses is agreed for qualifications, then the thicker pipe shall be used for the welding tests.

7.2.3 Joint configuration

Permanent backing rings or consumables inserts shall not be permitted.

The root gap for fillet welds shall not exceed 2 mm.

Refer also to § 10.1.e of this specification.

7.2.4 Filler metal and number of beads

The number and position of weld beads shall be chosen to give the completed weld a substantially uniform cross-section. No two weld beads shall start at the same point, unless the area is dressed clean and sound before the second bead is started.

Basic coated low hydrogen electrodes with a minimum of two weld passes shall be used for all fillet welds.

For any automatic process, the number of passes shall always be established by a welding test made on each different wall thickness.

Single pass welds or internal root sealing welds shall be minimized (refer to § 13.1 of this specification). This does not apply to an automatic back pass applied internally that is an integral part of the butt weld procedure.

7.2.5 Pipe positions/Welding positions

Roll welding and position welding as defined in [API 1104](#) shall be qualified separately.

For position welding, the following shall apply:

- Horizontal pipes/fittings shall be used to qualify for welds between pipes/fittings within 20° of the horizontal (5G position)
- Vertical pipes/fittings shall be used to qualify for welds between pipes/fittings within 20° of the vertical (2G position)
- Pipes/fittings at 45° to the horizontal shall be used to qualify for welds between pipes/fittings at 20° to 70° to the horizontal (6G position).

2G + 5G qualifies for 6G. However, the 6G position shall not qualify for the 2G and/or 5G position.

7.2.6 Direction of welding

For all tie-ins (closing welds), all welds where external line-up clamps are used, and for all repair welds, vertical-up welding shall be used for the root runs. For pipe diameters less than 150 mm and for all welds to valves, flanges or fittings including fillet welds, the complete weld shall be vertical-up.

7.2.7 Time lapse between runs

When vertical-down welding is used, the second run (hot pass) shall be deposited immediately after completion of the root run (stringer bead), and the time lapse shall not be greater than that used in the procedure qualification test, with a max. of 15 minutes.

No welds on fittings, tie-ins and repairs shall be allowed to cool below preheat temperature prior to their completion. This requirement also applies to pipe to pipe welds in offshore work. For onshore pipe to pipe welds, a minimum of four runs or one third of weld thickness, whichever is the greater, shall be completed before cooling below preheat temperature provided that this is confirmed by a qualification test. No welds shall be left partially completed overnight.

Reference is made to § 10.12 of this specification.

7.2.8 Line-up clamps (refer also to § 10.6)

For pipe to pipe welds on pipes with diameters above 150 mm, an internal line-up clamp shall be used, unless impracticable (e.g. tie-in welds).

7.2.9 Preheat/interpass temperature (refer also to § 10.3)

A minimum preheat of 100°C shall apply to the welding of fittings, repair welds, tie-ins and fillet welds.

Interpass temperature in construction shall not exceed the maximum value achieved in the welding procedure qualification test, which in any case shall not exceed 250°C. If the CONTRACTOR wishes to exceed 250°C in the qualification test, a similar preheat will be required for the cap in all production welds unless a supplementary procedure test is qualified at a lower interpass temperature.

8. Welding procedure qualification

8.1 General

1. CONTRACTOR shall demonstrate by qualification tests that the proposed WPS as well as the equipment he intends to use enable performance of welds and weld repairs meeting the quality and properties required in this specification.

Welding procedure qualifications shall be required for pipe to pipe welds but also for all other welds including fillet welds, fittings to pipes, fittings to fittings (refer to clause 7.2.1 of this specification) and all associated weld repairs (refer to section 14 of this specification).

Welding procedures qualified for previous jobs shall not be accepted.

2. Extreme welding conditions, such as the following ones, which may occur during production welding, shall require qualification tests:
 - min. and max. heat input (refer to § 8.2.11 and 11.3),
 - high-low exceeding 2.0 mm up to 2.5 mm (refer to § 10.2),
 - interpass temperature beyond 250°C up to 280°C (refer to § 7.2.9 and 10.3),
 - barge move-up/pipe move-up after root pass (refer to § 10.6 and 10.7).
3. The test welds shall be fully visually inspected and then non-destructively tested according to § 8.4 and 8.5 of this specification prior to conducting the destructive tests. If these inspections indicate the presence of flaws or other defects exceeding the levels permitted in this specification, the reason of this shall be investigated and explained, to the satisfaction of Inspector, before re-welding a test weld to the same (or any other) procedure.
4. All welding procedure qualification tests shall be conducted in the presence of the Inspector.
The CONTRACTOR shall notify the COMPANY of the date and location of the welding procedure qualification tests at least seven (7) working days before the start of the tests.
5. COMPANY shall give final acceptance and approval of all welding processes, systems and procedures.
6. Non-Destructive Testing procedures shall conform to the requirements of section 11 of this specification and, anyway, subject to COMPANY prior approval.
7. The Inspector shall witness all non-destructive examinations and destructive testings and shall review and approve all related results. All mechanical testings shall be carried out by a certified testing facility subject to prior approval of the COMPANY.

8.2 Essential variables

The following additional changes in the qualified procedure shall also require re-qualification of the procedure:

1. Any change in company which performed the qualification test or site where the qualification test weld was produced. Refer also to § 8.3.3 regarding barge welding.
2. Any change in material source, supply condition or manufacturing route of pipe or fitting. A change from seamless to welded pipe and vice-versa. A change between rolled, forged or cast process.
3. Any change in material MSYS groups of **API 1104**, always providing that a higher grade shall qualify for a lower grade, but not vice-versa, in each group.
4. Any increase in Pcm, CE (IIW) or carbon content of more than 0.02% respectively.
5. Any internal high-low exceeding 2.0 mm (refer to § 8.1 and 10.2 of this specification).
6. Any change in impact test requirements (notch location in weld or test temperature). However, for a stated energy absorption requirement at impact test, a lower test temperature qualifies for a higher test temperature.
7. Any change in specified consumable in trade name, classification, source of origin, size or combination. Any change in shielding flux manufacturer or brand.
8. Any change in pipe diameter from one to another of the following ranges:
 - O.D. < 100 mm
 - $100 \leq \text{O.D.} \leq 325$ mm
 - $325 < \text{O.D.} \leq 610$ mm
 - O.D. > 610 mm

Any change in pipe wall thickness beyond $\pm 20\%$ against that used at qualification test.

9. Any change in pipe position/welding position. Any change from roll to fixed/position welding. Any change in direction of welding.
10. Any change in electrical source of supply, type of current or polarity.
11. Any change in welding heat input beyond $\pm 10\%$. Deliberate changes in heat input shall not be permitted. Refer to § 8.1 and 11.3 of this specification.
12. Any change in pass distribution in the weld.
13. Any change of more than $\pm 25\%$ (rounding to highest integer number is not permitted) in the number of passes obtained at procedure qualification test, for manual and semi-automatic welding.
 For automatic welding no change is permitted in the number of passes for a same WT. Where the WT differs from that of the qualified test weld, then the number of welding passes shall be fixed by a separate welding test.
14. Any decrease in preheat from that recorded during weld procedure qualification. The preheat or interpass temperature may be increased up to 30°C without re-qualification, subject to the maximum interpass temperature limitations. (refer to § 7.2.9 and 10.3)
15. Any increase in the time lapse between root and hot pass (second pass).

16. Any removal of line-up clamp or any pipe/barge move-up at an earlier stage. Refer also to § 10.7 of this specification.

8.3 Welding of test joints

1. The welding equipment shall be the same as or equivalent to that which are intended for use during installation. The test shall be performed on line pipe or other materials, as supplied for the Project, under similar conditions as those expected during installation.
2. Materials to be used in the tests shall be selected with a Carbon Equivalent and Pcm on the upper side of the analysis of the supplied materials and shall be subject to Inspector's prior approval. (refer to § 8.2 hereabove).
3. For on-line barge welding (automatic welding), procedure approval test welds shall be made on the pipelay barge. Each pass shall be deposited at the welding station intended to be the normal location for it in production welding.

However, this requirement may be waived and qualification tests may be carried out under simulated site conditions if the same equipment are used and if the specified welding procedure is fully reproduced and representative of site work (removal of line-up clamp, time lapse between passes, pipe movement, etc.) to the satisfaction of COMPANY. This shall be clarified by CONTRACTOR and agreed with COMPANY at the bid stage.

Test welds shall be made between full pipe lengths. The use of less than full pipe lengths requires the prior agreement of COMPANY. Anyway, the minimum length of each pipe to be used shall not be less than three (3) metres.

4. For manual or semi-automatic welding tests made on pipe nipples of reduced length (1 metre minimum), a sufficient number of internal strong backs shall be fully fillet welded on pipe to give realistic restraint during welding.
5. Grinding of weld passes between runs shall not be of more extent than that expected on production.
6. When manual welding is to be used, a minimum of one complete test joint is to be made for each Welding Procedure. For semi-automatic or automatic welding equipment, a minimum of three consecutive complete test joints shall to be made.
7. The positions of the longitudinal seams should be chosen to avoid all mechanical test pieces apart from the additional macrosection/hardness test described in § 8.4.2.7 below. The longitudinal seams may be aligned.
8. Fillet test welds shall be carried out as per **API Std 1104** or otherwise agreed with COMPANY.

8.4 Testing of welded joints - Butt welds

8.4.1 Visual and non-destructive testing

Test welds shall be fully visually inspected and fully radiographed.

In addition to above inspections, the following test welds shall be fully Magnetic Particle Inspected and fully ultrasonically inspected:

- Test welds in steel grade X60 and above
- Test welds made by automatic or GMAW.

Test welds shall comply with the acceptance standards stated in section 12 of this specification, except that lacks of penetration at root, lacks of incomplete interpenetration between beads at root area (e.g. between back pass, if any, and root/hot pass) and lacks of root fusion, whatever those defects are surface breaking or not at pipe internal, shall not be accepted at this stage.

Test welds shall satisfactorily pass the above examinations before sampling the mechanical test specimens.

8.4.2 Destructive testing

8.4.2.1 General

The test welds shall be destructively tested in accordance with [API 1104](#) and amendments stated in the following paragraphs. For semi-automatic and automatic welding (see § 8.3 above), testing shall be made on one test weld only (out of the 3 test welds made).

8.4.2.2 Test specimens

The test specimens shall be cut from the joint at the locations shown in Appendix 1 and 2 of this specification.

Test specimens shall be cut mechanically (sawing, milling). Flame cutting shall only be permitted to facilitate machining, and only if cuts are spaced at least 50 mm from any test specimens.

8.4.2.3 Transverse tensile test

Tensile tests transverse to weld are not required for butt welds on pipe less than 4"1/2 (114 mm) in diameter.

Minimum tensile requirements shall be as stated in COMPANY material specifications (see section 3).

8.4.2.4 Nick Break test

Nick Break tests are not required.

8.4.2.5 Root and face bend test

Root and face bend tests shall be replaced by Side Bend tests for wall thickness greater than 12.7 mm.

8.4.2.6 Macrography

The macro-sections shall be ground and polished (diamond paste finished) and etched to show up the Weld Metal and Heat Affected Zones micro-structures.

The macrosection shall be visually examined using a magnification lens of at least X5 to ensure good weld profile and absence of out-of-tolerances imperfections. Acceptance criteria shall be those defined in section 12 of this specification, except that welds shall be free from lacks of penetration and lacks of root fusion at this stage (refer to § 8.4.1 above).

8.4.2.7 Hardness test

On the above macrographs, a Vickers hardness survey according to [ASTM E 384](#) (or equivalent Std) shall be made using a 5 kg load as shown in Appendix 3.

One additional macro-section shall be taken where a longitudinal weld intersects the circumferential weld and a hardness survey shall also be carried out at this location.

Another additional hardness test shall be made on the macrosection located at 3 o'clock position for automatic welding processes.

The maximum HV5 hardness shall not exceed the values stated in Table below:

Sour service	Weld Root	Weld Cap
Intermediate	280	300
Severe	250	275

Photomicrographs showing the indent locations shall be included with the Welding Procedure Qualification Record (WPQR).

8.4.2.8 Charpy V-notch impact test

Charpy impact tests (each test = three specimens) shall be prepared and tested in accordance with [ASTM A 370](#) and [ASTM E 23](#) or [ISO/EN 10 045-1](#).

The specimens shall be machined with their longitudinal axis transverse to the weld.

The specimens and notch locations with respect to weld cross-section shall be as shown in Appendix 5. It is highlighted that for wall thicknesses above 20 mm, additional impact tests shall be cut from the Weld Metal at root, as shown in the said Appendix.

The absorbed energy requirements shall be those stated in Appendix 6 for wall thicknesses up to and including 25 mm. For higher wall thicknesses, Charpy requirements shall be stated in the PPS.

The test temperature shall be stated in the PPS. However, in no way the test temperature shall be above 0°C.

The largest possible specimen size shall be selected from the following sizes:

- 10 x 10 mm (full size specimen)
- 10 x 7.5 mm
- 10 x 6.7 mm
- 10 x 5.0 mm.

When sub-size specimens are deemed necessary, the requirements for absorbed energy shall be those for full size specimens multiplied by the corresponding factors shown in Appendix 6.

If the stated impact requirements are not satisfied for one set, the COMPANY may request three further specimens to be tested. The mean value of all six tests shall be at least equal to the specified minimum average value. All three re-test specimens shall meet the specified minimum individual value.

8.4.2.9 CTOD Test

When so required in the PPS, Crack Tip Opening Displacement (CTOD) tests shall be conducted on test butt welds in accordance with [BS 7448](#) using the preferred geometry specimens and a through thickness notch. Two sets of three specimens shall be taken from

both the 12 o'clock and 3 o'clock (or 9 o'clock) positions: one set with the notch positioned in the Weld Metal centreline and one set with the notch positioned in the Fusion Line. Locating the notch shall be conducted according to the same procedure as for Charpy specimens (see Appendix 5). When the weld procedure qualification test includes three (3) consecutive welds, then one CTOD test specimen of each set as stated above shall be removed at the said o'clock locations from each of the three welds (i.e. twelve specimens in total).

Pop-ins shall be taken as critical events, unless they can be attributed to spurious occurrences, such as plate laminations.

An all-weld tensile test to [ASTM A 370](#) is then required on each weld from which CTOD tests are taken, at a location as close as possible to the CTOD tests.

The test temperature and minimum required values for CTOD shall be stated in the PPS.

8.4.2.10 All-weld tensile test

An all-weld metal tensile test (with specimen of max. practical size) is required from each procedure test in accordance with [ASTM A 370](#). Yield and Tensile Strength shall be as specified in COMPANY material specification (see section 5) and § 6.2 of this specification.

8.4.2.11 Weld chemical analysis

Quantitative chemical analyse of the weld cross-section shall be made in the root zone and filler passes to verify the chemical elements as per the chemistry requirement of the applicable consumable specification. Nickel content shall not exceed 1.0 percent. (Refer to § 6.2 of this specification).

In addition, a micro analysis of weld shall be carried out by "Electron Probe Micro Analysis (EPMA)" or equivalent equipment. The fusion lines between weld and base metal, and between passes shall be particularly investigated.

The results shall not indicate segregation peak exceeding 0.30% for Mn and 0.20% for Si.

Any other significant peak of segregation shall be investigated and demonstrated not harmful for the pipe service.

8.4.2.12 H₂S embrittlement tests

SSC tests shall be carried out on qualification test welds of main welds (and repair welds: refer to § 13.2) according to test specification stated in Appendix 10 of present General Specification (specimens stressed at 80% of actual yield strength of base material). Test specimens shall be located at 12, 3 and 6 o'clock position. Test solution and conditions shall be according to the specified sour service (Intermediate or Severe Sour Service) and pipeline effluent, as stated in the PPS and according to Table of Appendix 10. Test duration shall be 30 days.

8.5 Testing of welded joints - Fillet welds

A minimum of two weld passes shall be used for all welds made on pipes or fittings (see § 7.2.4 of this specification).

All fillet welds shall be fully visually and Magnetic Particle Inspected. Results shall be assessed according to the appropriate acceptance criteria specified in section 12.

Each test weld shall then be subject to a minimum of four Nick Break tests, two macro-examinations and one Vickers micro-hardness test as follows:

- The Nick Break tests shall be conducted and assessed as per clause 5.8 of [API Std 1104](#)

- The macro-examinations shall be carried out using a lens of X5 magnification. The weld shall show a profile, pass distribution and weld size as stated in the WPS. The other acceptance criteria shall be those of Nick-Break tests above.
- The VICKERS micro-hardness survey shall be carried out according to [ASTM E 384](#) as shown in Appendix 4, using a 5 kg load. Maximum hardness shall not exceed 250 HV5 for Severe Sour Service and 280HV5 for Intermediate Sour Service.

8.6 Testing of welded joints - Electrical connecting welds

Weld junctions of anode leads, made for example by thermit welding or pin brazing, shall be qualified by tests as follows.

Three consecutive test welds shall be made. They shall be fully visually examined for weld profile and undercuts. Then, one welded connection shall be subject to a micro-examination and a Vickers micro-hardness survey.

The micro-examination shall give evidence of a good bonding, and shall also detail the metallurgical constituents which are present in the pipe Heat Affected Zone and shall check for the absence of any micro-cracks in the base material of pipe.

The Vickers micro-hardness survey shall be carried out under a 5 kg load and shall comprise a line of indentations made in pipe material and located in HAZ within 0.6 mm max. from Fusion Line. The nature of metallurgical constituent at location of max. hardness shall be identified and recorded.

Maximum hardness shall not exceed 250 HV5 for Severe Sour Service and 280 HV5 for Intermediate Sour Service.

Note: Where anode leads are connected to pipe through a doubler plate, the fillet welds on pipe shall be tested as per § 8.5 hereabove.

8.7 Records (WPS and WPQR)

A form based upon that in [API 1104](#) or similar shall be used for recording all test performance conditions and results of the welding procedure qualification test.

The data sheets of as-deposited runs (format to be approved by Inspector) shall also be filled in during performance of each test welds and shall form part of the final Welding Procedure Qualification Record (WPQR).

Records shall be established by the CONTRACTOR and co-signed by CONTRACTOR and Inspector who attended the tests. Records shall be available on Site when the production welding is performed.

All WPQRs shall imperatively include the Mill Certificates of the test base materials and consumables used for the test.

Each revision of the documents shall be given a new identification number in sequential order and revisions shall be marked in order to identify the changes.

9. Welder qualification

1. Each welder shall be qualified in accordance with the requirements of [API 1104](#) and requirements of this specification before commencement of production welding. Only Single Qualification is accepted (Multiple Qualification shall not be permitted).

2. The CONTRACTOR shall use only skilled workmen for welding. Each welder employed by the CONTRACTOR shall be required to pass a welding test for the type and methods of welding he will perform, including for attachment welds. No welder shall do any phase of welding on the pipeline for which he has not been tested and previously approved by the Inspector.

Pre-qualified manual or semi-automatic welders shall not permitted.

3. With previous approval of Inspector, the qualification of a welding machine operator may be accepted without further testing provided CONTRACTOR submits satisfactory proof concerning the operator's professional skills (apprenticeship or advanced training, previous work in using similar welding procedures and equipment, previous qualification certificate dated of less than three months, etc.).
4. The CONTRACTOR shall use welding materials and equipment the same or equivalent (to COMPANY's satisfaction) to those to be used on the line. The pipe for test nipples shall be of the same size and grade as those to be used on the line. CONTRACTOR shall prepare all test nipples in a same way as in future production. The welder shall make a test weld under simulated field conditions or on the lay barge, as appropriate. All tests shall be witnessed and approved by Inspector.
5. Full size pipe nipples shall be used. No grouping is allowed regarding pipe diameter and/or wall thickness, unless specifically agreed with COMPANY. When the CONTRACTOR intends to use a different scheme, this scheme shall be proposed by CONTRACTOR and approved by COMPANY at the bid stage.
6. Manual and semi-automatic welders shall be separately qualified for each welding position encountered on the job, in a same way as for the welding procedure qualification test (see details in § 7.2.5. of this specification).

Again, 2G + 5G qualifies for 6G, but the 6G position shall not qualify for the 2G and/or 5G position.

7. When testing manual or semi-automatic welders for execution of a weld without back pass, the pipe nipple ends shall be closed so that internal check of the weld root cannot be made by welders during performance of welding.
8. For butt welds, all welders, including welders for mechanised welding, shall be qualified by non-destructive tests. Finished coupons shall be visually examined, fully radiographed and, then in the case of automatic (except SAW) or semi-automatic welds, ultrasonically tested. Ultrasonic testing may be waived, at COMPANY's option, for automatic welding, based on bevel configuration.

Welders for mechanised welding shall be approved for all parts of the welding operation.

9. For fillet welds, welders shall be qualified as per **API 1104** (i.e. visual + 4 Nick Break tests), with two additional macrographs located one at the greatest root gap and one at the least root gap.
10. Test welds shall be free from cracks, lack of penetration and lack of root fusion. Any other defects shall be within the limits of **API Standard 1104** and section 12 of this specification.
11. Welders having participated in the execution of the welding joints for successful qualification of the welding procedure in accordance with section 8 shall be considered as qualified.
12. For manual metal arc welding, a change in electrode trade name shall require welder re-approval for butt welds.

13. Each welder/operator shall be given a unique identification number which he shall mark in paint against all welds produced by him. A list of qualified personnel (with photographs) shall be kept up to date by CONTRACTOR and made available to Inspector for review.
14. Any welder found responsible for a high level of defects/repairs in production shall be removed from production. At the discretion of Inspector, the welder in question may be retested after an agreed period of retraining.
15. Requalification of welders or operators shall be required if any change is made to the welding procedure which necessitates requalification of the welding procedure. Requalification of welders or operators will be required where established tolerances on weld procedures are exceeded.
16. Arc-air gouging shall be carried out by personnel who have previously satisfied the Inspector that they are competent to do so in accordance with an approved procedure.

10. Production welding

10.1 Swabbing, pipe bevelling and cleaning ends of joints

- a) Immediately prior to aligning pipe for welding, the bevelled ends of each joint of pipe for a minimum distance of 40 mm shall be thoroughly cleaned of paint, rust, adhesions, dirt and any other foreign matter by use of power-driven wire buffing wheels, disc sanders, or by other methods previously approved by Inspector for each case. Fusion faces shall be visually inspected for laminations after cleaning to a bright finish. Any bevel showing evidence of laminations shall be cut back, re-bevelled and retested as indicated in § 10.1.b below for pipe ends.
- b) CONTRACTOR is to re-cut and bevel all damaged pipe ends when deemed necessary to the Inspector. When the re-cut is located at a distance of more than 25 mm from the original bevel, then the re-cut end shall be ultrasonically inspected for laminations over a zone extending 100 mm from the new field bevel. Otherwise, the new bevel shall be subject to MPI, as a minimum.
- c) All required field bevels on line pipe must be made with a bevelling machine. Hand bevelling shall not be permitted. All field bevels shall be cut and finished at right angles to the longitudinal axis of the pipe evenly and without rough surfaces.

Automatic flame bevelling is acceptable for tie-ins, subject to cleaning of the level faces to bright metal.
- d) The pipes will be supplied with bevelled ends as defined in the material specification. For weld procedures that require a different bevel, rebevelling shall be done by the CONTRACTOR.
- e) Where pipes or fittings of unequal wall thickness are to be welded, the end preparation shown in [ASME/ANSI B 31.4](#) Fig. 434.8.6 or [ANSI/ASME B 31.8](#) Fig. 15 (where applicable) shall be used. Any taper shall not be steeper than 1 in 4.

10.2 Alignment of pipe

- a) All joints with diameter over 150 mm shall be aligned with an internal line-up clamp, except for tie-in line-ups or under exceptional conditions approved by COMPANY, on which occasions an external line-up clamp may be used.

- b) Where external line-up clamps are used, all root runs shall be welded vertically-up. Root runs for riser and expansion loop fabrication shall also be welded vertically up.
- c) When lining up longitudinally welded pipe, the pipe shall be positioned so that the seam will be on the upper surface of the line and within that area of sixty (60) degrees each side of the top centre of the pipe, with a minimum offset of 200 mm, except at vertical bends. The seam is then to be at the neutral axis of the bend.
- d) Maximum misalignment or offset of surfaces shall not exceed 2.0 mm.

Where misalignment exceeds 2.0 mm, corrective action shall be subject to the approval of the Inspector in each case. Heat shall not be used for corrective purposes.

High-low up to 2.5 mm may be acceptable provided that a successful qualification test is carried out by the CONTRACTOR (refer to § 8.1).

10.3 Preheating and interpass temperature (refer also to § 7.2.9)

- a) The need for an appropriate level of welding preheat shall be determined at weld procedure qualification stage, taking into account any weldability results that may be available from the line pipe supplier.
- b) In any event, prior to commencement of welding, sufficient heat shall be applied to remove all traces of moisture. The preheat temperature required by the qualified WPS shall be maintained throughout the entire welding of the joint.
- c) Preheat or warm up shall be applied in a uniform manner using gas burner or electrical means except that hand held torch heating shall not be permitted other than where external line-up clamps are used. The method shall be subject to approval by the Inspector.
- d) Temperature shall be measured using contact pyrometer or indicating crayons of the melting type. Colour changing type shall not be permitted.
- e) The minimum preheat temperature shall be maintained and measured over a distance of at least 50 mm either side of the joint.
- f) The preheat temperature shall be checked at the 6 o'clock position (as a minimum) on each pipe prior to the start of welding of each run and where an upset in the continuity of welding has occurred.
- g) Unless otherwise agreed with COMPANY, the preheat for repair welds shall be 15°C greater than that used at qualification tests, and shall be applied uniformly around the circumferential weld.
- h) The interpass temperature measured immediately before the start of the subsequent weld run shall not be less than the minimum preheat temperature and shall not exceed the maximum interpass temperature recorded during procedure qualification. In no instance shall this exceed 250°C, unless a qualification test has been made (refer to § 8.1).

10.4 Post-weld heat treatment (PWHT)

PWHT is required for welds made on pipes or fittings in wall thickness exceeding 31.8 mm. Then, related base materials shall have been previously tested to ascertain that their physical properties are still acceptable after such a PWHT (refer to section 5 of this specification).

Any requirement for PWHT shall be established during welding qualifications. In such cases, the specific requirements (heating and cooling rates, soaking time and temperature, and

temperature tolerances) shall be proposed by the CONTRACTOR and be subject to the approval of COMPANY.

Only electrical methods shall be used for heating, and all operations shall have a printed chart of the heating cycle at 12 o'clock and 6 o'clock position of the weld, as a minimum.

10.5 Tack welds

- a) Tack welds shall be a minimum of 50 mm long, performed with the same weld procedure specification as the root run and by a welder qualified for that run. Where preheat is required for the root run, this shall be applied prior to tack welding and maintained until the joint is completed.
- b) All tacks are to be welded vertical-up.
- c) Tack welds incorporated into the final weld shall be ground to a feather edge at each end to ensure adequate fusion on the root pass.
- d) Tack welds shall not be permitted when a clamp is used.

10.6 Type and removal of line-up clamps

- a) For pipe to pipe welds on pipes with diameters over 150 mm, an internal line-up clamp shall be used, unless impracticable (e.g. tie-in welds).
- b) Power operated internal clamps shall be demonstrated as capable of reducing the maximum permitted manufacturing out-of-roundness sufficiently to meet the alignment requirements of clause 10.2 in this specification.
- c) Internal line-up clamps may be removed after the root pass is 100% completed, only when the pipes are to remain at rest (i.e. when no subsequent movement is anticipated for the pipes). Where movement (or relative movement) occurs for the pipes, then the requirements of § 10.7 herebelow shall to be met.
- d) External line-up clamps can be removed when the root pass is at least 50% complete and equally spaced around the pipe circumference. The same restrictions as stated above for internal line-up clamps shall also apply in present case.

10.7 Barge move-up/Pipe move-up

Barge move-up, or pipe move-up in double jointing station for example, shall not occur until the root and hot pass are completed.

This requirement will be waived when the root pass is 100% complete and, in addition, has a thickness of 4 mm minimum. In this case, the thickness of root pass shall be checked (at welding procedure qualification stage) by a minimum of four macrographs cut equally spaced around the pipe circumference (3, 6, 9 and 12 o'clock position) when root pass alone is deposited.

In any other situations, a relaxation may be granted by COMPANY only if the CONTRACTOR can demonstrate by means of a stress analysis that the root run is not stressed beyond 50% of MSYS of base material or weld metal, whichever is less.

No relaxation shall be granted for SMAW using cellulosic coated electrode in downhill welding for the root pass.

In all cases and particularly in onshore installation, the pipes on both sides of the joint shall not be raised or lowered (i.e. inducing bending stress in weld) until one third (1/3) of the weld filling

have been completed all around the pipe circumference, unless the CONTRACTOR can demonstrate by stress analysis and full scale test that a smaller weld thickness is adequate to resist to deformation and cracking.

The use of the "hinged method" (i.e. moving vertically the pipes at joint to close or adjust the root gap while part the weld filling has been made on a pipe sector) shall be forbidden.

10.8 Hot bends

Hot bends shall be inserted in the pipeline with their tangent lengths (i.e. hot bends shall not be cut into bends of smaller angles and no circular welds shall be present in the bent portion of hot bends).

10.9 Branches

- a) Unless otherwise approved by the COMPANY, only forged fittings e.g. hot extruded or pressed tee, etc., shall be used for branches and other pressure containing attachments. To ease welding of the fitting in the line, a pup piece may be welded to the fitting. Its length must be sufficient to accommodate the line-up clamp to be used.
- b) All branch outlet fittings (as per MSS SP 97 Std) shall be welded onto a piece of running pipe (shop fabrication) having a minimum length of one pipe diameter of the running pipe, so as a PWHT (if any) can be made on the finished prefabricated item before inserting this item into the pipeline system.
- c) All branches directly welded to main pipe shall be subject to COMPANY approval.
- d) Welding procedure qualification tests and production NDT of branches and branch outlet fittings shall have prior approval of COMPANY.

10.10 Golden welds

Golden welds (i.e. non-hydrotested welds) shall be minimized. Any golden weld shall be subject to the following NDT: 100% radiography (using AGFA D4 film, or equivalent), 100% UT and 100% MPI.

10.11 Inter-run cleaning/Grinding of welds

Each weld pass shall be cleaned by experienced helper/welder using power tools to remove all welding slag and foreign matter prior to welding the successive pass.

Where accessible, all welds to valves, flanges and fittings shall be ground back smooth internally prior to proceed with radiography or ultrasonics.

10.12 Partially completed joints

All on-line butt welds of the pipeline made on lay barge shall be completed in one cycle. For onshore butt welds, refer to § 7.2.7 of this specification.

10.13 Arc strikes

Arc strikes shall not be permitted outside the weld bevel. Should arc strikes occur outside the weld bevel area they shall be removed by grinding and inspected by magnetic particle examination to ensure freedom from cracks. The remaining wall thickness shall be checked ultrasonically. If the reading is below the specified minimum wall thickness, the defective pipe section shall be cut off. Repair welding shall not be permitted.

10.14 Proximity of welds

- a) Adjacent circumferential welds shall be separated by a minimum of one pipe diameter or 750 mm, whichever the least.
- b) Branches, fittings and attachments shall be sited away from other welds on the pipeline. The minimum separation shall be the greater of:
 - A diameter of Branch/Fitting
 - Six (6) times the wall thickness of thickest component
 - 150 mm.
- c) Attachment relating to anodic bonding leads shall be located at least 150 mm from any seam or circumferential weld.

10.15 Marking of welds

- a) All welds shall be marked with paint stick by the welders according to numbers assigned to them by CONTRACTOR at the time of their qualifications. Should any welder leaves the job, his number shall be voided and not duplicated on the project. No punch or steel stamping shall be permitted.

Alternatively, a record of which welder works in which station or weld may be kept by the welding foreman and QC inspector(s) of CONTRACTOR.

- b) Prior to radiography of the circumferential weld, the CONTRACTOR shall paint the weld location number on the covering of the pipe adjacent to the weld at a point where it shall remain visible after field coating. These numbers shall be used by the surveyors to locate and record the welds and for the radiographers for identification of the welds. The numbers shall be applied with a spray can or a brush and water-proof paint of a contrasting colour to the outside pipe coating.

10.16 Weather conditions

Welding shall not be carried on when the weather conditions are unsatisfactory and likely to impair the quality of the welds. CONTRACTOR shall provide wind breaks and welder's platforms when conditions, in opinion of Inspector, warrant their use.

10.17 End protection

The open end of pipe strings shall be securely closed at the end of each day's or shift's work and lunch breaks by suitable proprietary designed covers. They shall be placed over the pipe ends to prevent the entrance of water, trash, small animals or other objects. These covers shall not be removed until the work is to be resumed. Where the line is left apart at intervals to be later tied-in, ends shall likewise be fully closed. Metal covers shall not be tack welded to the pipe.

10.18 De-magnetising system

CONTRACTOR shall have available on site at all times a de-magnetising system for use when the pipe ends show a magnetism unsuitable for welding.

10.19 Supports, attachments, lifting devices...

These items and the like used for permanent positioning of risers and pipelines shall be welded on doubler ring or plate. Doubler rings for temporary use should be clamped. Welding of temporary attachments shall be subject to COMPANY approval and qualification tests.

Permanent doubler rings and plates shall be made of materials satisfying the requirements for pressure containing parts. Doubler ring shall be made as fully encircling sleeves with the longitudinal welds made with backing strips and avoiding penetration into the main pipeline material. Other welds shall be continuous and made in a manner to minimise the risk of root cracking.

11. Inspection and testing of production welds

11.1 General

- a) The frequency of non-destructive testing is specified under the § 11.4, 11.5 and 11.6 of this specification.

For onshore pipelines, at the commencement of welding using an approved mechanized GMAW process, a minimum of 30 welds shall be tested 100% by ultrasonic examination until the Inspector is satisfied that the welding process is under complete control and reliable.

- b) Each joint shall be thoroughly cleaned using power driven wire brushes, and all slag, spatter, etc., removed prior to weld examination. Any bonding media, or any inks or dyes used for crack detection, shall be removed. All completed circular welds shall be examined visually internally (as far as practicable) and externally to the pipe prior to being examined by radiography. All tie-in welds shall be witnessed and the fit-up and weld quality visually examined in full, by the Inspector.
- c) Ultrasonic and MPI equipment shall be available on Site to supplement radiography on any doubtful area nominated by the Inspector.
- d) All NDT procedures shall be submitted to Inspector's approval and shall be qualified on the welding procedure qualification test welds.
- e) All NDT operators/technicians shall have at least two years experience on pipeline working in the NDT grade qualified. See paragraphs 11.4.18, 11.5.3 and 11.6.6 of this specification.
- f) Refer also to section 4 of this specification.

11.2 Hardness test (onshore pipelines)

Random VICKERS hardness HV5 or HV10 tests of circumferential weld caps shall be carried out by CONTRACTOR at the discretion of Inspector. Each weld selected for hardness test shall be checked at the 4, 8, and 12 o'clock positions. The hardness transverse shall cover the weld cap, HAZ and pipe material, over a range 10 mm each side of the HAZ. Hardness readings shall be made with a portable hardness tester to be approved by the Inspector. Hardness readings shall be recorded.

11.3 Weld cut-out

If the Inspector detects a weld being made outside the allowances of the qualified procedure, the weld metal shall be removed and the joint re-welded. The CONTRACTOR may attempt to

guard against this eventuality by qualifying welding procedures at the extreme parameters (e.g. for mini. and max. heat input) that CONTRACTOR may consider using (refer to § 8.1).

11.4 Radiographic examination

1. CONTRACTOR shall supply all labour and materials necessary to perform 100% radiography on all circular welds. Each radiograph shall cover the entire weld. For weld repair, the film shall cover 100mm on either side of weld area of repair. All radiographic techniques and procedures as well as quality of films shall comply with [ISO 1027](#), [ISO 1106](#), [ISO 2504](#) and [ISO 5579](#) and this specification. Standards of acceptance shall comply with the requirements of [API Standard 1104](#) and this specification. Any weld which in Inspector's opinion is not satisfactory as indicated by the radiography shall be repaired or cut-out and re-welded.
2. Radiography shall be by means of X-rays only. Tie-in welds may be carried out by means of gamma-rays (using AGFA D4 film, or equivalent) plus ultrasonic inspection subject to approval of COMPANY.
3. Radiographic procedures shall be qualified using penetrameters located at both source side and film side. This applies for all Single Wall/Single Image (SW/SI) techniques.
4. The radiographic procedure qualification test shall be repeated at the discretion of the Inspector whenever any change is made to the operating techniques, or whenever production films differ appreciably from the sensitivity, contrast or density of the qualification radiographs.
5. On lay barge, no weld shall be moved past the repair station until the radiograph is completed and the weld is judged satisfactory.
6. Unless otherwise approved by Inspector, coating and wrapping of the joint shall not begin until the weld is judged satisfactory.
7. Radiographic films shall be fine grain or ultra fine grain, high contrast, type KODAK AA or AGFA D 7, or COMPANY approved equivalent.

For multiple exposure radiography, film overlap shall be 50 mm minimum.

8. Intensifying screens of the lead type shall be used for welder and welding procedure qualifications, and tie-ins. The use of fluorometallic screens is acceptable for pipelaying, except tie-ins, provided that the required sensitivity is easily met and that CONTRACTOR agrees to replace them on Inspector's request. Fluorometallic screens shall not be permitted with gamma-rays sources.

Salt screens shall not be used.

9. Back scatter control: A lead number "B" of appropriate thickness shall be placed at the back of the cassette to check the back scatter. If the image of "B" appears on the radiograph, the weld shall be reshoot and remedial action must be taken to improve the back scatter.
10. Only wire type Image Quality Indicators (IQI), according to [ISO 1027](#) shall be used. The sensitivity across the weld, using a source side penetrometer, shall meet the following max. with regard to weld thickness T:
 - $T \leq 10 \text{ mm}$: 2.0%
 - $10 \text{ mm} < T \leq 20 \text{ mm}$: 1.8%

- $20 \text{ mm} < T \leq 30 \text{ mm}$: 1.6%
- $30 \text{ mm} < T$: 1.5%

IQI's shall be placed so that each film has at least two: one within 25 mm from interpretable film extremity and one at center of film. When a complete girth weld is radiographed in a single exposure (panoramic exposure), four IQIs shall be placed 90° apart.

11. The geometrical unsharpness shall not exceed 0.25 mm for multiple exposure radiography and 0.50 mm for single panoramic exposure (i.e. radiation source inside the pipe).
12. Exposure shall be such that density through the weld is between 2.1 and 3.6.
13. Viewing conditions and facilities shall conform to [ISO 2504](#) Std and shall be such that film densities up to 4.0 can be viewed and interpreted. A densitometer (with valid calibration) shall be available on Site at all times.
14. Final film interpretation shall be carried out on dry film.
15. Processing: All radiographic films shall be dried thoroughly prior to viewing and shall be processed and fixed to allow storage of the films without image deterioration for at least 10 years. All films shall be refixed onshore to achieve the specified minimum archival life (unless the CONTRACTOR can demonstrate by routine residual thiosulphate testing offshore that the original fixing and washing was sufficient to guarantee the specified life).
16. As a minimum, the film identification shall include:
 - Project Identification (as previously agreed with COMPANY)
 - Line Size and Identification
 - Joint Number
 - Date (Day, Month, Year)
 - Radiographic Location.

The zero datum shall be located at the 12 o'clock position. The direction of numbering on tape shall be clockwise when looking in the direction of flow. Defect location shall be in the metric system. Each radiograph shall have reference markers at 100 mm (minimum) intervals.

17. All films shall be protected in individual plastic bags (with silicagel crystals) and stored in aluminium boxes closed with tight fit lids before delivery to the COMPANY. All film boxes shall be individually numbered and indexed (arrangement of films to be stated) on their top.
18. Radiographers shall be certified level 2 in accordance with the requirements of [EN 473](#), [CSWIP](#) scheme or equivalent COMPANY approved standard. At least one certified level 2 (minimum) radiographer shall be present on each shift for film interpretation.

The qualifications of each member of the NDT team shall be subject to approval of the Inspector.

19. Radiographic performance shall comply with the relevant Country and Project safety codes and radiation acts. Attention is drawn to the necessity for audible and visual warning arrangements and for regular monitoring or radiation levels.

11.5 Ultrasonic examination

1. The COMPANY shall require ultrasonic examination in the following cases:

- a) Following field cut back of pipe exceeding 25 mm, a zone extending 100 mm back from the new field bevel shall be ultrasonically tested for laminations (see § 10.1b).
 - b) A zone of 100 mm wide around planned cut-outs for nozzle, branches, etc.
 - c) To verify minimum acceptable pipe wall thickness after grinding (refer to material specifications for the minimum acceptable wall thickness)
 - d) To verify weld defects not fully defined by radiography.
 - e) To double check welds made by mechanized GMAW (refer to § 11.1).
2. Ultrasonic examination of pipe ends shall be carried out according to [ASTM A 578](#). Any discontinuity (e.g. lamination) causing a reflection echo exceeding 50% and accompanied by a 50% loss of back reflection shall be considered as rejectable when the discontinuity area exceeds 100 mm².
- Ultrasonic examination procedure of welds shall be as per [ASME V](#), [BS 3923](#): Part 1, or equivalent standard.
3. Ultrasonic operators shall be certified level 2 in accordance with [EN 473](#), [CSWIP](#) scheme or COMPANY approved equivalent standard. The Inspector reserves the right to test proposed UT operators on a test weld prior to accept them on the job.
 4. Ultrasonic procedures, where required, shall be submitted to COMPANY for approval prior to use.
 5. Unless otherwise stated in the PPS, automatic ultrasonic examination of welds shall not be permitted.

11.6 Magnetic Particle Inspection (MPI)

1. Where MPI is applied on parent material, e.g. following pipe re-bevelling, no cracks or crack like defects are permitted. Any indications revealed by MPI shall be investigated and removed by grinding or pipe re-cutting, as necessary.
 2. The following welds shall be Magnetic Particle Inspected:
 - a) All repair weld excavations
 - b) All welds to fittings
 - c) All fillet welds on steel grade X60 and above.
 - d) All arc strike outside weld groove area.
 3. The finished weld bevel shall be Magnetic Particle Inspected following field cut back of pipe, at least when this cut back is located within a range of 25 mm from original bevel (refer to § 10.1.b).
 4. Electromagnetic (a.c.) yoke and/or adjacent cable techniques shall be used.
 5. CONTRACTOR shall supply a MPI procedure based on [ASTM E 709](#) or equivalent for review and approval by COMPANY. Calibration blocks and approved magnetic flux indicators shall be available on Site at all times.
- Inspector reserves the right to test the proposed MPI procedure prior to acceptance.
6. MPI operators will be qualified level 2 in accordance with [EN 473](#), [CSWIP](#) scheme or COMPANY approved equivalent standard.

11.7 Inspection records

The system for reporting the defects shall be such that they can be quickly identified and accurately located in welds.

All radiographic and ultrasonic examination records shall be suitably stored in fire proof cabinets by CONTRACTOR for a period of ten years and shall be handed over to COMPANY at its request.

12. Standards of acceptance

12.1 General

The following acceptance standards shall apply to visual and non-destructive inspections (radiography, etc.) of welding procedure qualification tests (together with requirements stated in § 8.4.1), welder qualification tests and production welds, as applicable.

In case of dispute, the Inspector's interpretation of the NDT results shall prevail.

The standards of acceptance shall be as per **API 1104** and the amendments stated hereafter in the present section.

Acceptance criteria based on Engineering Critical Assessment to Appendix A of **API 1104** (or to any other standard) shall not apply within this specification.

Welding conditions shall be selected and maintained by CONTRACTOR so as to avoid occurrence of defects in the root area (whatever they are surface breaking or not surface breaking at pipe internal), although allowances for root defects are tolerated in the following § 12.5.

12.2 Weld preparation

In areas of weld preparation such as pipe ends, bevel faces and branches, planar defects shall not be acceptable whatever their sizes.

12.3 External profile

Weld reinforcement shall be uniform and not less than 1.0 mm nor more than 3.0 mm in height. It shall merge smoothly with the parent metal and shall extend beyond the original weld preparation by not more than 2.5 mm.

12.4 Internal profile

The weld shall fuse the pipe at the root without protruding excessively into the bore of the pipe. The maximum permissible penetration of the root bead into the bore of the pipe shall be 3 mm, although occasional local slight excess of penetration is allowable.

The root bead or any concavity shall merge smoothly with the adjacent surfaces. Refer also to "Root Concavity" in § 12.5 hereafter.

12.5 Flaw type and size

The standards of acceptance applicable to the type and size of defects detected shall be as defined in section 6 of [API 1104](#), unless otherwise modified by the following:

12.5.1 Cap undercut

Undercut exceeding 0.5 mm in depth shall be unacceptable and shall be blended out by light grinding prior to radiography. Grinding shall not reduce the pipe wall thickness below the specified minimum.

12.5.2 Root undercut/Shrinkage groove

Depth shall not exceed 0.4 mm. Length shall not exceed 20 mm in any continuous weld length of 300 mm.

12.5.3 Root concavity

Root concavity shall be permitted (up to 1.2 mm in depth) if there is no lack of root fusion and if the thickness of the weld (including cap reinforcement) is not less than the specified wall pipe thickness.

12.5.4 Incomplete root penetration and lack of root fusion ([API 1104 § 9.3.1 through 9.3.4](#) for root area defects)

Cumulated length shall not exceed 20 mm in any continuous weld length of 300 mm, with no single defect exceeding 10 mm in length.

This shall also apply where the indication is located on a high-low.

Reference shall also be made to particular requirements of § 8.4.1 applicable to qualification test welds.

All the above limitations shall also apply to incomplete interpenetration between beads at root area (e.g. between root pass and back pass, if any, or between root and hot pass).

12.5.5 Porosity (other than elongated porosity in root run)

Porosities shall not exceed a total area, when projected radially through the weld, of 1.5% of any 600 mm² of projected weld area. An isolated pore greater than 20% of the pipe thickness or 3 mm, whichever is the smaller, in any direction, shall be considered unacceptable.

Wormholes shall not be acceptable.

12.5.6 Hollow-bead porosity

Not acceptable whatever the size.

12.5.7 Cracks

Any form of crack or suspected crack shall not be acceptable.

Welds found with cracks (other than crater cracks) shall be cut out.

12.5.8 Tungsten inclusions

Tungsten inclusions shall be treated as individual inclusions. They shall not exceed two per weld and shall be separated by a minimum of 50 mm.

12.5.9 Copper inclusions

Not acceptable in root pass or when interfering with root pass. Otherwise, there shall be no more than one inclusion per weld.

12.5.10 Accumulation of discontinuities

The aggregate length of indications (except porosities) shall not exceed 50 mm in any continuous 300 mm of weld and 8% of the weld length.

12.6 Arc strikes

Arc strikes shall not be permitted: refer to § 10.13 of this specification.

13. Repair and removal of defects

13.1 Repair procedures

1. The CONTRACTOR shall submit to Inspector's approval full details of the proposed repair procedures to be used. This shall include:
 - The method of removing defects
 - The preparation and inspection of the area to be repaired
 - The welding procedure; it shall include a minimum preheat of 100°C, unless a higher temperature has been found necessary as a result of the qualification test.
2. Weld repairs are permitted for defects located in the filling and cover passes (i.e. partial penetration repairs) and shall be at least 50 mm long.
 Repairs at root or including the root shall be minimized and such repairs shall be subject to special approval of the Inspector on a case to case basis. Anyway, repairs at root or including the root (i.e. through thickness repairs or internal repairs) shall not exceed 8% of individual weld length.
3. Only one repair of weld root shall be permitted in the same area. Outside weld root, two repair attempts shall be permitted in the same area of weld. Should the repair weld(s) fails to meet the NDT requirements, then the whole weld shall be cut out. Such repairs of repairs shall be limited to one per weld.
4. Single-run repairs are permitted where the whole of the weld cap is replaced to the original procedure (such repairs do not require separate qualifications). For any other single-run repair (internal or cap repair), qualification tests shall be required (refer to § 13.2).
5. Weld repairs to pipe or fitting body or bevels shall not be permitted.
6. For barge welding, the limits on size and location of weld repairs at the repair station shall be supported by calculations (and appropriate diagrams/tables) and shall have prior approval of the COMPANY.

Repairs shall be limited to 30% of the weld length for a partial penetration repair, or 20% of the weld length for a full penetration repair, always providing that the stresses applied to the weld under repair do not exceed 70% of the MSYS of pipe.

7. Internal repairs when proposed by CONTRACTOR (diameter permitting) shall require the following from CONTRACTOR:
- Safety procedure to cover the "man in pipe" situation, with description of equipment involved (breathing apparatus, rope, welding equipment, etc.)
 - Procedure to monitor and control the extent of welding works inside the pipe
 - Time and distance limitations.

13.2 Qualification of repair procedures

Qualification of weld repair procedures shall be carried out at the same time as the qualification tests of main procedures. Repair procedure qualification tests shall include the following, unless a different repair scheme is proposed by CONTRACTOR and approved by COMPANY:

- a) Execution of a full thickness repair centered on the initial weld axis (through thickness repair)
- b) Execution of a mid-thickness or partial repair with groove centered on the initial weld Fusion Line (mid-thickness/partial repair)
- c) Execution of a simulated repair of an undercut by grinding and depositing a single bead or execution of a cover pass (i.e. the whole of the weld cap is locally replaced), at CONTRACTOR's option (cap repair)
- d) Execution of a simulated repair at root by internal welding using a single pass (internal repair), when internal repairs are proposed by CONTRACTOR
- e) Execution of a repair of repair (outside weld root), when such repairs are proposed by CONTRACTOR.

Grouping of materials and pipe sizes for qualification of welding repairs may be considered by COMPANY.

The test welds shall be subject to full visual and non-destructive testing according to § 8.4.1 of this specification and then to destructive tests as follows:

- For all kinds of repairs:
 - 1 macro-section and hardness survey as per § 8.4.2.6 and 8.4.2.7 (see also Appendix 7, 8 and 9 for hardness survey)
 - 1 chemical analysis as per § 8.4.2.11.
 - For mid-thickness/partial repairs, though thickness repairs and repairs of repairs:
 - 1 tensile test transverse to weld
 - 3 sets of 3 impact tests as per § 8.4.2.8 modified as follows:
 - 1 set with the notch centered on the weld metal axis
 - 1 set on both sides of weld repair with the notch located at 2 mm from fusion line.
- Charpy specimens shall be located at 2 mm max. from pipe surface at weld cap.
- 4 side bend tests (full pipe thickness specimens).

- For cap and internal repairs: 4 side bend tests (full pipe thickness specimens)
- For all kinds of repairs: SSC tests as per Appendix 10 of present specification at two locations: one test at repair start and one test at mid-length of repair.

Location of mechanical test specimens in repair welds shall be as per:

- Appendix 7 for through thickness repair and repair of repair.
- Appendix 8 for mid thickness/partial repair
- Appendix 9 for cap repair and internal repair.

13.3 Preparation for re-welding

Defects shall be removed by grinding, or by arc-air gouging following by grinding. The cavity shall be finished to a bright and smooth finish.

The removed portions shall be sufficiently deep and long to remove the defect. At the ends and sides of the cavity, there shall be gradual taper from the bottom of the groove to the surface of the weld metal. The width and profile of the cavity shall be such as adequate access for rewelding is met.

In the event that the defect is close to the weld root and the whole thickness of the weld seam is to be removed, the new gap opening at the weld root shall remain within the qualified root gap tolerances defined in the WPS.

Weld found with cracks shall be repaired by complete removal of the weld i.e. by cutting out a section of pipe containing the weld. (see § 12.5.7)

13.4 Re-welding

The weld repair shall be carried out in accordance with the approved repair welding procedure (see above).

The preheating and PWHT (if applicable) shall be applied to the whole girth weld. Reference is made to § 7.2.9, 10.3 and 10.4 of this specification.

13.5 Inspection of weld repairs

All welds repairs shall be re-inspected using the same inspection technique and requirements as for the original weld.

If defects have not been removed or new defects have been added as a result of a repair attempt, a repair shall be permitted as per § 13.1.

13.6 Record of repairs

A full record of all repairs shall be maintained by the CONTRACTOR. The record shall include the following:

- Weld number
- Type and size of defect
- Circumferential location (defined to an approved system)
- Estimate of the depth (assessed by ultrasonic test where possible)
- Where possible, the name of the welder who produced the defect

- Repair welding procedure number
- Name of repair welder
- Copy of the inspection report for the repair
- Date of repair.

14. Documentation

14.1 Pipe and weld log

CONTRACTOR shall maintain a welding log (within a pipe tracking system) and shall update it as the work progresses.

This document shall include, but is not restricted to, the following information:

- Number, origin, steel grade, nominal diameter and nominal thickness of each pipe, flange or fitting in its order of installation
- Actual length of each pipe laid/welded and cumulative length
- Date each weld or repair was made
- Number of each weld and welder/operator(s) used
- Location of each weld with respect to the pipeline kilometric point or with respect to one end of the pipeline, as appropriate or agreed with COMPANY
- Location of obstacles, accessories, anodes, potential test points, etc., and their location with respect to neighbouring welds
- Information pertaining to weld inspections carried out (results, defects found, repairs, etc.)
- Cut off lengths.

This document shall be available to the Inspector at all times for information and review.

14.2 Final dossier

Upon completion of the fabrication and/or installation work, CONTRACTOR shall provide COMPANY with a final dossier including at least the following documents:

- The laying/welding log
- The Welding Procedure Specifications (WPS) for main welds and repair welds
- The Welding Procedure Qualification Test Records (WPQR) for main welds and repair welds
- The H₂S embrittlement test procedure and test reports
- The welder and welding operator qualification certificates
- The radiographic and ultrasonic inspection procedures and qualification test reports
- The NDT operator qualification certificates
- The technical data sheets of welding consumables (coated electrodes, wire, fluxes), the Mill certificates and CONTRACTOR tests per batch, the consumables procedure for handling, drying and traceability.

- The non-destructive inspection reports
- The Quality Control Plan
- The present specification and related PPS.

The PPS shall state the number of originals and copies of the final dossier which is to be supplied to the COMPANY.

The final dossier shall be completed and submitted to COMPANY within one month after completion of site welding.

14.3 Dossier for bid submission

Upon submission of his proposal, CONTRACTOR shall provide COMPANY with the following minimum information and documentation:

- a) The specification data of the equipment to be used in the production welding line (offshore, onshore):
 - Layout and make up of the production welding line: welding stations, repair welding station, NDT station, etc., together with location of tensioners
 - Maximum and minimum pipe lengths which are acceptable for welding with the welding installation
 - Technical data of welding equipment for main line, double joints, etc.
 - Technical characteristics of preheating and post-weld heat treatment equipment (where applicable)
 - Alignment clamp type and technical data
 - Bevelling machine for main line, double joints, etc.
- b) Same data as above (where applicable) for pre-installation work (e.g. double jointing, expansion loop prefabrication, etc.)
- c) The proposed WPSs for welds and repair welds (including a summary table as stated in § 7.1), with execution sequence of the various passes in relation to the welding stations used or types of weld
- d) The welder qualification scheme
- e) The location where WPS and welders will be qualified
- f) The nominated company for performance of NDT
- g) The preliminary NDT procedures, together with data sheets on the equipment used
- h) The nominated laboratory for conducting the H₂S embrittlement tests, with preliminary SSC procedure or typical procedure
- i) Quality Assurance Certification ([ISO 9002](#), etc.)
- j) CONTRACTOR's past experience in welding/installing pipeline similar to that of the Project (e.g. past experiences from similar jobs performed successfully, WPS and WPQR previously used in production, etc.)
- k) Deviations to present specification, if any.



15. Technical Queries/Non-Conformance Reports

1. Any CONTRACTOR's requests for clarifications or deviations to COMPANY specifications shall be submitted to COMPANY only through Technical Queries (TQ), the format of which shall have prior approval of the COMPANY.

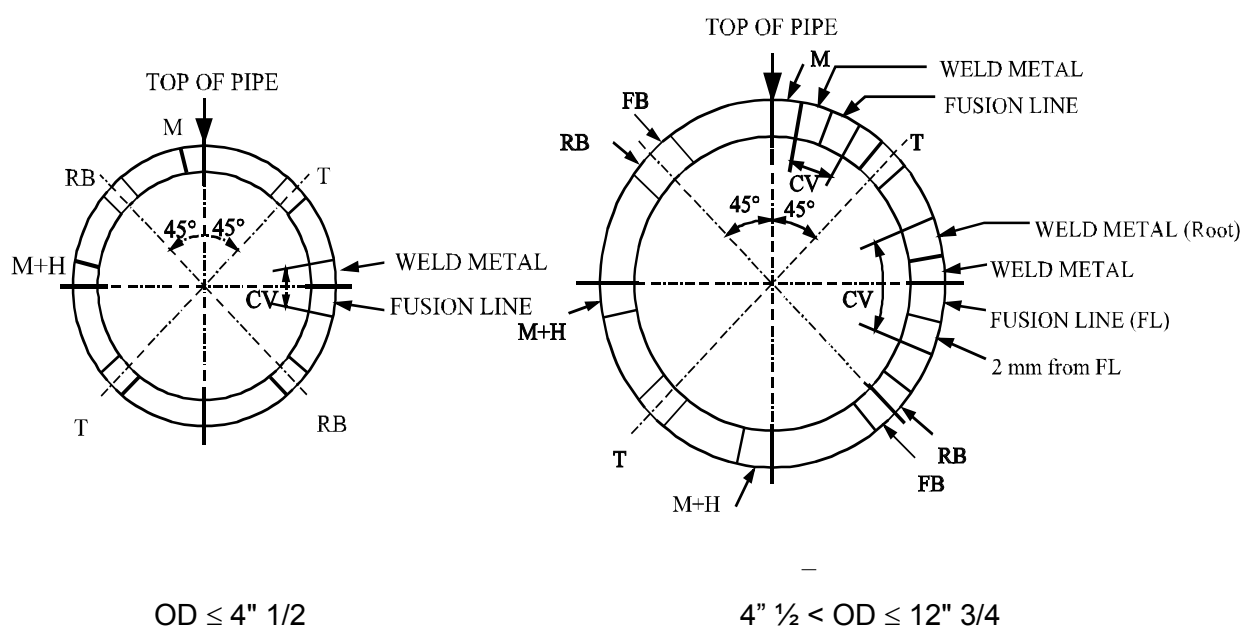
A deviation to specification shall not be considered as accepted if it has not been submitted to and accepted by COMPANY through a Technical Query.

2. Approval given by the COMPANY to any CONTRACTOR's work procedures, specifications, equipment, etc. shall not release in any way the CONTRACTOR from his obligation to meet the COMPANY specifications.
3. Any work performance or test result which is found, at a later date, not in conformance with COMPANY specifications or agreed procedure shall be subject to a Non-Conformance Report (NCR) to be issued by the CONTRACTOR for submission to COMPANY. NCR report shall indicate corrective action intended by the CONTRACTOR.

Appendix 1 Welding procedure qualification/Butt weld

Location of test specimens

(OD $\leq 12\frac{3}{4}$)



Key:

- T = Transverse Tensile
- FB = Face Bend
- RB = Root Bend
- M = Macrography (only)
- M+H = Macrography+ Hardness survey
- CV = Charpy V-notch impact

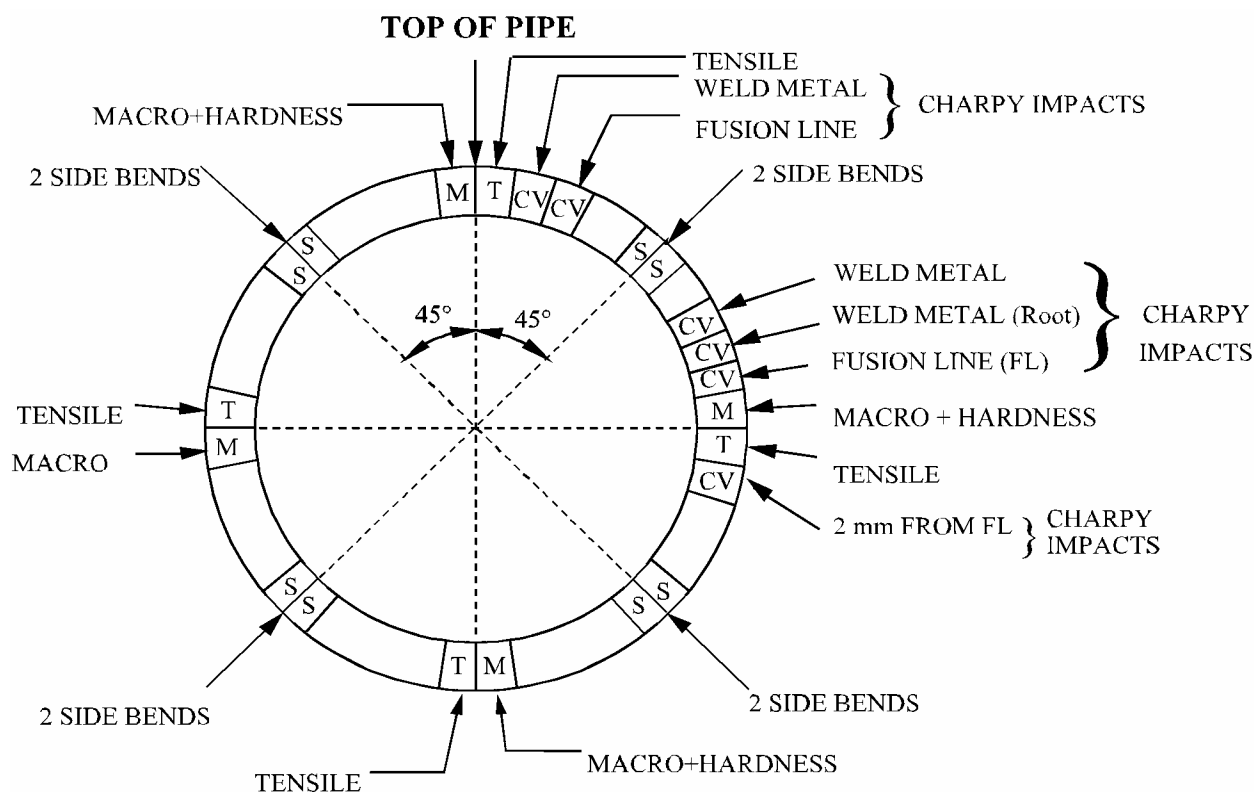
Notes:

- 1) Each couple of Root Bend and Face tests to be replaced by two Side Bend tests for WT > 12.7 mm.
- 2) For OD < 4" 1/2 Tensile test is not required.
- 3) For WT ≤ 20 mm, Charpy Test in Root Weld centreline is cancelled.

Appendix 2 Welding procedure qualification/Butt weld

Location of test specimens

(OD > 12"3/4)

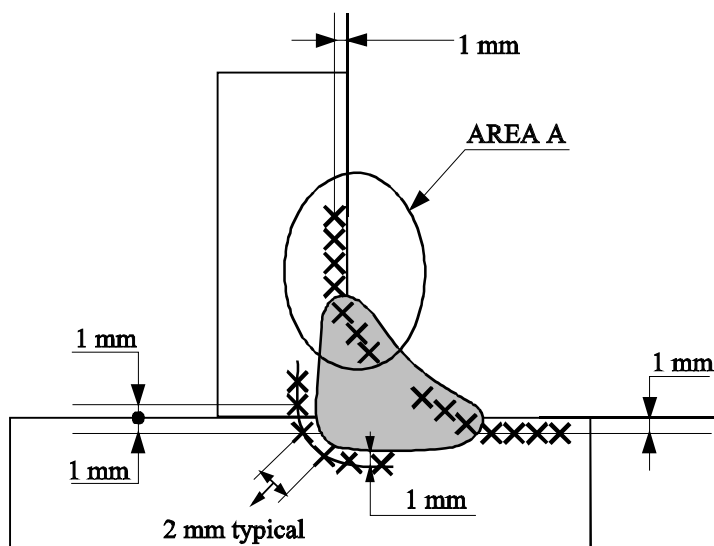


Notes:

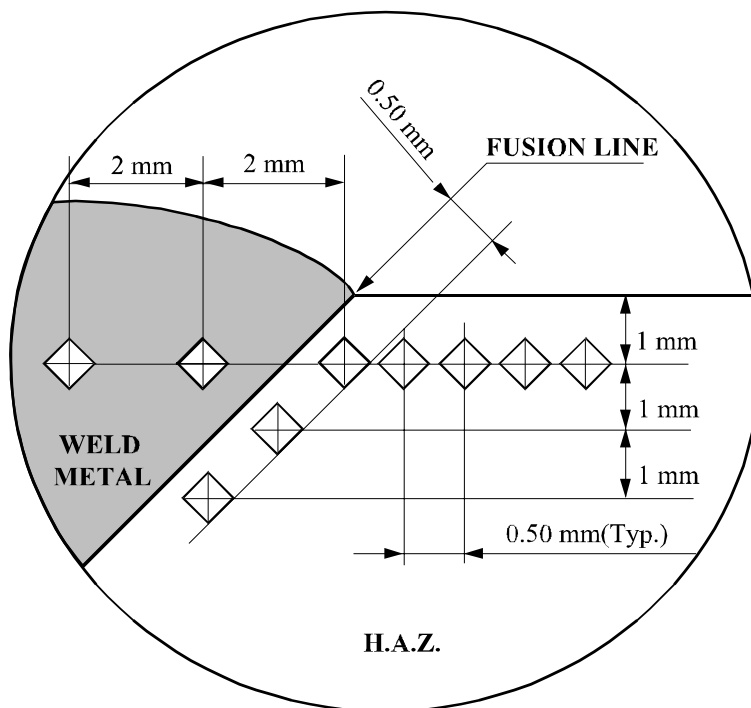
- 1) For WT less than or equal to 20 mm, the Charpy test in root weld metal centreline is cancelled.
- 2) For WT less than or equal to 12.7 mm, each couple of Side Bends are to be replaced by 1 Face Bend + 1 Root Bend.
- 3) CTOD tests, all-weld tensile tests, macrography + hardness at longitudinal/circular weld intersection and chemical analysis in weld metal are not indicated in sketch.

Appendix 4 Vickers hardness survey (5 kg load)

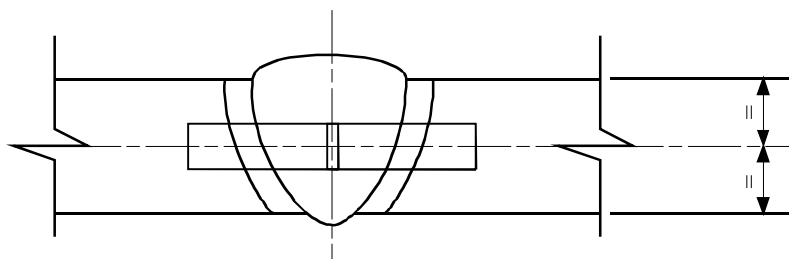
Fillet weld



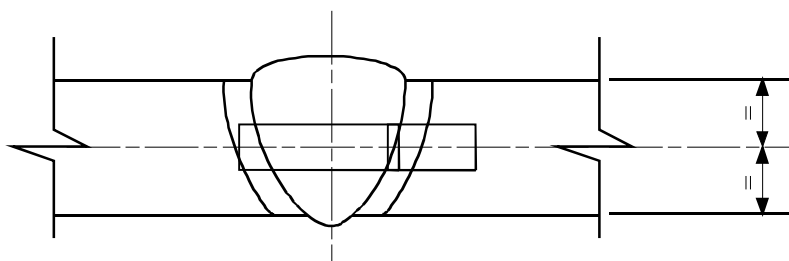
Enlargement of area A (typical)



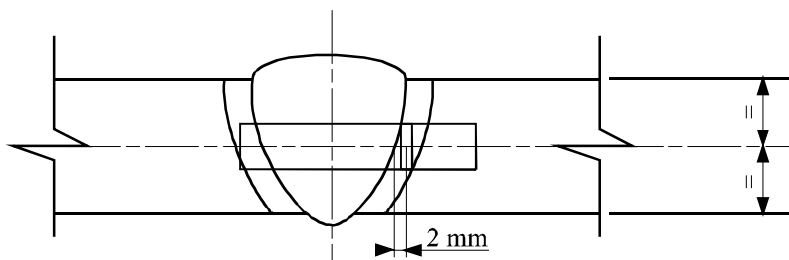
Appendix 5 Charpy V-notch impact tests - Specimen notch location



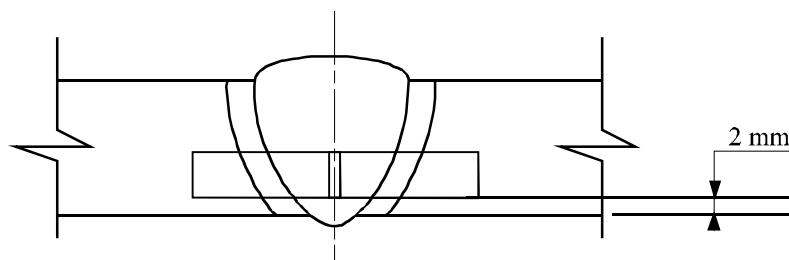
(i) Notch at centre line of Weld Metal



(ii) Centre of notch located at Fusion Line



(iii) Centre of notch located 2 mm from Fusion Line



(iv) Root Weld Metal Charpy location
(Additional test for WT > 20 mm. ; at 3 o'clock position only)

Appendix 6 Charpy V-notch impact test

Absorbed Energy Requirements ($WT \leq 25$ mm)

ASTM E 23 - Full size specimens 10 x 10 mm

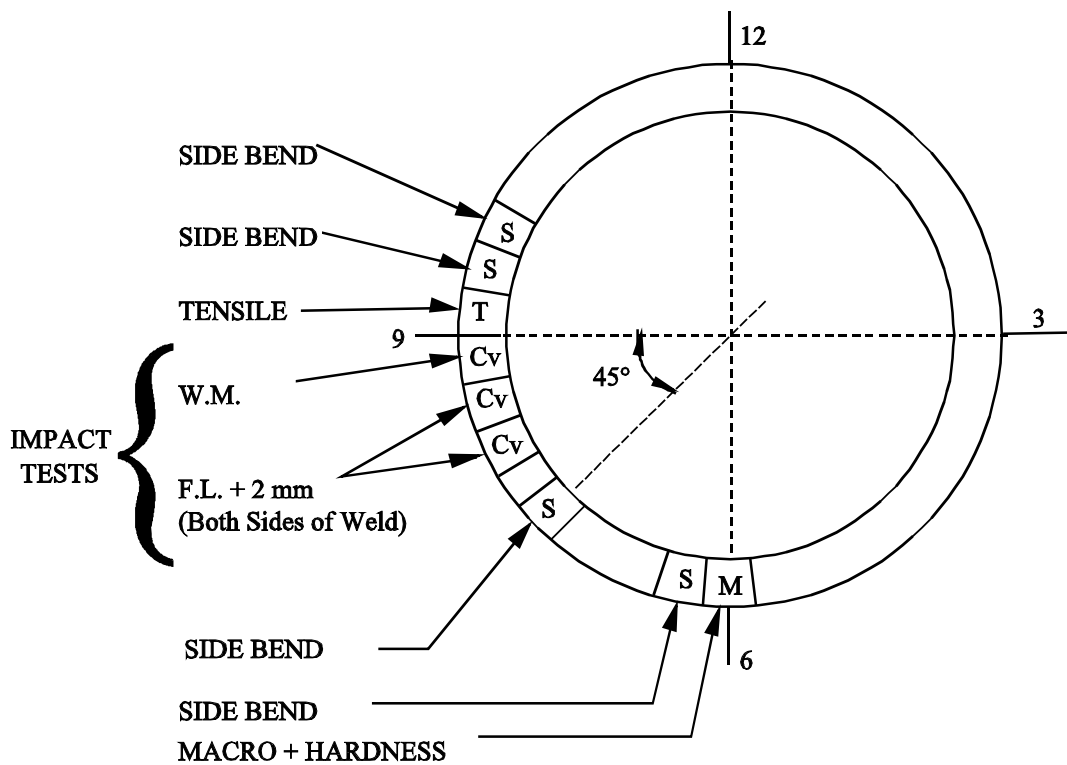
Steel Grade	Minimum Average (Joules)	Minimum Single (Joules)
B	28	22
X 42	30	24
X 46	32	26
X 52	36	30
X 56	39	32
X 60	42	35
X 65	45	38

Note: Multiplying Factors for sub-size specimens:

10 x 10 mm	1
10 x 7.5 mm	5/6
10 x 6.7 mm	7/9
10 x 5 mm	5/7

Appendix 7 Through thickness repair qualification tests

Location of tests specimens

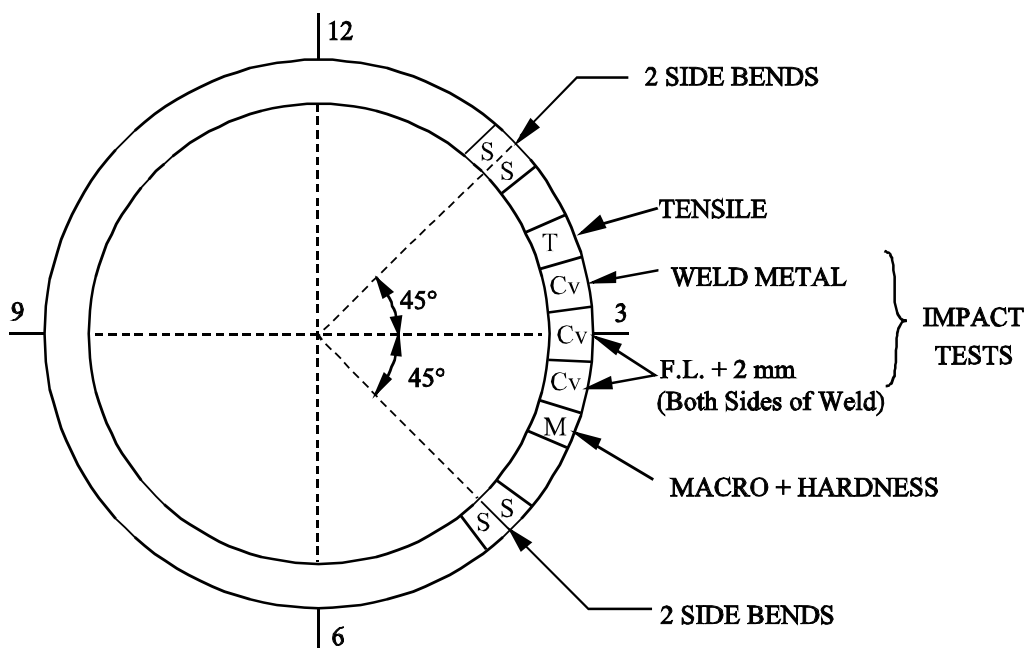


Vickers hardness survey (5 kg load)

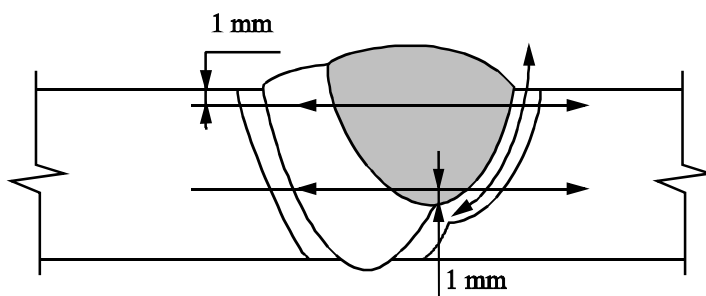
Indents to be carried out according to Appendix 3

Appendix 8 Partial or mid-thickness repair qualification tests

Location of test specimens



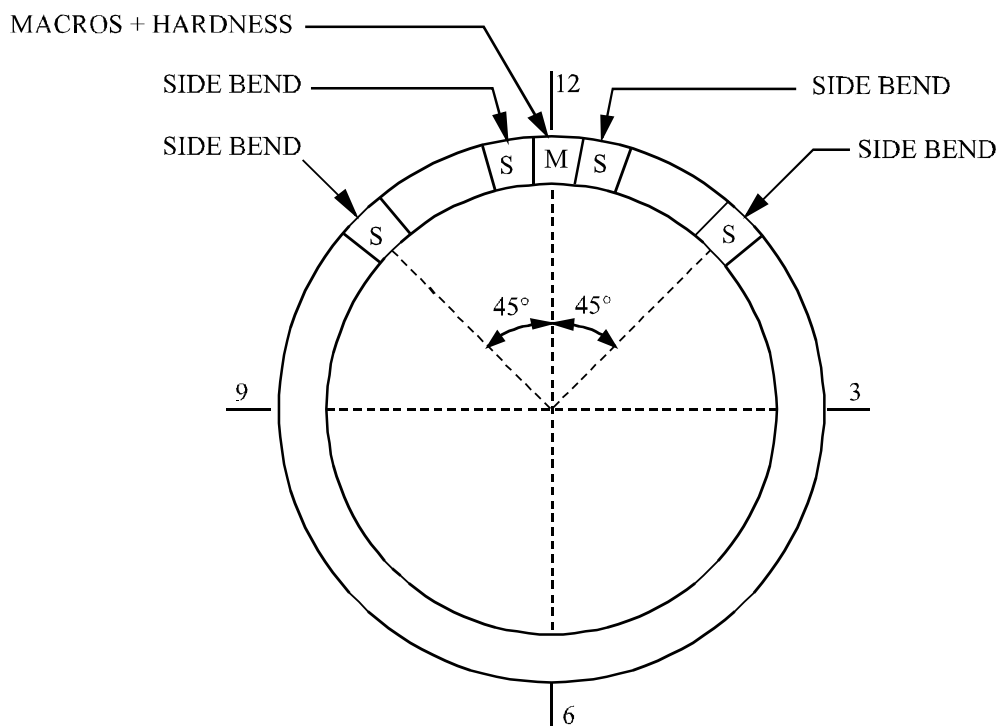
Vickers hardness survey (5 kg load)



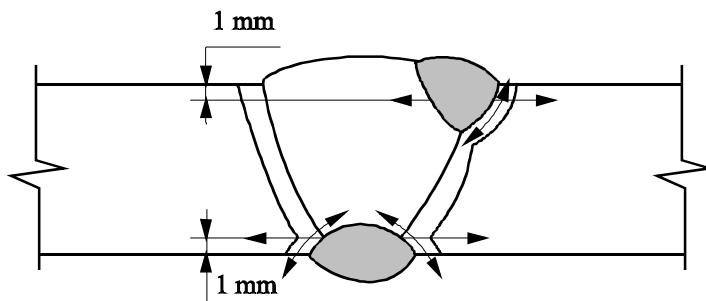
Indents to be carried out according to Appendix 3

Appendix 9 Cap or internal repair qualification tests

Location of test specimens



Vickers hardness survey (5 kg load)



Indents to be carried out according to Appendix 3

Appendix 10 Specification for Sulfide Stress Cracking tests on welds (SSC tests)

1. General

This specification applies to the testing of both the base metal and the longitudinal weld (including welding repairs) of line pipes by means of sulphide stress cracking tests using the 4-point bending test method (method B of [EFC Publication no. 16](#)). Apart from the type of specimen (no holes) and the bending method (4-point bending), all the provisions regarding method B of [NACE TM-01-77 Std](#) shall apply, unless otherwise stated hereafter.

The SUPPLIER shall prepare a fully detailed test procedure proposal based upon this specification and submit it to the COMPANY for prior approval.

2. Specimen preparation

Each set shall consist of three specimens cut transverse to pipe axis.

Two sets (minimum) of specimens (3 cap specimens and 3 root specimens) shall be removed from the weld at locations shown in Figure 1 hereafter and one (or two) set of specimens shall be removed from the Base Material.

Each specimen shall be prismatic with the following dimensions: 115 to 140 mm long, 15 mm wide and 5 mm thick.

Cap SSC specimens in weld shall be cut as close as possible to the inside pipe surface, with a minimised depth of machining to obtain flat surfaces.

Cap specimens in weld shall have the centreline of the loading span at the weld fusion line. Root SSC specimens in weld shall have the centreline of the loading span at the weld overlap line at weld root. When consumables of outer pass are different from those of inner pass, an additional set of specimens shall be cut at cap of outer pass.

For Base Material testing, the specimens shall be cut as close as possible to the inside pipe surface at a location opposite to weld in pipe. For pipe $WT \geq 15$ mm, 2 sets shall be cut: one at pipe inside (as above) and one at pipe mid-thickness.

All specimen surfaces shall be ground smooth to 600 grit emery paper, minimum, following machining.

Test identification shall be marked on each specimen by an approved method.

3. Test required

A machined round bar tensile specimen of maximum possible diameter shall be prepared with its axis longitudinal to pipe axis from the tested pipe.

Then, a tensile test shall be carried out and Yield Strength (0.2% proof stress) and Tensile Strength shall be recorded. This actual Yield Strength of base material will be the reference for calculating the stress level of the SSC tests.

All SSC tests shall be conducted at the stress level of 80% of actual Yield Strength of pipe base material. The measurement of applied stress shall be made using electrical strain gauges.

Spare test specimens shall also be cut and shall be available for additional tests in case of need.

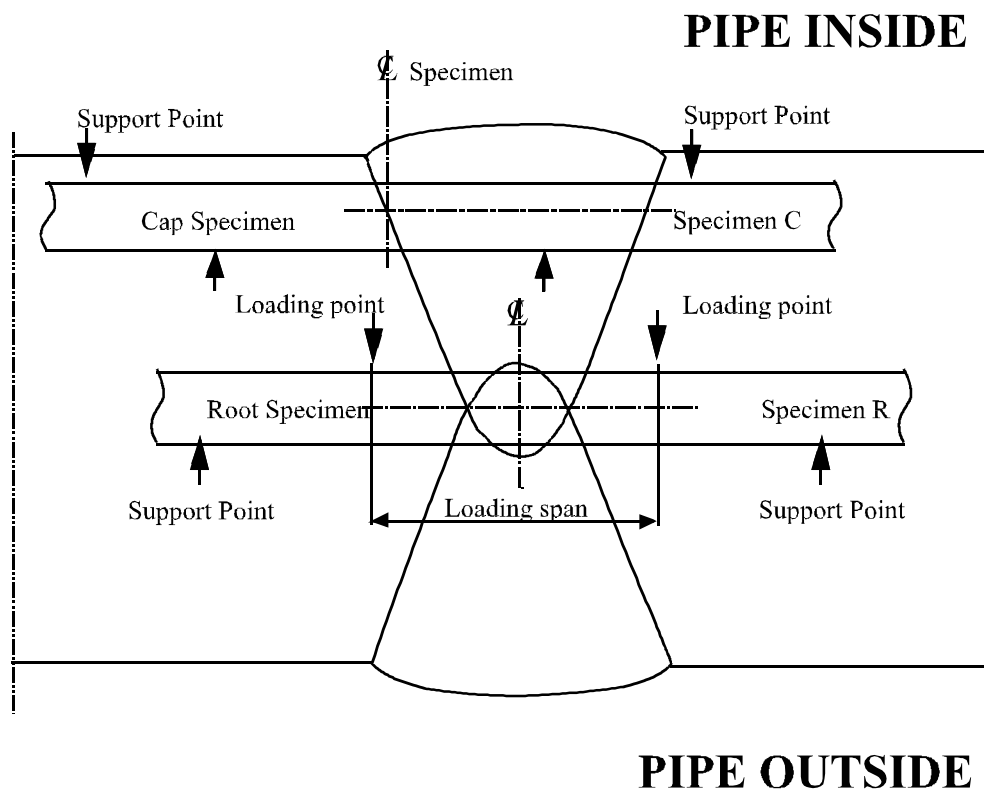


Figure 1 – Removal of specimens in weld

4. Test arrangement and test solution

Test arrangement and loading of specimens shall be as per [ASTM G39 Std](#) or [ISO 7539-2 Std](#).

The outer and inner rollers shall be made with materials that do not creep when subjected to the sustained loads (glass or ceramic rods) and avoiding galvanic coupling with the specimen.

Stress applied to specimens shall be adjusted as stated in above & 3 (strain gauges).

If the in situ pH of the pipeline wet environment can be determined, testing will be carried out according to EFC 16 procedure or ISO 15156-2 Table B.1 **under the conditions of the most severe pH encountered in service with the actual maximum design H₂S partial pressure**. The determination of pH is given in GS COR 170.

In cases where actual in situ pH is unknown, test solution, pH and H₂S partial pressure shall be as stated in the table below, according to sour service severity and type of pipeline effluent.

Test solutions A and B shall consist of 5.0 weight % NaCl + 0.4 weight % sodium acetate (CH₃COONa) in distilled or deionized water. However, throughout the test, pH shall be controlled periodically adjusted and continuously recorded to the above specified pH with an allowance of ± 0.1 by addition of HCL or NaOH.

All reagents added to the test solution shall be measured to ± 1.0 % of the quantities specified.

Pipeline ⁽¹⁾ Sour service	Area ⁽¹⁾	Pipeline effluent	Test conditions	Min. H ₂ S concentration (ppm)
Intermediate	2	Oil	EFC 16 solution B pH = 4.5 – PH ₂ S = 0.1 bar	230
		• Gas • Multiphase systems • Condensates	EFC 16 solution A pH = 3.5 – PH ₂ S = 0.01 bar	23
Severe	3	Oil	EFC 16 solution B pH = 4.5 – PH ₂ S = 1 bar	2300
		• Gas • Multiphase systems • Condensates	EFC 16 solution A pH = 3.5 – PH ₂ S = 1 bar	2300

Note 1: Refer to definitions in specification **GS COR 170**.

Test solutions A and B shall consist of 5.0 weight % NaCl + 0.4 weight % sodium acetate (CH₃ COONa) in distilled or deionized water. However, throughout the test, pH shall be controlled, periodically adjusted and continuously recorded to the above specified pH with an allowance of ± 0.1 by addition of HCL or NaOH.

All reagents added to the test solution shall be measured to ± 1.0 % of the quantities specified.

H₂S gas purity shall be 99.5% minimum.

The SUPPLIER shall ensure that saturation of the solution is obtained after one hour.

The solution shall be saturated by using H₂S + CO₂ gas mixtures to obtain the desired H₂S partial pressure.

Hydrogen sulphide concentration in the solution shall be measured by the iodine titration method. The minimum H₂S concentrations shall be as stated in Table of this paragraph.

Tests shall have a duration of 30 days (720 hours) minimum.

The temperature of the solution shall be maintained at 24°C ± 3° and regularly recorded from the start to the end of test.

The volume of test solution to the total exposed surface area of test specimens shall be 30 ± 10 ml/cm² minimum.

The pH shall be continuously recorded as said above. The H₂S concentration of the solution shall be recorded at the start of test, after initial H₂S saturation and end of test, as a minimum.

5. Specimen examination

Following failure or at the end of the test (whichever happens first), visual examination and photographs shall be made at x1 and x10 magnifications of the stressed surfaces of each specimen further to cleaning and MPI.

Whenever a crack is found, the specimen shall be cut longitudinally at crack location, polished and etched. Photographs of the stressed surface and macrosection shall then be taken. Any SSC cracks in weld need to be categorised by location namely: Base Metal, HAZ, Weld Metal. It shall be metallurgically examined and the metallurgical features recorded with photomicrographs.

Specimens which do not exhibit crack on their external surface, shall be cut transverse to weld (transverse to rolling direction) at 5 mm and at 10 mm from their external transverse faces. The sectioned surfaces shall be ground smooth to 600 grit emery paper, minimum, following machining.

Visual examination of unetched sections shall be made at X1, X10 and X100 magnifications.

If cracks are observed, specimens shall be properly etched. Photographs shall be made at a suitable magnification before and after etching.

6. Test acceptance criteria

No crack (or rupture) shall be accepted in any of the tested specimens (in HAZ, weld or base metal) within the 30 day period for any of the tests carried out at 80% of actual yield strength of base material.

For evaluation, only SSC or SOHIC cracks shall be considered. Cracks initiated in base material inclusion will not be considered.

Little grooves or pits caused by corrosion loss will not be considered, in mutual agreement between supplier and inspector.

7. Reporting

At end of testing, the SUPPLIER shall provide a test report giving the following data:

- a) Measurement of stress applied (strain gauges, etc.)
- b) Individual result for each specimen tested per set, with photographs and photomicrographs (when applicable)
- c) Type of solution as per Table above of this Appendix. pH of solution at start and end of test and also at end of each week of test. H₂S concentration at start and end of test.
- d) Location and dimensions of specimens
- e) Mill certificates of materials tested showing full chemical analysis and mechanical properties
- f) Testing procedure specification.
- g) Conclusions and pertinent explanations (where needed) or concluding informations. Any failure shall be analysed by the SUPPLIER and the causes of failure made clear to the COMPANY, before any re-test or remedial actions are decided.

Appendix 11 Flux dryness

1 – Procurement of flux:

At the time of flux packing, the diffusible hydrogen content in SAW weld deposit shall be checked on a sample of the batch of flux and shall be lower than 5 ml / 100 g of weld deposit. (This measurement may also be done through by the moisture content measurement, when evidence of correlation can be provided by flux manufacturer, based on previous comparative tests of diffusible Hydrogen versus flux moisture content. Otherwise, the acceptable maximum moisture content shall be 0.03 %. The “Karl Fisher” method shall be applied.)

For diffusible hydrogen testing or for moisture measurement, **NO PRE- DRYING NEITHER ANY PRE-HEATING OF FLUX SAMPLE will be carried out before testing.**

(Tests shall be carried out with the flux as it is at the time of sampling. Moisture measurement will be carried out at 1050° C approx.)

Results of diffusible hydrogen or moisture measurement shall be reported on the 3.1 B flux certificate for each batch. The testing conditions, as specified above, shall be confirmed on the certificate.

Packing shall be of humidity proof type.

Metallic / stiff plastic drums with rubber gasket for the tightness of top or double polymer top welded bags are acceptable. The packing shall be designed to guarantee no significant humidity absorption during a storage of one year as defined below.

2 – Storage of flux

Flux shall be stored in a controlled hygrometry room where the relative hygrometry shall be permanently maintained below 60%. The maximum duration of storage shall be one year (after the date of packing). Over one year, a spot check of diffusible hydrogen / moisture content shall be required.

3 – Use of flux

Drums / bags shall be checked before use. They shall be undamaged.

They shall be opened just before pouring the flux in the welding machine hooper where the temperature shall be maintained between 120 and 150° C.

In case of welding stop, the remaining flux stored in hoopers shall be scrapped after 12 hours maximum.

The system of feeding, downstream the hoopers, shall be drained off before welding restart when welding has been interrupted 2 hours max.

The feeding from hoopers shall be done by gravity where possible. Where pressurised air is used for flux conveying, the said air shall be dried with adequate equipment.

4 - Flux recycling

When supplier intends to recycle welding excess of flux, he shall implement the same good practice specified in above paragraph 3. The recycling procedure shall be submitted to Company for approval prior production start. The procedure shall include a sketch showing the circulation of recycled flux and of sucking air.