



PTT Exploration and Production Public Company Limited

PTTEP Engineering General Specification
(Engineering and Development Group)

Standard

**Welding of Onshore and Offshore Carbon Steel Pipelines to
API Standard 1104**

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1.0 INTRODUCTION

PEGS (PTTEP Engineering General Specification) is the PTT Exploration and Production PCL internal publishes standard. The objective of PEGS is to promote the best practices collecting from all PTTEP execution projects and to standardize those best practice to the future projects.

Every 5 years or upon request by the internal user, PEGS will be reviewed by related subject experts to reach decisions/agreements, then the document will be updated and publish to PTTEP intranet website. This is to ensure that all lesson learns from users can be applied to the future projects as the benefit to PTTEP.

2.0 PURPOSE

This specification defines the COMPANY general requirements for the welding and inspection of onshore and offshore pipelines (including risers) and associated equipment (e.g. pig traps) operating in Mild, Intermediate or Severe Sour Service (i.e. corresponding respectively to regions 1, 2 and 3 in specification 10008-STD-6-COR-032, PEGS-0842-COR-032).

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 specified minimum yield strength SMYS not exceeding 70,300 psi (485 MPa), during onshore work or offshore installation of the said pipelines.

Branches made of pipes directly welded to main pipeline are not allowed (see section 7.8.9 of this specification).

Pipe anchoring system (anchor flanges, etc.) shall consist of a single forged body as such it shall have the same internal diameter as that of the connecting line.

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

3.0 SCOPE

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.

4.0 RESPONSIBLE ACTION PARTIES

N/A

5.0 DEFINITIONS

A number of different terms are commonly used to describe the work stages, processes, and approvals which take place during the early stages of a development. This can often be a source of confusion so the following section is intended to show the PTTEP preferred terminology as used in this document.

5.1 LANGUAGE

In this document, the words should and shall have the following meanings:

Shall	Indicates a course of action with a mandatory status. The term “shall” shall be used if a requirement is considered to be necessary to claim compliance with a PEGS document.
Should	Indicates a preferred course of action. Should is a non-mandatory word and is not forbidden, but use in the body of the text should be the exception. Where none mandatory terms are used, each paragraph within these clauses shall also have an associated commentary paragraph that provides the rationale for why the stated choices and modifications are appropriate and circumstance under which the stated choices and modifications might be different.

5.2 TERMINOLOGY

Terminology	Description
Approval	The authorization in writing given by the COMPANY to the Contractor to proceed the work without releasing in any way the Contractor from any of his obligations to conform with the technical specifications, requisitions, etc. The words “Approve”, “Approved” and “Approval” shall be construed accordingly
Automatic welding / Mechanized welding	Reference shall be made to the definition of “automatic welding” in API 1104 Std. However, in the present specification, “automatic welding” shall also designate mechanized welding.
Company	PTT Exploration and Production Public Company Limited and affiliates.
Contractor	Per contract: Contractor – ‘The contractor who is a PARTY to this CONTRACT and where the context so requires including, SUBCONTRACTORS utilized by CONTRACTOR for the performance of the WORK’
Inspector	The COMPANY’s or Supplier’s representative(s), (as applicable), or member(s) from an Inspection Agency duly appointed by the COMPANY or the Contractor or the Supplier (as applicable) to act as its representative(s) for the purpose of the contract.
Manufacturer	The company or its sub-contractors selected by the COMPANY or the Contractor or the Supplier (as applicable) as the Manufacturer of the said material.
PPS	Designates Project Particular Specification detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions or the local legislation of the project.
Purchaser	The COMPANY or the Contractor or the Supplier (as applicable) which have placed the Purchase Order to the Supplier/Vendor/Manufacturer.
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.

Terminology	Description
Supplier/Vendor	The company designed on the Purchase Order form or Contract as being the selected supplier of the said materials.

5.3 COMMON ACRONYMS

Set out below in alphabetical order are common acronyms as found within this document:

CE	Carbon Equivalent
CTOD	Crack Tip Opening Displacement
ECA	Engineering Critical Assessment
FCAW	Flux-Cored Arc Welding
GMAW	Gas Metal Arc Welding
GTAW	Gas Tungsten Arc Welding
HAZ	Heat Affected Zone
IQI	Image Quality Indicators
LPI	Liquid Penetrant Inspection
MPI	Magnetic Particle Inspection
MPQT	Manufacturing Procedure Qualification Test
NDT	Non-Destructive Testing
OD	Outside Diameter
PWHT	Post Weld Heat Treatment
RT	Radiographic Testing
SAW	Submerged Arc Welding
SMAW	Shielded Metal Arc Welding
SMYS	Specified Minimum Yield Strength (steel pipe)
SSC	Sulphide Stress Cracking
TQ	Technical Query
UT	Ultrasonic Testing
WPQ	Welding Procedure Qualification
WPQR	Welding Procedure Qualification Record
WPQT	Welding Procedure Qualification Test
WPS	Welding Procedure Specifications
WT	Wall Thickness

6.0 REFERENCES

The reference documents listed below, including Industry Codes and Standards and COMPANY specifications, form an integral part of this Engineering General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published on the effective date of a contract.

The overall order of precedence of the applicable documents shall be:

1. Applicable Laws, Rules and Regulations of the country in which the system/equipment will be operated (if any);
2. Purchase Order/ Service Order/ Contract Documents (Only applicable for direct purchase by COMPANY);
3. Project Particular Specification (PPS), and relevant data sheet(s) if any;
4. COMPANY General Specification;
5. Codes and Standards in reference.

Any conflict between any of the Contract Documents, or between this specification and any other Contract Documents, shall be reported to COMPANY for decision. In such a case, and unless otherwise agreed or decided by COMPANY, it is understood that the more stringent requirement shall apply.

Exceptions to, or deviations from this specification are not permitted unless previously accepted in writing by COMPANY. For this purpose, requests for substitutions or changes of any kind shall be completed with all pertinent information required for COMPANY assessment. COMPANY's approval, nevertheless, will not, in any way, relieve the responsibility of the Contractor to meet the requirements of the industry Codes and Standards referred to and amended herein, in the event of conflict.

6.1 PTTEP INTERNAL REFERENCES

Internal documents applicable to this document are indicated in the table below.

Document Number	Document Title
10008-STD-6-GEN-004, PEGS-12060-ADM-004	Minimum Requirements for CONTRACTOR's Documentation
10008-STD-6-COR-032, PEGS-0842-COR-032	Materials for Sour Service
10008-STD-6-INT-001, PEGS-12060-INT-001	Inspection and Testing Requirements
10008-STD-6-PLR-011, PEGS-0710-PLR-003	Design, Materials and Fabrication of Tees for Carbon Steel Pipelines (Mild, Intermediate and Severe Sour Service)
10008-STD-6-PLR-008, PEGS-12059-PLR-004	Induction Bends for Carbon Steel Pipeline (Mild, Intermediate and Severe Sour Service)
10008-STD-6-PLR-006, PEGS-12059-PLR-005	Longitudinally Submerged Arc Welded (SAWL) Pipes for Carbon Steel Pipelines (Mild, Intermediate and Severe Sour Service)
10008-STD-6-PLR-009, PEGS-0710-PLR-007	Design, Materials and Fabrication of Flanges and Branch Outlet Fittings for Carbon Steel Pipelines (Mild, Intermediate and Severe Sour Service)
10008-STD-6-PLR-005, PEGS-12059-PLR-017	Seamless Pipes for Carbon Steel Pipelines (Mild, Intermediate and Severe Sour Service)

6.2 INTERNATIONAL STANDARDS

International standards applicable to this document are indicated in the table below i.e. ISO, IEC or ITU.

Document Number	Document Title
ISO 11699-1	Non-destructive testing – Industrial radiographic film – Part 1: Classification of film systems for industrial radiography
ISO 148-1	Metallic materials - Charpy pendulum impact test: Test method
ISO 15156-2	Petroleum and natural gas industries - Materials for use in H ₂ S - containing environments in oil and gas production - Part 2 :Cracking-resistant carbon and low alloy steels, and the use of cast irons
ISO 17636	Non-destructive testing of welds -- Radiographic testing
ISO 17640	Non-destructive testing of welds -- Ultrasonic testing – Techniques, testing levels, and assessment
ISO 19232	Non-destructive testing – Image quality of radiographs
ISO/TS 29001	Petroleum, petrochemical and natural gas industries -- Sector-specific quality management systems -- Requirements for product and service supply organizations
ISO 3690	Welding and allied processes - Determination of hydrogen content in arc weld metal

Document Number	Document Title
ISO 5579	Non-destructive testing - Radiographic testing of metallic materials using film and X- or gamma-rays - Basic rules
ISO 7539-2	Corrosion of metals and alloys - Stress corrosion testing - Part 2: Preparation and use of bent-beam specimens
ISO 9712	Non-destructive testing -- Qualification and certification of NDT personnel

6.3 CODE AND OTHER STANDARDS

Codes, standards and regional legislation applicable to this document are indicated in the table below.

Document Number	Document Title
API STD 1104	Welding of Pipelines and Related Facilities
ASME B 31.4	Pipeline Transportation Systems for Liquid and Slurries
ASME B 31.8	Gas Transmission and Distribution Piping Systems
ASME Section II, Part C	Specifications for Welding Rods, Electrodes and Filler Metals
ASME Section V	Nondestructive Examination
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM A578/A578M	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E709	Standard Guide for Magnetic Particle Testing
ASTM E92	Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
ASTM G39	Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens
AWS A5.01M/A5.01	Welding Consumables – Procurement of Filler Metals and Fluxes
BS 4105	Specification for liquid carbon dioxide, Industrial
BS 4365	Specification for industrial argon
BS 7448	Fracture mechanics toughness tests

Document Number	Document Title
CSWIP	Certification Scheme for Personnel
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
EN 10204	Metallic Products - Types of Inspection Documents
MSS SP-97	Integrally Reinforced Forged Branch Outlet Fittings – Socket Welding, Threaded and Buttwelding Ends
NACE MR0175/ISO 15156	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production
NACE TM0177	Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H ₂ S Environments
NACE TM0284	Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
DNV-OS-F101	Submarine Pipeline Systems

7.0 WELDING OF ONSHORE AND OFFSHORE CARBON STEEL PIPELINES TO API STANDARD 1104

7.1 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 7.3).
2. Materials ordered with a simulated PWHT (if any) (refer to section 7.3).
3. Impact test temperature(s) and impact test absorbed energy requirements for WT above 25mm (where needed) (refer to section 7.6.4.2.8).
4. CTOD test temperature (when required) (refer to section 7.6.4.2.9).
5. The sour service severity and pipeline effluent to clarify the H₂S test conditions (refer to section 7.6.4.2.12 and section 4 of Appendix 10).
6. Requirements for welding qualification of welds subject to plastic straining over 0.4% (refer to Appendix 12), where applicable.

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

7.2 QUALITY CONTROL / QUALITY ASSURANCE

7.2.1 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 or Inspection and Test Plan which describes the systematic control of the construction, inspection and testing, as dictated by the overall Contract quality program. 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.

7.2.2 QUALITY ASSURANCE

The Contractor shall operate a Quality Assurance system in accordance with ISO 9001 or ISO/TS 29001 approved by a COMPANY recognized authority. The Quality Plan shall be submitted prior the start of work.

7.3 BASE MATERIALS

Pipes and fittings supplied by COMPANY are defined in the relevant PEGS listed in section 6.1 of this specification, and in related PPS.

Unless otherwise stated in the PPS, pipes and fittings supplied by COMPANY will be finished with ends beveled (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.

7.4 GENERAL WELDING REQUIREMENTS

7.4.1 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.

7.4.2 ELECTRODES, FILLER WIRES AND FLUXES

1. All welding consumables shall conform to ASME, Section II, Part C or an approved equivalent standard.
2. SAW flux procurement, packing, storage and use shall comply with the requirements of the Appendix 11 of the present specification.
3. Each heat, lot (or so called batch herein) of consumables shall be subject to inspection and approval by the Inspector. Type 3.1 (according to EN 10204) mill test certificates from consumables Manufacturers showing test results actually obtained on the said lot shall be submitted to the Inspector. Type 2.2 certificate is sufficient for SAW flux

The lot and the level of testing are specified as per AWS A5.01M/A5.01 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 as per “AWS A5.01M/A5.01 - section 7.4 - Schedule I” as a minimum. In addition, for SAW flux, testing of granulometry and testing of diffusible hydrogen and/or moisture, shall be required

Note: For SAW, re-cycling of flux is not permitted.

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 60% are maintained.
5. The chemical composition shall comply with ISO 15156. The nickel content in weld metal shall not exceed 1.0 percent and 0.5 Mo. An increase of Ni content to 1.5% will be acceptable provided that SSC tests are satisfactory.
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.

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 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) ECA (where necessary) and hardness requirements of this specification.

The weld deposits shall have a yield strength which overmatches base material SMYS by at least 80 MPa.

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

10. The use of Cellulosic coated electrodes is subject to conditions described in section 7.4.4.8 and section 7.4.4.9.
11. For FCAW, the max diffusible hydrogen content shall be 5ml/100g of weld metal.
12. For all girth welds exposed to an unusual strain >0.4% or line pipe steel with SMYS > 450 MPa, ECA shall be conducted as per DNV-OS-F101.
13. All welding consumables (electrodes, wires and fluxes) shall be procured from a reputable manufacturer such as Avesta, Esab, Kobe, Lincoln, Metrode and Oerlikon. Other proposed brand shall be strictly subject to approval by COMPANY.

7.4.3 SHIELDING GAS

The requirements of API STD 1104 shall apply.

7.4.4 WELDING PROCESS

1. Gas Tungsten Arc Welding (GTAW) and Shielded Metal Arc Welding (SMAW) processes are approved for use.

GMAW and FCAW are regarded as methods with high potential of non-fusing type defects and shall be subjected to successfully welding procedure qualification and approved by COMPANY.

2. For mechanized, 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. Copper shoes are not allowed for weld subjected to fatigue loading or accumulated plastic strain > 0.4%.
6. Basic coated low hydrogen electrodes shall be used for all fillet welds.
7. 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
8. Welding processes for anode connecting welds or any other welds to electrically connect attachments (see section 7.6.6) shall have prior approval of COMPANY (refer to section 7.6.6).

Electrical connecting weld shall be qualified as per section 7.6.6 and connection method shall be as per section 7.8.20.

9. On steel grade X60 and above, cellulosic coated electrodes are not permitted.
10. On steel grade up to X56, cellulosic-coated electrodes are allowed provided impact test is not less than -20°C (minus 20°C) and that the cellulosic electrode of root pass is limited to 6010 type of AWS A 5.1.
11. Only basic coated electrodes and FCAW shall be used for welding repairs. These consumable electrodes shall be of the extra low hydrogen type (i.e. maximum specified hydrogen content of 5 ml per 100 grams of deposited Weld Metal). The electrodes shall be supplied in vacuum packing. Moreover, they shall be guaranteed against moisture absorption for 8 hours after pack opening.
12. Reference shall also be made to section 7.5.2.6 here-after.

7.5 WELDING PROCEDURE SPECIFICATIONS (WPS)

7.5.1 GENERAL

The proposed 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 proposed WPS shall be accompanied by a summary table showing: process, consumables, direction of welding, type of weld, proposed 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 summary table and proposed WPS.

The proposed WPS shall include, as a minimum, all items listed in section 5.3.2 or 12.4.2 or 13.4 (when applicable) of API STD 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
- Amperage
- Voltage
- Wire speed
- Torch angle
- Gas Flow
- Travel speed
- Oscillation width, dwell and frequency for automatic welding (if applicable)
- Heat input
- 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 proposed WPS shall conform to API STD 1104 together with amendments stated in section 7.5.2 hereafter and essential variables of section 7.6.2.

7.5.2 WELDING PROCEDURE SPECIFICATION INFORMATION

7.5.2.1 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 products from different sources will also qualify joints between products from the two sources and vice-versa provided that both side of HAZ are tested (i.e.: A/A + B/B do qualify A/B and A/B does qualify A/A and B/B).

7.5.2.2 DIAMETER GROUP – WALL THICKNESS GROUP

Different wall thicknesses and outside diameters shall be qualified separately as shown in section 7.6.2. When grouping of wall thicknesses is agreed for qualifications, then the thicker pipe / product shall be used for the welding tests.

7.5.2.3 JOINT CONFIGURATION

Permanent backing rings or consumables inserts shall not be permitted. The root gap for fillet welds shall be in between 1.0 to 2.5 mm.

Refer also to section 7.8.1.e of this specification.

7.5.2.4 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 welding and mechanized welding processes, the number of passes shall always be established by a welding test made on each wall thickness different from that used for main qualification test.

Single pass welds or internal root sealing welds shall be minimized (refer to section 7.11.1 of this specification). This does not apply to an automatic back pass applied internally that is an integral part of the butt weld procedure.

7.5.2.5 PIPE POSITIONS/WELDING POSITIONS

Roll welding and position welding as defined in API STD 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 $\pm 15^\circ$ of the horizontal (5G position)
- Vertical pipes/fittings shall be used to qualify for welds between pipes/fittings within $\pm 15^\circ$ of the vertical (2G position)
- Pipes/fittings at 45° to the horizontal (6G position) shall be used to qualify for welds in all positions.

2G + 5G qualifies for 6G and vice versa.

7.5.2.6 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.

7.5.2.7 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 maximum 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 section 7.8.12 of this specification.

7.5.2.8 LINE-UP CLAMPS (REFER ALSO TO SECTION 7.8.6)

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).

7.5.2.9 PRE-HEAT/INTER-PASSES TEMPERATURE (REFER ALSO TO SECTION 7.8.3 (H) AND SECTION 7.6.2 (15))

A minimum preheat of 100°C (-0/+30°C) shall apply to the welding of fittings, repair welds, tie-ins and fillet welds. The measuring control shall be carried at 50mm distance from bevel ends.

Inter-passes temperature in construction shall not exceed the maximum value achieved in the welding procedure qualification test (WPQ). 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 inter-passes temperature.

7.5.2.10 JOINT BETWEEN MATERIALS OF UNEQUAL WALL THICKNESS OR SMYS

When materials joined have unequal wall thickness, e.g. due to unequal material SMYS, the bevel for butt welding shall be designed as per ASME B 31.8, Appendix I. The deposited weld metal shall have the mechanical properties (tensile + impact) required for pipe material of the higher strength.

7.6 WELDING PROCEDURE QUALIFICATION TESTS (WPQT)

7.6.1 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 and also for all other welds including fillet welds, fittings to pipes, fittings to fittings (refer to section 7.5.2.1 of this specification) and all associated weld repairs (refer to section 7.11 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:

- a) Minimum and maximum heat input (refer to section 7.6.2 (12) and 7.9.2). This applies, also, when heat input variation around a same weld is beyond $\pm 5\%$.
 - b) High-low exceeding 2.0 mm up to 2.5 mm (refer to section 7.8.2)
 - c) Interpass temperature beyond 250°C up to 280°C (refer to section 7.5.2.9 and 7.8.3)
 - d) Barge move-up/pipe move-up after root pass (refer to section 7.8.6 and 5.8.7).
 - e) For mechanized GMAW, the extreme angles (min. and max.) of pipe axis to the horizontal beyond $\pm 15^\circ$.
 - f) When copper shoes are used, Contractor shall perform a Qualification before production welding. That qualification test shall demonstrate there is no detrimental effects in the root face due to copper pick up and/or copper contamination (refer to section 7.6.4.2.14).
3. The test welds shall be fully visually inspected and then non-destructively tested according to section 7.6.4 and 7.6.5 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 7.9 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.

7.6.2 ESSENTIAL VARIABLES

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

1. Any change in Contractor (including any partner company of a Contractor consortium) which performed the qualification test or Site where the qualification test weld was produced. Refer also to section 7.6.3(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 SMYS groups of API STD 1104, except that separate qualification is required for steel grade of X60 and above, 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 section 7.6.1(2) and 7.8.2 of this specification).
6. Any change in specified 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 nominal diameter from one to another of the following ranges:
 - O.D. < 100 mm (4")
 - $100 \leq \text{O.D.} \leq 324 \text{ mm}$ (12.75")
 - $324 < \text{O.D.} \leq 610 \text{ mm}$ (24")
 - O.D. > 610 mm (24")
9. Any change in pipe nominal wall thickness beyond $\pm 20\%$ against that used at qualification test.
10. Any change in pipe position/welding position as shown in section 7.5.2.5. Any change from roll to fixed/position welding. Any change in direction of welding.
11. Any change in electrical source of supply, type of current or polarity.
12. Any change in welding heat input outside the one qualified is not permitted (Refer to section 7.6.1(2) and 7.9.3 of this specification).
13. Any change in bevel dimensions and reduction in groove angle from that qualified.
14. Any change in voltage beyond $\pm 10\%$ for GMAW

15. Any change of more than $\pm 15^\circ$ in angle of pipe axis to the horizontal. Refer also to section 7.6.1(2)

The 45° inclined position qualities for all positions.

16. Any change in pass distribution in the weld.
17. 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 except that "strip passes" are acceptable. The number of welding passes may vary in production (-/+ one bead) in accordance with the pipe WT tolerances (refer to 5.5.2.4).

18. Any change in distance between wires or welding bugs if weld temperature does not drop below 250°C before the subsequent pass.
19. Any decrease in preheat from the one recorded during weld procedure qualification (WPQ). The preheat temperature may be increased up to 30°C without re-qualification but any increase of inter-passes over 250°C shall have been previously qualified (refer to para. 5.6.1(2)).
20. Any increase in the time lapse between root and hot pass (second pass).
21. Any removal of line-up clamp or any pipe/barge move-up at an earlier stage. Refer also to section 7.8.7 of this specification.
22. In the case of nominal plastic strain over 0.4% (i.e.: reeling, etc.), a specific welding procedure qualification program shall be addressed (see Appendix 12).

7.6.3 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 section 7.6.2(4) here-above).
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 is 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 shall be made for each Welding Procedure. For semi-automatic or automatic welding equipment, a minimum of three consecutive complete test joints shall 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 section 7.6.4.2.7 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.

7.6.4 TESTING OF WELDED JOINTS – BUTT WELDS

7.6.4.1 VISUAL AND NON-DESTRUCTIVE TESTING

Test welds shall be fully visually inspected, fully radiographed, fully Magnetic Particle inspected and fully ultrasonically inspected. In any case, NDT techniques used during installation and prefabrication (laying, etc.) shall also be applied at this stage.

Test welds shall comply with the acceptance standards stated in section 7.10 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), lacks of root fusion, slag inclusion in root area, whatever those defects are surface breaking or not surface breaking at pipe internal, and surface Copper contamination shall not be accepted at this stage.

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

7.6.4.2 DESTRUCTIVE TESTING

7.6.4.2.1 GENERAL

The test welds shall be destructively tested in accordance with API STD 1104 and amendments stated in the following paragraphs. For semi-automatic and automatic welding (see section 7.6.3(6) above), testing shall be made on one test weld only (out of the 3 test welds made).

7.6.4.2.2 TEST SPECIMENS

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

7.6.4.2.3 TRANSVERSE TENSILE TEST

Tensile tests transverse to weld shall be made as per API STD 1104.

Minimum tensile requirements shall be as stated in COMPANY material specifications (see section 7.3).

7.6.4.2.4 NICK BREAK TEST

Nick Break tests are not required.

7.6.4.2.5 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.

7.6.4.2.6 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 7.10 of this specification, except that welds shall be free from lacks of penetration and lacks of root fusion at this stage (refer to section 7.6.4.1 above).

7.6.4.2.7 HARDNESS TEST

On the above macrographs, a Vickers hardness survey according to ASTM E92 (or equivalent standard) 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.

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

Sour service	Weld root and cap
Mild	300
Intermediate	275
Severe	250

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

7.6.4.2.8 CHARPY V-NOTCH IMPACT TEST

Charpy impact tests (each test = three specimens) shall be prepared and tested in accordance with ASTM A370 and ASTM E23 or ISO 148-1.

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, the test temperature shall be 0°C as a maximum.

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.

7.6.4.2.9 CTOD TEST

Reference is made to section 7.8.4 of this specification. Unless specifically permitted in the PPS, CTOD tests and ECA shall not be used for acceptance criteria of weld defects. Crack Tip Opening Displacement (CTOD) tests shall be conducted on test butt welds in accordance with BS 7448. Two sets of three specimens shall be cut 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 / HAZ. 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 A370 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 as stated in section 7.8.4 or otherwise stated in the PPS.

7.6.4.2.10 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 A370. Yield and Tensile Strength shall be as specified in COMPANY material specification (see section 7.3) and section 7.4.2 of this specification.

7.6.4.2.11 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 section 7.4.2(5) of this specification).

7.6.4.2.12 H₂S EMBRITTLEMENT TESTS

SSC tests shall be carried out on qualification test welds of main welds (and repair welds: refer to section 7.11.2) according to test specification stated in Appendix 10 of present PEGS. 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.

The test laboratory shall have prior approval of the COMPANY. H₂S test is not required for Mild Sour Service material.

7.6.4.2.13 WELDING QUALIFICATION FOR REELING

In case the plastic strain is higher than 0.4% (reeling, etc.), the program for welding procedure qualification shall also address that additional plastic strain. The welds shall be subject to relevant deformation cycles as for the deformation cycles induced in the pipeline during fabrication & installation stages. (The proposed cycles shall be previously submitted to COMPANY for approval).

The following tests shall be taken out from both extension and elongation zone (0° and at 180° radial orientation).

- One transversal tensile test (across the circumferential welds)
- Three set of V-notch charpy (WM, FL and FL+2 mm)
- Hardness test (see Appendix 3)
- CTOD (when so required in PPS).

Those specific requirements apply for both main line welds qualification and associated repair qualification.

Mechanical tests shall be carried out on specimens before straining and after straining and ageing. Accelerated ageing shall be carried out at 250°C for one hour.

The specimen shall be taken out from a full scale bending test simulating the successive bending of pipeline from first spooling to final laying.

The bending scheme and equipment shall be mutually agreed with COMPANY.

7.6.4.2.14 PARTICULAR REQUIREMENT FOR WELDING ON COPPER SHOES

When using copper shoes, Contractor shall perform a qualification test.

That qualification shall consist of a welded test piece on project pipe with the project specific batch of welded consumables.

The performance of welding shall be based on the parameters of the relevant project preliminary Weld Procedure Specification (PWPS).

The root face of the weld joint bevel shall be machined at the minimum height stated on the PWPS.

The welding current shall be set 10 amps above the maximum setting to be used during final production.

After welding, areas exhibiting the highest copper contamination on the surface of the root shall be cut out from the weld.

COMPANY reserves the right to select three areas of the weld for sampling.

The following testing shall be carried out on these samples:

- Macro examination on cross sections
- Root and side bend tests
- Vickers HV5 hardness measurements shall be taken at 1 mm from the ID pipe surface with a maximum permitted value as per section 7.6.4.2.7.
- Chemical analysis shall be performed by EDX on a 1.5 mm x 1.5 mm zone within the weld root but not including the penetration beyond the pipe surface. Copper content within the root pass shall be less than 0.5% (with reference to maximum permitted in AWS A5.18 for the classification of weld consumable used).
- Micro analysis of the test zone shall be carried out by Scanning Electron Microscope (SEM) to determine the weld is free from any cracking due to copper contamination.

7.6.4.3 STORAGE OF TEST SPECIMENS

The test specimens and the remaining parts of test coupons shall be stored by Contractor till the full acceptance of qualification program by COMPANY. Those pieces may be used for any further investigation or counter tests as addressed in that present specification.

7.6.5 TESTING OF WELDED JOINTS – FILLET WELDS

A minimum of two weld passes shall be used for all welds made on pipes or fittings (see section 7.5.2.4 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 7.10.

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 section 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 hardness survey shall be carried out according to ASTM E92 as shown in Appendix 4, using a 5 kg load. Maximum hardness shall not exceed the values stated in section 7.6.4.2.7.

7.6.6 TESTING OF WELDED JOINTS – ELECTRICAL CONNECTING WELDS

Junctions of anode shall be carried out using doubler-plates previously welded onto pipe bodies. However, in the case of pipes having a yield strength lower than 415MPa (grade 60), the junctions may be carried out without using doubler-plates.

Weld junctions of anode leads, made 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, and another one, as a minimum, shall be subject to tensile test.

The micro-examination shall give evidence of a good bonding, and shall also detail the metallurgical constituents and chemical elements (Su, Pb, Cu, etc...) 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 maximum from Fusion Line. The nature of metallurgical constituent at location of maximum hardness shall be identified and recorded.

Maximum hardness shall not exceed the values stated in section 7.6.4.2.7.

Note: Where anode leads are connected to pipe through a doubler plate, the fillet welds on pipe shall be tested as per section 7.6.5 here-above.

7.6.7 RECORDS (WPS AND WPQR)

A form based upon that in API STD 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.

7.7 WELDER QUALIFICATION

1. Each welder shall be qualified in accordance with the requirements of API STD 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 be 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 the same or equivalent equipment (to COMPANY's satisfaction) to 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. Manual and semi-automatic welders shall be separately qualified for each welding position encountered on the job, within the same OD / WT variable as for the welding procedure qualification test (see details in section 7.6.2. of this specification).

2G + 5G qualifies for 6G, and vice versa.

6. 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.
7. For butt welds, all welders, including welders for mechanized welding, shall be qualified by non-destructive tests. Finished coupons shall be 100% inspected by visual, radiography and MPI or LPI. In the case of processes with high potential of run-fusing type defects (see section 7.4.4), welds shall, also, be 100% ultrasonically tested and, where deemed necessary by the Inspector bend tested.

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

8. For fillet welds, welders shall be qualified as per API STD 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.
9. 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 STD 1104 and section 7.10 of this specification.
10. Operators for pin brazing and aluminothermic welding shall be qualified through the execution of 3 test joints.
11. Welders having participated in the execution of the welding joints of successful WPQT in accordance with section 7.6 shall be considered as qualified.
12. For manual metal arc welding, a change in electrode trade name shall require welder reapproval 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. For the specific case of "On-line" activities, welders/operators stamp painting can be avoided, provided traceability of welders/operators is ensured. However, relevant procedure shall be issued for COMPANY's approval.
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.

7.8 PRODUCT WELDING

7.8.1 SWABBING, PIPE BEVELLING AND CLEANING ENDS OF JOINTS

- a) Immediately prior to aligning pipe for welding, the beveled 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-beveled and retested as indicated in section 7.8.1.b below for pipe ends.
- b) Contractor shall re-cut and bevel all damaged pipe ends when deemed necessary by 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 beveling machine. Hand beveling 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 beveling is acceptable for tie-ins, subject to cleaning of the bevel faces to bright metal.

- d) The pipes will be supplied with beveled ends as defined in the material specification. For weld procedures that require a different bevel, re-beveling 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 B31.4 Fig. 434.8.6-2 or ASME B 31.8 Fig. I-5 (where applicable) shall be used. Any taper shall not be steeper than 1 in 4.

7.8.2 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 section 7.6.1(2)).

7.8.3 PREHEATING AND INTER-PASSES TEMPERATURE (REFER ALSO TO SECTION 7.5.2.9)

- 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. The preheat temperature to be applied during fabrication shall not be less than the qualified preheat temperature (i.e.: 0 / +30°C).
- 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 inter-pass temperature, measured immediately before the start of the subsequent weld run (directly on the previously deposited pass) shall not exceed the maximum inter-passes temperature recorded during procedure qualification. Inter-passes temperature shall be considered 250°C as a maximum, unless higher inter-passes temperature has been qualified and tested (refer to section 7.6.1).

7.8.4 POST-WELD HEAT TREATMENT (PWHT) AND FRACTURE TOUGHNESS TESTING

PWHT is required for girth welds made on pipes or fittings in wall thickness above 25mm in topside riser and jacket riser, unless fracture toughness testing shows acceptable values in the as-welded condition at the minimum design temperature. Fracture toughness testing shall be made as per DNV-OS-F101, Appendix B, A 904, 913 and 916 in weld metal and FL/HAZ. The minimum CTOD value shall be 0.15mm. When PWHT is necessary 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 7.3 of this specification).

Fittings of NPS 2" and less will not require PWHT if hardness test results are acceptable at WPQ tests.

Requirements for PWHT shall be as per DNV-OS-F101 Appendix C, G400 and soaking temperature agreed with COMPANY.

On Site, 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.

7.8.5 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 shall 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.

7.8.6 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 section 7.8.2 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 section 7.8.7 here-below shall be met.
- d) External line-up clamps can be removed when the root pass is at least 50% completed and equally spaced around the pipe circumference. The same restrictions as stated above for internal line-up clamps shall also be applied in present case.
- e) For automatic GMAW, the copper shoes shall be visually inspected after each root pass completion. Attention shall be paid to the systematic cleaning of copper shoes prior to start with a new root pass welding. Should any damage be visible on shoes then, the shoes shall be immediately replaced and any evidence of "melting" shall lead to cut out the welded joint. The copper shoe shall be changed every shift. Copper shoes may be repaired to original condition and re-used at Contractor's discretion.

Note: Contractor shall ensure an adequate supply of new copper shoes.

7.8.7 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 may be waived when the root pass is 100% completed 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 SMYS of base material or weld metal, whichever is less. This analysis shall also consider the max misalignment allowed, support condition of pipe and any dynamic effects.

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.

7.8.8 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).

In onshore and inshore pipeline systems, the river crossing and channel crossing shall be designed and executed using hot bends, all having their original tangent lengths.

7.8.9 BRANCHES AND NOZZLES

- a) Only forged prefabricated fittings (e.g. hot extruded, forged 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) shall be welded onto a piece of running pipe (shop fabrication) having a minimum length of one pipe diameter of the running pipe, so that a PWHT (if necessary) can be made on the finished prefabricated item before inserting this item into the pipeline system. The main pipe shall be checked by UT for absence of lamellar defects at location of branch.
- c) Otherwise, all branch welding fittings directly welded onto main pipe are not allowed.

- d) Welding procedure qualification tests and production NDT of branches and branch outlet fittings shall have prior approval of COMPANY.

7.8.10 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.

7.8.11 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 ultrasonic examination.

7.8.12 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 section 7.5.2.7 of this specification.

7.8.13 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.

For GMAW process, specific “tip” electrical connector shall be ceramic coated for the root and hot pass performance in order to avoid any arc strikes inside the narrow bevel.

7.8.14 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.

7.8.15 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.

7.8.16 WEATHER CONDITIONS

Welding shall not be carried out 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.

7.8.17 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.

7.8.18 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.

7.8.19 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 minimize the risk of root cracking.

This is not applicable to "pipe anchoring system" (see section 2).

7.8.20 ANODES ELECTRICAL CONNECTION

Reference is made to section 7.6.6, however care shall be taken to the dimensions of the anodes, which could be damaged during their passage on the rollers of the stinger or in the tensioners during laying. When such a risk exists, then, the method of anode connection onto the pipe shall be through doubler plate method only.

7.8.21 PERFORMANCE OF WELDING

The heat input and welding parameters specific to each welding procedure shall be regularly checked by Contractor for conformance to the related WPS.

For mechanized welding process, print-out charts shall be submitted to the Inspector at a frequency to be agreed (minimum once every 2 hours of continuous work).

7.9 INSPECTION AND TESTING OF PRODUCTION WELDS

7.9.1 GENERAL

- a) The frequency of non-destructive testing is specified under the section 7.9.4, 7.9.5 and 7.9.6 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.

For offshore welding using a mechanized GMAW procedure, the first 30 welds shall be 100% ultrasonically tested. If ultrasonic testing reveals defects not discovered by radiography, the extent of ultrasonic testing shall be 100% for the next 10 welds. If results of this extended testing are unsatisfactory, the welding shall be suspended until the causes of defects have been established and rectified.

- 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 COMPANY's approval and shall be qualified on the welding procedure qualification test welds.
- e) All NDT operators/technicians shall have at least two years experiences on pipeline working in the NDT level qualified. See section 7.9.4(17), 7.9.5(3) and 7.9.6(6) of this specification.
- f) In general, NDT personnel qualification shall comply with 10008-STD-6-INT-001, PEGS-12060-INT-001 unless more stringent requirement is specified in this specification or PPS.

- g) Refer also to section 7.2 of this specification.

7.9.2 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.

7.9.3 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 shall 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 section 7.6.1(2)).

7.9.4 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 100 mm on either side of weld area of repair. All radiographic techniques and procedures as well as quality of films shall comply with ISO 5579, ISO 17636, ISO 19232-1, ISO 11699-1 and this specification. Standards of acceptance shall comply with the requirements of API STD 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. Radiographic performance shall comply with relevant Country and Project safety codes and radiation acts.
2. Radiography shall be by means of X-rays only. Film system shall be C5 according to ISO 11699-1 (e.g. AGFA Structurix D7 film or equivalent) film overlap shall be 50 mm minimum. Tie-in welds and riser welds may be carried out by means of gamma-rays (using film system C2 according to ISO 11699-1 (e.g. AGFA Structurix D3 film or equivalent) plus ultrasonic inspection, subject to approval of COMPANY. Double film technique is recommended by COMPANY to limit operator's exposure.
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. 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 offshore 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.

8. Back scatter control: A lead number "B" of 1.5mm 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.
9. Only wire type Image Quality Indicators (IQI), according to ISO 19232-1 shall be used. The radiographic technique shall comply with ISO 17636 class A.

Two IQIs shall be placed on each film: 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.

10. For qualification purpose (WPQ, welder qualification), radiographic technique shall comply with ISO 17636 class B using film system class C2 according to ISO 11699-1.
11. Exposure shall be such that density through the weld is between 2.1 and 3.6.
12. Viewing conditions and facilities 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.
13. Final film interpretation shall be carried out on dry film.
14. 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 re-fixed onshore to achieve the specified minimum archival life (unless the Contractor can demonstrate at end of each working shift by routine residual thiosulphate testing offshore that the original fixing and washing was sufficient to guarantee the specified life).
15. As a minimum, the film identification shall include:
 - Project Identification (as previously agreed with COMPANY)
 - Line Size and Identification
 - Joint Number
 - Repair N° (when applicable)
 - 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 effluent flow. Defect location shall be indicated in the metric system. Each radiograph shall have reference markers at 100 mm (minimum) intervals.

16. All films shall be protected in individual plastic bags 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.
17. Radiographers shall be certified level 2 in accordance with the requirements of ISO 9712, SNT-TC-1A, CSWIP scheme or equivalent COMPANY approved standard. At least one certified level 2 (minimum) RT interpreters as per CSWIP, PCN (ISO 9712) or ACCP certificates issued by independent parties shall be presented on each shift for film interpretation.

The qualifications of each member of the NDT team shall be subject to approval of the COMPANY.
18. Radiographic performance shall comply with regulation of the relevant government bodies and/or the local authorities including COMPANY SSHE requirements and guidelines. Attention is drawn to the necessity for audible and visual warning arrangements and for regular monitoring of radiation levels.
19. Computer radiography or radioscopy may be considered by COMPANY.

7.9.5 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 section 7.8.1(b)).
 - 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 section 7.9.1) or any welds in WT >25mm.
 - f) To inspect qualification test welds (refer to section 7.6.4.1)
2. Ultrasonic examination of pipe ends shall be carried out according to ASTM A578. 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 60 mm².

Ultrasonic examination procedure of welds shall be as per ASME V, ISO 17640, or equivalent standard. Notch to be N5 and side drilled holes to be $\varnothing$ 20 mm max.

Scanning sensitivity shall be DAC sensitivity +6dB.

All indications that exceed 20% of DAC shall be evaluated. Sizing of discontinuities shall be made using the 20dB amplitude drop for sizing the discontinuity in depth and height and the 6dB amplitude drop for sizing the discontinuity in length.

3. Ultrasonic operators shall be certified level 2 in accordance with ISO 9712, 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. Inspection by automatic UT (AUT), when so proposed by Contractor, is subject to derogation request. COMPANY may accept provided that the conditions and the requirements specified in 10008-STD-6-PLR-026, PEGS-12059-PLR-013 are fully met.

7.9.6 MAGNETIC PARTICLE INSPECTION (MPI)

1. Where MPI is applied on parent material, e.g. following pipe re-beveling, 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 section 7.8.1(b)).
4. Electromagnetic (a.c.) yoke and/or adjacent cable techniques shall be used.
5. Contractor shall supply a wet MPI procedure based on ASTM E709 or equivalent, for review and approval by COMPANY. An approved magnetic particle field indicator (such as ASME V Fig T-764.2(a) Burmah-Castrol indicator type I, etc.) shall be used and made 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 ISO 9712, SNT-TC-1A, ACCP, CSWIP scheme or COMPANY approved equivalent standard.

7.9.7 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. They shall be digitized prior to hand over to COMPANY at its request.

7.10 STANDARDS OF ACCEPTANCE

7.10.1 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 section 7.6.4.1), 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 STD 1104 (Section 9) and the amendments stated hereafter in the present section.

Acceptance criteria based on Engineering Critical Assessment to Annex A of API STD 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 section 7.10.5.

7.10.2 WELD PREPARATION

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

7.10.3 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 as per WPQR.

7.10.4 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 section 7.10.5.3 hereafter.

90°deg re-entrant angles and overlap are not permitted.

7.10.5 FLAW TYPE AND SIZE

The standards of acceptance applicable to the type and size of defects detected shall be as defined in section 9 of API STD 1104, unless otherwise modified by the following:

The “root area” means the root and hot pass region, as a minimum, of weld.

7.10.5.1 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.

7.10.5.2 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 for sour service.

7.10.5.3 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.

7.10.5.4 INCOMPLETE ROOT FUSION & INADEQUATE PENETRATION (API STD 1104 SECTION 9.3.1 THROUGH 9.3.4 FOR ROOT AREA DEFECTS)

For sour service, the 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 section 7.6.4.1 applicable to qualification test welds.

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

Incomplete root fusion & inadequate penetration shall not be permitted in case of fatigue service welds “FS1”.

7.10.5.5 SLAG INCLUSION

API STD 1104 applies, except the following:

- Length of any single Elongated Slag Inclusion shall not exceed 25mm
- Any slag inclusion located in root area shall be treated as per requirements of section 7.10.5.4 here-above

7.10.5.6 POROSITY (OTHER THAN HOLLOW-BEAD POROSITY IN ROOT RUN)

Porosities shall not exceed the following criteria:

- Max. diameter of isolated pore = 3mm or 20% of pipe thickness, whichever is less
- Max. diameter of any pore in cluster porosities = 1.5mm or 10% of pipe thickness, whichever is less
- Max. accumulated diameters of scattered positions in any 150 mm of weld length = 20mm, with no porosity exceeding 2mm in diameter

Wormholes shall not be acceptable.

7.10.5.7 HOLLOW-BEAD POROSITY

Not acceptable whatever the size.

7.10.5.8 CRACKS

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

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

7.10.5.9 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. The maximum inclusion diameter shall be ≤ 3 mm.

7.10.5.10 COPPER INCLUSION / CONTAMINATION AND SURFACE CONTAMINATION

Not acceptable when interfering with welds

7.10.5.11 ACCUMULATION OF IMPERFECTIONS

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

7.10.6 ARC STRIKES

Arc strikes shall not be permitted: refer to section 7.8.13 of this specification

7.11 REPAIR AND REMOVAL OF DEFECTS**7.11.1 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-by-case basis. Anyway, repairs at root or including the root (i.e. through thickness repairs or internal repairs) shall not exceed 20% of individual weld length.

3. Only one repair of weld root shall be permitted in the same area. Except for 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, where weld touch up is necessary or to repair an undercut. For any other single-run repair (internal or cap repair), qualification tests shall be required (refer to section 7.11.2).
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 where the pipeline is under stresses shall be supported by calculations (and appropriate diagrams/tables) and shall have prior approval of the COMPANY.

However, Repairs shall be limited to 30% of the weld length for a partial penetration repair, and 8% (as above) 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 SMYS of pipe. However, when the length to be repaired exceeds the above limits, sequential repairing will be allowed provided that each sequence does not exceed the limit.
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.
8. In case of Copper contamination, repair is not permitted.

7.11.2 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 (weld root area excluded: see section 7.11.1(3), 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 section 7.6.4.1 of this specification and then to destructive tests as follows:

- For all kinds of repairs:
 - 1 macro-section and hardness survey as per section 7.6.4.2.6 and 7.6.4.2.7 (see also Appendix 7, Appendix 8 and Appendix 9 for hardness survey)
 - For sour service conditions, 1 chemical analysis as per section 7.6.4.2.11. When a same consumable is used for different types of repairs, only certain repair welds may be selected for analyze, in agreement with the COMPANY.
- 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 section 7.6.4.2.8 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 maximum from pipe surface at weld cap.

- 4 side bend tests (full pipe thickness specimens) for WT > 12.7 mm, and 2 Face Bend + 2 Root Bend tests for WT ≤ 12.7 mm.
- For cap and internal repairs: 4 side bend tests (full pipe thickness specimens)

- In sour service conditions, for through thickness repairs and mid-thickness 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.

7.11.3 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 re-welding 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 section 7.10.5.8).

7.11.4 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 section 7.5.2.9, 7.8.3 and 7.8.4 of this specification.

7.11.5 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 section 7.11.1.

For barge welding and repairs performed under stress, the whole girth weld shall be re-inspected.

7.11.6 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.

7.12 DOCUMENTATION

7.12.1 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 neighboring 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.

7.12.2 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 testing reports
- The Quality Control Plan
- The present specification and related PPS.

The PPS shall state the number of originals, copies and CD-ROMs 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.

7.12.3 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

- Beveling 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 section 7.5.1), with execution sequence of the various passes in relation to the welding stations used or types of weld.
- d) The management procedure for welding consumables, including SAW flux where applicable (refer to Appendix 11)
- e) The welder qualification scheme.
- f) The location where WPS and welders will be qualified.
- g) The nominated company for performance of NDT.
- h) The preliminary NDT procedures, together with data sheets of the equipment used.
- i) The nominated laboratory for conducting the H₂S embrittlement tests, with preliminary SSC procedure or typical procedure.
- j) Quality Assurance Certification.
- k) 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.).
- l) Deviations to present specification, if any.

7.13 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.

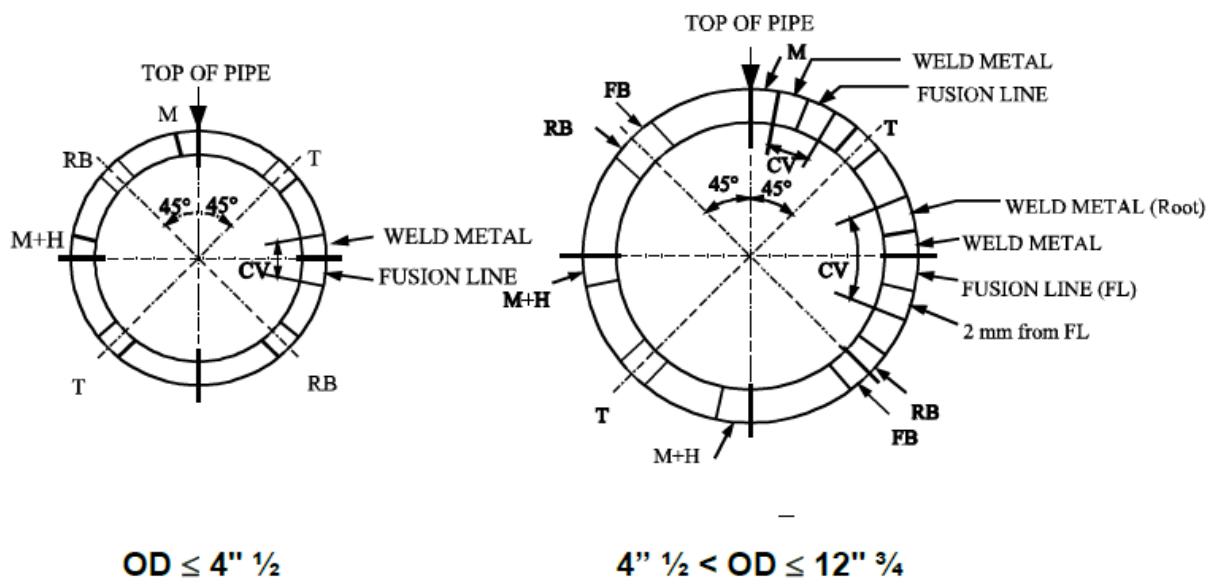
A deviation to specifications shall not be considered as accepted if it has not been submitted to and accepted by COMPANY here-above through a Technical Query.

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 the submitted corrective action intended by the Contractor.

8.0 APPENDICES

Appendix 1. Welding procedure qualification/Butt weld (OD 12" ³/₄)

Location of test specimens (OD ≤ 12" ³/₄)



Key:

T = Transverse Tensile

FB = Face Bend

RB = Root Bend

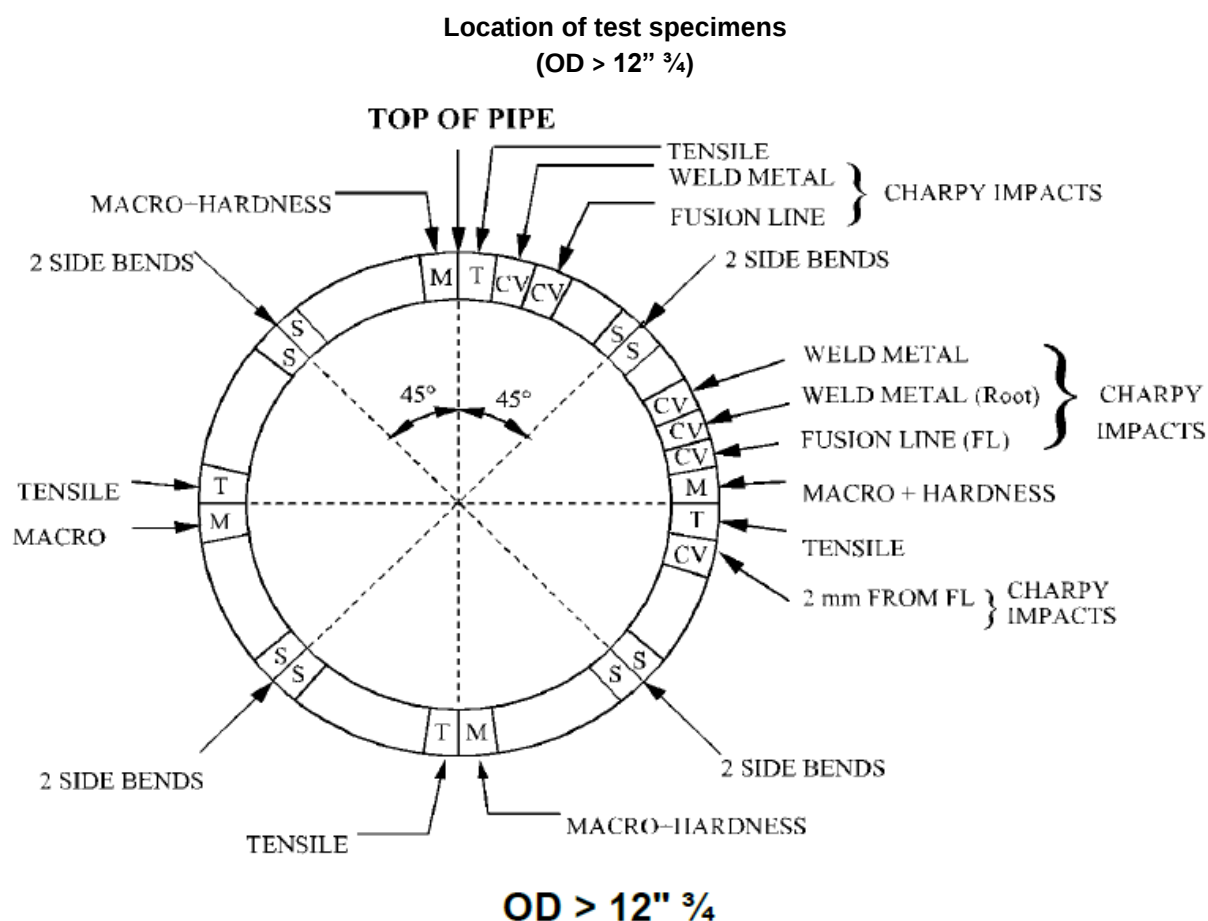
M = Macrography (only)

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 WT ≤ 20 mm, Charpy Test in Root Weld centreline is cancelled.

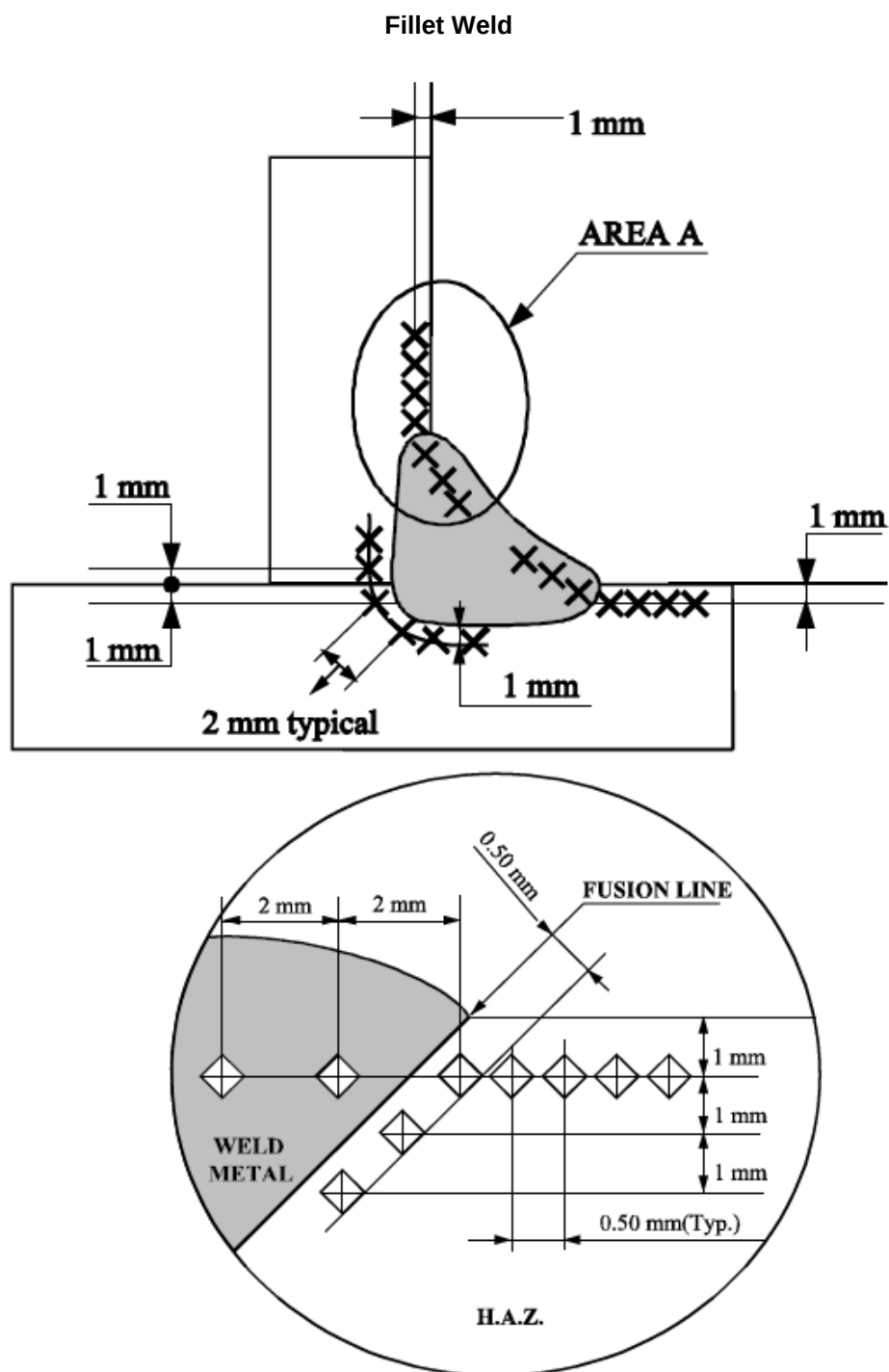
Appendix 2. Welding procedure qualification/Butt weld ($OD > 12'' \frac{3}{4}$)


Notes:

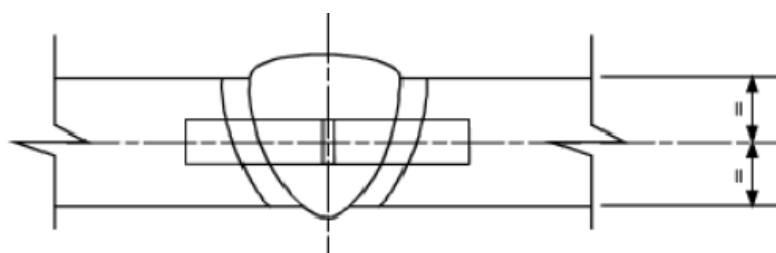
- 1) For WT less than or equal to 20 mm, the Charpy test in root weld metal centreline is cancelled.
- 2) For WT less than or equal to 12.7 mm, each couple of Side Bends are to be replaced by 1 Face Bend + 1 Root Bend.
- 3) CTOD tests, all-weld tensile tests, macrography + hardness at longitudinal/circular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

The diagram illustrates the weld metal, heat-affected zone (H.A.Z.), and fusion line. The weld metal is shown as a shaded area. The H.A.Z. is the region of the base metal that has been heated to a temperature high enough to cause a change in its mechanical properties. The fusion line is the boundary between the weld metal and the H.A.Z. The diagram includes dimensions for the weld metal, H.A.Z., and fusion line, and labels for the weld metal, H.A.Z., and fusion line.

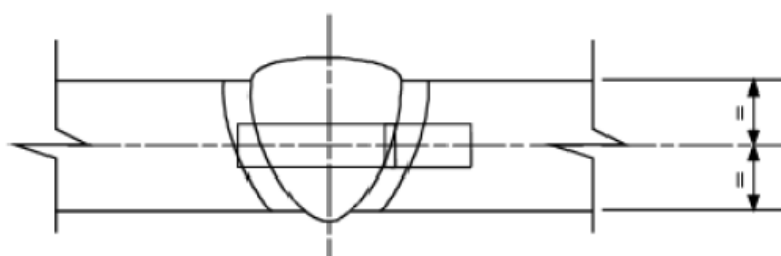
Appendix 4. Vickers hardness survey (5 kg load) – Fillet weld



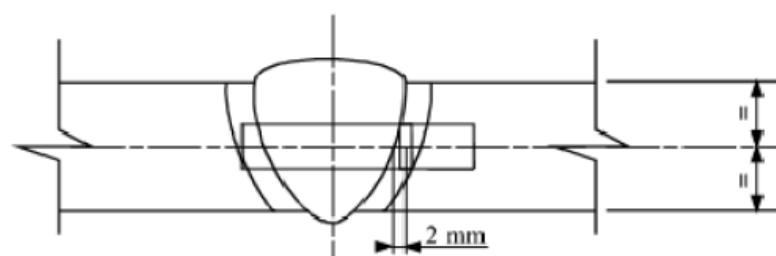
Appendix 5. Charpy V-notch impact tests – Specimen notch location



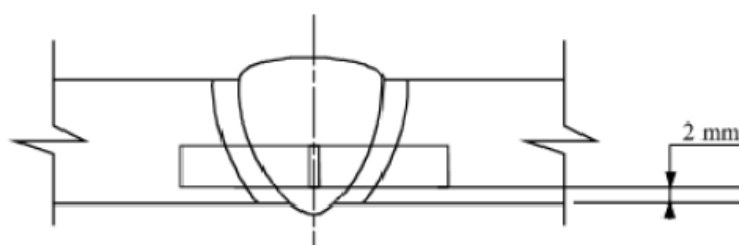
(i) Notch at centre line of Weld Metal



(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

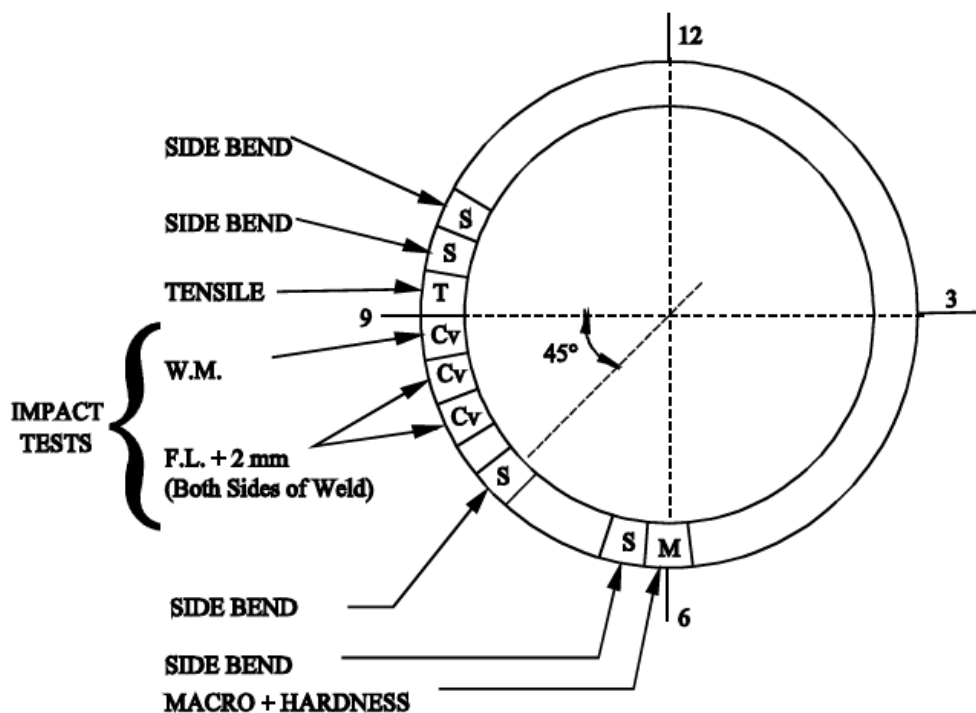
Steel Grade	Minimum Average (Joules)	Minimum Single (Joules)	Minimum Shear area Avg (Single)
L 290 or X 42	40	30	85% (75%)
L 320 or X 46	40	30	85% (75%)
L 360 or X 52	40	30	85% (75%)
L 390 or X 56	40	30	85% (75%)
L 415 or X 60	40	30	85% (75%)
L 450 or X 65	54	40	85% (75%)
L 485 or X 70	54	40	85% (75%)
Note: Lateral expansion (% shear area) of broken specimen shall be recorded.			

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 test specimens

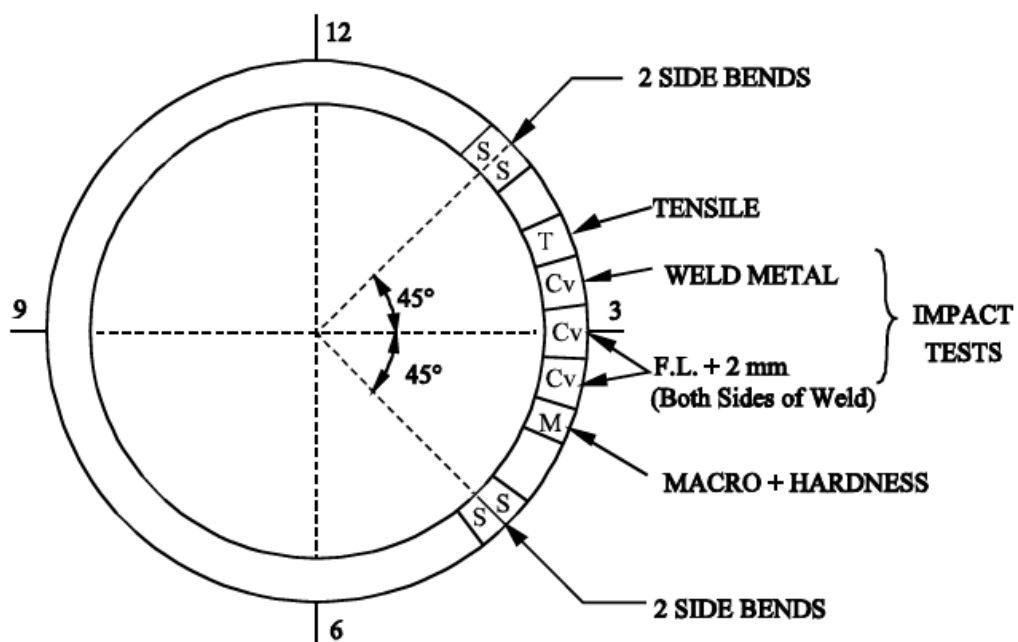


Vickers hardness survey (5 kg load)

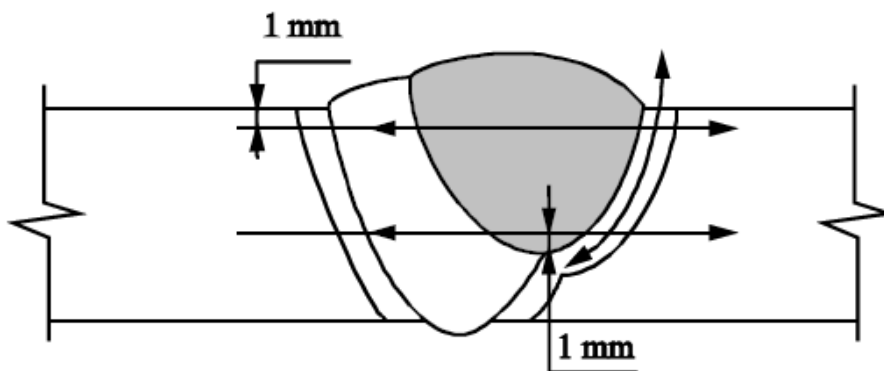
Indents to be carried out according to Appendix 3

Appendix 8. Partial or mid-thickness repair qualification tests

Location of test specimens

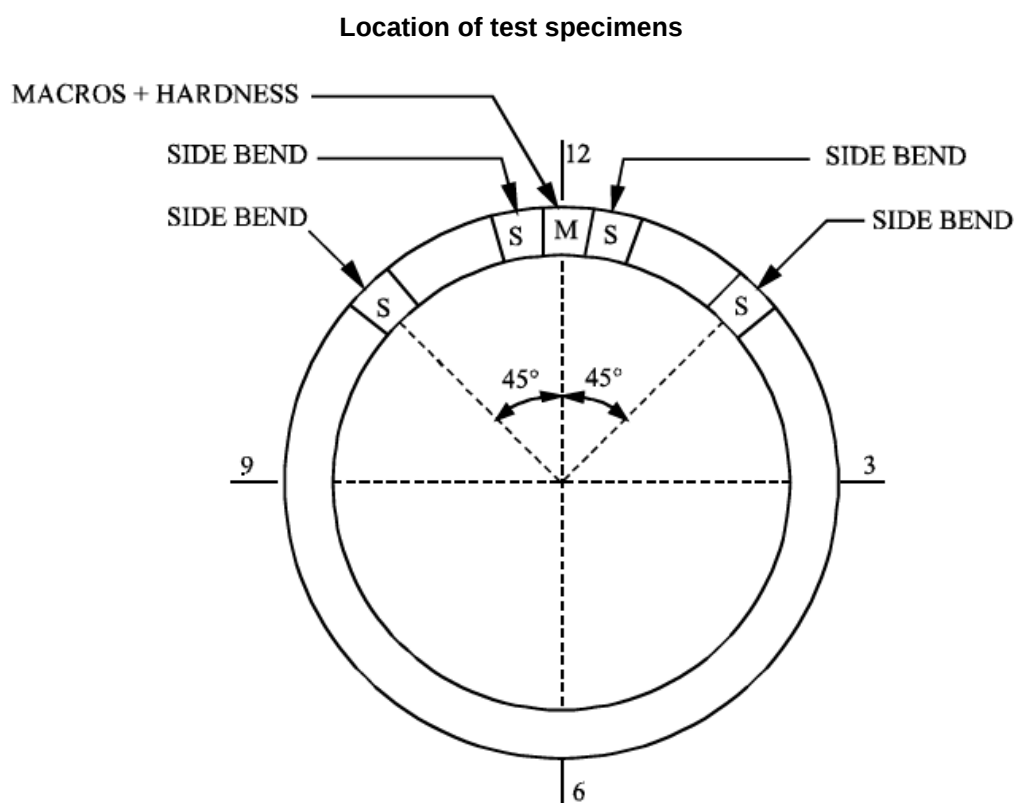


Vickers hardness survey (5 kg load)

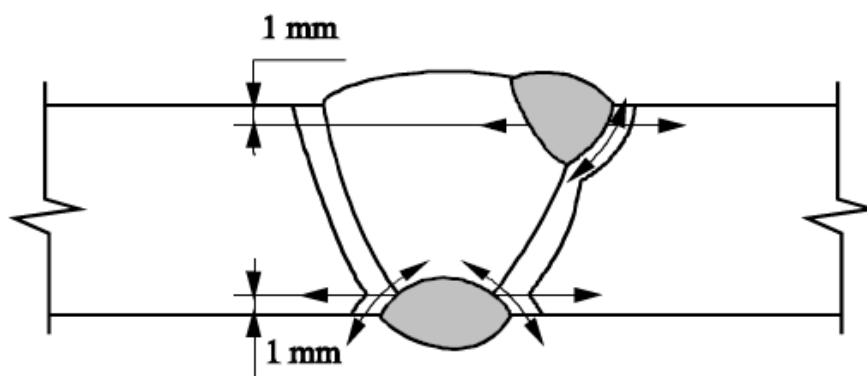


Indents to be carried out according to Appendix 3

Appendix 9. Cap or internal repair qualification tests



Vickers hardness survey (5 kg load)



Indents to be carried out according to Appendix 3

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

1. General

This specification applies to the testing of circular welds and repair welds of pipelines 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 TM0177 Std shall apply, unless otherwise stated hereafter.

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

SSC tests are not required for mild sour service.

2. Specimen preparation

Each set shall consist of three specimens

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

One set of root specimens shall be removed transverse to the weld at 12, 3 and 6 o'clock location i.e. 3 sets of specimens in total (or one set of 3 specimens equispaced around circumference for 2G position or for automatic welding 1G with rotating pipe).

Specimens shall be cut as close as possible to the pipe inside surface, with a minimized depth of machining to obtain flat surfaces.

For pipe WT $\geq$ 16 mm or, otherwise, when welding consumables in filling passes are different from those at root area, then SSC tests shall be repeated at 12, 3 and 6 o'clock position with specimens cut at mid-thickness or at any location agreed with COMPANY. In all cases, weld axis shall be located at mid-span of specimen.

SSC tests applies, also, for through thickness repairs and mid-thickness repairs as shown in Figure 2.

For Partial Thickness Repair (PTR), sampling shall be carried out at the root of the repair weld. The extracted specimen shall include about 1/3 of the Heat Affected Zone located right under the root of repair as shown in Figure 2.

Moreover, the sampling at mid thickness of repair weld may be avoided (See Figure 2) provided welding parameters at mid thickness of weld repair shall be the same for both Through Thickness Repair (TTR) and Partial Thickness Repair (PTR) which means within the same essential variable ranges

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

Additional test:

For information purposes only, one additional specimen shall be cut at 12, 3 and 6 o'clock locations, close to the SSC specimens. These specimens shall be full weld sections prepared as per macrographic tests. They shall be tested for 30 days at the same time and in the same cell as the SSC specimens but they shall not be stressed. They shall, also, be analysed for cracks at magnification x 100 as per HIC specimens and the test results reported.

3. Test required

Two machined round bar tensile specimens of maximum possible diameter shall be cut in base metal at same pipe end with their axis longitudinal to pipe axis. Then, tensile tests shall be carried out to measure and record the Yield Strengths (0.2% proof stress) and Tensile Strengths. The lowest actual Yield Strength will be the reference for calculating the actual stress level of the SSC tests.

All SSC tests shall be conducted at the stress level of 80% or 90% (where applicable refer to section 4 here-after) of above actual Yield Strength of pipe base material. When loading the specimen in test jig, the applied stress shall be adjusted and measured using electrical strain gauges. Personnel shall be certified for using electrical strain gauges

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

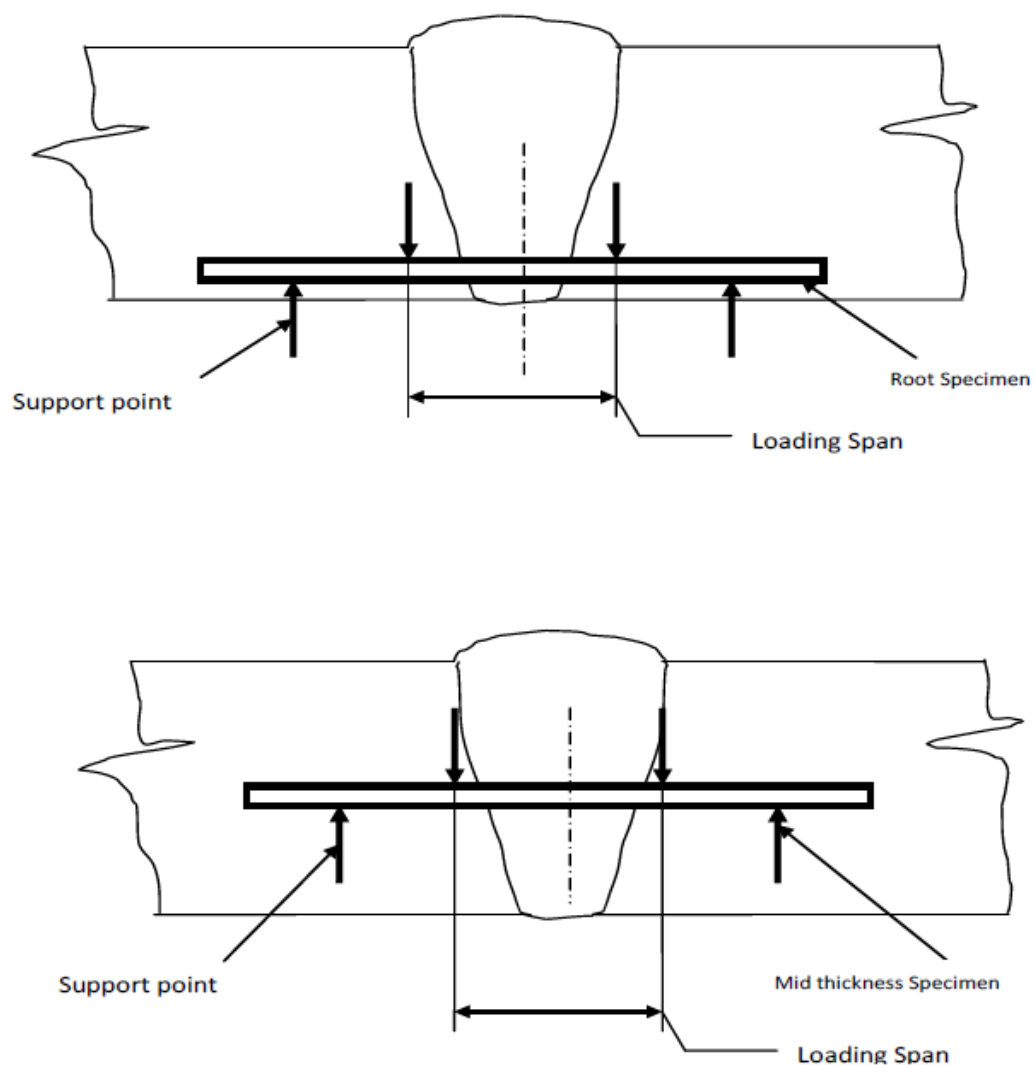


Figure 1 – Removal of specimens in girth welds

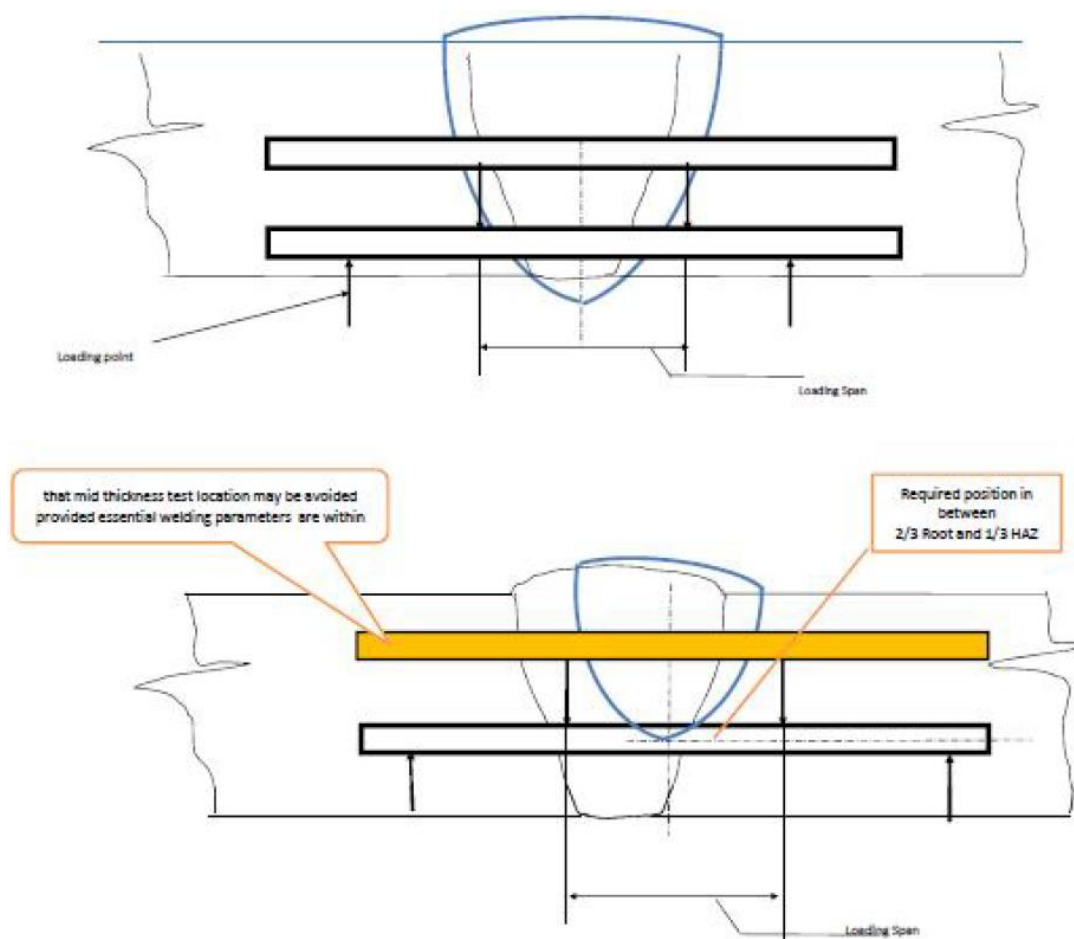


Figure 2 – Removal of specimens in Through and Partial Thickness Repair (TTR and PTR)

4. Test arrangement and test solution

Test arrangement and loading of specimens shall be as per Appendix 2 of EFC Publication No.16 and ASTM G39 Std or ISO 7539-2 Std. The procedure for strain gauge arrangement and specimen loading shall be submitted to COMPANY. 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 section 3 (strain gauges).

The pipe SUPPLIER shall select one option between the 2 following options for test solution, H₂S partial pressure and applied stress.

1) Option with NACE TM0177 test solution A

Pipeline ⁽¹⁾ Sour service	Region ⁽¹⁾	Pipeline effluent	Test conditions	Min H ₂ S concentration (ppm)	Stress level (%AYS)
Mild	1	All	NA		
Intermediate & Severe	2 & 3	All	NACE TM0177 solution A pH = 2.7 - P _{H₂S} = 1 bar	2300	80

Note 1: Refer to definitions in specification 10008-STD-6-COR-032, PEGS-0842-COR-032

NACE TM0177 solution A shall consist of 5% mass fraction NaCl + 0.5% mass fraction CH₃COOH in distilled or deionised water.

2) Option with EFC 16 test solution A or B (where applicable)

Pipeline ⁽¹⁾ Sour service	Region ⁽¹⁾	Pipeline effluent	Test conditions	Min H ₂ S concentration (ppm)	Stress level (%AYS)
Mild	1	All	NA	NA	NA
Intermediate	2	Oil	EFC 16 solution B pH = 4.5 – P _{H₂S} = 0.1 bar	230	90
		- Gas - Multiphase system - Condensates	EFC 16 solution A pH = 3.5 – P _{H₂S} = 0.01 bar	23	90
Severe	3	Oil	EFC 16 solution B pH = 4.5 – P _{H₂S} = 1 bar	2300	90
		- Gas - Multiphase system - Condensates	EFC 16 solution A pH = 3.5 – P _{H₂S} = 1 bar	2300	90

Note 1: Refer to definitions in specification 10008-STD-6-COR-032, PEGS-0842-COR-032

EFC 16 test solutions shall consist of 5% mass fraction of NaCl + 0.4% mass fraction CH₃COONa in distilled or deionised water. Throughout the test, pH shall be controlled and adjusted, using a calibrated pH-meter, to the above specified pH with an allowance of ± 0.1 by addition of HCL (or CH₃COOH) 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. Gas flow shall be controlled using a flowmeter.

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

Hydrogen sulphide concentration in the solution shall be measured by the iodine titration method as per NACE TM0284 at start and at the end of the test. The related procedure shall be submitted to COMPANY.

Tests shall have a duration of 30 days (720 hours) minimum counted after saturation of test solution.

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 and H₂S concentration of the solution shall be measured and recorded at start of test, after initial H₂S saturation, at end of each week of test 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 X5 magnification of the stressed surfaces of each specimen further to cleaning and MPI.

Whenever a crack is found, the specimen shall be cut, perpendicularly to crack, polished and etched. Any SSC crack need to be examined and the metallurgical features at location of crack shall be analysed (including definition of microstructure) and recorded with photomicrographs. Micro-hardness shall be made at locations of cracks as part of the investigation.

Specimens which do not exhibit crack on their external surface, shall be cut along longitudinal direction of specimen at 5 mm and at 10 mm according to specimen width. The sectioned surfaces shall be ground smooth to 600 grit emery paper, minimum, following machining and visually examined for crack as above at x 5 magnification.

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 metal or base metal) within the 30 day period for any of the tests carried out.

Test specimens shall be evaluated for any evidence of hydrogen cracking including surface breaking and sub-surface cracks. All cracks shall be considered regardless of whether it is interpreted as sulfide stress cracking (SSC), stress-oriented hydrogen induced cracking (SOHIC), soft zone cracking (SZC) or hydrogen induced cracking (HIC).

Note: Cracks which initiate from macroscopic weld flaws will not be considered but it will invalidate the specimen (i.e. one more specimen shall be tested). In any case, test shall be unacceptable if specimen contains also other cracks not associated with a weld flaw. A sufficient number of specimens shall be put into the test solution to cover this possibility.

Little grooves, pits caused by corrosion loss or surface cracks not exceeding 0.1 mm in depth shall not be considered, in mutual agreement between Laboratory specialist and inspector.

7. Reporting

At end of testing, the laboratory specialist shall provide a report giving the following data:

- a) Measurement of stress applied (strain gauges).
- b) Individual result for each specimen tested as per set, with photographs (and photomicrographs, when applicable)
- c) Type of solution used for the tests as per Table above of this Appendix. pH and H₂S concentration of solution at start (after initial H₂S saturation) and end of test, also at end of each week of test.

- d) Location (using sketches), identification and dimensions of specimens.
- e) Mill certificates of materials tested showing full chemical analysis and mechanical properties.
- f) Conclusions and pertinent explanations (where needed) or concluding information.

Any failure shall be analysed by the Laboratory specialist, and the causes of failure made clear to the COMPANY, before any re-test or remedial actions are decided.
- g) Testing procedure specification.

Appendix 11. Management procedure of SAW flux

Flux Manufacturer shall issue a dedicated procedure for flux management as described below. This procedure shall cover all steps from flux purchasing to “ready-to-used” step (welding heads).

This procedure shall be submitted to COMPANY for review at the bid stage.

The resulting diffusible Hydrogen in weld deposit shall be 5 ml / 100 g max.

1) Procurement of flux

At the time of flux packing, the diffusible hydrogen content of 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 moisture content measurement, when evidence of correlation for the flux, intended to be used, can be provided by flux Manufacturer. This correlation curve shall be based on previous comparative tests of diffusible Hydrogen versus flux moisture content. The “Karl Fisher” method shall be applied.

For diffusible hydrogen testing or for moisture measurement, NEITHER PRE- DRYING NOR ANY PRE-HEATING OF FLUX SAMPLE shall be carried out before testing.

Tests shall be carried out with the flux as it is at the time of sampling. Moisture measurement shall be carried out at 982°C approx., carrier gas shall contain 10% minimum of oxygen.

Results of diffusible hydrogen or moisture measurement shall be reported on the EN 10204 Type 3.1 flux certificate for each batch. The testing conditions, as specified above, shall be confirmed on the certificate.

Flux Packing shall be made in moisture proof sealed containers.

Acceptable packing shall be:

- Metallic/stiff plastic drums with rubber gasket for top tightness
- Double polymer top welded bags
- PEHD-aluminium-PEHD top welded bags.

The packing shall be designed to guarantee no significant humidity absorption during storage of one year.

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 hoppers where the temperature shall be maintained between 120 and 150°C.

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

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

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

4) Flux recycling

Recycling of flux is not permitted.

Appendix 12. Additional welding procedure qualification program in the case of circumferential welds subject to plastic strain over 0.4% (i.e.: reeling)

In the case of plastic deformation of welds over 0.4% (i.e.: reeling, etc.), an additional welding procedure qualification program shall be developed to address the mechanical characteristics of circumferential welds after cycled deformation.

That program shall consist of a full scale deformation of circumferential welds butting two (2) pipes. Full scale straining shall represent the strain history ending up in tension. The specimens shall be extracted for a full scale bending test simulating the successive bending cycle of pipeline from the first spooling till final laying.

The welds shall be subject to the cycles of deformation generating the plastic strain during fabrication and installation. The bending scheme, equipment and relevant procedure shall be previously approved by COMPANY.

After deformation, specimens for mechanical testing shall be extracted from both extended and compressed sectors of spool such as:

- 6 O'clock (12 O'clock position is defined as the top of weld when reeling on)
- 12 O'clock position.

The samples shall be artificially aged at 250°C for one hour before testing.

The following testing shall be conducted after straining and ageing:

- One (1) Weld metal tensile testing (all weld)
- One (1) Transversal tensile of circumferential weld (across the weld)
- Hardness testing in weld at mid-wall thickness
- Three (3) sets of Charpy V-notch impact toughness testing (transverse specimen) in Weld Metal (WM), Fusion Line (FL) & HAZ (FL+2 mm).

Note: Test temperature shall be addressed in the PPS.

CTOD tests may be required by PPS.

That specific welding qualification program is required for both Main line welding & repair welding procedures.

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