PTT Exploration and Production Public Company Limited

PTTEP Engineering General Specification

(Engineering and Development Group)

Standard

Longitudinally Submerged Arc Welded (SAWL) Pipes for Carbon Steel Pipelines

(Mild, Intermediate and Severe Sour Service)

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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

The purpose of this PEGS is to provide the general requirements applied to Longitudinally Submerged Arc Welded pipes (SAWL).

3.0 SCOPE

This specification defines the COMPANY's general requirements for the manufacture and supply of bare carbon steel pipes to be used in the construction of onshore or underwater pipelines, for crude oil, gas, multiphase or condensate effluents, operating in Mild Sour Service, Intermediate Sour Service" or "Severe Sour Service" (i.e. corresponding respectively to regions 1, 2, 3 in specification 10008-STD-6-COR-032, PEGS-0842-COR-032~~PEGS-0842-COR-032~~.

It applies to Longitudinally Submerged Arc Welded pipes (SAWL) in steel grade L290M (X42M) up to grade L485M (X70M) of API Spec 5L / ISO 3183 , manufactured by the UOE process, JCOE process, the Press bending Process or the Roll Bending process. It also takes into considerations DNV-OS-F101 requirements (see Appendix 14).

This specification shall always be used in conjunction with a Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions of the Pipeline Project (see section 7~~5~~.2 of this specification).

Requirements are also provided in this specification for line pipes with Wall Thickness requiring a Post Weld Heat Treatment (PWHT) at pre-fabrication or installation stage, where the pipe properties of Base Steel and Weld are to be ascertained after the PWHT is made.

No deviation from the requirements stated in the present specification shall be permitted unless prior written approval has been obtained from the COMPANY.

4.0 RESPONSIBLE ACTION PARTIES

This specification is distributed under the responsibility of the relevant department and divisions in PTTEP engineering entity in accordance with the procedures, approved by the line management.

This specification is applicable for all PTTEP operated assets and new project at the time of the study phase or pre-project or project sanction phase apply.

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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
Company	PTT Exploration and Production Public Company Limited and affiliates.
Contract	"CONTRACT" means this signed AGREEMENT together with the Exhibits and Annexes which are made part thereof, and any future amendments thereto
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’
Equipment	Is used for all ancillary items of the precommissioning, not part of the permanent facilities.
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.
Mill	The plants, Mills, workshops, laboratories or other locations where the fabrication, inspection and testing of materials are to be performed complete or in part, shall be referred to herein as the "Mill"
Precommissioning	All tasks and operations performed on the pipeline subsequent to the pipeline construction and prior to the Commissioning.

Terminology	Description
Project Particular Specification (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.
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:

CTOD	Crack Tip Opening Displacement
CVN	Charpy V-Notch
DWTT	Drop Weight Tear Test
El	Elongation
EPMA	Electron Probe Micro Analysis
FL	Fusion Line
FSH	Full Screen Height
HIC	Hydrogen Induced Cracking
ID	Inside Diameter
ITP	Inspection and Test Plan
MPI	Magnetic Particle Inspection
MPQT	Pipe Manufacturing Procedure Qualification Test
MPS	Manufacturing Procedure Specification
NCR	Non-Conformance Report
NDE	Non-Destructive Examination
NDT	Non-Destructive Test / Testing
OD	Outside Diameter
PEHD	Polyethylene High-Density
PHS	Pipe History System
PPS	Project Particular Specification
PWHT	Post Weld Heat Treatment
QA	Quality Assurance
QC	Quality Control
QCP	Quality Control Plan
SAWL	Longitudinally Submerged Arc Welded
SMYS	Specified Minimum Yield Strength
SSC	Sulphide Stress Cracking
TMCP	Thermo-Mechanical Controlled Process
TQ	Technical Query
TS	Tensile Strength
UT	Ultrasonic Testing
WT	Wall Thickness
YS	Yield Strength

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-PLR-008, PEGS-12059-PLR-004 ~~PEGS-12059-PLR-004~~	Induction Bends for Carbon Steel Pipelines (Mild, Intermediate and Severe Sour Service)
10008-STD-6-PLR-030, PEGS-0710-PLR-010~~PEGS-0710-PLR-010~~	Storage and Transportation of Line Pipes
10008-STD-6-COR-032, PEGS-0842-COR-032~~PEGS-0842-COR-032~~	Materials for Sour Service
10008-STD-6-GEN-005, PEGS-12060-ADM-006 ~~PEGS-12060-ADM-006~~	Quality Requirements for Contractor / Vendor

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 10893-9	Non-destructive testing of steel tubes - Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes
ISO 10893-6	Non-destructive testing of steel tubes - Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections
ISO 10893-5	Non-destructive testing of steel tubes - Part 5: Magnetic particle inspection of seamless and welded ferromagnetic steel tubes for the detection of surface imperfections
ISO 148-1	Charpy pendulum impact test (V-notch)
ISO 15156-2	Materials for use in H_2S - containing environments in oil and gas productions – Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons
ISO 17025	General requirements for the competence of testing and calibration laboratories
ISO 19232-1	Non-destructive testing – Image quality of radiographs – Part 1: Determination of the image quality value using wire-type image quality indicators
ISO 3690	Welding and allied processes - Determination of hydrogen content in arc weld metal
ISO 643	Steels - Micrographic determination of the apparent grain size

Document Number	Document Title
ISO 6507-1	Metallic materials - Vickers hardness test - Part 1: Test method
ISO 6892	Metallic materials - Tensile testing - Method of testing at ambient temperature
ISO 7438	Metallic materials - Bend test
ISO 7539-2	Corrosion of metals and alloys - Stress corrosion testing - Part 2: Preparation and use of bent-beam specimens
ISO/TS 29001	Petroleum, petrochemical and natural gas industries - Sector-specific quality management systems - Requirements for product and service supply organizations
ISO 3183	Petroleum and natural gas industries - Steel pipe for pipeline transportation systems
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
AWS A4.3	Standard Methods for Determination of the Diffusible Hydrogen Content of Martensitic, Bainitic, and Ferritic Steel Weld Metal Produced by Arc Welding
AWS A4.4M	Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings
AWS A5.01M/A5.01	Welding Consumables - Procurement of Filler Metals and Fluxes
AWS A5.1/5.1M	Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
API RP 5L1	Railroad Transportation of Line Pipe
API RP 5L3	Recommended Practice for Conducting Drop-Weight Tear Tests on Line Pipe
API RP 5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
API Spec 5L	Specification for Line Pipe
ASME, Section II-C	Boiler and Pressure Vessel Code, Section II: Materials - Part C: Specifications for Welding Rods, Electrodes and Filler Metals
ASME, Section V	Boiler and Pressure Vessel Code. Non-destructive Examination
ASTM A578/A578M	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

Document Number	Document Title
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E112	Standard Test Methods for Determining Average Grain Size
ASTM G39	Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens
BS EN 10160	Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)
CSWIP	Certification Scheme for Personnel - NDT Operator
DNV-OS-F101	Offshore Standard – Submarine Pipeline Systems
EFC Publication 16	Guidelines on Materials Requirements for Carbon and Low Alloy Steels for H_2S – Containing Environments in Oil and Gas Production
EN 10204	Types of inspection documents
NACE TM0177	Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments
NACE TM0284	Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking

7.0 REQUIREMENTS OF SAWL PIPES FOR CARBON STEEL PIPELINES

7.1 QUALITY ASSURANCE / QUALITY CONTROL

1. The SUPPLIER shall operate a Quality Assurance (QA) system in accordance with ISO/TS29001, or equivalent, approved by a COMPANY recognized authority. The Quality Assurance Manual shall be submitted to COMPANY prior to the start of work and made available to the Inspector(s) at all times.
2. Four weeks prior to commencement of the pipe manufacturing, the SUPPLIER shall prepare and submit to COMPANY a Quality Control Plan which described the inspections to be performed during the supply of steel, plates and pipes. The Quality Control Plan (QCP) or Inspection and Test Plan (ITP) shall set forth “witness”, “hold”, “review” and “monitor” points.
3. Just before production starts, Mill QA Representative accompanied by Inspector shall check at every production and inspection station, that the relevant working instructions and procedures are available, complete, conform to be procedures agreed by COMPANY or to the Inspector. A report shall be issued by supplier signed by the Inspector and enclosed with the final dossier.

7.2 PROJECT PARTICULAR SPECIFICATION (PPS)

The following information shall be provided in the PPS:

1. Steel grade
2. Pipe nominal dimension in mm (OD x WT)
3. The sour service severity and pipeline effluent to clarify the H_2S test conditions (see Appendix 15 and Appendix 16)
4. The type(s) of pipeline (s) onshore or offshore
5. If it is a gas pipeline (in regard to applicable particular requirements for CVN in table 4 appendix 2)
6. If Appendix 14 of this specification (DNV Particular Requirements §1) are applicable
7. If Appendix 14 of this specification (DNV Particular Requirements §2) “Supplementary Requirements” F, P, D or U is/are applicable
8. If Press Bending process or Roll Bending process is accepted (see §75.5.2)
9. If pipes shorter than 11.60 meters are acceptable (where necessary (see § 75.5.9.6)
10. The required length for welds reinforcement grinding (ID/OD) for girth welding and AUT applicable (if any)
11. Routine impact test temperature (see §75.7.5.4)
12. Routine test temperature of DWTT (see §75.7.5.7)
13. If welding test results on similar pipe materials are required (see § 75.12.2)
14. If § 5.5.9.4 b is applicable (when automatic UT on girth welds is foreseen)
15. If histograms are required (see § 75.12.3 a)

16. Number of originals and copies of Mill certificates and final production report (see §7~~5~~.12.3 b)
17. If PWHT test is required (see Appendix 7, Clause B, Item 12)
18. If weldability test are required (see §7~~5~~.5.1 and Appendix 7, Clause B, Item 13)
19. If colored painted band on pipe is maintained or is pending (see section 7~~5~~.9)
20. If a bar code system is required or, otherwise, acceptable (see Section 7~~5~~.9)
21. If bevel protectors are confirmed (where necessary) (see Section 7~~5~~.10)
22. If spare bend mother pipes for contingency are to be added to bend order
23. The COMPANY/purchaser inspection scope

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

Before the mass production starts, (usually after a pre-production or pre-inspection meeting), the PPS shall be revised for including all the particular production, inspection, topics and qualifications mutually agreed by both the pipe manufacturer and COMPANY. Any further technical agreement, modification, major points, that occurs during the production stage shall be reported in the PPS by Inspector

7.3 INSPECTION BY THE COMPANY AND INSPECTOR

1. All procedures shall have prior approval of COMPANY. All qualification tests shall take place under the supervision of the Inspector.
2. The SUPPLIER shall notify the Inspector sufficiently in advance to enable him to be present at qualification tests and at all other tests or stages of manufacture subject to acceptance in accordance with this specification.
3. The SUPPLIER shall ensure that the Inspector has full and free access to all parts of the Mill during all fabrication and inspection stages
4. At steel making mills, plate rolling mills and pipe mills: offices, workshops, storage yard etc., information on paper and/or in computers (procedures, working instructions, data; records, tracking system, etc.) concerning the manufacturing and inspection, shall be made fully available and comprehensible to Inspector reading. Where the mill country language is not English, all information shall be written in double language, i.e. Mill country language and English language.
5. A free access to the Mill computerized system shall be made available in the Inspector office:
    - Tracking system of production and inspection
    - All data and results of mechanical tests, NDE results
    - Plate input, pipe output, rejections status with causes, repairs
    - Any other information considered pertinent by the inspector for his monitoring

Computer, software environment compatible with the mill software, software interface where necessary for data exploration with EXCEL shall be made available by the Supplier. The Inspector shall be provided with equipment for sending/receiving faxes, communicating through emails and high speed Internet access.

6. The Inspector shall ensure that materials and pipes are fabricated in accordance with all the specified requirements and COMPANY's approved procedures.
7. Inspection by the Inspector shall be carried out during pipe production in order to avoid any special or additional handling. Inspection will be a made in such a manner to avoid delay in pipe production insofar as the pipes which are presented to him meet the specified requirements.
8. The inspector shall finalize his inspection by a special stamp (or indelible paint marking, when so previously agreed) on the accepted pipes. Die stamping is permitted only on the bevel surface.
9. The Inspector shall notify the COMPANY without delay of any difficulty, irregularity, problem or delay likely to occur during pipe production.
10. The COMPANY and/or Inspector reserves the right to re-check tests carried out by the SUPPLIER. For this purpose, the COMPANY may request the delivery of samples or specimens for analyze in an independent laboratory chosen by the COMPANY.

7.4 STEEL MAKING, SLAB CONTINUOUS CASTING AND PLATE MANUFACTURE

7.4.1 GENERAL REQUIREMENTS

1. The SUPPLIER shall provide the COMPANY four (4) weeks minimum before commencement of production with a detailed plate Manufacturing Procedure Specification giving full details of all the characteristics of the proposed steel plate (see details in Appendix 6 relating to pipe manufacturing procedure).
2. All calibration certificates of control devices, thermometers, recorders, shall be made available to Inspector's review prior to start the rolling campaign.
3. Except as otherwise previously agreed between the SUPPLIER and the COMPANY, all inspections and tests required for steel plate acceptance shall be carried out the SUPPLIER's mill.

7.4.2 STEEL MAKING

1. Steel shall be made by the Electrical Furnace or Basic Oxygen Converter. Steel shall be fully killed and made to fine grain practice (grain size ASTM No.: 8 or finer according to ASTM E112/ISO 643). Grain size evaluation shall be made once at qualification of plate/pipe manufacturing procedure. Then, it shall be done only when a doubt arises about steel properties

2. The steel making process shall result in the manufacture of steel plates/pipes having a high resistance to H_2S embrittlement and associated effects.

   During its manufacture, the base steel shall undergo the following treatments:

   - Thorough desulphurization treatment and dephosphorization treatment
   - Vacuum degassing
   - Specific treatment to control size, shape and distribution of oxide and manganese sulphide inclusion (e.g. calcium treatment).

7.4.3 CASTING

1. Continuous casting process is required.

   The casting speed shall be that proposed by the SUPPLIER and approved by the COMPANY at the bid stage. The actual production casting speed range (speed max – speed min) shall not exceed 0.1 m/min. This parameter recording shall be made available to Inspector. The SUPPLIER shall give full detail about the casting sequences (number of heats, tons, scrapping lengths…)

2. Where continuous casting line is of fully bent type, the SUPPLIER shall provide, at the bid stage, a technical documentation concerning the implemented particular cares to overcome the weakness of a fully bent casting process in terms of inclusion segregations close to the surface edges of plates. It shall be demonstrated that the process does not impact the final pipe quality (NDE, macro, HIC reports from past experience).

3. The SUPPLIER shall give full details of Mill control of sequential heats.

4. Macro-etching or sulphur prints shall be carried out on slabs (or plates) at a frequency of once per casting sequence with a minimum of once per shift and casting sequence, on each strand. The Mill's reference chart of grading and acceptance level will be agreed with the COMPANY.

5. All surfaces of the slab shall be inspected for defects and scarfing carried out if necessary. Slabs shall be correctly marked and stored to avoid any confusion between heats of steel.

7.4.4 SLAB/PLATE SLITTING

Slitting of mother plates and / or slabs is not permitted.

7.4.5 ROLLING TECHNIQUE/HEAT TREATMENT

1. Plate shall be manufactured by the Thermomechanical Controlled Process, including a subsequent accelerated water cooling method. Accelerated cooling of plates shall be performed at a controlled temperature higher than AR3.
2. The SUPPLIER shall provide the Inspector with the temperature measurements made at all important stages of the plate fabrication flow. For TMCP steel, this shall include the temperatures and reduction ratios of the rolling steps, and temperatures at inlet and outlet of accelerated cooling facilities, with cooling rates.
3. The rolling records of each mother plate shall be made available for review at the plate Mill, on Inspector's request.
4. In all cases, steel plates shall show a homogeneous very fine-grained microstructure through the full WT.
5. The rolling records shall be made available at pipe mill as well for Inspector review and selection of production test pipes.
6. Banded structure in terms of segregated bands of carbides shall not be acceptable.
7. Rolling Ratio shall be equal to or above 3.5.

7.4.6 CHEMICAL COMPOSITION

1. Chemical composition of steel and its Carbon Equivalent (CE) and Pcm, as determined on each heat and product, shall be in accordance with Tables 1 and 2 (Appendix 1). However, the ruling composition shall be that proposed by the pipe SUPPLIER and approved by the COMPANY at the bid stage. The production actual composition ranges shall not be significant in terms of metallurgical influence.
2. The SUPPLIER shall carry out ladle and product analysis for all specified elements (plus all other intentionally added elements, when applicable). Location of sampling shall be at midway between plate edges.
3. Test frequency shall be as follows:
    - Ladle analysis: one per each heat. Residual elements shall be analyzed only on the first heat produced and then every 20 heats
    - Product analysis: at least one per each heat. Analysis of residual elements is not required on product. Product analysis may be carried out either on plates or on pipes, at the SUPPLIER's option. However, the selected option shall be clarified by the SUPPLIER at the bid stage.

4. Recheck analyses

   If any part of the product analysis fails to meet the requirements above, either the whole heat shall be rejected, or each individual plate shall be fully analyzed, and all plates failing to meet the requirements shall be rejected. Samples for recheck analysis shall be taken at the same location as that specified for product analysis samples.

5. For steel/plate/pipe mills recognized by COMPANY as fully integrated, product analysis may be made on pipes instead of on plates, provided that products traceability is fully demonstrated by SUPPLIER to COMPANY.

7.4.7 MECHANICAL PROPERTIES AND TESTS ON PLATES

1. Mechanical properties of the plates shall be measured by means of tensile and impact tests carried out transverse to the principle rolling direction.

   Sampling shall be located midway between edge and centre of plate.

   Charpy V notch tests shall be taken out at mid thickness.

2. Testing procedures and specimens shall be as defined under §75.7.5 for finished pipe.

3. Frequency of mechanical tests: at least one tensile test and one impact test (including a set of three Charpy V-notch specimens) shall be made once per each heat.

4. Results from mechanical testing carried out on steel plates shall meet the working ranges required by the pipe SUPPLIER at the bid stage.

5. For steel / plate / pipe mills recognized as fully integrated by COMPANY mechanical tests may be made on pipes only, subject to prior agreement of the COMPANY.

7.4.8 VISUAL, DIMENSIONAL AND ULTRASONIC INSPECTION

Steel plates shall be subjected to visual, dimensional and ultrasonic inspections on finished product. For fully integrated steel/plate/pipe mills, visual and ultrasonic inspection may be carried out at the pipe mill. Wall thickness checking shall be made at both the plate rolling mill and the pipe mill.

7.4.8.1 VISUAL INSPECTION

Steel plate shall be visually examined on both surfaces.

Steel plate shall be free from surface defects such as cracks, notches, laps, tears, from foreign materials, loose mill scale and rust, and from abnormal thickness variations.

Cracks, notches and sharp bottom imperfections are unacceptable whatever their dimensions. Any other imperfection having a depth greater than 3% of the specified nominal thickness shall be considered as unacceptable defect and shall be repaired provided that the specified minimum wall thickness is maintained.

7.4.8.2 THICKNESS MEASUREMENT

Plate thickness measurement shall be made once every five plates, as a minimum. Measurement shall be carried out on middle and both edges of plates, at both plate ends. This may not apply when an automatic gauge control system including a recording is used at rolling Mill to check/measure the thickness, along the whole plate length, on both the plate axis and on one plate longitudinal edge, as a minimum. The type of automatic equipment used with details shall be supplied at bid stage. Calibration of this system shall be made minimum twice per month.

Any repair grinding shall initiate thickness checking.

Steel plate thickness measurements shall be such that the specified minimum and maximum wall thickness of finished pipes are met.

Supplier shall provide histogram per each pipe size (measures on plates) with the detail of the range min/max, the mean value (M) and the standard deviation (Sd) of wall thickness records for all measurement results, irrespectively of the measurement location. Sd shall be conventionally calculated as follows:

Sd = (w.t. max – w.t. min) / 6

Ground repair locations and marginal wall thickness values shall not be counted.

7.4.8.3 ULTRASONIC INSPECTION

Each steel plate shall be 100% ultrasonically inspected in accordance with the provisions stated in Appendix 3 of the present specification.

Inspection records and print out charts of all plates (including calibration plates) showing locations and dimensions of reflectors shall be made available to the inspector for review at the Mill.

The acceptance limits of imperfections are specified in Appendix 3.

7.4.9 REPAIR

Welding repairs shall not be permitted on plates. The defects can be eliminated only by grinding provided that the plate thickness is not locally reduced below the specified minimum thickness of pipes.

A local Magnetic Particle Inspection according to ASME Code, Section V, may be requested by the Inspector to ensure that the defect has been completely removed. This does not apply to cosmetic grinding areas.

Moreover, plate thickness measurement shall be carried out where a repair grinding (except cosmetic grinding) has been made.

A cosmetic grinding shall be understood as shallow imperfection which is corrected by using a smooth flap wheel (i.e. Grain size disk #100).

7.4.10 PLATE FOR BEND MOTHER PIPES

7.4.10.1 MOTHER PIPE MANUFACTURING PROCEDURE

Particular attention shall be paid to mother plates manufacturing (chemical composition, rolling technique) and to mother pipes longitudinal welding in order to achieve acceptable mechanical characteristics on bends (process of bending = induction heating).

The mother pipe manufacturing procedure (chemical analysis of plate and of weld, welding procedure) shall have prior approval from the Bend Manufacturer and shall be submitted to COMPANY at the bid stage.

Any deviations to the present specification shall be submitted to the COMPANY (Refer to 10008-STD-6-PLR-008, PEGS-12059-PLR-004 ~~PEGS-12059-PLR-004~~ for bends).

7.4.10.2 MICROGRAPHY OF MOTHER PLATE

Before starting the bend mother pipe production,

Three specimens of 50mm long in the rolling direction shall be extracted from a mother plate at 50 mm from each longitudinal edge and at mid width. The rolling direction cross sections of the specimens shall be properly polished and etched to reveal carbides. They shall be examined every 10mm, at 2 mm from each surface and at mid wall, with a magnification of x100. The microstructure shall not exhibit banded structure in terms of carbon / carbides minor and major segregation. Three photography of typical structure shall be issued for the inspection file. The COMPANY Inspector shall attend the test.

7.4.11 MARKING OF PLATES

Each plate shall be clearly identified by means of weather resisting markings.

The following minimum indications shall be marked on each plate:

- Purchaser’s name
- Plate Manufacturer and Mill name
- Heat No.
- Plate No.
- Plate wall thickness x width
- Steel grade
- Order identification

The SUPPLIER’s in-house plate marking may be proposed at bid stage for steel/plate/pipe fabrication integrated plants. However, this marking shall include plate number and job identification, as a minimum, provided that traceability is demonstrated to COMPANY and included in the SUPPLIER’s documentation.

7.4.12 MILL CERTIFICATES

The SUPPLIER shall provide the COMPANY with Type 3.2 Mill certificates according to EN 10204 for plates, together with reports of all tests and inspections carried out on plates in accordance with the present specification:

- Results of heat and product analyses (see §75.4.6)
- Results of mechanical tests (see § 75.4.7)
- Results of visual inspection (see § 75.4.8.1)
- Results of thickness measurements (see § 75.4.8.2)
- Results of ultrasonic inspection (see § 75.4.8.3)

On Mill certification, each plate shall be identified in respect of the heat and slab from which it has been produced. Mill certificates shall clearly indicate the as-delivery condition of plates (e.g. controlled rolled with accelerated cooling).

Format of Mill certificates shall be agreed prior to production between the COMPANY and the SUPPLIER.

7.5 PIPE MANUFACTURING

WARNING: Before starting any trial or production, Pipe Manufacturer is requested to read the Appendix 17 and to proceed, as a first priority, with the tests required in the said appendix.

7.5.1 GENERAL REQUIREMENTS

1. Pipes shall be manufactured to PSL 2 and all the requirements of API Spec 5L/ISO 3183, unless otherwise indicated in the present specification, i.e. API Spec 5L/ISO 3183 remains applicable for all points not specifically mentioned or modified in the present specification.
2. HIC tests (as per Appendix 16) and SSC tests (as per Appendix 15) shall be required according to provisions of § 75.7.6 and 75.7.7 of this specification.
3. Weldability Tests (as per Appendix 13) are to be carried out only when so required in the PPS: refer to Appendix 7 of this specification.
4. The SUPPLIER shall guarantee the overall consistency of the pipe order (including chemical composition, dimensional, weldability, material traceability), especially if pipes are manufactured at different mills with the COMPANY's previous approval.
5. Except as otherwise previously agreed between the SUPPLIER and the COMPANY, all inspections and tests required for pipe acceptance shall be performed at the pipe manufacturing Mill.
6. Reference is to be made to Section 75.4 of 10008-STD-6-PLR-008, PEGS-12059-PLR-004 ~~PEGS-12059-PLR-004~~ for mother pipes of bends.

7.5.2 PROCESS OF MANUFACTURE

The pipes shall be manufactured from plates by cold forming using the UOE or JCOE process (i.e. with mechanical expansion), and, when so agreed with the COMPANY at the bid stage, by the Press Bending process or the Roll Bending process, and shall have one longitudinal seam made by the automatic Submerged Arc Welding process. In all cases, the longitudinal weld seam shall include at least one pass made on the inside and at least one pass made on the outside, according to definition of API Spec 5L/ISO 3183. The joint efficiency factor shall be 1.

After execution of the longitudinal seam, the run-on and run-off tabs shall be removed by flame cutting or sawing only (mechanical breaking of tabs shall be forbidden).

7.5.3 COLD EXPANSION

UOE/JCOE pipes shall be cold expanded at a permanent straining rate in the range 0.8% to 1.5%. The expansion ratio shall be recorded on 10 pipes minimum per shift and, also, on pipe used for qualification of MPS.

No cold expansion is required on Press Bending pipes and Roll Bending pipes.

7.5.4 BASE MATERIALS

The steel plates used in the fabrication of pipes shall meet the requirements defined under Section 7~~5~~.4 of this specification.

7.5.5 PIPE MANUFACTURING PROCEDURE SPECIFICATION (MPS)

The SUPPLIER shall establish a detailed specification for manufacture and inspection of pipes describing all proposed operations in their correct sequence together with their parameters of execution. This document shall also mention the characteristics of equipment and procedures used to carry out these operations.

The proposed MPS shall include, but not limited to, all pertinent information required in Appendix 6, together with the detailed HIC procedure and SSC procedure.

The MPS shall also describe the system for traceability of the heat N°, plate N°, welding records, and records of all required tests and inspections to each individual pipe.

7.5.6 QUALIFICATION OF PIPE MANUFACTURING PROCEDURE (MPQT)

1. One finished pipe among the first pipes produced in each size (each diameter and each wall thickness), grade and steel source (first shift production) shall be subject to all the inspections and test as described in Appendix 7 in order to qualify the pipe manufacturing procedure. This pipe shall be selected by the inspector.
2. The essential variables are stated in Appendix 7, Section A.

3. The SUPPLIER shall submit to the COMPANY the pipe manufacturing procedure qualification test report giving the results of all tests required by the present specification. The report shall be approved and signed by the Inspector who attended the tests.
4. The SUPPLIER is allowed to proceed with the pipe manufacture without waiting for the test results and the Inspector's approval, as long as the SUPPLIER is accepting the risk and responsibility of the consequences of any test failure, as stated here-after.
5. In case of qualification test results which do not comply with the requirements of this specification, the pipe tested as well as all preceding pipes shall be rejected. The causes of failure shall be investigated by the SUPPLIER and reported to the COMPANY. Manufacture shall resume only after the procedure has been suitably revised to the satisfaction of the COMPANY and after a new pipe has successfully passed all the qualification tests laid down in this specification.

7.5.7 CHEMICAL PROPERTIES

All pipes shall be manufactured from steel which shall have a chemical composition ensuring proper ductility, strength, toughness and weldability under all conventional welding processes and techniques used on lay barges and onshore installation works, where applicable.

The SUPPLIER shall carry out product analyses for all specified chemical elements (plus all other intentionally added elements). Those chemical compositions shall be included in Mill certificates.

Heat and Product analyses shall meet the requirements contained in Tables 1 and 2 of Appendix 1. However, the ruling composition shall be that proposed by the SUPPLIER and approved by the COMPANY at the bid stage (see § 75.4.6 above).

Number, type, location and frequency of tests shall be as defined under § 75.4.6

7.5.8 MECHANICAL PROPERTIES

The finished pipes shall meet the requirements stated in Tables 3 and 4 of Appendix 2 for tensile properties and Charpy V-notch test requirements respectively.

Number, type, location and frequency of tests shall be as defined under § 75.7.5.

Results of mechanical tests carried out on finished pipes shall be stated on Mill certificates.

7.5.9 DIMENSIONAL AND WEIGHT REQUIREMENTS

The following requirements shall be met on each finished pipe.

Frequencies of dimensional checking, measurement and recording shall be as described in § 75.7.2, 75.7.3 and Table 5 of section 75.7 of present specification.

7.5.9.1 DIAMETERS

a) Outside Diameter of pipe body

The tolerance shall not exceed ± 0.5% of the specified nominal Outside Diameter, with a max. of ± 4 mm.

b) Inside Diameter of pipe ends

The tolerance on the Internal Diameter within 100 mm (4") of the pipe ends shall not exceed ± 1.6 mm from the nominal Internal Diameter defined as follows:

Nominal ID = nominal OD – 2 x nominal WT

Above diameters shall be checked with circumferential tape or diameter tape. However, for pipes with OD less than 20" a caliper gauge may be used provided that equipment and procedure have the prior agreement of the Inspector.

7.5.9.2 OUT-OF-ROUNDNESS

a) Pipes with OD less than 20"

Out-of-roundness at pipe ends shall be checked using an internal ring gauge of diameter 3.2 mm less than the nominal Inside Diameter. This gauge shall pass freely 100 mm into each end of the pipe when held normal to the pipe axis.

b) Pipes with OD 20" and larger

Out-of-roundness at pipe ends shall be checked using a rod gauge or a caliper gauge and measurement of actual major and minor inside diameters of pipe shall be made. The difference between maximum ID and minimum ID measured within 100mm at each pipe end shall not exceed 0.80% of the specified nominal Inside Diameter, with a maximum of 5 mm. Nominal Inside Diameter is defined in § 75.5.9.1 b) above.

7.5.9.3 PEAKING

Peaking of the pipe at the weld location shall not deviate by more than 1.6 mm from the theoretical form, when measured transverse to pipe axis using Inspector approved inside and outside templates (sector of 20° minimum) or dial gauge.

7.5.9.4 WALL THICKNESS

a) Minimum wall thickness guarantee

The tolerance on wall thickness shall be -5%; +10% of the specified nominal wall thickness.

The thickness shall be checked on a circumferential area (as a minimum, at both sides of weld and at the area opposite to weld) at both ends of pipe.

Wall thickness shall be checked using a micro-meter, a limit gage, a caliper or ultrasonic.

The SUPPLIER shall guarantee the specified wall thickness along full length of finished pipe. However, random checking at mid-length of pipe shall be made by SUPPLIER at a frequency to be agreed (with a minimum of three times per shift), unless measurement and recording of plate wall thickness was made continuously at plate mill on both the strip longitudinal axis and one strip edge, as a minimum (refer to § 7~~5~~.4.8.2 of this specification). Wall thickness print-outs shall be made available to the Inspector in that case, for review at the pipe Mill.

b) Particular requirement (for further Automatic UT on pipe laying girth welds)

When so required in the PPS and when the pipe item wall thickness Standard deviation has been found in plate mill in excess of 0.25 mm, (see § 7~~5~~.4.8.2), the following shall apply:

- Wall thickness shall be measured and recorded on 100% of pipe ends, at 2 locations of each end: at 20 mm approx. from one weld toe and at the weld opposite side (i.e. 4 measurements on each pipe)
- Measurements shall not be carried out on ground areas
- A dial micro-meter shall be used for measurement. Its fingers (jaws) shall be sharp or round ended for a proper touch on internal pipe surface
- The accuracy of measurements and records shall be of 0.1 mm (examples: 17.2 mm, 20.6 mm)
- The results shall presented on a histogram and shall indicate the Mean value (M) and the Standard deviation (Sd).

The measured wall thickness versus the pipe numbers and end sides shall be traceable. The records shall be made available to COMPANY or pipe laying Contractor review and shall be included in the final documentation as a computer file, compatible with EXCEL.

7.5.9.5 WEIGHT

Each pipe length shall be weighted individually.

The tolerance on the weight of any single length of pipe shall be -3.5%; +10% of the nominal weight.

7.5.9.6 UNIT LENGTH

a) Pipes shall be supplied in lengths of 12.20 m ± 0.60 m with a minimum average length of 12.20 m for each item of the order.

However, when so permitted in PPS, 3% of the pipes may have an individual length between 10.00 m and 11.59m, always providing that the average length of each item of the order is 12.20 m.

No pipes shall be shorter than 10.00 m.

The shorter pipes shall be differentiated from the other pipes by a band of a different colour at one pipe end.

b) Jointers made by welding two pipe sections to produce the specified pipe length shall not be permitted.

7.5.9.7 STRAIGHTNESS

The deviation from a straight line (taut wire), positioned at 3 or 9 O'clock shall not exceed 1.4 mm per meter of length. Straightness shall be checked at two planes, as a minimum, displaced by 90°. One of these planes shall include the longitudinal seam.

Cold straightening is allowed provided that the resulting permanent straining does not exceed 1%.

7.5.9.8 SQUARENESS OF PIPE ENDS

The pipe ends shall be cut perpendicular to the pipe longitudinal axis within 1.6 mm across any diameter. Checking shall be made either at the end facing machine or using an angle.

7.5.9.9 PIPE END PREPARATION

a) Pipes shall be furnished with both ends beveled to an angle of 30° +5°, -0° with a root face of 1.6 mm ± 0.6 mm (1.6 mm ± 0.8 mm at weld seam area).

b) Any repair by grinding on the bevel edge further to machine beveling shall be cause for full re-beveling. However, internal burrs can be removed by filing provided that the root face is not altered to the satisfaction of the Inspector.

c) The inside and outside weld reinforcements shall be ground flush (to -0.0 mm, +0.5 mm) with the inside contour of the pipe for a minimum distance of 100 mm from each end.

d) When pipes are planned to be beveled on barge or at site, the laying Contractor may elect to have the pipes pre-beveled at pipe mill to an angle of 0° or 15° with a root face of 1.6 mm ± 0.6 mm (1.6 mm ± 0.8 mm at weld seam area). This must be stated in the PPS or, otherwise, agreed with pipe mill in due time.

7.5.9.10 HEIGHT OF WELD BEADS

The weld bead height above the original surface of the pipe shall be within 0.5 mm and 3.0 mm, whatever the wall thickness. Weld concavity is not permitted.

7.5.9.11 OFFSET OF PLATE EDGES

The maximum radial offset shall be 10% of the nominal wall thickness of the pipe, with a maximum of 1.5 mm.

7.5.9.12 BULGES, DENTS AND FLAT AREAS

On the pipe body, deviations from the original contour of the pipe shall not exceed 3mm depth, nor shall they extend in any direction greater than ¼ of the diameter of the pipe. Any sharp bottom deformation shall be unacceptable.

7.5.10 WELDING

7.5.10.1 PIPE MILL WELDING ENGINEER

A Welding Engineer appointed to the mill welding is required. He will carry the responsibility for the welding quality management. He will be the COMPANY/Inspector interlocutor for all welding matters. The Welding Engineer shall be available at any time in or close to the workshop. His name shall be stated in the "Pipe Manufacturing Procedure Specification" (see § 75.12.2).

7.5.10.2 WELDING PROCESSES

The welding process for longitudinal seam shall be confined to the automatic Submerged Arc Welding (SAW) process.

Gas Metal Arc Welding (GMAW) process may be used for tack-welding only, provided that the weld is completely re-melted by the Submerged Arc Welding process. Refer to § 75.5.10.6 of this specification.

Weld repairs shall be carried out by SAW process or manual Shielded Metal Arc Welding (SMAW) process using extra-low hydrogen electrodes.

Each welding procedure shall be fully detailed in a Welding Procedure Specification (WPS) form previously approved by the Inspector.

7.5.10.3 WELDING CONSUMABLES

a) The weld deposits obtained from the consumables shall satisfy the impact toughness and hardness requirements of this specification and shall have tensile properties that are equal to or slightly higher than those of the base metal. YS and TS of weld metal shall not exceed the specified maximum YS and TS of base metal shown in Table 3 of Appendix 2. YS to TS ratio of weld metal shall be reported for information only.

b) The chemical analysis of weld deposit shall not include more than 1.0% Nickel and 0.5% Molybdenum.

c) All welding consumables shall conform to ASME, Section II Part C (AWS) or approved equivalent. Consumable manufacturer's data sheets shall be supplied to COMPANY for information.

d) Each heat, lot (or so called batch herein) of consumables shall be supplied with an inspection certificate type 3.1 according to EN 10204 or equivalent and subject to inspection and approval by the Inspector.

The lot and level of testing are specified as per AWS A5.01M/A5.01:2013 as follows:

- Covered electrodes: class C5
- Bare solid electrodes and rods: class S3
- Flux cored electrodes and metal cored electrodes and rods: class T3
- Flux for submerged arc welding: class F2.

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

For SAW flux, additional diffusible hydrogen test and/or moisture test shall be required as per Appendix 5 of the present specification when “Method B” is proposed.

e) Coated electrodes shall be of the extra low hydrogen type (i.e. maximum specified hydrogen content of 5 ml per 100 grams of Weld Metal).

f) Low hydrogen coated electrodes and welding fluxes shall give a diffusible hydrogen content of max 5 ml / 100 g weld metal and shall be supplied in moisture guaranted proof containers and used according to the recommendations of their manufacturers. If there are no written recommendations available from the manufacturers of consumables the following instructions shall be applied:

- Low hydrogen coated electrodes conforming to AWS A5.01M/A5.01 shall be oven dried for at least two hours between 350°C and 430°C. A lower temperature for a longer holding time is not acceptable. Immediately upon withdrawal from their hermetically sealed container or drying oven, the electrodes shall be kept in a holding oven at approximately 100°C before use. Electrodes withdrawn from the holding oven shall be used within two hours after withdrawal. If unused they shall be re-dried as above.
- Fluxes procurement, packing, storage and use shall conform to the Appendix 5 of this specification.
- The SUPPLIER shall verify the grain-size of the flux at the beginning of each working shift. The recorded grain-size shall comply with the recommendation of flux manufacturer. Should any deviation be recorded, the flux shall be rejected.

g) The SUPPLIER’s consumable procedure for storing, handling, drying, recycling and traceability shall be approved by the Inspector before commencement of production welding.

h) All welding consumable certificates shall be submitted to the Inspector. The welding consumable Manufacturer’s test certificates for each batch and lot of consumables shall be made available for that purpose. These documents shall certify that the consumables meet the requirements of the relevant standards for classification and grade and testing as stated in the above § c).

7.5.10.4 WELDING PROCEDURE QUALIFICATIONS (WPQT)

a) Longitudinal weld seam

The welding procedure for longitudinal weld shall be qualified together with the pipe manufacturing procedure (see § 75.5.6 and Appendix 7) based on the submitted WPS.

Previously qualified welding procedures are not acceptable.

Intermittent tack welding of SAW groove shall not be used.

b) Repair welding

Repairs due to welding process failures i.e. “blow-through” during tack-welding, “flux stop”, “wire stop” during SAW, etc. including Base Metal repair, are not permitted.

Unless otherwise agreed with the COMPANY, two repair types shall be qualified by tests on a pipe of the order:

- One partial repair (minimum of 2/3 thickness repair) simulating a defect located on Fusion Line, and
- One shallow repair inside of pipe with two weld passes minimum simulating a defect located at weld toe.

Where welding from inside of pipe is not intended by the SUPPLIER, nor practicable, nor accepted by the COMPANY, then a through thickness repair simulating a defect centred in Weld Metal axis shall also be required.

Any repair welding made from the inside or outside of the pipe shall be qualified by test.

All repairs shall include a minimum preheating of 100°C, unless the qualification test has shown that a higher temperature is necessary.

Each welding repair shall be qualified on a pipe section under realistic conditions to the satisfaction of the Inspector, in accordance with Appendix 12 and ISO 3183, Annex C.4 and D.

c) SSC tests

SSC tests shall be carried out on all qualification test welds (main welds and repair welds) according to test procedures stated in Appendix 15 of the present specification.

For all kinds of test weld repairs, SSC tests shall be carried out at the following two locations: one test at repair start and one test at middle length of repair (refer to Appendix 12). On partial repair and on through thickness repair, if any, specimen shall be located at root of repair weld. On all repairs (including shallow repair), specimen ID side shall be in tension.

7.5.10.5 QUALIFICATION OF MANUAL WELDERS

All manual welders shall be qualified as follows:

- Welders who have performed the above § 75.5.10.4 b) satisfactory welding procedure qualification tests are thereby qualified.
- Other welders shall be qualified in accordance with Appendix 12 by visual and radiographic examinations and four side bend tests at locations selected by the Inspector.

7.5.10.6 PRODUCTION WELDING

1. Welding conditions

a) Pipe cleanliness

Any lubricant and contamination on the weld bevel or the surrounding areas shall be removed before making the seam welds (tack weld and SAW weld) (as per DNV-OS-F101 Sec. 7 B321). Weld bevel shall be free from any water or dampness.

b) Welding parameters

The welding conditions used for the longitudinal weld and repair welds shall not depart from those of the related procedure qualification test.

However, the following variations shall be acceptable, always providing that variation of welding heat input shall be within ± 10%

- Amperage: ± 10%
- Voltage: ± 7% (± 10% for manual repairs)
- Travel speed: ± 10% for automatic welding (± 15% for manual repairs)
- Preheating/interpass temperature: -0°C, +50°C (providing that max. interpass temperature of 280°C is not exceeded).

Note: The integration time of the parameter display (and/or recorded) mean value shall not exceed one second.

c) Flux coverage

Specific attention shall be paid to flux coverage of all arcs, especially to the last one in case of multi-wires process. Visible arc shall not be permitted.

d) Tack weld repairs

The height of tack weld made by automatic welding, if any, shall be indicated on WPS. Any repair of tack weld by manual welding may be allowed provided that the weld is ground down to the height of the automatic pass.

Intermittent tack welding shall not be used.

2. Weld seam geometric characteristics

a) Weld concavity at pipe ends

Supplier shall take cares of run on/off tab length, suitable welding speed, effective welding start and stop distance from pipe ends, straightening of tabs before external welding where necessary, welding wire sequenced stop/start, etc., in order to avoid any weld shrinkage concavity at pipe ends. The welding end concavity shall be fully located in the tab.

Internal and external welds at pipe ends shall be inspected before any grinding. Where a concavity is found at pipe end, and even if the further grinding can eliminate the concavity, the concerned end shall be cut off.

b) Out-Of-Line Weld Bead

The offset between the centerlines of the internal and external weld beads shall not exceed 3 mm. The narrowest point of the weld bead cross-section shall not be less than one-fourth (1/4) of the nominal wall thickness of the pipe with a minimum of 4 mm (see Figure 1 and 2 of Appendix 8). Checking for bead misalignment shall be performed on specimens prepared for hardness test (see § 75.7.5.5 of this specification).

c) Drift of welding groove after forming (welding angle)

The welding angle due to the groove drift may cause a lack of interpenetration (see figures 3 of Appendix 8). The drift angle is affecting the Automatic Ultrasonic Testing (AUT) efficiency as well when the AUT weld seam tracking is also not based on pipe rotation.

When the seam tracking system of welding is not based on pipe rotation the special inspection requirement of § 75.7.3.2.c shall apply.

d) Weld toe profile

The weld toe shall merge smoothly onto the base material. The connection angle shall not exceed 20° (refer to figure 4 of Appendix 8 and § 75.7.5.5 of this specification).

7.6 MILL HYDROSTATIC TESTING

1. The required test pressure shall be computed using the following formula which includes a fiber stress of 90% of the Minimum Specified Yield Strength of the pipe material:

$$P = \frac{20 \times 0.90 \times S \times t}{D}$$

P Hydrostatic test pressure in bar

S Minimum Specified Yield Strength in N/mm^2 or MPa

t Specified nominal wall thickness in mm

D Nominal outside diameter in mm

When DNV-OS-F101 is applicable, formula of section 7 § E102 shall apply to determine the test pressure.

2. When sealing against the end face of the pipe is made by means of a ram which produces a compressive longitudinal stress, an appropriate calculation shall be produced by the SUPPLIER to prove that the actual hoop stress in the tested pipes is equal to 90% min. of SMYS as stated in the above formula. The RAM pressure system shall be designed such that the RAM pressure increases progressively and proportionally to the pipe internal pressure.

3. The test pressure shall be held for duration of not less than 10 seconds for each pipe.

   The test configuration shall permit bleeding of trapped air prior to pressurization of pipe. The equipment shall be capable of registering a pressure drop of minimum 2% of the applied pressure (DNV-OS-F101, Sec. 7, E106)

4. The pipe positioning procedure shall be such that the weld seam can be seen by the operator during testing.

5. A certificate of calibration established less than 12 months before the pipe fabrication, by a recognized authority, shall be provided by the SUPPLIER for the master gauge or dead weight tester. However, the pressure gauge and recorder shall be calibrated in-house against the said master gauge before start of production, and at least once per week thereafter. The pressure gauge and the recorder pressure measurement mechanisms shall be independent.

6. Mill Hydrostatic test pressure prints shall show clearly the pipe number, the date of test, the applied test pressure and the test duration for each pipe. Prints shall be available to the Inspector for conformance check at the Mill.

7. A Mill hydrostatic test certificate of compliance giving Mill Hydrostatic test requirements (test pressure and duration) shall be established by the SUPPLIER and furnished to the COMPANY. The SUPPLIER shall certify that every length of pipes has been tested without any leak or sweat in accordance with the requirements of this specification.

7.7 INSPECTION AND TESTING

7.7.1 GENERAL REQUIREMENTS

1. The production preventive measures and the inspections required in the present specification are stated as a minimum. The SUPPLIER shall bear the responsibility for the conformity of its supply to all requirements of this specification in terms of characteristics and soundness. He shall for this purpose, take all measures such as additional inspection, metallurgical investigations…when, as an expert, he judges necessary to extend the scope for the required pipe quality and for what is implicit for the pipe quality. Moreover, the SUPPLIER shall make use of suitable means, devices and qualified personnel, enabling him to ensure permanent and effective control at each stage of manufacture.
2. The SUPPLIER shall develop a Quality Control Plan (refer to § 7~~5~~.1.2 of this specification) for approval by the COMPANY and shall carry out all inspections and tests required by this specification.
3. The SUPPLIER shall develop, in the pipe mill, a fast-track feedback system between the inspection and the production for the occurrence of abnormality, progressive drift and recurrent defects, in order to implement immediate corrective actions.
4. All inspections carried out by the SUPPLIER during pipe manufacture shall form the subject of constantly updated reports. These reports shall be available for consultation by the Inspector at any time.
5. If during the main production, more than 7% of the pipes are rejected in any day's production or re-routed for repairs or re-processing, then the Inspector shall have the right to ask the SUPPLIER to increase his Quality Control Programme to an appropriate level and to maintain it until the causes of defective quality are identified and eliminated. Where above rate attains 10%, the Inspector may require the main production to be stopped. In such a case COMPANY may require a program of investigation to determine the root cause(s) of the defective quality. This program will be established in mutual agreement between COMPANY and SUPPLIER (see also § 7~~5~~.5.1 above). The rest of production shall be put on hold until result of investigations and COMPANY acceptance.
6. Only pipes fully meeting the requirements of this specification shall be presented to the Inspector for final acceptance.
7. The SUPPLIER shall provide office space and inspection facilities, as required by the Inspector, in the Mill. Free access shall be allowed to him at all production and inspection stations at all times during manufacture and testing. A suitable working area shall be reserved for him at the end of the production line at any other agreed location so that he can carry out his own inspections on the finished pipes.
8. See also the provisions of Section 7~~5~~.3 of this specification, for information.

9. All finished pipes shall be submitted to production tests and inspections as defined in the following paragraphs.

10. All visual inspection, dimensional inspection and Non-Destructive inspection procedures shall have prior approval of the Inspector and shall be subject to qualification test prior to their use in production. Further to acceptable results, qualification records shall be established by the SUPPLIER, duly signed by the Inspector and filed in the final documentation.

    Note: A “Qualification” shall consist at the very start of production, to implement the COMPANY approved written procedure in the presence of the mill QA/QC representative and of the Inspector. This Inspector and the mill QA/QC shall check that the working instructions are complete and correct, that the procedure has been implemented as it is written, that the environment (e.g. lighting, access way) is suitable, that tools, equipment are convenient, that the procedure is fully efficient for the inspection purpose in view of specification requirements, that recording and traceability are satisfactory, etc.

11. All Non-Destructive inspection personnel shall be properly certified according to CSWIP scheme or ISO 9712, or equivalent COMPANY approved standard (ASNT “in-house” qualification is not acceptable, only qualification by a third party may be accepted), and shall have also been approved by the Inspector before any involvement on the order. NDT operators shall be certified level 2, as a minimum. The SUPPLIER shall supply the Inspector with a list of inspection personnel working on the job, showing their scope of qualification and date(s) of qualifications.

7.7.2 DIMENSIONAL INSPECTION

All specified dimensions (as per § 7~~5~~.5.9) shall be checked measured and recorded to the frequencies shown in Table 5, of this specification, unless otherwise agreed at the bid stage.

Measurement and recording of all stated dimensions shall be required on every Press Bending or Roll Bending pipes.

Additional wall thickness measurements shall be carried out on ground areas (see Section 7~~5~~.8 of this specification), except for cosmetic grinding.

Note on definitions:

- “Checking” means that inspection consists to verify that the said dimension is within the permitted tolerances (exact dimension is not required) e.g. go-no-go gauge check
- “Measurement” means that a real measurement is carried out and a precise figure is obtained as a result of it
- “Recording” means that the value of actual measurement as above is recorded and filed.

7.7.3 VISUAL EXAMINATION/WORKMANSHIP

7.7.3.1 VISUAL EXAMINATION

A visual examination of the entire inside and outside pipe surfaces including the weld seam shall be carried out on each pipe. For pipe of 24" OD and larger, the inside inspection shall be made by "crawling" through the pipe. Reference shall be made to Table 5 of present Section.

The bevels shall be smooth and free from tool marks.

Reference shall also be made to § 75.5.10.6 Clause 2 of this specification.

7.7.3.2 WORKMANSHIP AND DEFECTS

The standard of acceptance shall conform to API Spec 5L / ISO 3183, Clause 9.10, with modifications as follows: The provisions of Table 5 of present Section shall apply.

a) Bulges, dents and flat areas

   Refers to § 75.5.9.12 of this specification.

b) Offset of Plate Edges

   Refers to § 75.5.9.11 of this specification.

c) Lack of Weld Penetration

   When the special inspection requirement of § 75.5.10.6 Clause 2c) is applicable, the weld penetration shall be visually checked at both pipe ends on every pipe by chemical etching on the machined weld sections. The narrowest point of the weld bead cross-section shall not be less than 4 mm (see Figure in Appendix 8).

d) Height of Weld Beads

   Refer to § 75.5.9.10 of this specification

e) Hard Spots

   The hardness is limited to 250 HV5 (or 22 HRC) to all parts of the pipe.

f) Cracks and leaks

   All cracks, sweats and leaks are not acceptable. They shall be clearly marked and the pipe set aside for investigation by the SUPPLIER and the Inspector.

   The SUPPLIER shall determine the cause of cracks with reporting to the Inspector. Based on the findings, the SUPPLIER shall then define and maintain all appropriate measures to avoid occurrence of cracks, to the satisfaction of the Inspector.

   According to the origin of cracks the Inspector may require an increase of inspection from the SUPPLIER's quality control.

g) Laminations

Pipe bevels showing linear indications exceeding 3 mm shall be cut back.

h) Arc Burns

Repair by welding is not permitted.

i) Undercuts

Undercuts with a max. depth of 0.3 mm are acceptable in any length.

Undercuts with a max. depth of 0.8 mm and not exceeding 5% of the wall thickness are acceptable provided that:

- Their length is less than one-half of the wall thickness.
- There is no more than two such undercuts in any 300 mm of weld length.

Undercuts which are coincident at inside and outside weld are not permitted

Undercuts exceeding the above limits shall be removed by grinding or repaired by welding.

Undercut repairs after pipe expansion is not accepted.

j) Surface condition of pipe

Pipes shall be free from defects and shall have a workmanlike finish. Pipe surface shall be substantially free from mill scales, scabs, pits, scores and laps, as well as unrepaired tears, raised silvers, bristles of steel, sharp notches, scratches or mechanical marks.

All those defects shall be removed by grinding before expansion and hydrotest, except for cosmetic grinding on pipe base material. Thickness measurements shall be made on all areas where grinding has been carried out, except for cosmetic grinding.

A cosmetic grinding shall be understood as shallow imperfection which shall be corrected by using a smooth flap wheel (i/e: Grain size disk #100).

The final thickness after grinding shall not be less than the specified minimum wall thickness.

k) Other Defects

- All sharp-bottom imperfections shall be considered as unacceptable defects, regardless of depth
- Any imperfection showing a depth exceeding 5% of the specified nominal wall thickness shall be considered as unacceptable.

Table 5 – Frequencies of visual and dimensional inspections

Inspection Item (3)	Mini. Frequency Check (2)	Mini. Frequency Measurement/Recording (1) (2)
• Bevel • Height of weld bead • Offset of plate edges	20/shift	5/shift
• Bulges, dents, flat areas	All pipes (visual)	All pipes with anomaly
• I.D. (ends) • Inside O.O.R (ends)	All pipes	20/shift
• O.D. (ends) • O.D. (body) • Straightness • Squareness (ends) • Residual magnetism	5/shift	5/shift
• Peaking (ends)	All pipes	20/shift
• Peaking (mid-length)	20/shift	5/shift
• Surface condition (inside, outside) (arc burns, undercuts, surface imperfections, etc.)	All pipes (visual)	UT on ground areas (except for cosmetic grinding)
• Unit length • Unit weight	All pipes	All pipes
• Weld penetration (ends) (5)	All pipes (etching + visual)	5/shift
• WT (ends)	All pipes	All (4) or 20/shift

1. Measurement /recording frequency shall be increased in mutual agreement with the COMPANY when dimensional histograms are required.
2. Definitions of “checking”, “measurement” and “recording” are stated in § 75.7.2.
3. All inspection items contained in above table shall be checked on each Press Bending pipes or Roll Bending pipe.
4. When § 75.5.9.4.b is applicable
5. When special inspection requirement of § 75.5.10.6.2.c is applicable.

7.7.4 NON-DESTRUCTIVE INSPECTION

The standards of inspection scope and acceptance shall conform to API Spec 5L/ISO 3183 Annex E and K with modifications as follows:

7.7.4.1 ULTRASONIC TESTING (UT)

Apart from the ultrasonic examination to be performed on the plates (refer to § 75.4.8.3 of this specification), all non-destructive inspections shall be carried out after completion of pipe manufacture, expansion (for UOE/JCOE pipes) and hydrostatic test.

1. Inspection of longitudinal weld seam

   The longitudinal weld seam of UOE/JCOE pipes shall be examined full length by multiprobe automatic ultrasonic method according to requirements stated in Appendix 4. Longitudinal weld at each pipe end shall be inspected by manual UT on those parts of the weld not scanned by all probes of the automatic ultrasonic inspection. For Press Bending and Roll Bending pipes where manual UT is carried out, the UT procedure shall be similar, especially regarding equipment calibration. In all cases, a detailed procedure shall be submitted by the SUPPLIER to COMPANY's approval.

   a) Ultrasonic inspection equipment and procedure

      The equipment shall examine the weld and adjacent area for both longitudinal and transverse defects. The inspection shall be efficient in detecting defects in any direction, wherever, they are located within the pipe thickness at pipe internal or external surfaces.

      The AUT equipment and procedure shall comply with all requirements of Appendix 4.

   b) Acceptance limits

      Any imperfection which produces a signal of height exceeding the threshold as defined in Appendix 4, shall be considered an unacceptable defect, unless it can be demonstrated that the imperfection does not exceed the provision of § 75.7.3 and 75.7.4.2 of this specification. Any imperfection found by the automatic ultrasonic system shall be further investigated by radiography and manual ultrasonic testing where applicable as per Appendix 4.

2. Inspection of pipe ends

   The full circumference of each pipe end after beveling shall be ultrasonically checked for laminar imperfections over a band 50 mm width with manual or automatic ultrasonic tester. This band is extended to 100 mm when AUT on pipe laying girth welds is foreseen, refer to PPS when § 75.5.9.4 b) is applicable. This band width is extended to 60 mm when the inspection is made before beveling.

   Inspection procedure shall be according to ASTM A578/A578M, or EN 10160.

   Any internal laminar imperfection exceeding an area of 25 mm^2 shall not be acceptable.

7.7.4.2 RADIOGRAPHIC INSPECTION

a) Radiographic inspection in accordance with ISO 10893-6 shall be carried out on the longitudinal weld at each pipe end over a minimum distance of 240 mm and also on those parts of the weld not scanned by all probes in the automatic ultrasonic inspection, on all welding re-starts, repair welds, ultrasonic indications and welding procedure qualification test welds.

b) Radiographic inspection shall be made by X-rays using fine grained high contrast direct films (GE-AGFA Structurix Type D5, Carestream-Industrex Type T200, or equivalent), lead screens and a single wall/single image technique.

Procedure for making of radiographs shall have prior approval of the Inspector.

c) The following shall also apply:

- ISO wire penetrameter and sensitivity as per API Spec 5L/ISO 3183 Table E3 (ISO 19232-1) or Table E4 (ASTM E 747-10)
- Two (2) penetrameters shall be placed on each radiograph: one on the as-weld reinforcement and one on the ground reinforcement of weld
- Maximum geometrical unsharpness: 0.25 mm
- Image density: 2.2 – 3.5 with regard to the weld seam with reinforcement, but may be up to 3.9 on the ground portion or on pipe body. Density shall be measured and recorded on 10% of films of each shift, as a minimum.

d) Except as specified in § 7~~5~~.7.3 above, the acceptance standards for radiography shall conform to API Spec 5L/ISO 3183 Table E.5 and E.6 and the following:

- Crack, incomplete penetration and lack of fusion of any size are not acceptable
- Elongated slag inclusions shall not exceed 1.5 mm in width and 6.4 mm in length
- Circular slag-inclusions and gas-pockets shall not exceed 2.5 mm in diameter
- The cumulated length of all discontinuities in any 150 mm of weld length shall not exceed 13 mm
- Porosities and inclusions appearing on the radiograph within 50 mm of the pipe end shall be considered as unacceptable defects, whatever their sizes.

7.7.4.3 MAGNETIC PARTICLE INSPECTION (MPI)

Prior to start with any MPI controls, the equipment shall be verified with “Berthold” method (or equivalent agreed by Inspector) to verify the efficiency of the magnetic flux.

a) All finished weld bevels shall be 100% inspected by wet MPI using the yoke method and AC.

   The sensitivity of the method shall be checked using a recognized calibration block or using a pipe containing appropriated defects to the satisfaction of the Inspector.

   Inspection shall be made in accordance with ASME Section V, Article 7.

   Any indication exceeding 3 mm in length detected on the bevel shall be cause of re-bevelling.

b) When pipe size is such that O.D. ≤ 25 WT, then the pipe external shall be MPI tested on full body and weld at a frequency of one pipe per shift for the first ten shifts and if no defects are found once per ten shifts thereafter. Acceptance shall be to § 75.7.3.2 of this specification.

7.7.5 PRODUCTION TESTS

- The following production tests shall be carried out on base material and weld seam in accordance of API Spec 5L / ISO 3183 requirements and the following. The Inspector will select a list of pipe to be preferentially tested, based on the review of the mother plate rolling parameters, and/or of the minimum levels of tensile properties obtained on plates. The Inspector reserves also the right to select the pipe to be tested for any other reason, justified to his opinion.
- The Inspector reserves the right to witness and stamp the test samples, to require to keep his stamp traceable ~~upto~~up to the testing and to witness the tests.
- Traceability of specimens shall be made by hard marking.
- Specimen cutting shall be made by sawing (flame cutting shall not be acceptable).

7.7.5.1 PRODUCT CHEMICAL ANALYSES

A product analysis (refer also to § 75.4.6) shall be carried out on both the pipe selected for tensile test and on another pipe from same heat.

Sampling shall be located at 180° to the weld seam.

7.7.5.2 TENSILE TESTS (BASE METAL AND WELD)

a) Tensile tests in base material shall be transverse to pipe axis and located at 180° to the weld seam.

Strip specimens shall be used for longitudinal and transverse tests. Flattening procedure of pipe samples/specimens shall be submitted to the Inspector. Round bar specimens may be used where practicable for transverse tests, only when so previously agreed with the COMPANY. Round bar specimens shall then be machined directly in the formed sample without any flattening of the samples, as specified in API Spec 5L / ISO 3183 paragraph 10.2.3.2. In case of dispute, the results with round bar specimens shall prevail.

b) When transverse tensile tests in base material using strip specimens show results within +3% of Minimum Specified Yield Strength, then the Inspector shall have the right to request additional tensile tests using round bar specimens, as defined above, located as close as possible to the previous ones, to cross-check the tensile properties.

When transverse tensile test in base-material, using strip specimen, show a Yield Strength failure, the Manufacturer will be allowed to the retest using, from the same pipe, 2 round bar specimens, as defined above, located as close as possible to the previous one. The result will be acceptable providing that the 2 retests meet the requirements and that the characteristic values are coherent (very low differences) to the Inspector opinion.

c) Tensile test charts shall be recorded with a suitable and defined scale.

d) 2 Transverse weld tensile tests shall apply regardless of diameter.

- One Transverse weld tensile test with ID and OD weld reinforcements ground flush to base material surface. The ultimate tensile strength shall be at least equal to the SMTS. The transverse Tensile Strength and location of rupture shall be recorded.
- One Transverse weld tensile test with ID and OD weld reinforcements (not ground). The fracture shall not be located in the weld metal. The ultimate tensile strength shall be at least equal to the SMTS. The transverse Tensile Strength and location of rupture shall be recorded.

e) Requirements of Table 3 of Appendix 2 shall be met for all above tensile tests.

f) Tensile tests in base metal and weld shall be carried out on one finished pipe from each lot of produced pipes as defined hereafter:

- OD less than 20” 100 pipes
- OD equal to or above 20” 50 pipes

A lot of pipes is defined as the group of pipes of a same size (OD and w.t.) and grade coming from a same heat and manufactured in sequence. Any fraction of a lot shall be subjected to full testing as above.

g) On 10% of production tests, a transverse tensile test round bar specimen shall be machined and kept available to COMPANY. These specimens may be used for counter testing, when, at a late stage of production, the pipe tensile characteristics are made questionable. Specimens shall be properly identified by hard marking pipe number and Inspector stamp as a minimum. The specimens shall be kept available to COMPANY for 6 months at least, after pipe delivery.

7.7.5.3 GUIDED BEND TESTS

- Two Guided bend tests shall be conducted transverse to weld seam in accordance with ISO 7438 and the requirements of Clauses 9.7, 10.2.3.6 and 10.2.4.6 and Figure 8 & 9 of ISO 3183.
- One face-bend and one root-bend test, with weld reinforcement removed from both faces, shall be carried out for wall thickness of 12.7 mm and less. For wall thickness above 12.7 mm, these tests shall be replaced by two side bend tests having full pipe wall thickness and a width of 12.5 mm.
- Testing frequency shall be two bend specimens as above per each lot of 50 pipes or less per heat.

7.7.5.4 CHARPY V-NOTCH TESTS (BASE MATERIAL AND WELD)

Three Charpy V-notch impact tests (one for base material testing and two for weld testing as indicated hereafter) shall be taken from the same pipe as that selected for tensile testing (see § 75.7.5.2 above). Each test shall consist of three specimens notched through the pipe wall thickness.

- One set shall be cut in base material transverse to pipe axis at mid-thickness and located at 90° to the weld seam
- One set at one pipe end shall be cut with the notch centred in weld metal axis
- One set shall be cut with the notch centred in Heat Affected Zone (HAZ) at the position selected for the routine production test according to § B.7 of Appendix 7.

The figure for double-Vee weld in Appendix 9 shows the notch locations in weld.

The Inspector may require having the specimens etched before testing to check that notch location is correct.

All sets shall be tested at the test temperature stated in the PPS (this will be the so-called routine test temperature). The test temperature shall not be higher than 0°C

For acceptance, the results of energy absorption for the above notch locations shall not be less than the values stated in Table 4 of Appendix 2 for full size specimens (10 x 10 mm). Note that the impact test requirements are applicable to pipes of gas transmission lines up to 56" OD and 25 mm WT. Otherwise, particular requirements will be provided by COMPANY (refer to Annex G of ISO 3183).

As far as possible, full size specimens shall be used. If sub-size specimens are found necessary due to pipe curvature and wall thickness, the required absorbed energy figures shall be those for full size specimens (see Table 4 of Appendix 2) multiplied by the corresponding factors given in the Table below.

Specimen (mm)	Multiplying Factor
10 x 10	1
10 x 7.5	5/6
10 x 6.7	7/9
10 x 5	2/3

Impact tests are not required for wall thickness below 6.35 mm.

7.7.5.5 MACROGRAPHY/HARDNESS TEST/WELD TOE PROFILE

Two specimens shall be polished and etched for macrographic examination. The weld cross-section shall be examined to ensure that weld profile is satisfactory as per § 7~~5~~.5.10.6 Clause 2 Item b) and d) above and Appendix 8.

A VICKERS hardness survey shall then be carried out using a 5 kg load in accordance with Appendix 11. No individual hardness value shall exceed the limits stated in the table below:

Sour Service	Weld and HAZ
Mild	300
Intermediate	275
Severe	250

If any result exceeds this limit, all pipes from that lot/heat shall be rejected.

7.7.5.6 MICROGRAPHY ON BASE MATERIAL (MOTHER PIPES FOR BENDS ONLY)

When for any reason, the testing of plates for "banded structure" has not been performed on mother plates as required in § 7~~5~~.4.10.2, the said tests shall be performed on the mother pipe manufacturing procedure qualification.

7.7.5.7 DROP WEIGHT TEAR TESTS (DWTT)

In case of gas pipeline with 20" OD or larger, grade X 52 or higher, wall thickness exceeding 8 mm, a pipe from each heat shall be tested by Drop Weight Tear Testing of two specimens in

accordance with sections 10.2.3.4 and 10.2.4.4 of API Spec 5L/ISO 3183 and API RP 5L3. The routine testing temperature shall be 0°C, unless otherwise stated in the PPS

Full wall thickness specimens shall be used, as far as possible. When full wall thickness specimens cannot be used due to capacity limitation of testing equipment, then the Table 1 “Test Temperature Reduction” in API RP 5L3 shall apply.

The minimum individual shear area value shall be 85% for all tests. The absorbed energy will be reported, where possible, for information.

Relevant marking of pipes is not required.

DWTT applies to line pipes and riser pipes (including pipes of expansion loop). DWTT are not required on mother pipes to be used for bends and, also, on riser pipes above hanger flange on topsides.

7.7.5.8 DEFECTIVE TEST SPECIMENS

If both the SUPPLIER and the Inspector are of the opinion that a specimen fails due to improper machining or preparation, then the said specimen will be discarded and another specimen substituted.

If any test specimen fails due to some defect in the material, it may be substituted by another test specimen with prior approval of the Inspector. The nature of the defects shall be made clear by the SUPPLIER and the Inspector will specify additional non-destructive testing to ensure that the defect constitutes really an isolated anomaly.

7.7.5.9 RETESTS

a) Failure related to Base Material

Where a specimen fails to conform to the specified requirements, a retest may be accepted by the Inspector pending further investigation of the failure is made by the SUPPLIER. Where it is thought that the failure can be an isolated case, then a retest on four (4) additional pipes from the same lot of pipes shall be carried out.

Should all retests give acceptable results, then only the pipe which gave the unacceptable result shall be rejected.

Should one (or more) of the retests give unacceptable results, then the complete lot of pipes shall be rejected unless each of the remaining pipes of the said lot is tested individually. The pipes which will give acceptable results according to this specification will not be rejected, always providing that such individual tests shall not produce a rejection equal or more than 50% of the pipes so tested. Should that be the case then all pipes of the said lot shall be rejected.

b) Failure related to forming, welding process

Pipes, on which a failure occurred, will be rejected.

After identification of the process which has caused the failure, and agreement on that point between SUPPLIER and Inspector, pipes processed just before and just after the rejected pipes will be identified and also tested.

As an example: Failed pipe N°100 shall lead to retest the pipes N°98/99/101/102.

This re-test procedure will be repeated as long as the additional tested pipes failed, in order to isolated and reject the lot of failed pipes (if any).

7.7.6 HIC TESTS

HIC tests shall be carried out per each steel source, pipe size, steel grade and manufacturing process using uncoated specimens on one test pipe from each of the first three heats (i.e. three test pipes to be tested) and then at a frequency of one test per 10 heats, or part thereof. The pipe selected for manufacturing procedure qualification shall be one of the three tested pipes. The procedure for determining HIC sensitivity and acceptance criteria shall be in accordance with Appendix 16.

In the event of failure to meet the acceptance criteria of Appendix 16 the COMPANY may accept to have four pipes of the same heat re-tested. If a re-test fails, the said heat shall be rejected and all heats of the said casting sequence shall be tested on two pipes minimum before release or reject of each individual heat of the sequence.

In all cases, re-test pipes shall be selected in mutual agreement between the SUPPLIER and the Inspector.

The SUPPLIER shall investigate and clarify the cause of any failure in order to initiate corrective actions, to the satisfaction of COMPANY.

Any HIC detected in weld metal or HAZ shall initiate an investigation on consumables and welding conditions.

HIC tests are not required on mother pipes for bends (because those tests are actually required on finished bends).

7.7.7 SSC TESTS

SSC test as per Appendix 15 shall be carried out in weld seam and pipe material per each steel source, pipe size, steel grade and manufacturing process. SSC tests shall be performed during qualification of pipe manufacturing procedure (refer to § 7~~5~~.5.6 and Appendix 7) for 720 hours as stated in Appendix 15. Production tests shall then be carried out at ¼th, ½th, ¾th and end of pipe production, still according to provisions of Appendix 15, except that test duration shall be 360 hours only (15 days).

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In the event of failure to meet the acceptance criteria of Appendix 15 in base material, the COMPANY may accept to apply to base material the re-testing procedure stated above in § 75.7.6 for HIC tests. However, when a test fails in weld metal or HAZ of weld seam, the re-testing procedure will be agreed between the SUPPLIER and the COMPANY based on a review of welding conditions to identify the lot of pipes to be further tested.

SSC tests are not required on mother pipes for bends (because those tests are actually required on finished bends).

7.7.8 RESIDUAL MAGNETISM

Residual magnetism at pipe ends shall not exceed 25 Gauss. Checking shall be made at random within the SUPPLIER's Mill, with a minimum of five pipes checked per shift, using a calibrated Hall Effect gauss-meter or other equipment approved by the Inspector.

7.8 REPAIR OF DEFECTS

Apart from cosmetic grinding, all repairs shall be carried out before cold expansion (if any) and hydrostatic test.

7.8.1 REPAIR ON BASE MATERIAL

1. Repair by welding on pipe base metal shall not be permitted. This requirement applies also to welding repairs of any cavity from removing of arc burns (see § 75.7.3.2).
2. Repair of dents and flat areas shall not be permitted.
3. Defects in the body of pipe shall be removed by grinding. A smooth curved surface shall be obtained. Thickness measurements shall be made on all areas where grinding has been carried out, except for cosmetic grinding. The final thickness after grinding shall be not less than the specified minimum wall thickness.

   Measured thickness after grinding shall always be written (e.g. with chalk) on the pipe ground area. The marking shall be made in such a way to be readable by the Inspector when the pipes are presented at final bench.
4. Repair of bevels shall be made by full re-machining only.

7.8.2 REPAIR OF LONGITUDINAL WELD SEAM

1. Unacceptable defects in the longitudinal weld seam, except as specified below, may be removed by grinding and repaired by welding carried out by qualified welders (see § 75.5.10.5) and using a previously qualified welding procedure (see § 75.5.10.4).
2. No welding repair is permitted over a length of 200 mm from each pipe end.
3. Longitudinal weld seam containing cracks shall not be weld repaired. The section of pipe containing cracks shall be cut off. Then, acceptability of the remaining pipe shall be based on length requirements as per § 75.5.9.6

4. For each pipe, the total length of manual welding repairs shall not exceed 5% of the pipe length and the number of repaired areas is limited to three maximum. Repairs shall be separated by at least one pipe OD of un-repaired weld.
5. Repair of a weld area previously repaired shall not be permitted.
6. Back to back repair shall not be permitted.
7. Each welding repair shall have a minimum length of 100 mm, even if the defect is of less extent.
8. The defect shall be completely removed by arc gouging and/or grinding and the resulting cavity shall be thoroughly cleaned. If the defect remains, the pipe shall be cut or rejected.
9. The external surface of the repair weld shall be subject to suitable grinding in order to obtain a uniform appearance and to merge smoothly into the base material.
10. Each repaired area shall be 100% examined by radiography, ultrasonic and MPI according to § 7~~5~~.7.4.1, 7~~5~~.7.4.2 and 7~~5~~.7.4.3 of this specification.
11. Repairs due to welding process failures i.e. “blow-through” during tack-welding, “flux stop”, “wire stop” during SAW, etc. inducing Base metal repair, are not permitted.
12. Repairs on weld seam of mother pipes for bends are not permitted.

7.9 MARKING OF PIPES

a) Each pipe shall be clearly identified by means of markings made with indelible white paint, and a circumferential coloured painted band 50 mm wide on the external surface of one pipe end at 200 mm approx. of pipe end.

b) The colour shall be defined in the PPS or otherwise agreed with SUPPLIER in due time.

The quality of paint employed and its application shall be designed to provide inscriptions that shall be perfectly readable for at least 6 months after delivery on pipes exposed to outdoor weather conditions. The marking shall be designed also to withstand heating 200/250°C during the further coating stage. Marking and stamping will be protected by varnish.

c) Marking (paint stenciling) shall begin at least 200 mm from the bevel and shall be made circumferentially using letters and figures of 25 mm minimum in height. Metric units shall be used to state pipe length.

The marking position on the circumference shall be centred at 3 O’clock with reference being made to weld seam positioned at 12 O’clock.

Free-hand marking is limited to variables only and shall be properly carried out to the satisfaction of the Inspector.

d) Unique pipe number shall be allocated sequentially and marked on the pipes.

e) Stencilling shall be made at inside surface of both pipe ends as follows.

Marking may be made in a sequence convenient to the pipe Manufacturer but shall include the following minimum information.

- At one pipe end (full stenciling):
  - COMPANY/Purchaser's name
  - Purchase Order No.
  - Steel Grade
  - OD x WT
  - Heat Number
  - Pipe Number
  - Pipe length
  - Pipe weight
  - Brand mark/logo of Mill
- At the second pipe end (reduce stenciling):
  - Pipe number
  - Pipe length

Alternatively, when so stated in the PPS, a bar code system, placed on the inside of the pipe at both ends, may be implemented to ease pipe identification.

f) The following shall be die-stamped on the bevel surface at longitudinal seam position, at the pipe end where full stenciling as above has been made:

- The mark of the Inspector
- The pipe number,

g) Marking shall be approved by the Inspector prior to pipe production.

7.10 PROTECTION OF BEVELS

All beveled pipes (except pipes supplied with a preliminary bevel for mechanized site welding) shall be delivered with bevel protectors. Bevel protectors (refer to PPS) shall be submitted to COMPANY with full details by the SUPPLIER at the bid stage.

7.11 HANDLING, TRANSPORT AND STORAGE OF PIPES

7.11.1 GENERAL

The SUPPLIER shall submit to the COMPANY for review and approval a handling, transport and storage procedure detailing the proposed methods of handling, stacking during storage, and stacking and securing pipes for transportation and shipment.

All handling, loading and unloading shall be performed in such a way as to avoid mechanical damages and to prevent stresses which might result in dent or out-of-roundness. The SUPPLIER shall be responsible for any permanent deformations subsequent to Mill acceptance and resulting from loading, storing, stacking, transportation or shipping, where applicable according to the scope of Contract.

7.11.2 HANDLING AND STORAGE

All handling shall be performed with slings, or pipe-shaped padded hooks approved by the Inspector.

Stored pipes shall be adequately supported at all times to prevent permanent deformation of pipes and to give protection to beveled ends.

Pipe shall be stored with the weld seam located at 12 O'clock. No part of stenciling shall be stored at 6 O'clock.

The SUPPLIER shall take all necessary precautions during storage to prevent pipes from corrosion, as well as from dirt and surface defects which could be injurious for the subsequent coating.

Pipes shall be free from lubricant or any other product that would have accidentally spoiled the pipe surface.

7.11.3 TRANSPORT

Loading onto or into rail cars, trucks, ships or other conveyances shall be performed in accordance with API RP 5L1 or API RP 5LW, as appropriate. In all cases loading shall be in accordance with a procedure approved by the COMPANY.

Rail cars, trucks, ships or other conveyances shall be cleaned of debris or any substance that might damage the pipes.

Suitable timber and other dunnage shall be used to protect the pipes against damage during transit.

7.12 DOCUMENTATION

The following documentation shall be delivered by the SUPPLIER.

7.12.1 MILL CERTIFICATES

1. Unless otherwise stated in the PPS., the inspection test certificate required to support the delivered pipes shall be Type 3.2 according to EN 10204 Std. Mill certificate shall be established by the pipe Manufacturer.
2. Mill certificates shall make reference to API Spec 5L/ISO 3183 together with the present General Specification and applicable PPS.
3. Mill certificates shall show the following:
   - Rolling technique/heat treatment of base material (e.g. normalized, TMCP with accelerated cooling, etc.)
   - Manufacturing process (e.g. UOE, JCOE, Bending Roll, Press bending)
   - Ladle Analysis, including Carbon Equivalent and Pcm
   - Pipe No.: with reference to heat No.: (and slab No.:, where possible)
   - Mechanical test results and product chemical analysis (including CE and Pcm) with reference to pipe No.:
   - Dimensional inspections with results
   - Non-Destructive tests performed with results
   - Results of H_2S embrittlement tests
   - Any supplementary tests and inspections carried out
   - Certificate No.: and date of issue.
4. Format of Mill certificates shall be agreed with the COMPANY prior to pipe production.
5. Refer to § 75.12.3 for number of originals and copies to be supplied and, also, for stamping and signing these certificates.

7.12.2 WHEN THE BIDS ARE SUBMITTED

- Manufacturer and mill names
- A preliminary Pipe Manufacturing Procedure Specification (including plate manufacturing procedure specification) giving the main features and characteristics of proposed base materials and pipes. This MPS shall , however, include, as minimum, all information required at items 1 through 10, and at items 12, 13, 18, 19, 25 and 26 of Appendix 6 of this specification
- Steel ruling composition (§ 75.4.6)
- Flux management procedure (Appendix 5)
- Weldability test programme (when applicable)

- Description of the proposed bevel protectors (if any)
- Handling, transport and storage procedure for pipes (typical)
- Quality Assurance certification
- Quality Control Plan (typical)
- Pipe supply track record as well as histograms of chemical and mechanical test (including impact tests on base metal and weld seam) results from previous orders of the same pipe grade and similar dimensions, as proofs of capability to produce pipes according to this specification
- Nominated laboratory for conducting the H_2S embrittlement tests
- Past experiences of SUPPLIER and laboratory on HIC and SSC tests as per this specification (including the laboratory's typical procedures)
- Welding tests carried out by the SUPPLIER on similar pipe material and dimensions giving evidence of acceptable weldability in regard to the utilizations defined in § 75.5.7 of this specification (when so required in the PPS)
- Details of offered fabrication Pipe History System (HPS)
- At SUPPLIER's option, any other pertinent technical information relating to the proposed pipe supply
- The SUPPLIER's deviations/qualifications to present specification. Where no deviations are stated in the bid, then the potential SUPPLIER shall be considered as fully accepting the requirements of the present specifications.

7.12.3 UPON COMPLETION OF PIPE PRODUCTION

a) A close-out production dossier shall be established by the SUPPLIER and submitted to the COMPANY. It shall include, but not be limited to, the information and documents stated hereafter:

- Steel making process and plate Manufacturing Procedure Specification
- Non-Destructive Testing reports of steel plates
- Mill test certificates of plates
- Pipe Manufacturing Procedure Specification
- Mill certificates of pipes
- Reports of pipe manufacturing procedure qualification tests, including WPS and WPQR
- Reports of HIC and SSC tests
- Reports of NDT procedure qualification tests

- Reports of production tests made on pipes
- Reports of all dimensional and NDT made on pipes
- Mill hydrostatic test certificate of compliance
- Quality Control Plan
- Report of weldability tests (if any) and SUPPLIER's recommendations or guidance for site welding of supplied pipes
- List of heat numbers showing pipe numbers, individual length and weight, total length and weight produced per heat
- Pipe list with sequential numbers of produced pipes related to heat numbers
- Pipe list of shipments
- Histogram of production test results (chemical and mechanical) and dimension of pipes (length, as a minimum)
- Where applicable Records of wall thickness as stated in § 7~~5~~.5.9.4 Item b)
- Fabrication Pipe History system (if any)
- Compilation of concessions/deviations, if any, granted by the COMPANY.

b) The PPS shall state the number or originals and copies of Mill certificates and the close-out production report which are to be supplied to the COMPANY.

c) The Inspector shall stamp (rubber-stamp), sign and date the original documentation. The copies shall be stamped (as a minimum) by the Inspector.

7.12.4 SCHEDULE

1. The pipes shall be dispatched only after a Release Certificate has been issued by the Inspector.
2. Mill Certificates shall be supplied at the time of dispatch of the pipes
3. The full production report shall be transmitted to the COMPANY three (3) weeks max. after dispatch of the pipes

7.13 STORAGE OF MECHANICAL TEST SPECIMENS AND RADIOGRAPHS

The SUPPLIER shall ensure preservation and storage of the following:

7.13.1 TEST SPECIMENS

The test specimens (including HIC and SSC ones) and the remaining part of tested pipes shall be stored by Manufacturer till the final release of goods.

7.13.2 RADIOGRAPHS

All radiographs shall be kept available to the COMPANY for a minimum duration of five years but shall be processed in such a way as to ensure a minimum life of ten years.

7.14 FABRICATION PIPE HISTORY SYSTEM (PHS)

The SUPPLIER shall provide a computerised fabrication pipe history. Such a computer program shall provide the minimum following information (unless otherwise detailed in a PPS):

- For each pipe number: Grade, OD, WT, Length, Weight, CE/Pcm with reference to heat number, mechanical properties (with reference to test No.: and Mill certificates)
- For each heat number: Chemical analysis, individual weight, length of accepted pipes, pipe No.:

Full description of existing or proposed program will be provided at the bid stage with the possible means of transmitting data (CD ROM, etc.)

7.15 TECHNICAL QUERIES/NON-CONFORMANCE REPORTS

1. Any SUPPLIER's requests for clarifications or deviations to COMPANY specifications shall be submitted only to the COMPANY, through Technical Queries (TQ), the format of which shall have prior approval of the COMPANY.
   A deviation to specification shall not be considered as accepted if it has not been submitted to and accepted by COMPANY through a Technical Query.
2. Approval given by the COMPANY to any SUPPLIER's work procedures, specifications, equipment, etc. shall not release in any way the SUPPLIER 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 SUPPLIER for submission to COMPANY. NCR report shall indicate corrective action intended by the SUPPLIER.

8.0 APPENDICES

Appendix 1. Chemical composition

Table 1 – Ladle chemical composition (1) (% weight max.)

Steel grade	C	Si	Mn	P	S	V	Nb	Ti	Others	CE (4)	Pcm (5)
Pipes thermo-mechanically rolled											
L290M or X42M	0.10	0.40	1.25	0.015	0.002	0.04	0.05	0.04	(2) (3)	0.38	0.19
L320M or X46M	0.10	0.45	1.35	0.015	0.002	0.04	0.05	0.04	(2) (3)	0.38	0.20
L360M or X52M	0.10	0.45	1.45	0.015	0.002	0.05	0.06	0.04	(2) (3)	0.39	0.20
L415M or X60M	0.10	0.45	1.45	0.015	0.002	0.07	0.06	0.06	(2) (3)	0.40	0.21
L450M or X65M	0.10	0.45	1.60	0.015	0.002	0.08	0.06	0.06	(2) (3)	0.41	0.21
L485M or X70M	0.11	0.45	1.60	0.015	0.002	0.08	0.06	0.06	(2) (3)	0.41	0.22

Notes:

1) Elements not mentioned in this Table shall not be added intentionally without COMPANY's approval.

   The maximum working percentages of residual elements shall be as follows (ladle and product check) for Grades X52 up to Grade X70:

   Sn = 0.015 Pb = 0.005

   Sb = 0.010 As = 0.015

   Bi = 0.005 B = 0.0004 (i.e. no deliberate addition)

2) Cu ≤ 0.35 Al total ≤ 0.050

   Cr ≤ 0.25 N ≤ 0.012

   Mo ≤ 0.10 Al/N ≥ 2 (not applicable to titanium-killed or titanium-treated steel)

   Ni ≤ 0.30 O ≤ 0.0025 (to be measured on ladle only)

   for S ≥ 15 ppm: $\frac{Ca}{S}$ = 2 to 5 with Ca ≤ 0.004

   for S < 15 ppm: 0.001 ≤ Ca ≤ 0.004

3) The total percentage of:
   - Nb + V + Ti + Cu + Mo + Cr ≤ 0.50%
   - Nb + V < 0.12%

4) $CE = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15}$ %

5) $PCM = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$

Table 2 – Product chemical composition (% weight max.)

Max. permissible variations of product composition against Max. required ladle composition of Table 1	
Carbon	+ 0.01%
Carbon Equivalent (CE)	+ 0.01
Manganese	+ 0.05%
Nitrogen	+ 0.001%
Other elements	0
PCM	0
Phosphorus	0
Silicon	+ 0.05%
Sulphur	0
Vanadium, Niobium, Titanium, Copper, Aluminium	+ 0.005%

Appendix 2. Tensile and impact properties

Table 3 – Tensile properties of base metal and weld

API Spec 5L/ISO 3183 – Tensile test (strip or round bar specimen)

Grade (API Spec 5L)	YS MPa (psi)		TS[2] MPa (psi)		$\frac{YS}{TS}$ maxi [1]	El% min.[3]
	min.	max.	min.	max.		
L290M or X42M	290 (42 100)	415 (60 200)	415 (60 200)	655 (95 000)	0.88	As per API Spec 5L/ISO3183
L320M or X46M	320 (46 400)	441 (64 000)	435 (63 100)	655 (95 000)	0.88	
L360M or X52M	360 (52 200)	483 (70 000)	460 (66 700)	760 (110 200)	0.88	
L415M or X60M	415 (60 200)	538 (78 000)	520 (75 400)	760 (110 200)	0.90	
L450M or X65M	450 (65 300)	572 (83 000)	535 (77 600)	760 (110 200)	0.92	
L485M or X70M	485 (70 300)	606 (88 000)	570 (82 700)	760 (110 200)	0.92	

1. Applicable to base metal only.
2. For transverse weld tensile test, only the mini. TS shall be met and record.
3. Uniform elongation shall be recorded for information only.

Table 4 – Transverse impact energy of base metal and weld – Charpy – V impact test

Full size specimens 10 x 10 mm (ASTM E 23 or ISO 148-1)

Grade (API Spec 5L / ISO 3183)	Min. average / Single value (joules)	Particular requirement for base material of gas transmission pipes[1] (API Spec 5L Annex G modified as follows) Minimum average/single value (joules)	Minimum Shear area[2] Avge (single)
L290M or X42M	40 / 30	42 / 31	85% (75%)
L320M or X46M	40 / 30	49 / 36	85% (75%)
L360M or X52M	40 / 30	49 / 36	85% (75%)
L415M or X60M	40 / 30	61 / 45	85% (75%)
L450M or X65M	54 / 40	69 / 51	85% (75%)
L485M or X70M	54 / 40	91 / 67	85% (75%)

1. Refer to § 7~~5~~.2 of this specification and to PPS.
2. Percent of shear area and lateral expansion of broken specimen shall be recorded.
3. From the set of three Charpy V-notch specimens, only one is allowed to be below the specified average value and shall meet the minimum single value requirement.
4. The required KVL (Longitudinal direction specimens) value shall be 50% higher than those stated above.

Appendix 3. Ultrasonic inspection of steel plates

1. General

The ultrasonic inspection of plates shall be carried out in accordance with ISO 10893-9 and the following. Scanning of transverse plate edges may be omitted provided that pipe ends are ultrasonically tested as per present specification.

The SUPPLIER is required to supply the COMPANY with a detailed ultrasonic inspection procedure for prior approval. This procedure shall detail the probe type, number, the scanning mode, the scanning coverage, the setting of detection trigger threshold, the coupling setting for the static and the dynamic calibrations, automatic system principles, if any, the detection marking/recording type, the production scanning instructions.

Any equipment / procedures other than those stated hereafter may also be used providing that prior approval is obtained from the COMPANY at the bid stage.

2. Performance of the inspection

The longitudinal and transverse edges of plates shall be 100% ultrasonically tested for laminar imperfections over a width of 50 mm minimum (transverse edges may be inspected at pipe mill).

The plate body shall be ultrasonically tested along parallel lines. The scanning pattern or probes arrangement shall be such that 100% examination coverage of plate body is achieved per plate.

The automatic ultrasonic device shall be equipped with a warning system which must act in case of defect found and in case of lack of coupling with the plate, together with an automatic printer which can produce a printed cartography of laminar imperfections.

The recording of static and dynamic calibrations (printed charts, computer records) shall be made available to the Inspector for review and acceptance. The production scanning printed charts shall be made available to the Inspector for review at the plate Mill.

3. Calibration

3.1 Static calibration

The static calibration shall be carried out according to ISO 10893-9 and the following:

On each probe, the amplitude obtained from the reference standard shall be adjusted (with gain), where necessary, in order to obtain the same signal height FSH % (Reference Standard Height RSH) on all probes. The setting of the Trigger/alarm Threshold Level (TTL) shall take into account the signal drop due to the dynamic scanning condition, the coupling variations, the oxide layer on production plates, the depths of laminar defects such that the sensitivity is appropriate to detect the FBH on the dynamic calibration plate. The Calibration Sensitivity (CS) set at the static calibration stage (RSH - TTL) converted in dB shall be reported by the AUT operator.

3.2 Coupling control

The back wall signal in static condition shall be used as the coupling reference signal (CRS). The threshold of “lack of coupling” shall not exceed a drop of (CS + 3 dB) from CRS.

Where an electronic Automatic Gain Control (AGC) is used, a coupling of “Go/No Go” type may be accepted. The procedure shall detail its setting.

3.3 Dynamic calibration

WT and steel grade of the dynamic calibration plate shall be that or very close (±15%) to that of the production plates to be examined. Its length shall not be less than 12 m and the reflectors shall be located within the last 3 meters of the scanning. The reflectors shall be homogeneously distributed on the plate width. The calibration plate width shall be, as a minimum, the same as the plates to be inspected.

The dynamic reference standard shall comprise the following FBH at a depth of 3 mm max from each plate surface: (i.e. 2 types of FBH):

- On plate body: 10 x Ø10 mm of each type FBH, (i.e. 20 FBH on body)
- On each edge: 4 x Ø 5 mm of each type FBH, (i.e. 8 FBH on each edge)

When the static calibration is not accessible (e.g. not intelligible enough for checking the parameters setting as stated above) to the COMPANY Inspector, the dynamic calibration plate shall comprise also a transverse notch full plate width (or 2 x ½ plate width) depth 3 mm, width 6 mm.

Full plate body, calibration plate or probe beam(s) shall be shifted at random in such a way that for each calibration, different probes from previous calibrations, can detect the reflectors.

The dynamic calibration shall be performed at the same scanning speed as per the actual production.

The dynamic calibration shall be performed at the beginning and at the end of any scanning run of COMPANY plate order and at least every 8 hours maximum.

Dynamic calibration acceptance criteria: as a minimum: the following FBH shall be detected (i.e. the detection trigger alarm activated):

- On body: 5 FBH of each type (50%)
- On each edge: 2 FBH of each type (50%)

Note: The non-detected FBH should be those located at a scanning track border, not fully covered by a transducer.

When applicable, as a minimum, the notch shall be detected by 97% of probes on the “body” area and by 100% on edge areas. Failure of two adjacent probes is not acceptable.

If on checking during production testing, the dynamic calibration fails, all plates inspected since the last dynamic calibration shall be re-inspected.

3.4 Production scanning

3.4.1 Lack of coupling

On any transverse line, the lack of coupling detection shall not concern more than 3% of the scanning probes. Where lack of coupling is exceeding 3%, the area shall be regarded as defect detection and manual UT examined. On any transverse band, the lack of coupling of adjacent probes shall not involve more than 2 scanning tracks and shall not be exceed 50 mm.

3.4.2 AUT indications

Indications obtained at the automatic ultrasonic inspection shall be rechecked by manual UT according to ISO 10893-9 Annex A to determine the size of the laminar imperfections.

Frequency of calibration shall be as per ISO 10893-9 Annex A.

4. Acceptance standards (at manual UT examination)
   - Two adjacent defective areas shall be considered as unique defect having an area equal to the summation of these two defective areas, if the distance between them is less than or equal to the highest dimension of the smaller defective area
   - Each plate shall fully meet the following acceptance standards for laminar imperfections.

(1) Within plate body:

Maximum acceptance area of single defect in mm^2	Maximum cumulated area in mm^2 / m^2		Maximum frequency of acceptable imperfections	
	(*)	(**)	Locally (*)	Globally (**)
500	3,000	2,000	10 per m2	5 per m2

Notes:

(*) With respect to any area of 1 m^2 within the plate surface.

(**) With respect to any 12m length of plate.

(2) Within plate edges:

Maximum acceptance area of single defect in mm^2	Maximum frequency of acceptable imperfections
25	3

Laminar imperfections of any size which are surface breaking on the plate edge shall not be acceptable.

Appendix 4. Automatic Ultrasonic testing of longitudinal weld seam and subsequent investigations

1. Automatic ultrasonic inspection equipment

   The equipment shall allow for the complete examination of the weld and its adjacent area for both longitudinal and transverse defects. The equipment shall be fitted with an automatic paint spray system (or alternative system, e.g. recording) for marking the areas giving ultrasonic indications and areas where a loss of ultrasonic coupling with the pipe has occurred.

2. Reference standards

   The reference standard shall be made from a pipe manufactured for the order.

   One reference standard (calibration pipe) shall be made and used for AUT static and dynamic calibration for each pipe size (OD), for each wall thickness, for each steel grade, for each steel source and delivery condition, for each welding procedure including bevel design.

   However, with prior approval of the COMPANY, pipe production may start with a reference standard made from a pipe of same diameter, wall thickness and grade, having a longitudinal weld of same profile and width (similar welding procedure), always providing that the specified reflectors are included.

   The calibration pipe issued from the P.O. shall be made available not more than three working days after starting the production. It shall be scanned in dynamic condition, using the same calibration parameters as those applied with the previous calibration pipe. Should any failure occur, based on the acceptance criteria stated below, all pipes inspected since the beginning, shall be re-tested after re-adjustment of the calibration parameters.

   The reference standard shall be 10 meters long minimum (or less when the production current length is less than 12 meters).

   Note: this requirement may be discussed when the P.O. item to be inspected contains less than 100 pipes.

   The standard reflectors shall consist, as a minimum, of the following:

   - At 240 mm from each pipe end and at mid pipe length, one 1.6 mm radially drilled hole (through thickness) in the weld centerline
   - Within the scanning last 2 meters of calibration pipe:
     - Four longitudinal N5 notches, two internal and two external of pipe, machined in the HAZ on both sides of weld
     - Two weld centerline N5 notches machined longitudinally, one internal and one external of pipe

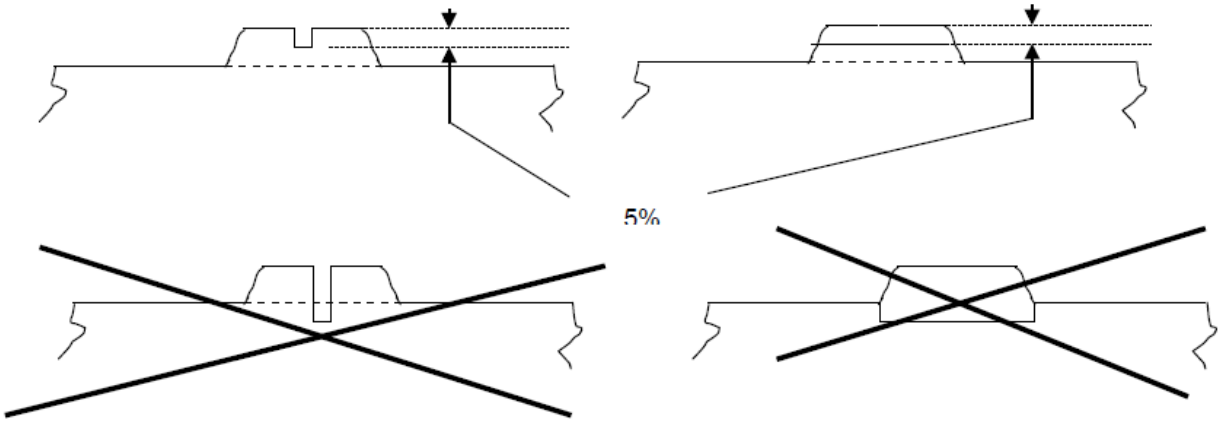
- Two 5 notches machined transverse to weld, one internal and one external
- For pipes of 16 mm wall thickness and above, a ceramic insert of 2 to 3 mm in height, 1 mm thick maximum and 10 mm long maximum, located at mid thickness of the weld and in the centreline (This ceramic insert can be replaced by a longitudinally mild thickness drilled hole dia 3 mm maximum).

The reference pipe shall also contain two 1.6 mm or 3 mm dia. (at Mill's option) drilled holes located in base metal 4 mm away from weld toes (one on each side of weld seam) for checking the ultrasonic gate width.

Notch profile standard reflectors:

- The width of notches shall not exceed 1.0 mm
- Weld profile (reinforcement) shall not be ground for notch machining
- The full depth of notch shall be 5% of the pipe wall thickness

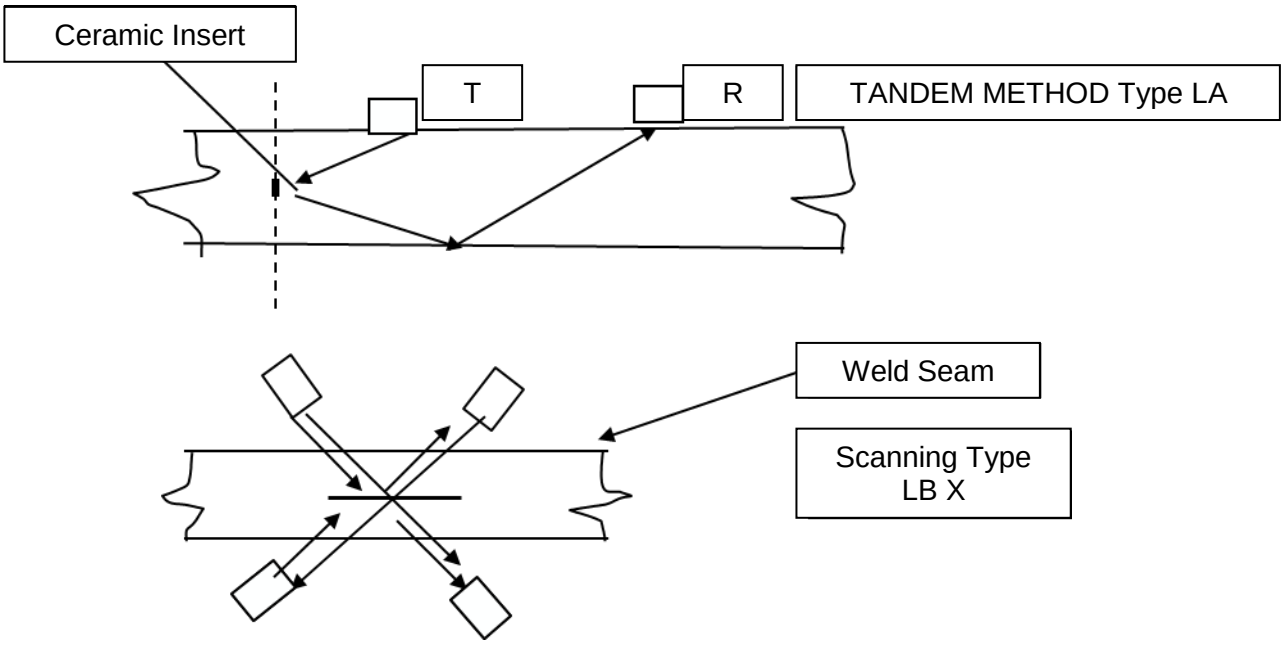
Note: Notch (longitudinal or transverse), with a depth equal to weld reinforcement + 5% of w.t. is not acceptable.



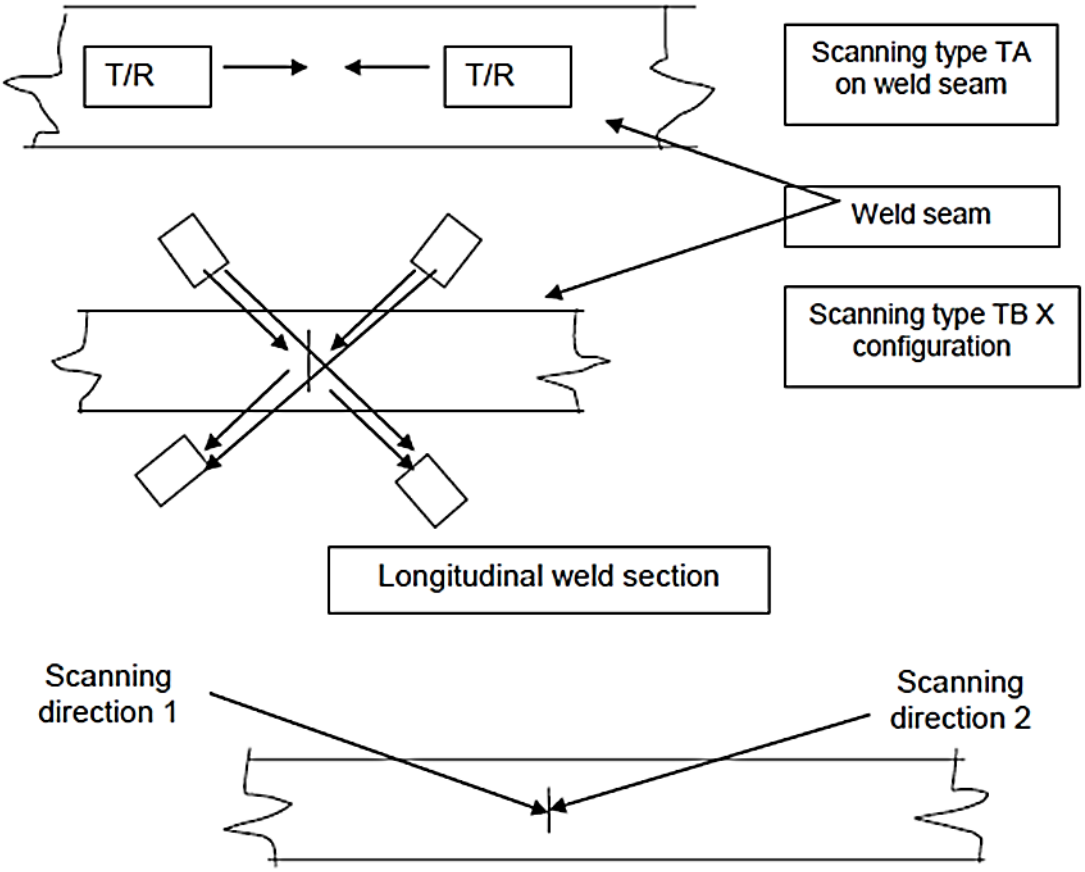
3. Particular probe arrangements and scanning techniques

Unless otherwise designed and demonstrated as efficient by the SUPPLIER, the probe arrangement and the scanning techniques for the transverse and the longitudinal mid thickness scanning will be as follows:

3.1 Scanning for longitudinal flaws at mid thickness



3.2 Scanning for transverse flaws



Scanning of both 1 and 2 longitudinal directions is required.

Coupling control is required.

The arrangement and the setting shall be such that each probe or pair of probes can detect OD and ID notches. Otherwise, a procedure shall be proposed to demonstrate that full weld thickness is inspected for transverse flaws.

The scanning type TA, on weld seam will be preferred.

4. Calibration

4.1 Static calibration

- Reference level: on each channel, the reference level shall be the lowest of the signals produced from the relevant reflectors. It shall be set at 80% FSH.
- Detection thresholds: the detection trigger thresholds shall be set at 40% FSH.
- Coupling:

  A coupling type “go/no go” is not acceptable. A coupling control by transmission shall be installed for each pair of symmetrical probes.
  The reference level shall be signal received on calibration pipe, in each coupling channel.
  The reference level will be set at the SUPPLIER option, but gains and levels shall be recorded.
  Gains shall not be modified for production scanning.
  The thresholds of “lacks of coupling” detection shall be set at 8 dB drop maximum, below the reference level.
  When production scanning cannot reasonably be achieved with a drop of 8 dB maximum, the following procedure will be considered:

  a) The thresholds of coupling by transmission will be increased up to 16 dB drop maximum.
  b) One compression probe shall be installed at either side of weld seam scanning, at the same distance from the weld as the farthest flaw detection probes. The reference level shall be the signal from back wall on calibration pipe. The signal shall be set at 80% FSH. The threshold of coupling drop detection shall be set at 2 dB drop.

Note: Where AUT machines are equipped with an automatic coupling adjustment system, the SUPPLIER shall demonstrate the efficiency of the equipment, and, as a minimum, the above compression probes shall be installed in the conditions described.

Reporting: The following parameters shall be reported in computer and a print out shall be made available at AUT station:

- A comprehensive detailed list probes/channels, longitudinal/transverse, ID/OD/Mid, flaw detection/coupling
- In each channel, including coupling channels: gain signal height, trigger threshold

- Date, time, operator name and signature, Inspector name and signature.

4.2 Dynamic verification (so called dynamic calibration)

4.2.1 Definition

In the present document, the term “to detect” will be understood as: the trigger alarm must be activated by the signal received from an artificial or from a natural reflector.

4.2.2 Performance and frequency

On completion of static calibration, a dynamic calibration will be carried out on the calibration pipe at production testing speed. The production speed shall not exceed 12 m/min.

The dynamic test will be done a minimum of 3 times and the subsequent print outs will be evaluated to ensure that the response from each reflector is correct, i.e. not less than 3 dB (63% FSH) from the reference level (80% FSH)

If any additional dB is required to maintain the signals to the correct height, the enhanced values will be used for production testing. Gate threshold positions are also set at this time, ensuring that geometric echoes from weld reinforcement do not interfere with the ultrasonic test.

Dynamic calibration shall also be done at the start of each shift, wherever there is an equipment change over, whenever there is an operator change, after every 40 production testing or every 4 hours, whichever is the first event met, at end of any scanning sequence shorter than 4 hours, whenever any doubt arises on the ultrasonic efficiency, by agreement between the Inspector and the SUPPLIER.

A pipe inspection sequence is validated by the dynamic calibration ending the sequence.

4.2.3 Acceptance criteria of dynamic calibration

A table “channels/reflectors (C/R)”, (a typical is shown here-after), shall be included in the AUT procedure/working instructions and submitted to COMPANY for approval.

It shall specify which reflectors must be detected in the relevant channels.

The attached table shows the minimum required reflectors/channels to be detected.

The three dynamic print outs shall be checked, based on the table C/R criteria.

On one of the first conform scanning print outs, the indications to be found will be marked off. This print out will be a more convenient reference for checking the further dynamic calibration print outs.

For the third dynamic calibration run, and at least once per shift, the paint sprays shall be set “on” after scanning, the operator/inspector shall check that the sprays are working properly and that the paint spots are properly located to the relevant reflector.

The equipment shall be deemed to be out of calibration if:

- Any reflector signal in its relevant channels (as specified in C/R) has not activated the trigger alarm
- Any gate need to be moved from the recorded position/width from the static calibration
- Any parameter used for static calibration is changed

If the equipment requires re-calibration, the static and dynamic runs shall be repeated. When the re-calibration is to be carried out during a scanning sequence or as the validation of an ending sequence, all pipes tested since the last successful dynamic check shall be re-tested. This re-testing shall apply as well when a paint spray failure is found (see above).

4.2.4 Reporting

On one of the print outs, the scanning speed shall be indicated. The print out shall be signed by operator and Inspector. Print outs of dynamic calibrations shall be made available at any time to Inspector at AUT station.

5. Production scanning

AUT print outs of production scanning shall be made available to Inspector at any time for review.

At any time during production scanning, Inspector shall have the right to require checking any of the calibration parameters.

6. Investigations of AUT indications

6.1 Indications of coupling drops

- Where only some spot indications are found, the locations may be investigated by manual UT. Radiography is not required on coupling indications.
- Where the lack of coupling indication extent is deemed important, the reason of coupling drops shall be investigated and an adequate corrective action shall be implemented, e.g. pipe surfaces ID/OD to be brushed.

6.2 Indications from flaw detection channels

Any imperfection which produces a signal of height exceeding the threshold level defined above shall be considered as unacceptable defect, unless it can be demonstrated that the imperfection does not exceed the provisions of section ~~paragraph~~ 7~~5~~.7.3 and 7~~5~~.7.4 of the specification. Any indication found by the automatic ultrasonic system, shall be further investigated by radiography. The indications detected by the AUT transverse channels shall be also examined by manual UT, using the procedure of scanning on weld seam hereafter.

Repair welds and welding re-start locations shall be also examined by manual UT and by radiography.

The here-below “decision tree” shall apply for the evaluation of flaw acceptance.

SUPPLIER shall issue his own “decision tree” corresponding with his internal organization. It shall be included in the procedures and working instructions to NDE operators.

6.3 Manual UT

Manual UT shall not consist of reproducing the AUT scanning.

Manual UT shall be properly performed using all appropriate probes 60°, 45° and 70° for identification, sizing and locating of flaws in the weld section.

Calibration shall be examined by moving and oscillating the search unit over the examination surface so as to scan the entire volume of the weld.

SUPPLIER shall submit the manual UT procedure to COMPANY for approval. The operator shall report the indication type, size, % FSH, and position in the weld section.

Manual UT reports (computer records are acceptable) shall be made available for radiography interpretation.

Note: When manual UT on weld seam is applied for the detection of chevron cracks, the attached relevant requirements shall apply. This procedure shall apply as well for manual UT on any indication detected by the AUT transverse channels

Table R/C (Typical)

Scanning Speed: -

CHANNEL	L1 E/R	L2 E/L	L3 I/R	L4 I/L	L5 MW/R	L6 MW/L	T1 E	T2 I
REFLECTOR								
H 1.6 mm center Mid length	x	x	x	x			x	x
H 1.6 mm center Scan end	x	x	x	x			x	x
H 1.6 mm center Scan start	x	x	x	x			x	x
H 4 mm weld toe left		x		x				
H 4 mm weld toe right	x		x					
Insert MW					x	x		
N 5 longi center ext	x	x						
N 5 longi center int			x	x				
N 5 toe ext. Left		x						
N 5 toe ext. Right	x							
N 5 toe int. left				x				
N 5 toe int. Right			x					
N 5 trans. Ext							x	
N 5 trans. Int.								x

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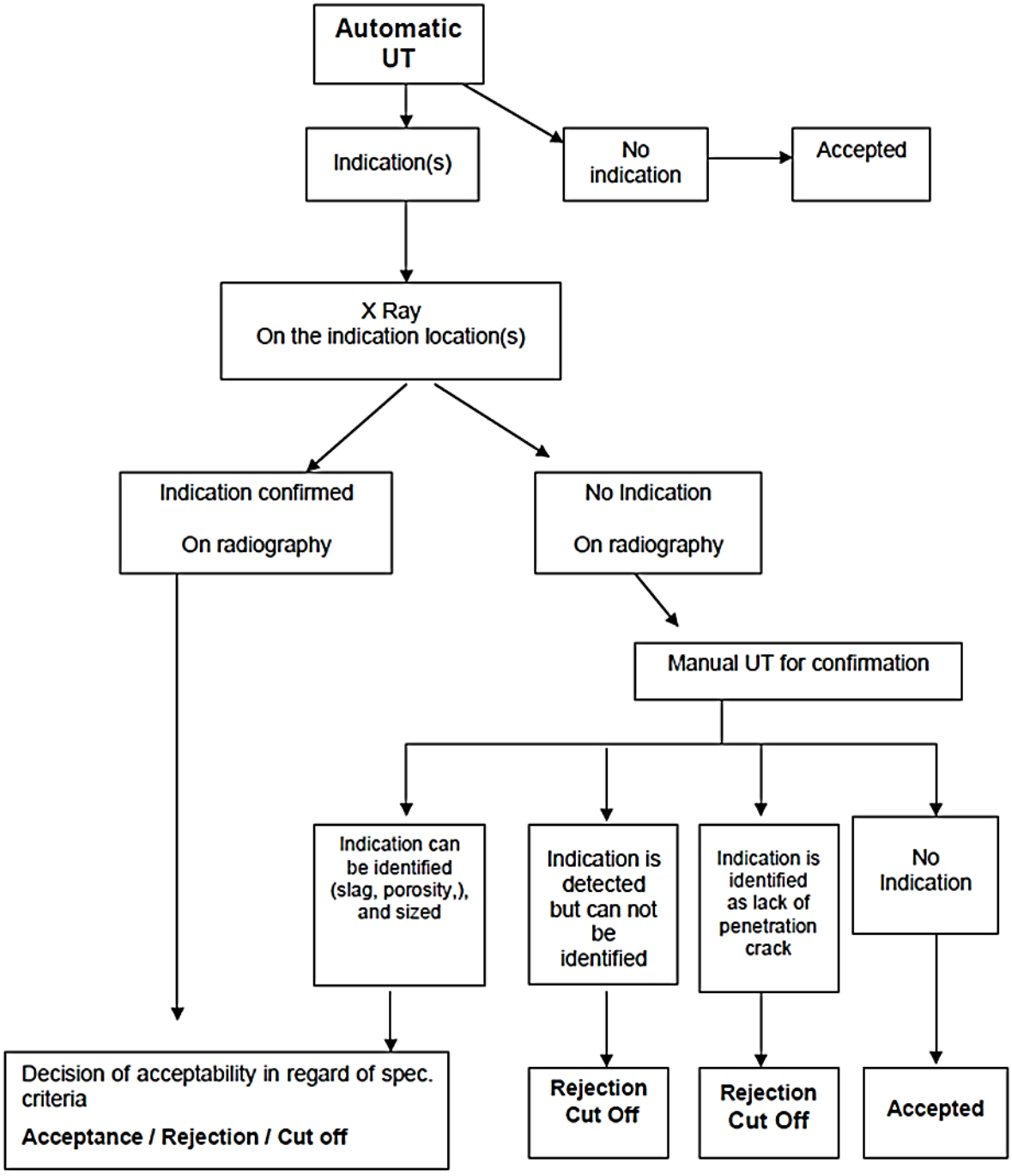
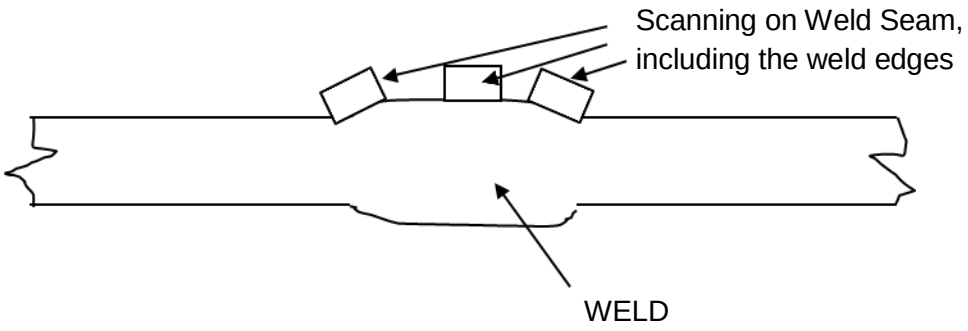
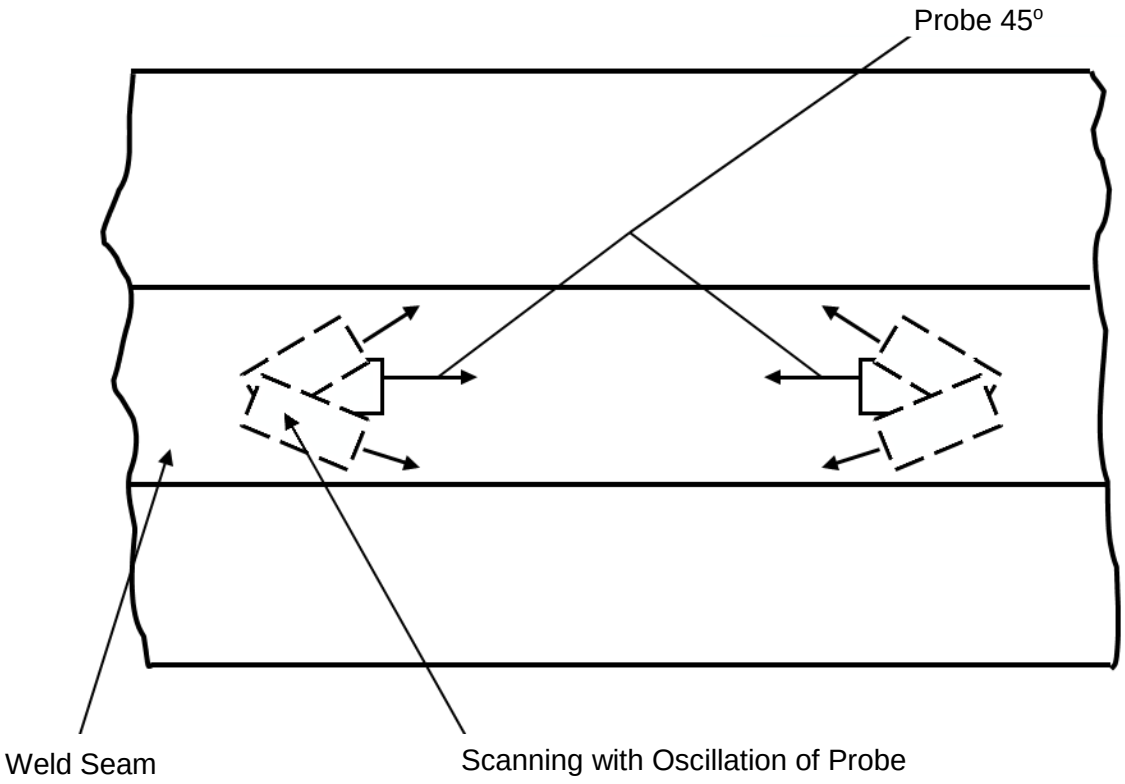
Longitudinal Weld Seam Inspection Decision Tree



Procedure for Manual Ultrasonic Scanning

On Weld Seam for the Detection of Chevron Cracks in Weld





Manual UT Calibration:

- On hole 1.6 mm through thickness on calibration pipe weld seam, 80% FSH.

Production Scanning:

- Add 12 dB for the detection in production scanning.

Acceptance Criteria:

- 40% FSH with the original calibration parameters

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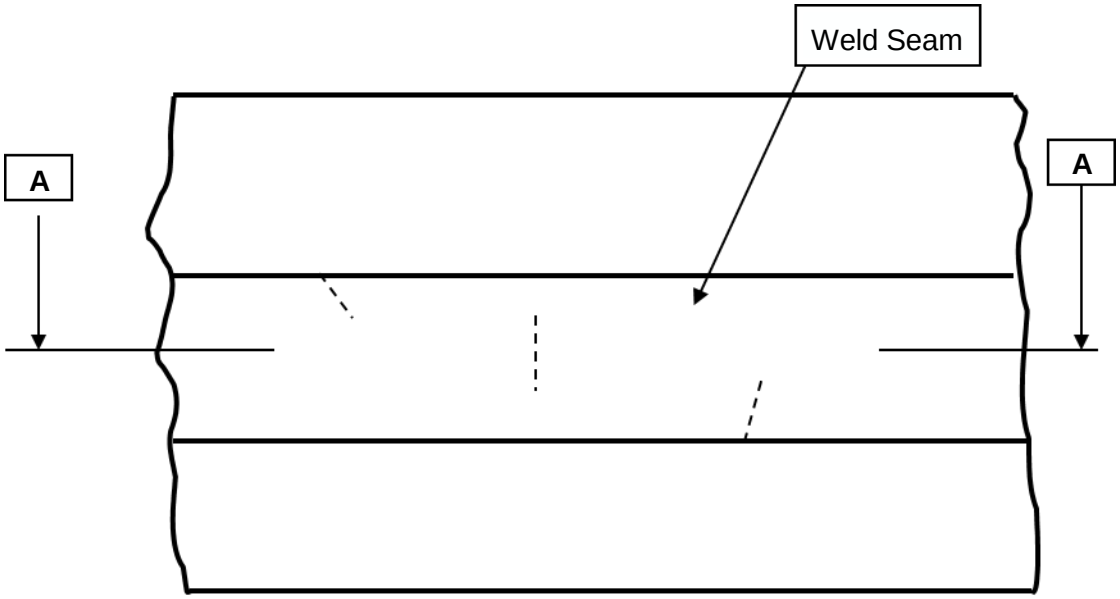
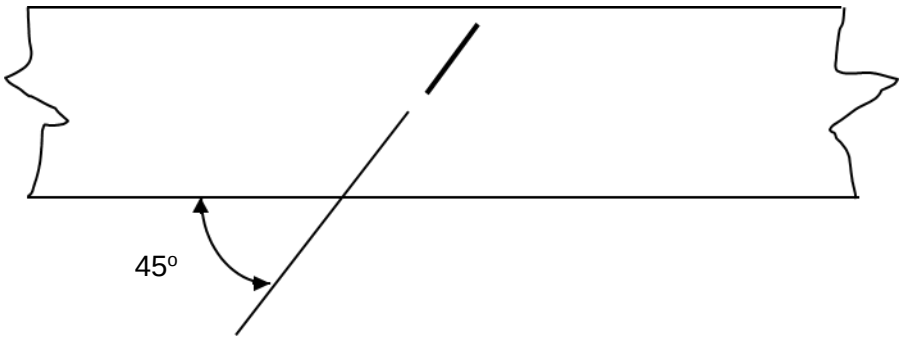
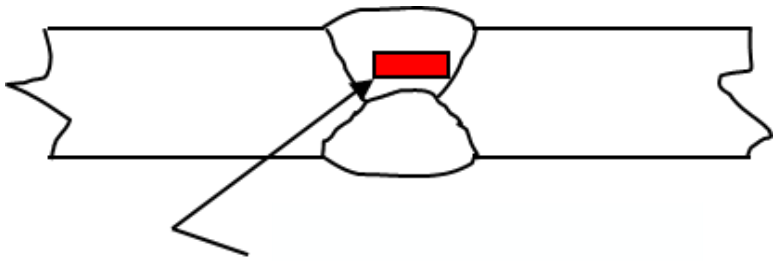
Guidance Note: Expected Location and Orientation of Chevron Cracks in the Saw Weld Seam



Section A - A



Transverse Weld Section



Cracks are usually located in the first pass of SAW

Appendix 5. Management procedure of SAW Flux

Flux management procedure

Pipe Manufacturer shall issue a dedicated procedure for flux management according to the selected method (A or B) 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.

Pipe Manufacturer can choose one of the following methods to guarantee the flux dryness. The resulting diffusible Hydrogen in weld deposit shall be 5 ml / 100 g **max**.

Method A (a dry flux is originally packed in moisture proof sealed containers)

1) Procurement of flux

At the time of flux packing, the diffusible hydrogen content of SAW weld deposit shall be checked by flux manufacturer 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, can be provided by flux manufacturer. This correlation curve shall be based on previous comparative tests of diffusible Hydrogen versus flux moisture content. Otherwise, the max acceptable residual moisture content shall be 0.03%.

The moisture content shall be measured by the “Karl Fisher” method, at a testing temperature of 982°C minimum.

For diffusible hydrogen testing or moisture measurement, **NO PRE-DRYING NEITHER ANY PRE-HEATING OF FLUX SAMPLE shall be carried out before testing (whatever the statements of the applied standard).**

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 minimum, 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 minimum.

2) Storage of flux

Flux shall be stored in a controlled hygrometry and temperature room. The resulting relative hygrometry and temperature values shall be permanently maintained such that the resulting absolute hygrometry is below 10 g of water per kg of air (see graph here-after). The maximum duration of storage shall be one year (after the date of packing). Over one year, a spot check of diffusible hydrogen or moisture content shall be required.

3) Use of flux

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

They shall be opened just before pouring the flux in the welding machine hopper 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 or more.

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 and made oil free with adequate equipment.

4) Flux recycling

When SUPPLIER intends to recycle welding excess of flux, only “method B” shall be applied.

Method B (any other procedures)

Pipe mill shall demonstrate that its flux management procedure allows to obtain dry flux (i.e. 5ml/100g of weld metal max) at the welding point.

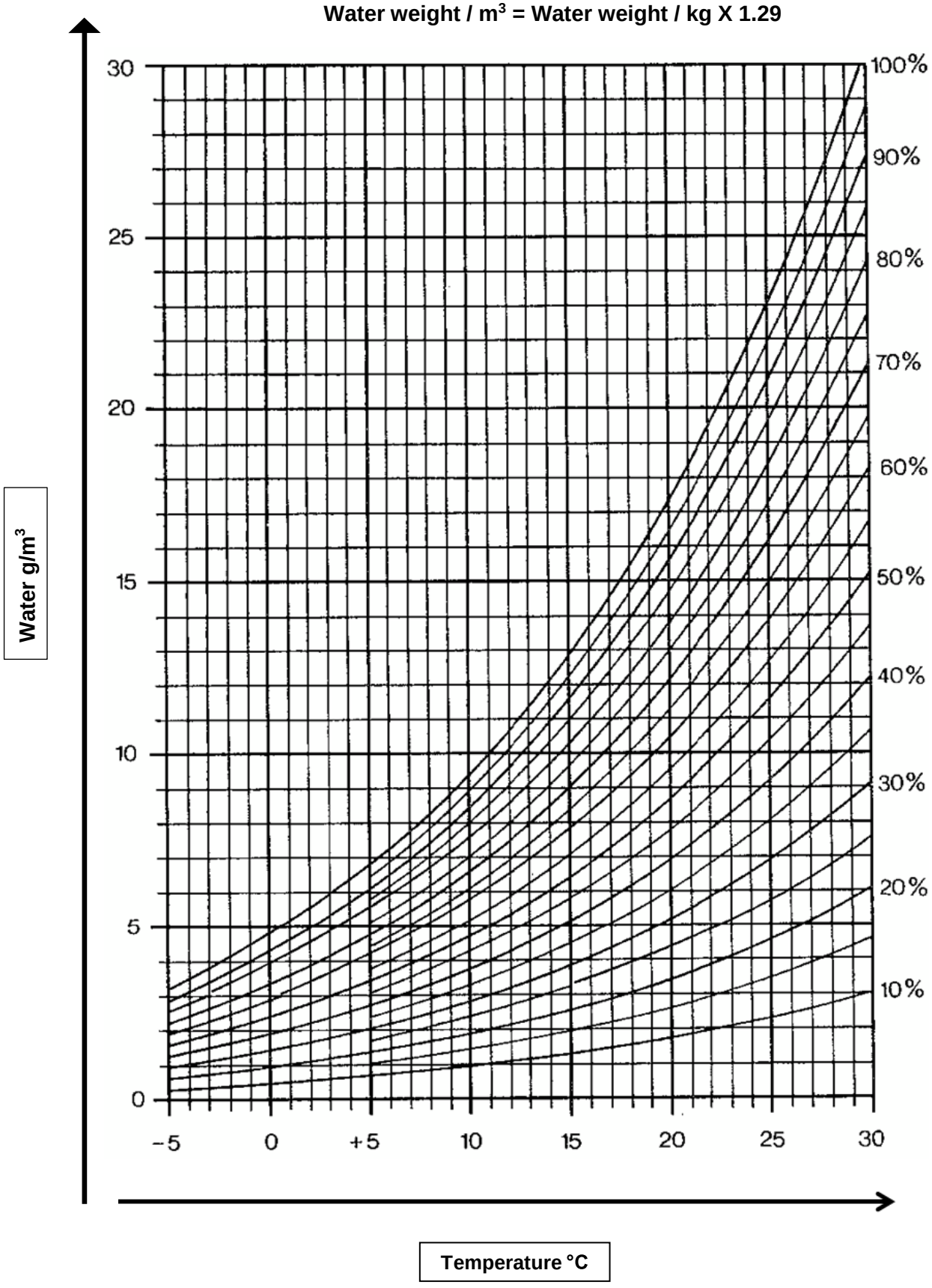
Flux shall be sampled at the welding point and checked at the start of production and, then, once per shift for pipe inside welding and once per shift for pipe outside welding. All welding lines shall be sequentially tested.

Inspector shall have the right to require the time of sampling when it is justified in his opinion. Check test procedures and results shall comply with paragraph A.1) here-above.

Reference documents

- AWS A4.3 or ISO 3690 (diffusible H2)
- AWS A4.4M (moisture content measurement)

Water weight / m^3 = Water weight / kg X 1.29



Appendix 6. Pipe Manufacturing Procedure Specification (MPS)

The SUPPLIER's Manufacturing Procedure Specification shall include all factors which can influence the quality and reliability of production. In particular, the specification shall include the following:

1. Name of steelmaker and plant at which steel and plates are produced.
2. Steelmaking process and nominal weight of each heat. State percentage of scraps used.
3. Techniques proposed for desulphurization, dephosphorization and degassing
4. Techniques proposed for sulfide shape control. Confirm that calcium treatment is used.
5. Minimum and maximum working limits on heat and product chemical analysis which are selected and guaranteed by the SUPPLIER for the order.
6. Casting technique (including the use or not of Electromagnetic Stirring), size and weight of ingots or slabs. Give the procedure for controlling sequential heats.
7. Method for checking residuals and segregation on slab/plate (macro-etching, surphur prints, etc.), with frequency and Mill reference chart/grading system.
8. Selected working ranges for tensile properties, impact properties and wall thickness on plates.
9. Rolling technique/heat treatment of plates. For Thermomechanical Controlled Process, state if accelerated water cooling is used or not used and give the type of system used.
10. Equipment for automatic checking/measuring the plate wall thickness at plate Mill, with locations of measurement on plate (along plate edge, plate axis, etc.).
11. Nominal size of discard from plate edges and ends.
12. Plate ultrasonic testing procedure, including 100% examination coverage, thickness and sketch with reflectors of reference plate for calibration of inspection equipment. State if ultrasonic testing is made before or after plate end cropping.
13. Pipe fabrication process (UOE, Press Bending, Roll Bending process) and name of Pipe Mill.
14. Method of tack welding and spacing of tack welds (if any).
15. Methods and stages of fixing and removal of run-on/run-off plates, with dimensions of run-on/run-off plates (tabs).
16. Full details of submerged Arc Welding procedure, including number of wires, welding parameters, electrical characteristics, travel speed, welding sequence, dimensions and number of weld passes and guiding methods of welding heads.
17. Full details of proposed repair welding procedures, including methods of weld defect removal

18. Types, data sheets, sizes, classes and brand names of all welding consumables.
19. Full details of automatic ultrasonic testing equipment and procedure for the longitudinal weld, stating the weld length at the pipe ends not scanned by all probes, and including methods of making defects and indicating loss of coupling, as well as calibration procedure.
20. Pipe end ultrasonic testing procedure, with equipment, method and frequency of calibrating testing equipment.
21. Full details of radiographic testing procedure and equipment, including film type, brand and class.
22. Procedures for wet Magnetic Particle Inspection (pipe ends and weld repaired areas).
23. Methods, equipment and sensitivity proposed for pipe dimensional checking and measurement, including pipe wall thickness, peaking at the weld.
24. Welding Engineer Name.
25. HIC test procedure.
26. SSC test procedure.

Appendix 7. Pipe Manufacturing Procedure Qualification Test (MPQT)

A. At least one pipe, produced during the first shift, of each size (each diameter and each wall thickness), steel grade, steel source and manufacturing process shall be subject to all of the inspections and testing required in Section 7~~5~~.7 of this specification and, also, in section B hereafter, this pipe representing one lot of pipes.

Essential Variables:

As per DNV-OS-F101, the following changes to the manufacturing processes shall require a re-qualification:

- Any change in steel source and making practice
- Any change in steel grade
- Any change in casting speed exceeding 0.1 m/mm
- Any change beyond the allowable variation for rolling practice, accelerated cooling and/or QT process
- Change in nominal wall thickness exceeding +5% to -10%
- Change in ladle analysis outside ±0.02% C, ± 0.03 CE and 0.02% in Pcm, ±20% in the percentage of elements intentionally added such as V, Nb, Ti
- Any change in alignment and joint design for welding (restricted scope of testing to be agreed)
- Any change in the weld seam tracking system (restricted scope of testing to be agreed)
- Change in welding heat input, ±10% and/or in variation of parameters exceeding the max of § 7~~5~~.5.10.6.1 of the present specification (restricted scope of testing to be agreed)
- Any change of welding consumable (flux and/or wire) (restricted scope of testing to be agreed).

B. The following additional inspections and tests shall also be carried out on the manufacturing procedure qualification pipe. Unless otherwise stated, all tests shall meet the requirements of this specification.

1. The longitudinal weld seam shall be X-radiographed along its full length.
2. The pipe external shall be MPI tested on full body and full weld length. For diameters 24” and above the entire surface of internal weld shall also be inspected.
3. Two longitudinal and two transverse (with respect to pipe axis) tensile strip specimens shall be cut in base material at one pipe end, at 180° from the weld seam. A second set of two longitudinal and two transverse tensile specimens shall also be cut as close as possible to the previous ones using round bar specimens as defined in § 7~~5~~.7.5.2 of this specification.

4. Two all-weld-metal (longitudinal) tensile test specimens shall be prepared: one from the inside weld bead and one from the outside weld bead. This YS and TS shall meet the requirement of the pipe base material. Elongation shall be as per API Spec 5L/ISO 3183 with a min. of18%. Reduction of area and YS to TS ratio will be reported for information only. All the results shall meet the requirements of § 7~~5~~.5.10.3 of this specification. The Uniform elongation shall be properly measured and reported for information only.
5. A full chemical analysis shall be made on inside weld bead and outside weld bead. As a minimum, all the elements as per the composition requirement of the applicable consumable specification shall be analyzed. The Nickel and Molybdenum content shall also be reported.
6. Weld macrosections for macrographic examination tests shall be taken at five positions at intervals of two metres along the pipe length. Three of them shall be selected by the Inspector for hardness tests. All the results shall meet the requirements of § 7~~5~~.5.10.6.2 and § 7~~5~~.7.5.5 and Appendix 8 of this specification.

   Macrographic examination tests shall be performed also at both ends of other pipes welded on the other ID/OD welding lines, if any.

   For Press Bending or Roll Bending pipes, (i.e. non-expanded pipes), macrosections shall be taken at both ends only.

7. At both ends of pipe, Charpy V-notch tests shall be cut in weld metal axis, Fusion Line +2mm and Fusion Line +5mm (including FL for single Vee weld), as shown in Figure of Appendix 9, and in pipe body at location 90° from weld seam. Each test shall meet the requirements of this specification at the test temperature stated in the PPS (i.e. routine test temperature). Among the two positions FL + 2 mm and FL + 5 mm, the one giving the lowest average value shall be selected for routine production test and shall be referred to in this specification as “Heat Affected Zone Charpy test”. All impact test specimens in weld area shall be etched before testing to check that notch location is correct.
8. Additional Charpy tests on weld metal axis, Heat Affected Zone (as defined above) and pipe body shall be carried out at temperatures 10°C and 20°C above and 10°C, 20°C and 30°C below the routine test temperature. The temperatures of testing shall be extended when necessary in order to get sufficient data for representing properly a transition curve showing the transition area. The tests with test temperatures below the routine temperature test will be for information only, but the transition temperature shall not be higher than the specified routine test temperature. All results (Charpy energies and shear areas) shall also be plotted on a transition curve. All impact test specimens in weld area shall be etched before testing to check that notch location is correct.

9. When the effluent in the pipeline is a gas, Drop Weight Tear Tests shall be conducted according to § 7~~5~~.7.5.7
10. Additional DWTT shall be conducted at temperatures 10°C and 20°C above and 10°C, 20°C and 30°C below the routine test temperature, for information only. Results shall be recorded by means of transition curves.
11. Strain Ageing tests
    a) For onshore pipelines, strain aged Charpy V-notch tests shall be carried out from samples located opposite the welded seam (i.e. at mid-distance of plate edges.) Each sample shall be strained 3% longitudinally to pipe axis and one set of specimens extracted, the remainder of the strained sample shall be heated for one hour at 250°C and a further set of specimens extracted. Each set shall comprise three specimens cut transverse to pipe axis.
    b) For all pipelines, when the percentage of permanent straining of base material due to pipe forming is 5% (forming + expansion) or above, strain aged Charpy V-notch tests shall be made from a pipe sample cut at location opposite to weld seam. The sample shall be aged for one hour at 250°C and then the Charpy specimens shall be cut transverse to pipe axis.
    c) For TMCP pipes of all pipelines, a pipe sample for longitudinal tensile test shall be cut at location opposite to weld seam. Two longitudinal tensile tests round bar specimens shall be machined from the sample.
    One specimen shall be tensile tested as it is. The second one shall be aged at 280°C for one hour and tensile tested.
    All tensile characteristics shall be measured and recorded for information only. The uniform elongation (UE) shall be properly measured and recorded. UE shall not be less than 4%.

    Note: When the required straining is reached, the specimen/sample/pipe shall be maintained under stress for at least 5 minutes before relieving.

12. Post Weld Heat Treatment tests
    When required in the PPS and in all cases for pipes of the portion of riser on platform topsides or jacket when WT > 25 mm, tensile tests and Charpy V-notch impact tests as per § 7~~5~~.7.5.2 and 7~~5~~.7.5.4 of this specification shall be repeated after a simulated Post Weld Heat Treatment (PWHT) is made. These tests shall also be acceptance tests and tests results shall meet the requirements of this specification. PWHT soaking temperature shall be basically 580°C ± 10°C for controlled rolled steel, for one hour per 25 mm wall thickness. The PWHT procedure shall comply with App, C, G400 of DNV-OS-F101 and shall be approved by the COMPANY.

13. Weldability Tests

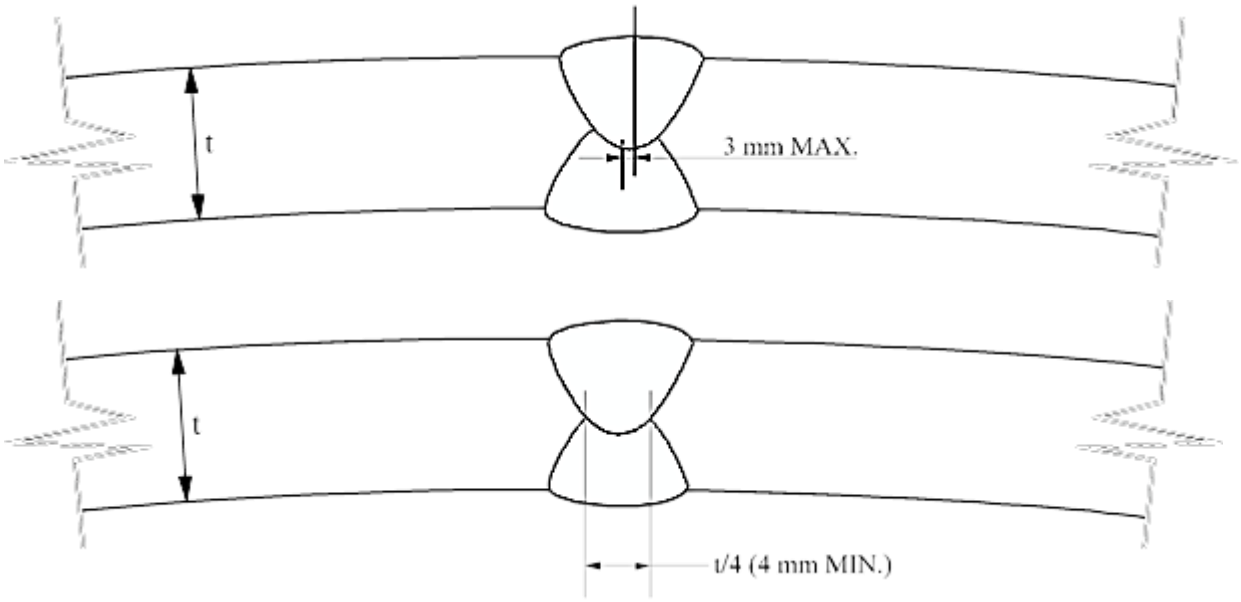
    When so required in the PPS, full scale weldability trials shall be conducted on pipes produced at early production stage

    The tests shall be carried out in accordance with Appendix 13.

    When weldability tests are not required in the PPS, then the SUPPLIER shall produce, to the satisfaction of the COMPANY, a comprehensive documentation to support the weldability of the supplied pipes, such as in-house laboratory test results (e.g. impact tests) weldability test results from previous orders, welding recommendations, etc.
14. Hydrogen Induced Cracking tests (HIC tests) shall be carried out according to § 75.7.6 and Appendix 16 of this specification.
15. Sulphide Stress Cracking tests (SSC tests) shall be made in weld seam and base material in full compliance with § 75.7.7 and Appendix 15 of this specification (8 specimens for the MPQT)
16. Base metal metallurgical microstructure and grain size evaluation shall be carried out (refer to § 75.4) at mid-thickness. Photographs of microstructure shall be supplied.
17. With reference to Appendix 17, a micro analysis of weld shall be carried out by “Electron Probe Micro Analysis (EPMA)” or equivalent equipment on a weld section extracted at each pipe end. The fusion lines between weld and base metal and between passes shall be particularly investigated. The results shall not indicate segregation peak. The said areas shall be also investigated by micrography and micro hardness. The results shall not reveal any martensite nor hardness peak.

Appendix 8. Weld bead alignment and interpenetration

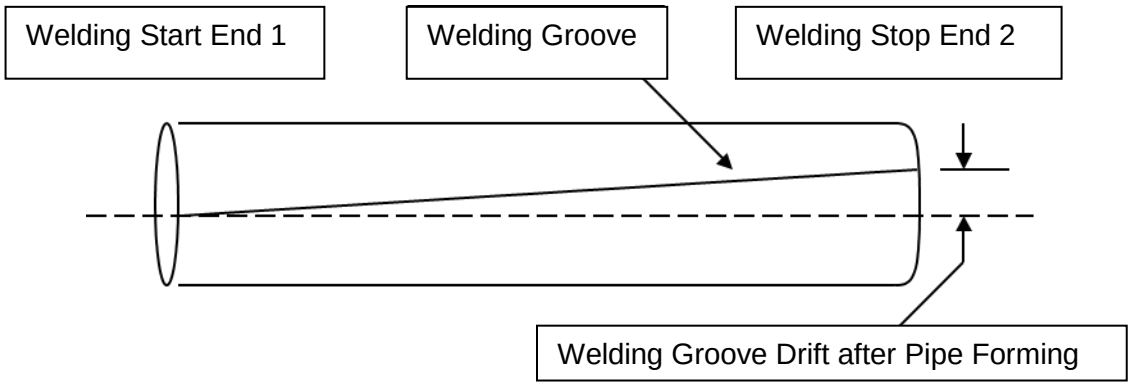
1. Figure 1 and 2: Acceptance criteria of production test macrography as per § 75.7.5.5

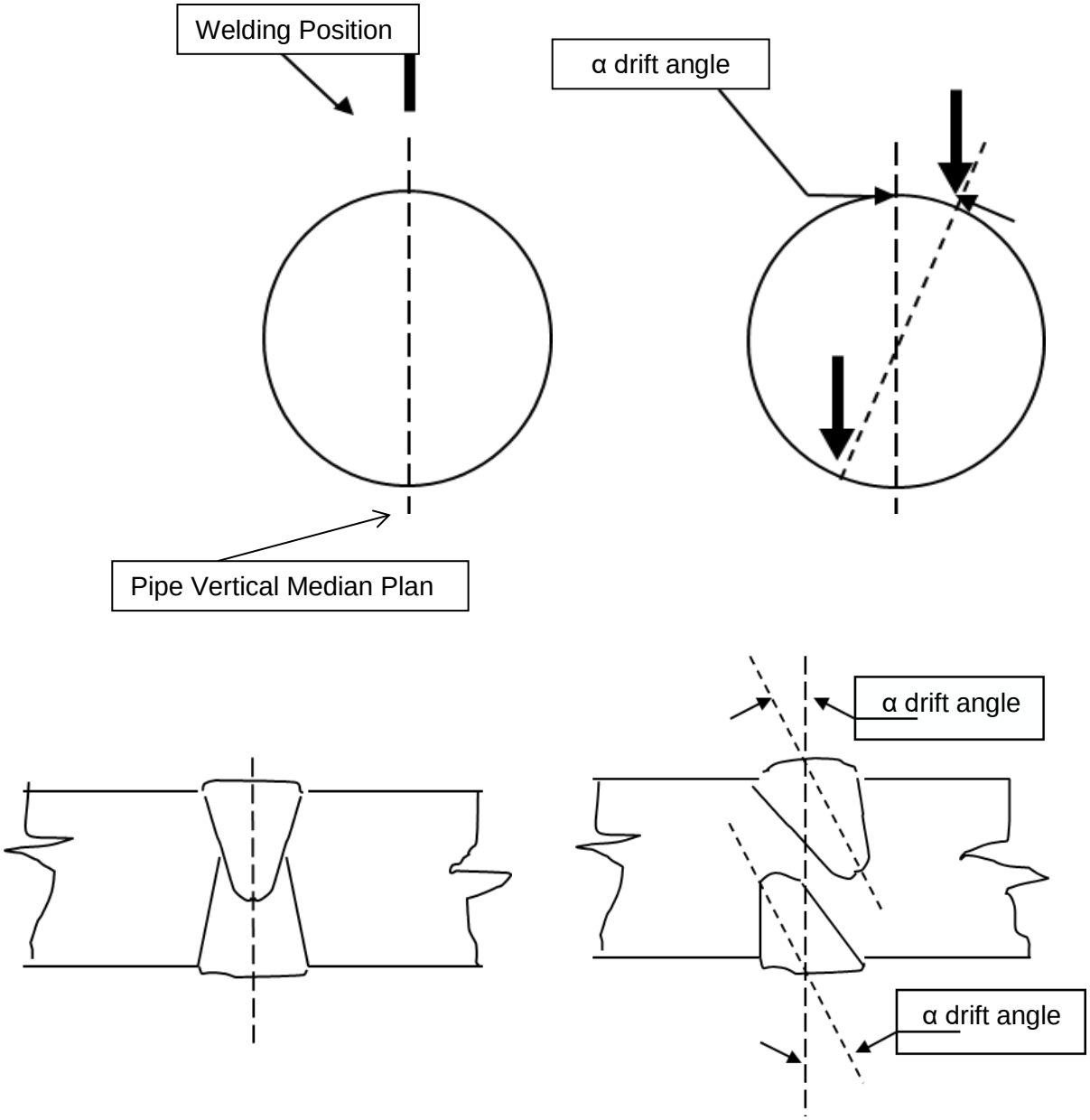


2. Figure 3: Case where welding seam tracking system is not based on pipe rotation (clarification concerning § 75.5.10.6.2.C)

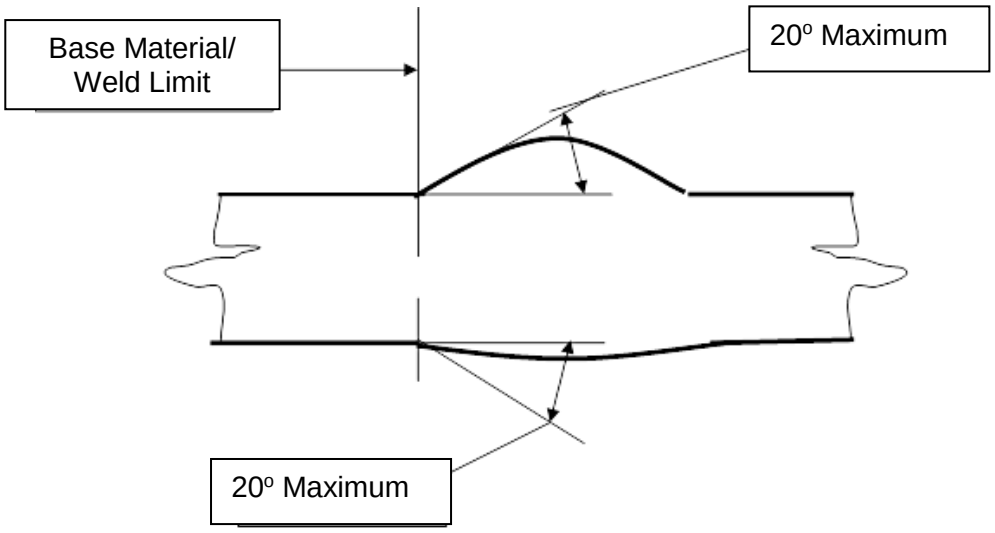
The lack of weld penetration relating to the weld groove drift after pipe forming is due to the welding head position to the pipe median plan.

The drift angle is also affecting the Automatic Ultrasonic Testing (AUT) efficiency when the AUT weld seam tracking is also not based on pipe rotation



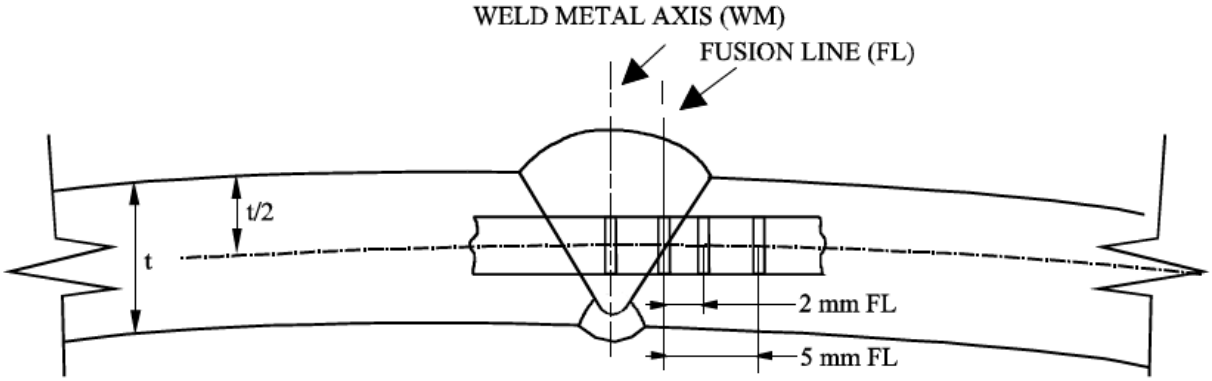


3. Figure 4: WELD TOE – Angle of connection weld / base material

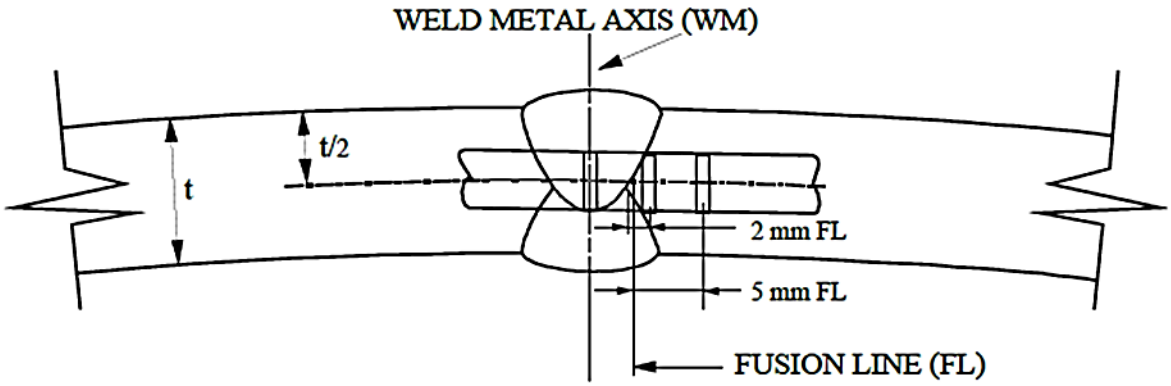


Appendix 9. Location of Charpy V-notch specimens

a) Single V-weld



b) Double V-weld



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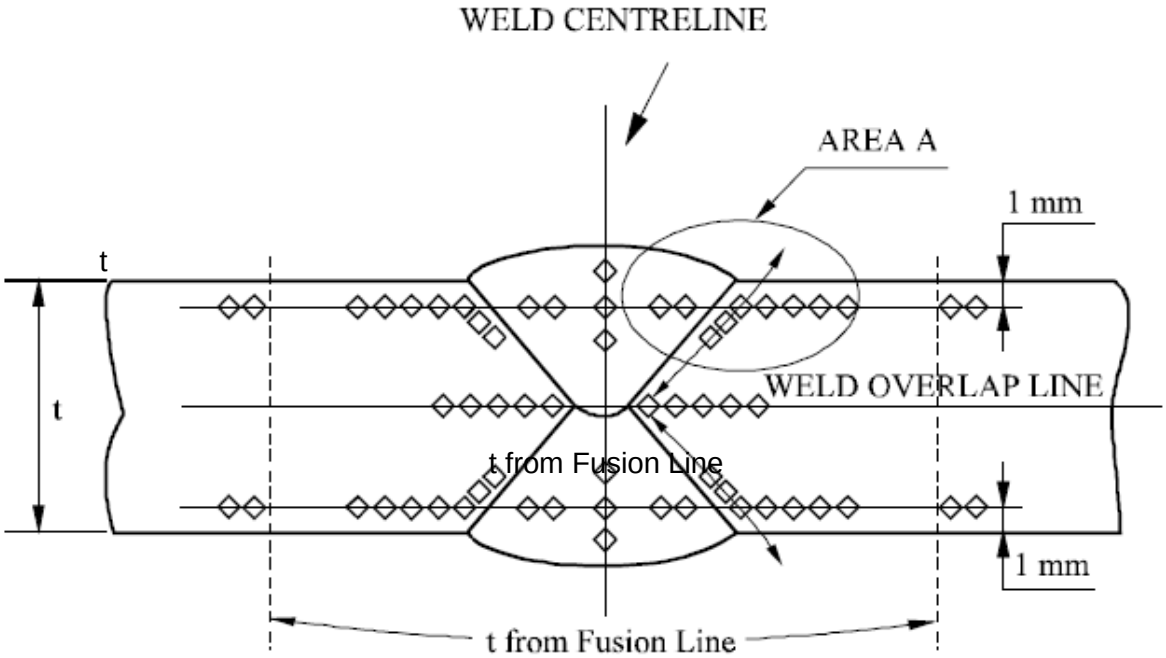
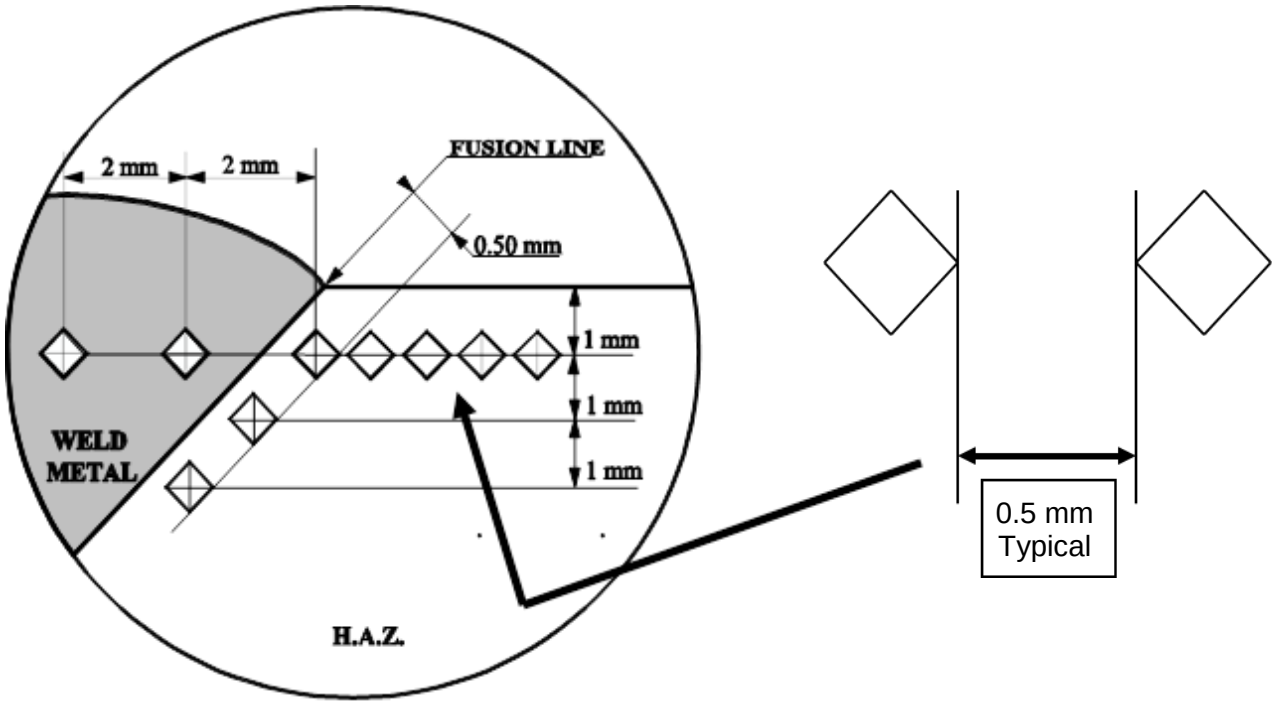
Appendix 10. Vickers hardness survey in weld for procedure qualification tests

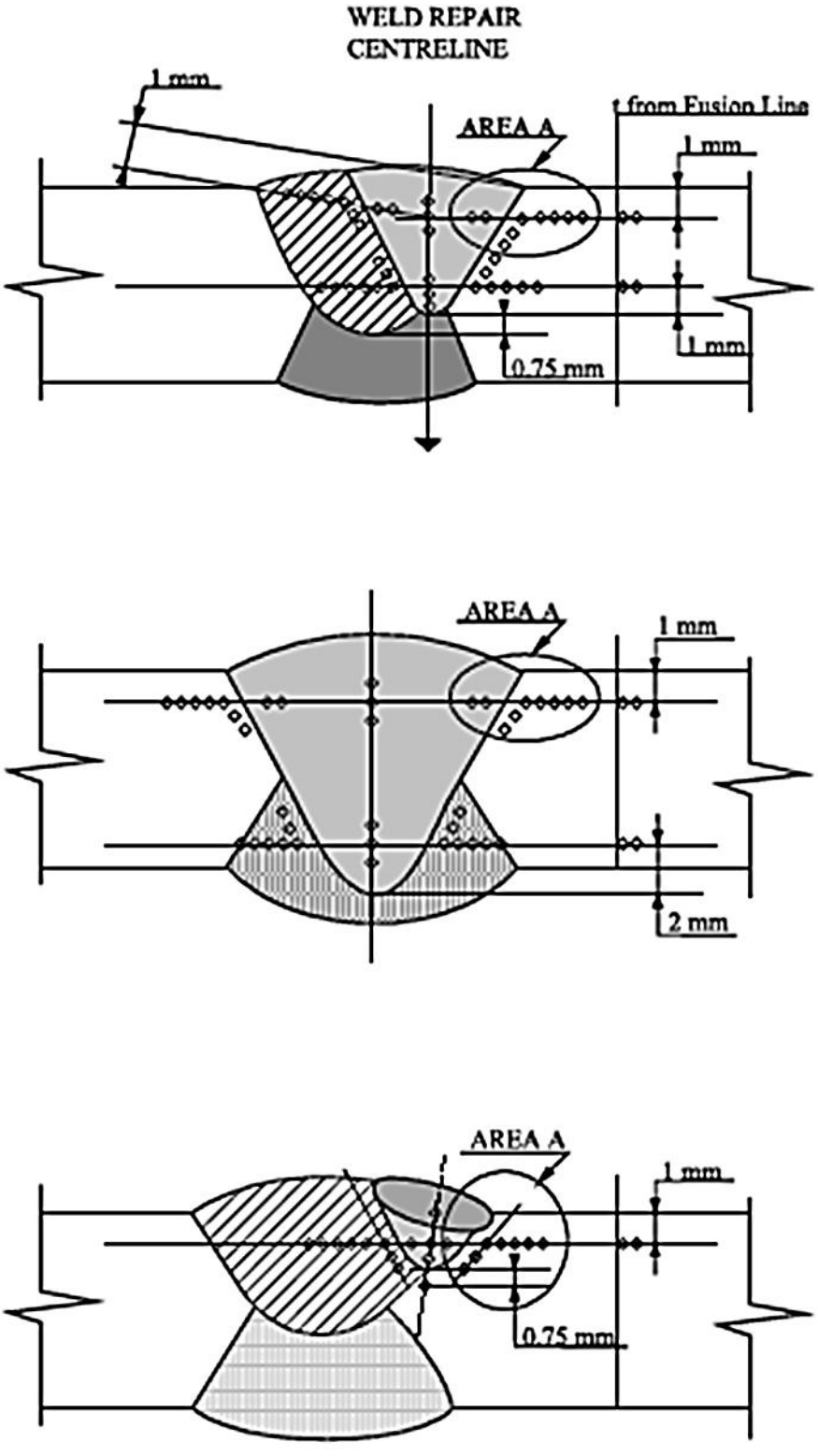
a) Longitudinal seam



Enlargement of Area A (typical)

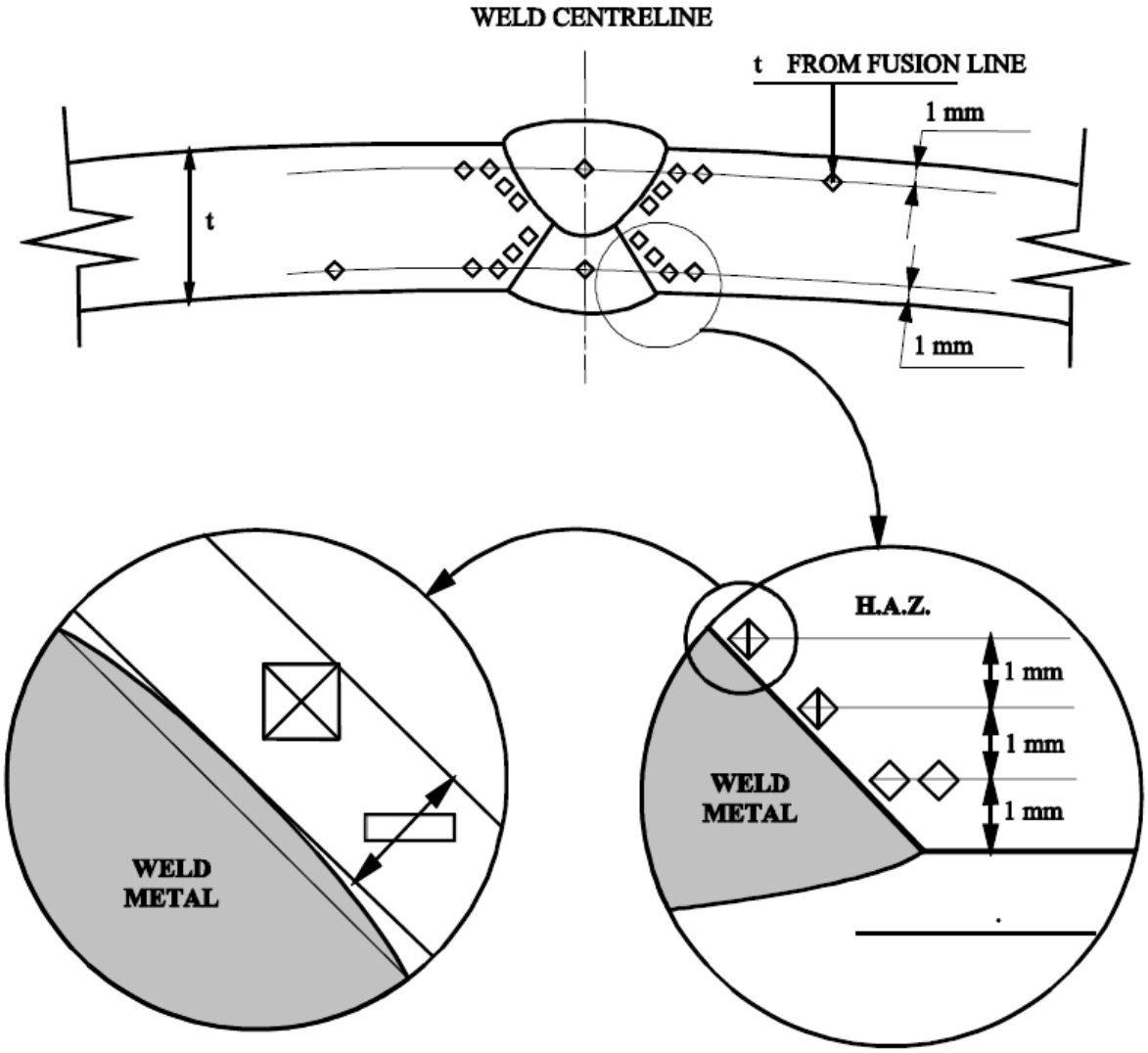


b) Repairs welds



Appendix 11. Vickers hardness survey in weld for production tests

(Longitudinal seam)



Appendix 12. Qualification of weld repair procedures

All weld repairs (including any re-welding or welding restart, using the automatic process with the same conditions as those used for main weld) shall be qualified by tests according to § 75.5.10.4 of this specification and the following.

Each test weld shall represent a repair of simulated (or actual) defects oriented longitudinally in the longitudinal weld seam.

The test pipe section shall be of sufficient length so as the repairs do not reach its ends.

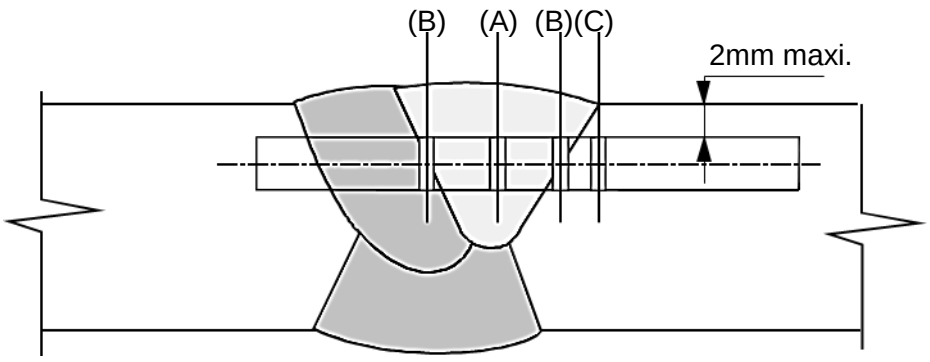
The following inspections and tests shall be made on the test welds. Inspection results shall meet the requirements defined in this specification for longitudinal weld seam.

- 100% visual, X-rays and MPI as per § 75.7.3 and 75.7.4 and manual UT examination as per “Procedure for manual ultrasonic on weld seam…” in Appendix 4
- Two tensile tests transverse to weld as per § 75.7.5.2
- Two face/two root bend tests or four side bend tests as per § 75.7.5.3
- Four sets of Charpy-V tests as per Figure 1 in this Appendix and § 75.7.5.4 (See Figure 1)
- One macrography/hardness test as per § 75.7.5.5 and Appendix 10
- SSC Tests as per § 75.5.10.4

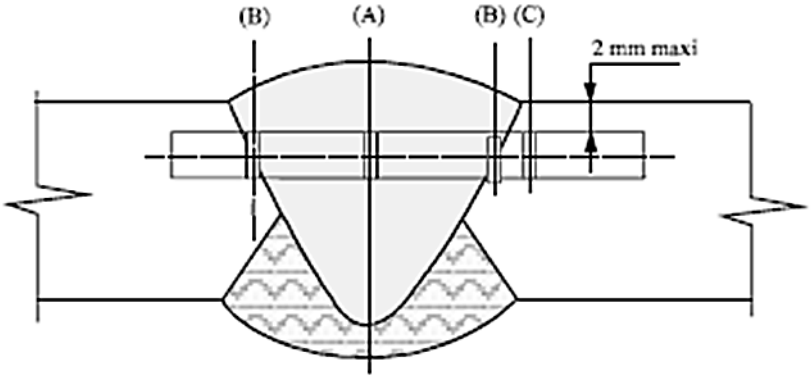
For shallow repairs, only guided bend tests, macrography/hardness test and SSC tests are required.

Figure 1 – Charpy-V notch impact test in weld repairs

a) Partial-thickness repair



b) Through-thickness repair



Notch specimen location:

(A) Notch at centerline of repair weld

(B) Center of notch located on fusion line

(C) Center of notch located 2 mm from fusion line

Appendix 13. Weldability tests (SMAW and GMAW)

1. Purpose

To prove the weldability of the pipes produced, the SUPPLIER is required to carry out full scale weldability trials to ensure that the material supplied can be welded on a lay-barge or onshore (where applicable) without significant or excessive precautions. The intent is that, during pipe installation welding, the hardness and impact requirements stated in § 8~~6~~.0 of this Appendix can be met in the Heat Affected Zone (HAZ) of welds.

2. Material

The material shall be selected with the maximum Carbon Equivalent/Pcm of the supplied pipes in the order. The steel used may, however, have the production maximum Carbon Equivalent minus 0.02%, or Pcm minus 0.01%.

The COMPANY shall approve the heat analysis of steel or pipes to be used for the weldability tests.

3. Welding Procedure Specification (WPS)

The SUPPLIER shall submit to the COMPANY a Welding Procedure Specification detailing his proposals. This shall include:

- A full Welding Procedure Specification including details of welding consumables, type of welding process, welding parameters, etc.
- Proposals on pipe sample dimensions (width, length) so as to represent realistic welding conditions
- Full details of weld bevel geometries. The proposed groove profile shall be such that the welding will result in a straight HAZ on one side of the bevel (i.e. half-V 0-45° bevel angle must be used as shown in Figure 1).

No welding test shall be carried out until the SUPPLIER's proposals have been approved by the COMPANY.

4. Test welds

Two welds trials are required as follows.

The tests shall consist of butt welding together two pipe sections in the 5G vertical downhill position using, on one case, SMAW and basic coated electrodes and, in the second case, mechanized GMAW (solid wire). The heat input range from root pass to cap pass shall be 5 to 16 Kj/cm for SMAW and 5 to 12 Kj/cm for GMAW

When so previously agreed with the COMPANY, mechanized welding may be replaced by semi-automatic welding made in 1G and 5G position.

The welds shall be single sided.

Per each welding process, one weld shall be made with a maximum preheating of 40°C (for drying purposes only) and one weld with a mini preheating of 100°C

Maximum inter-passes temperature shall be 250°C

5. Testing and inspection

a) Radiography

Before cutting the specimens, the weld shall be 100% radiographed by X-rays.

b) Charpy-V notch Test

Specimens shall be cut at the 1o'clock and 3 o'clock positions and shall be located 2 mm below outer surface. For each set, three specimens shall be cut and tested.

The notches shall be located as follows:

- In the Coarse Grain Zone of the HAZ, i.e. within a 0.5 mm band from the fusion line
- At 2 mm from the Fusion Line
- At 5 mm from the Fusion Line

c) Macrography

Three specimens shall be extracted, one at the 12 o'clock, one at 3 o'clock and one at the 6 o'clock position.

d) Vickers Hardness Survey

On the above macrographic cross-sections, a VICKERS hardness survey shall be conducted under 5 kg load in accordance with Figure 1 of this Appendix.

Note: The Weld Metal will not be part of the testing.

6. Acceptance criteria

The test welds as described above shall meet the following requirements:

- Maximum HV5 hardness shall not exceed 250 in HAZ
- Minimum Charpy V-notch impact energy at the required routine test temperature stated in the PPS shall be according to Table 4 of Appendix 2 of this specification, unless otherwise stated in the PPS

The SUPPLIER should note that the weldability tests are acceptance tests for the pipes, and that pipes cannot be approved until these tests are successfully completed.

7. Reporting

Following completion of the test programme, the results and final report form the SUPPLIER shall be submitted to the COMPANY.

The final report shall include, as a minimum, the following:

- Welding Procedure Specification
- Weld Procedure Qualification Records giving details of the welding parameters for each pass, consumables used, bevel geometry, etc.
- Mill certificates of pipe materials used.

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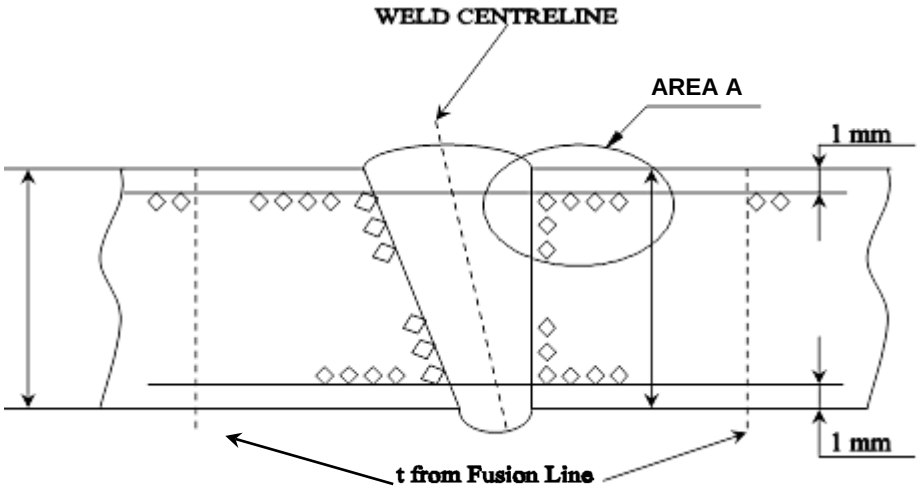
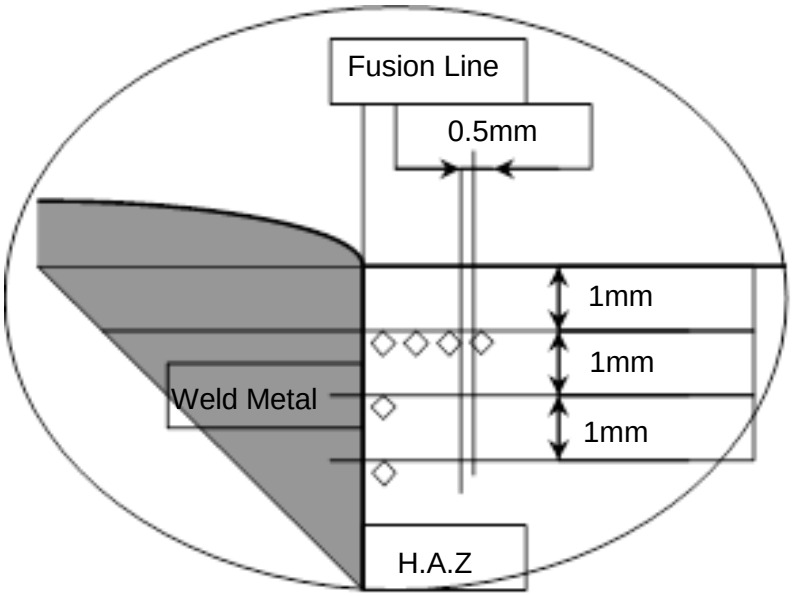
- NDT and mechanical test results (including any failures)
- Any other testing agreed with the COMPANY
- Any necessary photographs, macrographs and micrograph (if any)
- The interpretation of the results and the conclusions of the SUPPLIER, including his recommendations for welding the pipes at installation site.

Figure 1 – Vickers hardness survey (5 kg load)

SMAW and GMAW Butt weld (Single ½ V-groove 0-45° deg)



Enlargement of area A (typical)



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Appendix 14. DNV Particular Requirements (when applicable: refer to § 75.2)

When so required in the PPS, the following requirements shall apply

Note: All in all, the above COMPANY specification is in line and meets the requirements of the Offshore Standard DNV-OS-F101 (DNV Std) except in few points where the DNV Std is more stringent than the COMPANY specification. Therefore, when the DNV Std is applicable, the following modifications and/or additions to the above COMPANY specification shall apply.

Moreover, on a case by case, the pipeline Engineering may require also one or several of the "Supplementary Requirements" of the DNV Std Section 7 Part I. Those "Supplementary Requirements", if any, shall be stated in the PPS. Unless specified otherwise in the PPS, any required "Supplementary Requirement" implies the application of all the "General Requirements" stated in the Section 1 below.

1. Additions and Modifications to COMPANY specification, based on DNV-OS-F101 General Requirements.

1.1 MPQT

- Number of pipes tested: DNV Sec. 7, § A604 shall apply
- 2 pipes (from 2 different heats) instead of one shall be tested
- The NDE Inspection will be applied on one pipe only
- Destructive Testing shall apply to the 2 pipes as per COMPANY specification § 75.2 and CVN shall be as per: DNV Sec. 7 Table 7-9 and Appendix B, Figure 5 concerning the number and location of specimens (i.e. W, FL, FL+2, FL+5), and cap and root where applicable.
- Fracture toughness (CTOD) DNV Sec. 7 Table 7-8 and B415 shall apply.
- Fracture toughness of weld metal
- Acceptance criteria are those specified in the COMPANY specification, except for "fracture toughness of weld" where DNV Sec. 7 B415 shall apply.
- Mill hydrostatic testing: test pressure to be calculated as per formula of Section 7 § E102.

1.2 Production Tests

- Charpy V-notch (CVN)
- CVN at FL+2 or FL+5 is maintained as defined in the COMPANY specification Appendix 7.
- Additional CVN at FL and at cap and root (where applicable) as per DNV Sec. 7 Table 7-9 and Appendix B, Figure 5 shall apply.

2. Supplementary requirements (when required in the PPS)

- **Supplementary requirement (F)** Fracture Arrest Properties DNV Sec. 7: I200 to I205 and Table 7-23 and 7-24 shall apply.

- **Supplementary requirement (P)**

  Line-pipe for Plastic Deformation DNV Sec. 7: I301 and I309 and Tables 7-25 shall apply with the following additional acceptance criteria:

  - § I303 the Uniform Elongation (UE) shall be measured and shall be minimum 8%
  - § I308 the Uniform Elongation (UE) shall be measured and shall be minimum 4%
  - Note: § I304: The PPS shall specify the type of deformation to be applied to the pipe material, “full scale” or “simulated deformation”.

- **Supplementary requirement (D)** – Enhanced dimensional DNV Sec. 7; I401 and Table 7-26 shall apply.
- **Supplementary requirement (U)** – High Utilization DNV Sec: 7; I501 to I512 shall apply

Appendix 15. Specification for Sulphide Stress Cracking tests (SSC tests)

1. General

This specification applies to the testing of both the base metal and the longitudinal weld (including welding repairs) of line pipes by means of sulphide stress cracking tests using the 4 point bending test method (NACE TM0177 Method B and EFC Publication No. 16). Apart from the type of specimen (which contains no holes) and the bending method (it is a 4-points bending), all the provisions regarding Method B of NACE TM0177 shall apply, unless otherwise stated hereafter.

The Laboratory 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 (i.e. for region 1)

2. Specimen preparation

Each set shall consist of three specimens. Each specimen shall be prismatic with the following dimension: 115 mm long, 15 mm wide and 5 mm thick.

Regardless of pipe wall thickness, four sets of specimens shall be cut as follows, at one pipe end:

- 2 sets in weld seam (one at “inside weld cap” and one at “weld root”), transverse to weld, at locations shown in Figure 1 here-after,
- 2 sets in base material (one at “inner pipe surface” and one at “pipe mid-thickness”), transverse to pipe axis, at a location opposite to weld seam

“Inside weld cap” specimens and specimens in base material at “inner pipe surface” shall be cut as close as possible to the inside pipe surface, with the minimized depth of machining to obtain flat surfaces.

“Inside weld cap” specimens shall have the certerline of the loading span located at the weld fusion line. “Weld root” specimens shall have the certerline of the loading span located at the weld overlap line at weld root (see Figure 1)

SSC test applies, also, for through thickness repairs and mid-thickness repairs.

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 that 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 specimens surfaces shall be ground smooth to 600 grit emery paper (as a minimum), after machining.

Test identification shall be marked on each specimen by electric pen. The identification procedure shall be detailed by the laboratory.

Additional test (for pipe manufacturing qualification only):

For information purposes only, one full thickness weld macrosection shall be cut transverse to weld and tested for 30 days at the same time and in the same call as the SSC test specimens, but it shall not be stressed. It shall be analyzed for cracks at magnification x 100 as per the HIC specimens (see provision of Appendix 16) and the results reported.

The results of this test may be helpful in the understanding of the origin of certain cracks that may occur in weld at SSC test.

3. Test required

Two machined round bar tensile specimens of maximum possible diameter shall be cut in base material, at the 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 measured 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 Para. 4 here-after) of above actual Yield Strength of pipe base material. When loading the specimen in test rig, the load shall be monitored by the deflection at the center of the specimen using a dial gauge (accuracy of 0.01 mm minimum) and the applied stress shall be adjusted and measured using electric 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 Weld

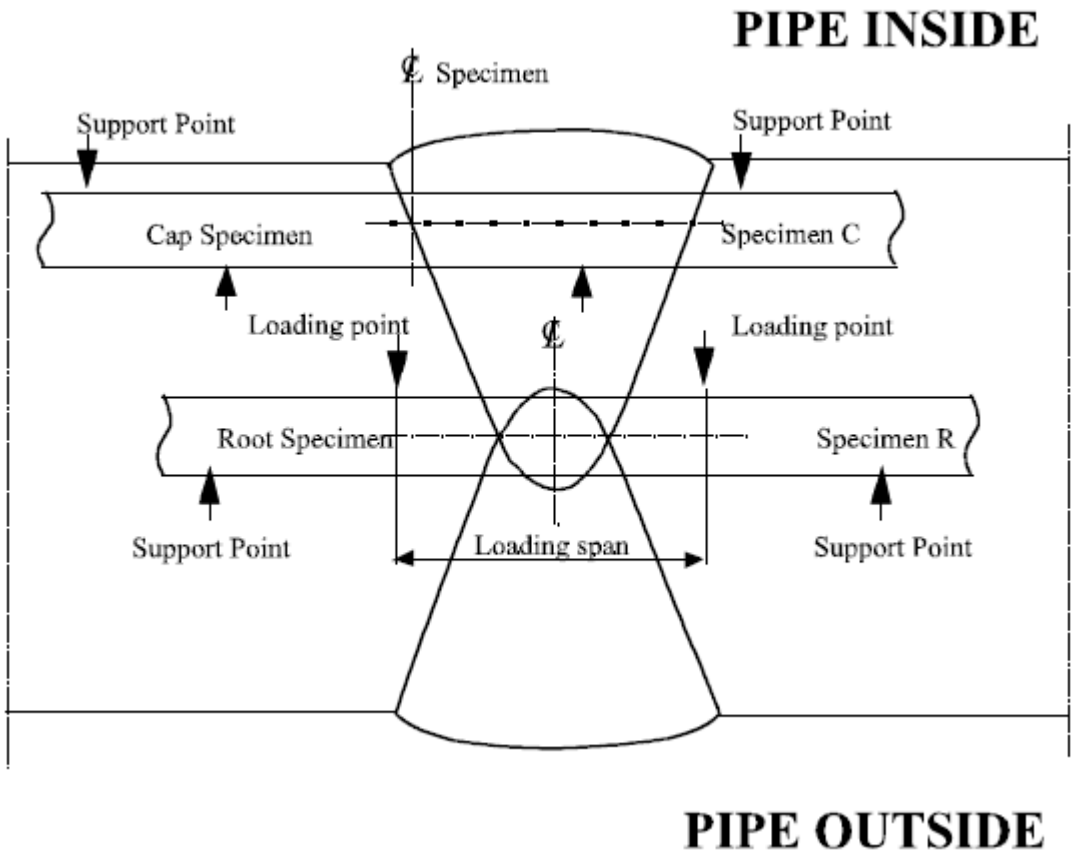
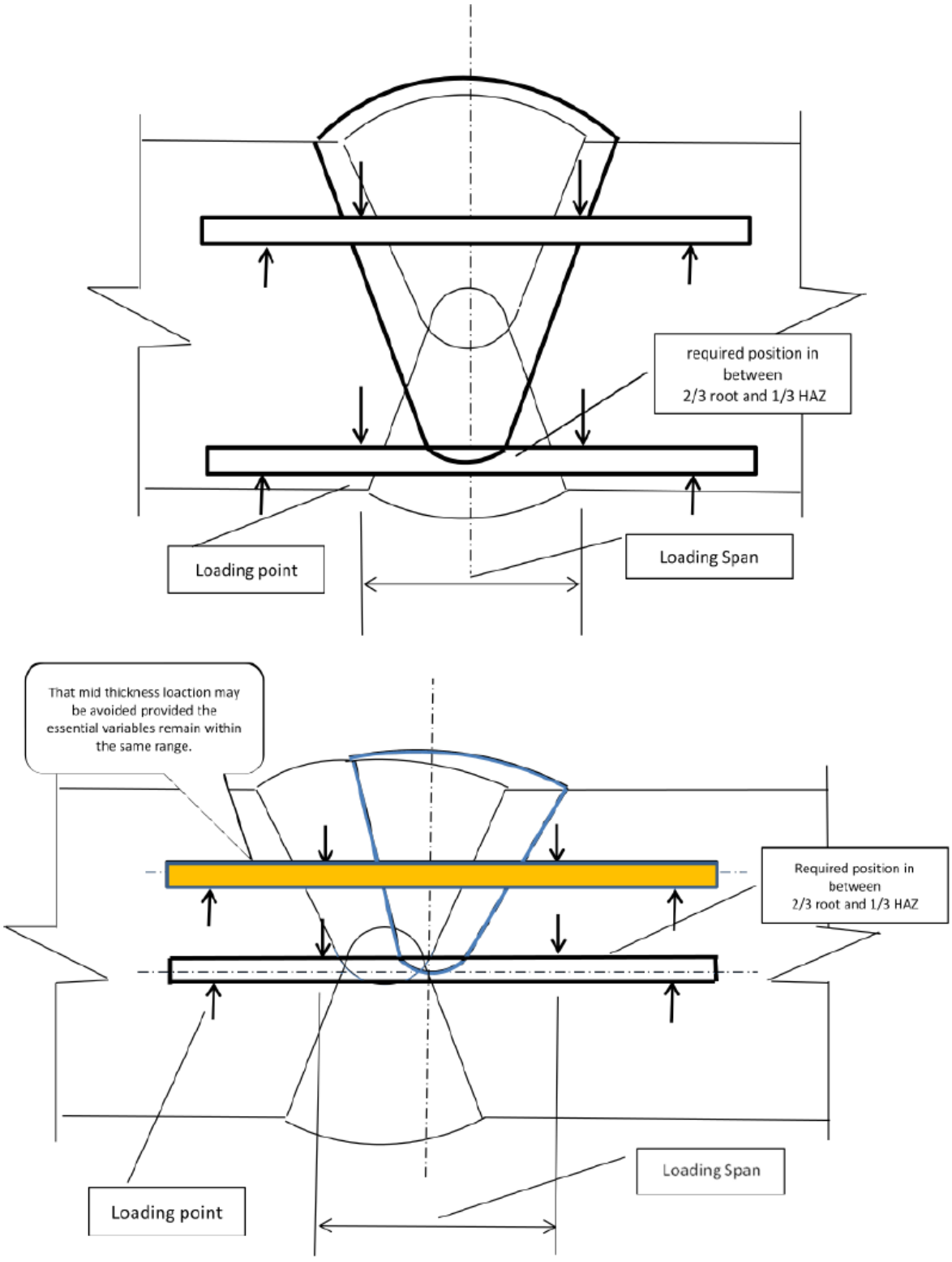


Figure 2 – Sampling in Through Thickness (TTR) and Partial Thickness (PTR) repair



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4. Test arrangement and test solution

Test arrangement and loading of specimens shall be as per Appendix 2 of EFC Publication n° 16 and ASTM G 39 Std or ISO 7539 – 2 Std

The outer and inner rollers shall be made with materials which 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 paragraph 3 (strain gauges)

The pipe SUPPLIER shall select one option between the 2 following options for the test solutions, H_2S partial pressure and applied stress.

(1) Option with NACE TM 0177 test solution A

Pipeline (1) Sour Service	Region (1)	Pipeline effluent	Test conditions	Min. H_2S concentration (ppm)	Stress level (%AYS)
Mild	1	All	NA	NA	NA
Intermediate & Severe	2 & 3	All	NACE TM0177 solution A pH = 2.7 – PH_2S =1 bar	2300	80

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

NACE TM 0177 solution A shall consist of 5% mass fraction NaCl +0.5% mass fraction CH3 COOH in distilled or deionized water.

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

Pipeline (1) Sour Service	Region (1)	Pipeline effluent	Test conditions	Min. H_2S concentration (ppm)	Stress level (%AYS)
Mild	1	All	NA	NA	NA
Intermediate	2	Oil	EFC 16 solution B pH = 4.5 – PH_2S =0.1 bar	230	90
		Gas Multiphase systems Condensate	EFC 16 solution A pH = 3.5 – PH_2S =0.01 bar	23	90
Severe	3	Oil	EFC 16 solution B pH = 4.5 – PH_2S =1 bar	2300	90
		Gas Multiphase systems Condensate	EFC 16 solution A pH = 3.5 – PH_2S =1 bar	2300	90

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

EFC 16 test solutions shall consist of 5% mass fraction of NaCl + 0.4% mass fraction of sodium acetate (CH_3 COONa) in distilled or deionized water.

Throughout the rest, 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 CH_3 COOH) or NaOH.

All reagents added to the test solution shall be measured to ± 1.0% of the quantities specified. H_2S 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. The related procedure shall be submitted to COMPANY. The minimum H_2S concentrations shall be stated in Table of this paragraph.

Tests shall have a duration of 30 days (720 hours) minimum counting 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/cm^2

The pH and H_2S concentration of the solution shall be measured and recorded at start of test, after initial H_2S 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 at X5 minimum magnification and photographs shall be made at X2 minimum magnification of the stressed surfaces of each specimen further to cleaning and MPI. Photomicrograph at X100 and X500 magnification (or at any appropriate magnifications) shall also be provided of base material, together with an analysis of the metallurgical microstructure found.

Whenever a crack is found, the specimen shall be cut perpendicularly to the 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 photomicrograph. Micro-hardness will 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 X5 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 rapture) 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.

For evaluation, only SSC or SOHIC cracks shall be considered.

Little grooves, pits caused by corrosion loss or surface cracks not exceeding 0.1 mm in vertical depth will 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 per set, with photographs (and photomicrograph, when applicable)
c) Type of solution used for the tests as per Tables above of this Appendix. pH and H_2S concentration of solution at start (after initial H_2S saturation) and end of test, and 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 analyzed 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

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Appendix 16. Specification for Hydrogen Induced Cracking test (HIC tests)

1. General

This specification applies to the testing of both the base metal and the longitudinal weld of line pipe by means of Hydrogen Induced Cracking test (HIC tests).

This specification shall be read in conjunction with NACE TM0284.

Test specimens shall be cut from pipes and immersed in the test solution prescribed hereafter. No applied stress is required. After 96 hours immersion, damage due to hydrogen pressure induced cracking related features such as blistering, straight and stepwise crack shall be measured and reported. Acceptance criteria shall be as stated hereafter.

The laboratory shall prepare a detailed HIC test procedure (including the UT procedure of specimens) and submit it to the COMPANY for prior approval.

HIC tests are not required for mild sour service (i.e. for region 1).

2. Size, number and orientation of test specimens

Six test specimens shall be cut from each test pipe as follows:

- Two specimens cut transverse to the longitudinal weld (+2 additional specimens, one at 100 mm max from each pipe end for MPQT only)
- Two specimens cut in base material in a direction parallel to the rolling direction at each of the two following locations: at 90 degrees from weld and at 180 degrees from weld.

However, for wall thickness (WT) above 30 mm, the specimens shall be staggered at each location as per “Pressure Vessel Plate” in NACE TM0284, with an overlap of 1 ± 0.5 mm between adjacent specimens

Specimen dimensions shall be as follows:

- Length (L) = 100 mm ± 1 mm
- Width (W) = 20 mm ± 1mm
- Thickness (T) = specimen thickness after a minimum amount (with a max. of 1 mm) of material has been removed from the outside and inside surfaces of pipe to prepare finish of specimen.

After machining, all specimen surfaces shall be ground and finished to 320 grit (as a minimum) emery paper. The test specimens shall not be flattened.

3. Test solution

Test solution A of NACE TM 0284 shall be used

pH and H_2S partial pressure of test shall be as stated in the table below.

Test duration shall be 96 hours.

Pipeline (1) Sour Service	Region (1)	Pipeline effluent	Test conditions	Min. H_2S concentration (ppm)
Mild	1	All	NA	NA
Intermediate and Severe	2 & 3	All	NACE TM0284 solution A pH = 2.7 – PH_2S =1 bar	2300

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

Test solution A shall consist of 5.0 weight% NaCI +0.5 weight% CH_3 COOH in distilled or deionized water. However, 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 unit by addition of HCL (or CH_3 COOH) or NaOH

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

The ratio of solution volume to total specimen surface area shall be minimum of 10 ml/cm^2

The solution shall be deaerated by bubbling nitrogen and then H_2S or H_2S + CO_2 saturated as per NACE TM 02-84 Std.

H_2S gas purity shall be 99.5% minimum. The gas flow shall be controlled by a flowmeter.

Hydrogen sulphide concentration in the solution shall be measured by the iodine titration method. The related procedure shall be submitted to COMPANY. The minimum H_2S concentrations shall be as stated in Table of this paragraph.

The pH and H_2S concentration shall be measured and recorded at start of test, after initial hydrogen sulphide saturation and just prior to test termination, as a minimum.

Test temperature shall be maintained at 25°C ± 3°C and regularly recorded (continuously or minimum once per day) from the start to the end of test.

4. Evaluation of hydrogen induced cracking

4.1 Hydrogen Induced Cracking (HIC)

After 96 hours immersion, counted after saturation of test solution, the specimens shall cleaned (brush + detergent) and then be examined by automatic UT using compression waves and the immersion technique. The UT procedure shall comply with the provision of § 4.2 hereafter.

All personnel performing UT examination shall be qualified level II or higher.

The SUPPLIER shall submit a detailed UT procedure to the COMPANY prior approval.

Further to UT, each specimen shall be sectioned transversally at three equispaced locations within the specimen length as per NACE Std TM 0284 (I.e. 25mm apart). The sections shall be mounted in epoxy resin or equal and polished as described in § 2 hereabove. Each section

shall be unetched or slightly etched (2% Nital) and microscopically examined for hydrogen induced cracking at magnification of X 100.

In this evaluation, cracks that lie within 1.0 mm of the internal or external surface of the test specimen shall be disregarded. Cracks separated by less than 0.5 mm shall be considered as a single crack.

4.2 Ultrasonic testing of specimens

4.2.1 Ultrasonic Testing Method

Ultrasonic testing shall be fully automatic. It shall be made using the pulse-echo-method, compression waves and immersion technique (clean fresh water). It shall be made from the one side of specimen with ultrasonic beam perpendicular to specimen surface.

Water path distance transducer/specimen shall be stated.

4.2.2 Ultrasonic Generator

a) It shall have been calibrated less than six months ago by an independent and recognized laboratory. A copy of the calibration certificate shall be made available to the Inspector.
b) It shall have the possibility to realize, as a minimum, one of the two following adjustments:
   - The Distance-Amplitude Correction (DAC)
   - The equalization of heights of echo from several artificial reflectors: Time Correction Gain (TCG).

4.2.3 Transducer

a) Transducer shall have the following characteristics:
   - Mono or double transducer
   - Focalized or cylindrical type ultrasonic beam
   - Frequency = 10 to 15 MHz.
b) The following shall also be defined by the SUPPLIER:
   - Transducer type, characteristics, serial number
   - Active diameter.

The manufacturer's data sheet of transducer shall be available.

4.2.4 Calibration

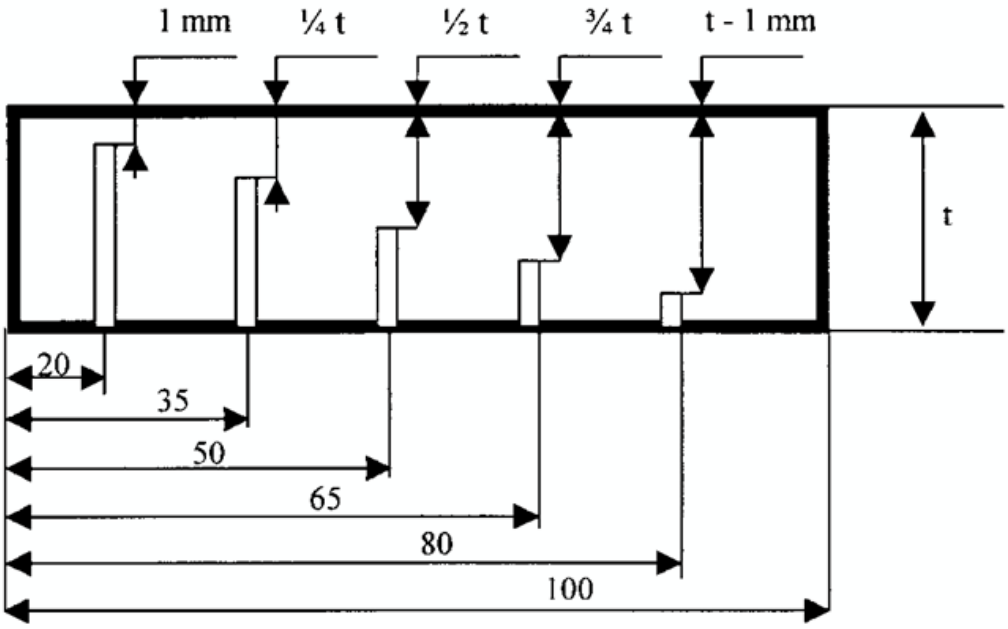
a) Calibration of time base

   It shall be made using a block cut from a pipe sample having the dimensions of specimens to be tested (thickness x width x length).

The distance shall be measured between water/specimens interface echo and the first back wall echo, or between first and second back wall echo.

b) Calibration of sensitivity

It shall be made with a block of same dimensions as above which includes five transverse flat bottom notches 1 mm wide, with depths 1 mm, ¼ t, ½ t, ¾ t and t less 1 mm, as shown on sketch below:



Sensitivity may be made using either the DAC curve method or the TCG level method.

The echo from the 1 mm deep notch shall be adjusted to 80% Full Screen Height (FSH), whatever the selected method (i.e. DAC curve method or TCG level method).

The threshold/referenced level shall be the said DAC curve or TCG level. All indications equal to or above DAC curve or TCG level (when applicable) shall be recorded.

Calibration shall be made once every 4 hours, or when there is an interruption of more than 30 minutes or whenever there is a change of search unit.

4.2.5 Transducer movement

Transducer movement shall comply with the following:

- Strictly parallel to specimen surface within 0.5% in all directions and any correction will be made easily, where necessary
- Distance transducers/specimen surface accurately adjusted, measured and recorded
- Smooth movement, without any stopping
- Speed less than 130 mm/second
- Scanning pitch so that to ensure an overlapping of 20% minimum of transducer diameter.

4.2.6 Extent UT inspection

Scanning shall cover 100% of specimen surface plus a peripherical band of at least half the diameter of transducer (i.e. scanning over 100% of specimen volume).

The scan resolution shall be 0.5 x 0.5 mm, or better.

4.2.7 Cartography/Print-outs

A chart in A-scan or B-scan, as a minimum, shall be produced. C-scan chart may also be produced but as additional only.

The cartography shall give the sizing and location of detected cracks with an accuracy of ±0.05 mm. The method of calculating the defective areas shall be detailed.

Amplitudes of echos from cracks may be referenced with different colors.

Print-outs shall be properly marked (specimen No.:, heat No.:, date of tests, etc.).

4.3 Acceptance Criteria

4.3.1 Ultrasonic examination of specimens

The total Crack Area Ratio (CAR) per specimen shall be reported. The printed chart of automatic UT scanning (of a reasonable size and scale) shall be provided for each specimen.

$$CAR\% = \frac{\text{Total Area of Indication}}{\text{Total Area of Specimen}} \times 100$$

CAR shall be ± 5% max. of specimen area, per specimen. The CAR shall include all cracks and all laminations whatever they are associated or not associated with cracks. When CAR exceeds the acceptance limit, the laboratory may produce evidence by re-scanning and sufficient micrographies that non-cracked inclusions are the cause of unacceptable CAR.

4.3.2 Preparation of cross-sections for examination and crack evaluation

The specimen cross-sections shall be ground dry employing a number of intermediate grinding steps to remove any prior metal deformation. The surface shall be finished by fine grinding with 800 grit paper or finer paper and then polished with diamond paste (grain size: 3 microns, 1 micron) and AL_2O_3 alumina paste or diamond paste (max. grain size: 0.25 micron). The consecutive steps of grinding and polishing shall be detailed in the HIC procedure. The surface shall finally be cleaned using water, alcohol and hot air.

All cracks visible at magnification X100 (as said above) shall be measured and reported.

In this evaluation, cracks that lie within 1.0 mm of the internal or external surface of the test specimen shall be disregarded. Cracks separated by less than 0.5 mm shall be considered a single crack.

CLR, CTR and CSR shall be calculated and reported **for each section** as well as the **average for each test specimen** as per NACE Std TM-02-84.

The following acceptance criteria shall apply to the average of the three cross-sections which are cut from each specimen:

- Crack Length Ratio (CLR): 12% maximum
- Crack Thickness Ratio (CTR): 3% maximum
- Crack Sensitivity Ratio (CSR): 1% maximum

In addition, no individual crack shall exceed 5 mm in length.

No untempered martensite or untempered bainite shall be present in the tested material based on photomicrographs required in para. 5 here-after.

5. Reporting

The following data shall be provided in the Laboratory report per each heat tested for COMPANY acceptance:

a) The printed charts of UT scanning of specimens, unless the UT cartography does not show any defects.
b) The CAR percentage result per each specimen
c) Individual CLR, CTR and CSR for each of the three sections per specimen, and the average CLR, CTR and CSR per each specimen.
d) Photographs of all unetched (or slightly etched) sections at X3 magnification minimum
e) Type of solution as per Table above of this Appendix. pH and H_2S concentration of solution at start (after initial H_2S saturation) and end of test.
f) Locations (using sketches), identification and dimensions of specimens in tested pipe.
g) Photomicrographs of typical micro-structures X200 and X500 of parent material, with definition of the microstructures present in tested material.
h) Mill certificates of material tested showing full chemical analysis and mechanical properties.
i) All pertinent explanations (where needed) and concluding comments.

Any failure shall be analyzed by the Laboratory and the causes of failure made clear to the COMPANY, before any re-tests or remedial actions are decided.

Appendix 17. Required testing before any production

1. Warning cause

Past experience has shown some occurrences of HIC cracking in the fusion line (FL) of line pipe SAW welds. The further lab investigations have revealed peaks mainly of Mn and Si segregation in FL. The width of the segregation is so fine that an Electron Probe Micro Analysis (EPMA) spot area cannot indicate the real element content in the segregation. But it is deemed high since martensite structure can be revealed.

When the phenomenon occurs, the segregation is present all along the weld but its density may vary such that martensite appears or not.

So far, the metallurgical explanation has not been clarified. But it has been demonstrated that a change of welding flux can prevent the phenomenon from occurring.

Such a type of defect in pipes intended to be used in sour service causes obviously the rejection of the whole production. Therefore, it is imperative to relieve Manufacturer and COMPANY of any doubt concerning this matter before the starting of any production.

2. Testing requirement

2.1 Before starting production

Either a pipe of the order manufactured in advance or a pipe from a previous production with similar characteristics of grade, steel source, chemistry, welding procedure and same consumables wires and flux shall be selected. A sample transverse to weld shall be extracted from each pipe end.

An EPMA shall be performed in the trough weld section with paying particular attention to all FL.

Acceptance criteria: no segregation peak at FL.

A report shall be issued and submitted to Inspector before starting production. The report shall be filed in the production dossier.

2.2 The test shall be re-performed on MPQT pipe: see Appendix 7 item B 17).

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