PTT Exploration and Production Public Company Limited

PTTEP Engineering General Specification

(Engineering and Development Group)

Standard

Seamless 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

This specification defines the COMPANY's requirements for the manufacture and inspection of bare carbon steel pipes. This to be used in the construction of onshore or underwater pipelines and risers, including mother pipes for bends, 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 and 3 in design specification 10008-STD-6-COR-032, PEGS-0842-COR-032)

3.0 SCOPE

It applies to seamless pipes in steel Grade L290Q (X42Q) up to Grade L485Q (X70Q) of API Spec 5L / ISO 3183 (modified) Specification.

This specification shall be used in conjunction with API Spec 5L / ISO 3183 specification and a Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the design conditions of the pipeline project (see section 7.1 in this specification). It takes also into consideration DNV-OS-F101 requirements (see Appendix 5)

Additional requirements specifically stated in this specification for pipes shall be used in pipelines to be laid using the reeling technique. The related pipes shall thus be suitable for cold forming operations involving spooling, un-spooling, straightening and bending.

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 are to be ascertained after the PWHT has been 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.

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.
Contractor	Per contract: Contractor – ‘The contractor who is a PARTY to this CONTRACT and where the context so requires including, SUBCONTRACTORS utilized by CONTRACTOR for the performance of the WORK’
Inspector	The COMPANY’s or Supplier’s representative(s), (as applicable), or member(s) from an Inspection Agency duly appointed by the COMPANY or the Contractor or the Supplier (as applicable) to act as its representative(s) for the purpose of the contract.
Manufacturer	The company or its sub-contractors selected by the COMPANY or the Contractor or the Supplier (as applicable) as the Manufacturer of the said material.

Terminology	Description
Mill	The plants, mills, workshops, laboratories or other locations where the fabrication, inspection and testing of materials and pipes are to be performed complete or in part.
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:

AUT	Automatic Ultrasonic Testing
CE	Carbon Equivalent
CVN	Charpy V-Notch
EMI	Electromagnetic Testing
FSH	Full Screen Height
HAZ	Heat Affected Zone
HIC	Hydrogen Induced Cracking
HT	Heat Treatment
ITP	Inspection and Test Plan
LPI	Liquid Penetrant Inspection
MPI	Magnetic Particle Inspection
MPQT	Manufacturing Procedure Qualification Test
MPS	Manufacturing Procedure Specification
MSYS	Minimum Specified Yield Strength
NDT	Non-Destructive Testing
OD	Outside Diameter
OOR	Out-Of-Roundness
PPS	Project Particular Specification
PWHT	Post Weld Heat Treatment
QA	Quality Assurance
QCP	Quality Control Plan
SD	Standard Deviation
SMYS	Specified Minimum Yield Strength

SSC	Sulphide Stress Cracking
TQ	Technical Query
TS	Tensile Strength
UE	Uniform Elongation
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-GEN-005 , PEGS-12060-ADM-006	Quality Requirements for Contractor / Vendor
10008-STD-6-GEN-007 , PEGS-12060-MMA-001	Material Traceability
10008-STD-6-PLR-008 , PEGS-12059-PLR-004	Induction Bends for Pipelines (Mild, Intermediate and Severe Sour Service)
10008-STD-6-PLR-030 , PEGS-0710-PLR-010	Storage and Transportation of Carbon Steel Line Pipes
10008-STD-6-COR-032 , PEGS-0842-COR-032	Materials for Sour Service

6.2 INTERNATIONAL STANDARDS

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

Document Number	Document Title
ISO 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 11484	Steel products -- Employer's qualification system for non-destructive testing (NDT) personnel
ISO 11699-1	Non-destructive testing – Industrial radiographic film – Part 1: Classification of film systems for industrial radiography
ISO 148-1	Metallic materials – Charpy pendulum impact test – Part 1: Test method
ISO 15156-2	Petroleum and natural gas industries – Materials for use in H_2S-containing environments in oil and gas production - Part 2: Cracking-resistant carbon and low alloy steels, and the use of cast irons
ISO/IEC 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/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 6507-1	Metallic materials – Vickers hardness test - Part 1: Test Method
ISO 6892	Metallic materials – Tensile testing – Method od testing at ambient temperature
ISO 7438	Metallic materials – Bend test

Document Number	Document Title
ISO 7539-2	Corrosion of metals and alloys – Stress corrosion testing – Part 2: Preparation and use of bent-beam specimens
ISO 9712	Non-destructive testing – Qualification and certification of NDT personnel

6.3 CODE AND OTHER STANDARDS

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

Document Number	Document Title
API RP 5L1	Recommended Practice for Railroad Transportation of Line Pipe
API RP 5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
API SPEC 5L	Specification for Line Pipe
API SPEC Q1	Specification for Quality Management System Requirements for Manufacturing Organizations for the Petroleum and Natural Gas Industry
ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E23	Standard Test Methods for Notch Bar Impact Testing of Metallic Materials
ASTM G39	Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens
BS EN 10204	Metallic materials. Types of inspection documents
EFC Publication No.: 16	Guidelines on material requirements for carbon and low alloy steels for H_2S containing environments in oil and gas production
NACE TM0177	Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H2S Environments
NACE TM0284	Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
DNV-OS-F101	Offshore Standard Submarine Pipeline Systems

7.0 SEAMLESS PIPES FOR CARBON STEEL PIPELINES

7.1 PROJECT PARTICULAR SPECIFICATION (PPS)

The following information shall be provided in the PPS:

a) Steel grade

b) Pipe nominal dimensions (OD mm x WT mm)

c) The sour service severity and type of pipeline effluent to clarify the H_2S test conditions (see section 7.4.6.4, 7.4.6.5, Appendix 6 and Appendix 7).

d) The type(s) of pipeline(s) onshore or offshore (applicable particular requirements of strain ageing for onshore)

e) If it is a gas pipeline (for applicable particular requirements for CVN)

f) If Appendix 5 of the present specification: DNV-OS-F101 “Particular Requirements” is applicable.

g) Appendix 5 of the present specification: DNV-OS-F101 “Supplementary Requirement” F, P, D or U is/are applicable.

h) If the line pipes of the pipeline to be laid by the reeling technique (see section 7.4.6.3)

i) If line pipe is subject to fatigue loading (see section 7.4.9.11)

j) Wall thickness particular requirements in section 7.4.9.3.b) and UT covering section 7.6.3.5 in applicable (when automatic UT on girth welds is foreseen).

k) Routine impact test temperature (see section 7.4.6.3 (d) and 7.6.2.2)

l) If welding tests results on similar pipe materials are required

m) If weldability tests are required (see section 7.4.1 and 7.4.6.6)

n) If PWHT test is required (see section 7.4.6.3 (n))

o) If spare bend mother pipes for contingency are to be added to bend order

p) If pipes shorter than 11.60 metres are acceptable (where necessary) (see section 7.4.9.6)

q) If coloured painted band on pipe is maintained or is pending (see section 7.8)

r) If bevel protectors are confirmed (where necessary) (see section 7.9)

s) If histograms are required (see section 7.11.2)

t) Number of originals and copies of Mill certificates and final production report (see section 7.11.2)

u) The required length for cut back coating

v) If a bar code system is required or, otherwise, acceptable

w) The COMPANY / purchaser inspection scope

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

Before the mass production starts, (usually after the pre-production or pre-inspection meeting), the PPS shall be revised to include all the particular production, inspection, testing and qualifications mutually agreed by both pipe Manufacturer and COMPANY. Inspector shall report any further technical agreement, modification, major points, that occurs during the production stage in the PPS.

7.2 QUALITY ASSURANCE/QUALITY CONTROL

1. The Supplier shall operate a Quality Assurance system in accordance with ISO/TS 29001, or equivalent, approved by a COMPANY-recognised authority. The Quality Assurance Manual shall be submitted prior to the start of work and made available to the Inspector at all times.
2. Four weeks prior to the commencement of the pipe manufacture, the Supplier shall prepare and submit a Quality Control Plan, which describes the inspections to be performed during the supply of 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 the procedures agreed by COMPANY or to COMPANY specification requirements. A report shall be issued by the Supplier, signed by the Inspector and enclosed with the final dossier.

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. The Inspector shall ensure that materials and pipes are manufactured in accordance with all the specified requirements and COMPANY's approved procedures.
5. At steel making mills, billet casting mills and pipe mills: offices, workshops, storage yards etc., information on paper and/or in computers (procedures, working instructions, data, records, tracking system, etc.) concerning the manufacturing and inspection of pipes, shall be made fully available and comprehensible to Inspector reading. Where the

mother tongue of the mill country is not English, all informations shall be written in dual language, i.e. mother tongue of the mill country and English language.

6. A free access to the Mill computerised system shall be made available in the Inspector office:
    - Tracking system of production and inspection
    - All data and results of mechanical tests, NDT results
    - Billet 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 exploitation with Microsoft Excel or other agreed formats shall be made available by the Supplier
    - Inspector shall be provided with facilities/equipment for sending and receiving faxes, communicating by e-mails and fast Internet access.
7. Inspection by the Inspector will be carried out during pipe production in order to avoid any special or additional handling and to avoid delay in pipe production insofar as the pipes, which are submitted to him, meet the specified requirements.
8. The Inspector shall finalise (when required) its 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.

The COMPANY and/or Inspector reserves the right to check tests carried out by the Supplier. For this purpose, the COMPANY may request the delivery of the corresponding samples or specimens to be analysed in an independent laboratory with ISO/IEC 17025 accreditation for the required test methods chosen by the COMPANY.

7.4 PIPE MANUFACTURING

7.4.1 GENERAL REQUIREMENTS

1. The pipes shall be manufactured to Product Specification Level 2 (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 matters not specifically mentioned or modified in the present specification.
2. SSC tests and HIC tests are required on a pipe selected by the Inspector at an early production stage (see section 7.4.6.4 and 7.4.6.5) and at production tests (see section 7.6.2).
3. All inspections and tests required for qualification and pipe acceptance shall be performed at the manufacturing Mill or performed externally in a COMPANY approved laboratory.
4. Mother pipes for bends shall be of the same source, same manufacturing procedure and of similar chemical composition as the line pipes, unless otherwise agreed. Any deviations to present specification shall be submitted to the COMPANY (refer to 10008-STD-6-PLR-008, PEGS-12059-PLR-004 for fabrication of induction bends).
5. Pipe production shall not start without the approval of the COMPANY and until a pre-production meeting (or pre-inspection meeting) is held between the COMPANY, the Supplier (and the pipe Manufacturer) and the Inspector.

7.4.2 PROCESS OF MANAUFACTURE

The pipes shall be seamless. They shall be manufactured from billets by the hot rolling process/hot finished process using the Plug Rolling Mill Process or the Mandrel Mill Process. All other processes are not acceptable (e.g. Pilger Mill process, etc.).

7.4.3 STEEL AND BILLET MANUFACTURING PROCEDURE SPECIFICATION (MPS)

1. Steel shall be fully killed and manufactured to fine grain practice. Steel making shall be by the Basic Electric arc Furnace with double deslagging or Basic Oxygen Furnace steel making processes. The steel making process used shall result in the supply of steel pipes with a high resistance to H_2S embrittlement and associated effects. During its manufacture; the base steel shall undergo the following treatments:
   - Vacuum degassing (where possible)
   - Thorough desulphurisation treatment
   - And specific treatment to control size, shape and distribution of oxide and manganese sulphide inclusions (e.g. Ca treatment when S > 0.0015%).

   The COMPANY shall be provided with all ladle analyses (see section 7.4.7 of this specification).

2. Continuous casting process shall be used for billet manufacturing. 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 0.4 m/min. The recording of casting speed shall be made available to Inspector. The Supplier shall give full details about the casting sequences (number of heats, tonnage, scrapping lengths, etc.). Electromagnetic stirring process is preferred.

   Continuous casting machine of fully bent type is not considered as appropriate. Where the Supplier maintains this type of machine, detailed supporting documents, such as technical documentation concerning the implemented particular cares to overcome the inconvenience of a fully bent casting process in terms of inclusion segregations close to the billet/pipe external surface shall be submitted at the bid stage. Supplier shall provide evidence that the process does not affect the final pipe quality. Other relevant documents such as NDT, macro, micro, HIC, etc. reports from past experience shall also be submitted for review.

   All billets shall be visually examined to ensure freedom from injurious surface defects. Billets shall be correctly marked and stored to avoid any confusion between heats of steel (e.g. heat Nº, casting machine and strand Nº, sequential Nº).

3. The Supplier shall provide the COMPANY, at the bid stage, with a Steel and Billet Manufacturing Procedure Specification taking into account the above and giving full details of all the characteristics of the proposed steel, the steel making process, the billet manufacturing process and the related inspection procedures.

   This Supplier's specification shall include the following minimum information concerning the steel making process:

   - Steel producer
   - Steel making process (Electric Furnace or Basic Oxygen Furnace)
   - Killing / refining / de-oxidisation method
   - Special treatments for controlling residual elements and segregations
   - Nominal weight of each heat and number of heats per casting sequence.
   - Aimed chemical analysis, together with minimum and maximum working limits (ladle and product) selected for the order.
   - Type and details of casting machine
   - Aimed Casting speed and production range
   - Electromagnetic stirring, if any

7.4.4 PIPE MANUFACTURING

Pipes furnished to this specification shall be manufactured by the hot rolling seamless process as stated in section 7.4.2 above.

Pipes shall be supplied in Quenched and Tempered Condition. Heat Treatment by induction heating is not permitted. Before quenching, the soaking time at “Ac3” +50°C or higher, shall not be less than 7 minutes.

Microstructure of pipes and mother pipes shall not exhibit banded structure in terms of carbon / carbides minor or major segregation. Micrography (X 100) in longitudinal direction shall be made available to COMPANY Inspector before starting of production. In case of doubt on banded structure, Vickers micro hardness (5 or 10 g) evaluation shall be required.

Pipe shall be sized, straightened and hydrostatically tested. Cold sizing ratio shall not exceed 0.015 %.

The Supplier shall also refer to the provisions of section 7.4.9.11 of this specification for pipe surface condition.

A higher steel grade of API Spec 5L / ISO 3183 shall not be substituted to the grade specified on the Purchase Order or PPS.

7.4.5 PIPE MANUFACTURING PROCEDURE SPECIFICATION (MPS)

The Supplier shall establish a detailed specification for the manufacture and inspection of pipes, describing all proposed operations in their correct sequence together with their parameters of execution. The proposed specification shall include, but not be limited to, all information concerning:

- Billet heating
- Type of Mill process: Plug Rolling Mill or Mandrel Mill process.
- Equipment details for pipe rolling, sizing, straightening
- Parameters for Heat treatments of pipe (heating, quenching, tempering), including soaking time, max time between end of heating and quenching, type and equipment used for quenching (inside, outside quenching), control of water temperature of quenching bath, etc.
- Typical metallographic structure of base metal with supporting documentation, such as microphotographs, grain size, definition of the microstructure, absence of banded structure (refer to section 7.4.4) etc.
- Visual inspection procedure,
- NDT procedures,
- Dimensional inspection procedure with frequencies of execution,
- HIC and SSC test procedures.

The MPS shall mention the characteristics of equipment and tools used to carry out these operations.

The MPS shall, also, detail the system for traceability of heat N°, pipe N°, heat treatment batch, test unit N° and records from all required tests and inspections of each individual pipe.

7.4.6 PIPE MANUFACTURING PROCEDURE QUALIFICATION TEST (MPQT)

7.4.6.1 GENERAL

The MPS shall be qualified as follows.

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 the inspections and tests as described below in order to qualify the pipe manufacturing procedure. The Inspector shall select this pipe. In order to get mechanical test results earlier, a second pipe may be selected during the same shift just after tempering treatment.
2. 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, signed and dated by the Inspector who attended the tests.
3. The Supplier is allowed to proceed with the pipe manufacture without waiting for the test results, as long as the Supplier is accepting the risk and responsibility of the consequences of any test failure, as stated hereafter.
4. 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 Inspector. Manufacture shall resume only after the procedure has been suitably revised to the satisfaction of the Inspector and after a new pipe has successfully completed the qualification tests laid down in this specification.

7.4.6.2 ESSENTIAL VARIABLES (AS PER DNV-OS-F101 MODIFIED AS FOLLOWS)

The following changes to the manufacturing procedure shall require a new qualification:

1. Any change in steel source and steel making practice
2. Any change in steel grade
3. Any change in casting speed exceeding the min-max range of 0.4 m/min
4. Any changes beyond the allowable variation of pipe rolling temperatures
5. Any changes in heat treatment beyond the allowable variation of heating temperature and soaking time and/or quenching process
6. Any change in nominal wall thickness exceeding +5% to -10%
7. Any change in pipe diameter
8. Any change in ladle analysis outside ±0.02% C, ±0.03 CE and/or 0.02% in Pcm, ± 20% in the percent of elements intentionally added
9. Any change in pipe forming / rolling process.
10. Any change in the steel making and pipe manufacturing facilities.

7.4.6.3 DESTRUCTIVE AND NON-DESTRUCTIVE TESTS

The selected pipe shall be visually inspected for compliance with dimensional tolerances for wall thickness, diameters, out-of-roundness, straightness, surface defects, etc. (see section 7.4.9).

Then, the said pipe shall be tested as follows:

- Line pipes for standard laying technique: all following tests, except tests of section (j) through (l),
- Line pipes for reeling technique: all following tests including tests of section (j) through (l),
- Mother pipe for bends: only tests of section (a), (b) and (g).

a) The entire pipe shall be ultrasonically examined for longitudinal, transverse and oblique defects, and laminations. The external and internal pipe surfaces shall be electromagnetically (EMI) examined for longitudinal and transverse defects.

b) A product chemical analysis shall be carried out. At this stage, one cast shall be analysed for residual elements as shown in the notes of Table 1 of Appendix 1. Results shall be in accordance with Table 1 of Appendix 1. However, the ruling composition proposed by Supplier and approved by COMPANY at the bid stage (see section 7.4.3 above) shall prevail that of Table 1.

c) Two tensile specimens (one longitudinal and one transverse to pipe axis) shall be removed from each pipe end. Strip specimens shall be used unless round bar specimens are found more practicable and approved by COMPANY (see section 7.6.2.1).

The Yield and Tensile Strength plus Percentage Elongation shall be determined according to API Spec 5L / ISO 3183. The Yield Strength (YS) to Ultimate Tensile Strength (TS) ratio shall be calculated. All results shall conform to Table 2 of Appendix 2 of this specification. The “Uniform Elongation’’ (UE) on the tensile test in longitudinal direction shall be measured and recorded. The UE shall not be less than 8%.

d) Two sets of three Charpy V-notch specimens shall be removed, one set at each end of the pipe. The specimens shall be cut transverse (for pipe OD equal to or above 4.5") to the pipe axis and the axis of notch shall be per pendicular to pipe surface. Required impact test results are stated in Table 3 of Appendix 2. Where Charpy-V tests are impracticable in the transverse direction, they shall be carried out in the longitudinal direction, with COMPANY prior approval, and, then, the figures to be met for 10 mm x 10 mm specimens shall be those indicated in Table 3 increased by 50% (KVL).

The required impact test temperature (i.e. the so-called routine test temperature) shall be that stated in the PPS, but in no way, this temperature shall be above 0°C.

Test specimens shall be sampled 2 mm below the pipe external surface.

As far as possible, full size specimens (10 x 10 mm) are to be used. If sub-size test specimens are found necessary, to the satisfaction of COMPANY, absorbed energy figures required shall be those for full size specimens (see Appendix 2) multiplied by the corresponding factors given in the following table.

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

Charpy tests are not required for nominal wall thickness less than 6.35 mm. In that case, a check of microstructure and grain size shall be made instead. Grain size of 8 minimum is required.

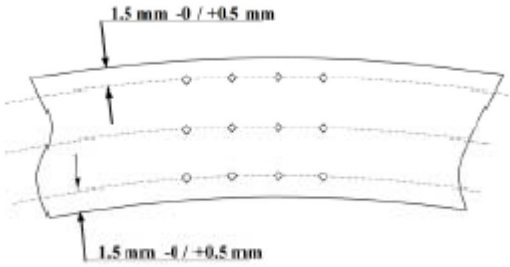
e) Charpy V-notch tests shall be conducted to determine full Charpy energy and shear area transition curves. The tests shall be carried out in the transverse direction (or longitudinal direction, when so agreed for the routine test) at temperatures 10°C and 20°C above and 10°C and 20°C below the routine 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. For pipeline to be laid by the

reeling technique, transition curves (energy and shear) shall be supplied for both the longitudinal and transverse directions.

Size and location of Charpy V-notch specimens shall be as per section d) above.

For WT > 25 mm, the same Charpy V-notch tests, as stated above, shall be repeated at ID. Then the Charpy V-notch specimen location for production tests shall be the one of the above two testing which gives the highest transition temperature.

f) At both ends of the pipe, three cross sections (at 120°) shall be sampled for micrography and hardness. They shall be polished and etched to show the metallurgical microstructure. Photographs of microstructure shall be provided at three locations minimum, namely at mid-thickness and below internal and external surface. No banded structure or untempered bainite or untempered martensite shall be present in the steel microstructure. On each section, Vickers 10 kg Hardness measurements shall be carried out (see sketch below). Hardness shall not exceed 220 HV10. In case of doubt on "banded structure", Vickers microhardness (5 or 10g) evaluation shall be required.



g) Micrography using a longitudiual specimen is required. One specimen of 30 mm long in the rolling direction shall be extracted. It shall be properly polished and etched. It shall be examined at 5 mm from the external surface, at 1mm from internal surface and at mid thickness, every 10 mm in the rolling direction, with a magnification of X 100. The microstructure shall not show any banded structure in terms of bands of minor or major segregation of carbon/carbides components. Photomicrography and interpretation of micrography shall be provided.

h) Vickers 10 kg Hardness measurements shall be carried out on pipe external surface (where a slight grinding or machining may be made) at each pipe end and at ¼, ½ and ¾ length of pipe (two readings per location). Hardness shall not exceed 220 HV10

i) The pipe wall thickness shall be measured using ultrasonics in three longitudinal planes displaced by 90°. The measurements shall be carried out at minimum intervals of one metre along the pipe length.

At Mill's option, wall thickness may be measured by automatic ultrasonic tester examining spirally the pipe with a minimum coverage of 20% of the pipe body area.

Recordings shall be made available to the Inspector at the Mill. The minimum required wall thickness shall be met all locations of the pipe.

j) (For reeling technique only) One bend test specimen shall be removed from each pipe end. The bend test specimens shall be cut longitudinally to the pipe axis and shall include the full wall thickness of the pipe. It shall be bent through 180 degrees using a plunger with maximum diameter of four times the specimen wall thickness. A Liquid Penetrant Inspection (LPI) shall be performed on the whole bent area. There shall be no cracks on the outside surface of the bent portion of the specimen.

k) (For reeling technique only) a ring-flattening test is requested. A section of pipe not less than 100 mm in length shall be flattened cold between parallel plates without cracks or breaks on the inside or outside pipe surface, until the distance between the plates is less than the value H calculated by following formula:

$$H = \frac{(1+C)\,x\,t}{C + t/d}$$

C Constant = 0.1

H Distance between parallel plates in mm

t Specified nominal wall thickness of the pipe in mm

d Specified outside diameter of the pipe in mm

l) (For reeling technique only) Mechanical testing (as stated here – below) shall be performed on specimens cut from a pipeline spool subjected to a full scale-bending test simulating the successive bending of pipeline from first spooling to final laying. The bending scheme and equipment shall be mutually agreed with the COMPANY. The plastic strain shall be, at least, equal to the plastic strain introduced during installation and service.

The installation Contractor shall submit to COMPANY for approval, a procedure for locating the maximum straining on the spool.

Then, all testing specimens shall be extracted from this maximum strained area.

The mechanical tests shall be carried out on specimens before straining and after straining and ageing. Ageing shall be 250°C for one hour.

The tests shall include:

- Longitudinal tensile testing
- Hardness testing
- Charpy V notch testing on specimens cut longitudinally at routine test temperature.

Full Charpy energy and shear area transition curves shall be carried out in the strained condition and in the strained plus aged condition at temperatures 10°C and 20°C above and 10°C and 20°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 test temperature will be for information only, but the transition temperature shall not be higher than the specified routine test temperature.

The following requirements shall be met after straining and ageing (specimens before straining shall meet what is required in the other sections of the present specification).

- Yield strength, tensile strength and Charpy V notch shall meet the requirements of Appendix 2
- The uniform elongation shall be 6% minimum
- The YS to TS ratio shall be recorded for information only
- The hardness requirements shall not exceed 250 HV10

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

m) HIC and SSC tests shall be as per 5.4.6.4 & 5.4.6.5 here after.

n) Post Weld Heat Treatment tests, when required in PPS and in all cases for pipes of topside riser, and jacket risers when WT > 25 mm, tensile tests (as per section 7.4.6.3 c above) and Charpy-V notch impact tests (as per section 7.4.6.3 d and e above) shall be repeated after a simulated Post Weld Heat Treatment (PWHT) is made. These tests shall also be acceptance tests. PWHT procedure shall be mutually agreed (basically, soaking temperature of 600°C for one hour per 25 mm WT). The PWHT procedure shall comply with Appendix C, G400 of DNV-OS-F101 and shall be approved by COMPANY.

7.4.6.4 SSC TESTS

SSC tests as per Appendix 6 shall be carried out in pipe material of MPQT pipe for 720 hours. Production tests shall then be carried out at ¼ th, ½ th, ¾ th and end of pipe production, still according to provisions of Appendix 6, except that test duration shall be 360 hours only (15 days).

In case of reeling, SSC tests shall be performed before and after reeling simulation described in test of section 7.4.6.3 l.

SSC shall be sampled as per Appendix 6 at compression and extension areas (intrados and extrados).

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

SSC tests are not required for Mild Sour Service (Region 1).

7.4.6.5 HIC TESTS

HIC tests shall be carried out using uncoated specimens on one test pipe from each of the first three heats (i.e. three test pipes) and then at a frequency of one test per 10 heats or part thereof. The pipe selected for MPQT shall be one of the three tested pipes. The procedure for determining HIC sensitivity and acceptance criteria shall be in accordance with Appendix 7.

In case of reeling, HIC tests shall be performed before and after reeling simulation described in test of section 7.4.6.3 l.

HIC shall be sampled as per Appendix 7 at compression and extension areas (intrados and extrados).

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

HIC tests are not required for Mild Sour Service (i.e. for Region 1).

7.4.6.6 WELDABILITY TESTS

When so required in the PPS, one test shall be conducted per steel grade, pipe size and steel source on pipes produced at an early production stage.

The tests shall be carried out in accordance with Appendix 4.

When weldability tests are not required in the PPS, then the Supplier may be requested to 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, weldability test results from previous orders, welding recommendations, etc.

7.4.6.7 TEST FAILURE

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 Inspector. Manufacture shall resume only after the procedure has been suitably revised to the satisfaction of the Inspector and after a new pipe has successfully passed the qualification tests laid down in this specification.

7.4.7 CHEMICAL PROPERTIES

All pipes supplied shall be made from steel, which is to have a chemical composition ensuring proper ductility, strength, toughness and weldability with all conventional welding processes and techniques used on lay-barges or on onshore installation works, where applicable.

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

Ladle and Product analyses shall meet the requirements contained in Table 1 of Appendix 1. However, the ruling composition shall be that proposed by Supplier and approved by COMPANY at the bid stage (see section 7.4.3 above).

Number, type, location, and frequency of tests shall be as defined under section 7.6.2.

7.4.8 MECHANICAL PROPERTIES

The supplied pipes shall meet the requirements stated in Table 2 and Table 3 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 section 7.6.2.

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

7.4.9 DIMENSIONAL, WEIGHT AND SURFACE CONDITION

7.4.9.1 GENERAL

The following requirements shall be met on each finished pipe.

Dimensional checks and measurements/recordings shall be as stated in section 7.4.9.12 hereafter.

Note on definitions:

- “Checking” means that inspection consists to verify that the said dimension in 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.

7.4.9.2 DIAMETERS

a) Dimensional tolerance on inside diameter at pipe ends shall conform to the following tolerances against the nominal inside diameter at any location within 100 mm from either pipe end.

- ± 1.6 mm for OD ≤ 12”
- ± 2.0 mm for OD > 12”, with W.T. ≤ 20 mm
- ± 2.2 mm for OD > 12”, with W.T. > 20 mm.

Nominal ID = nominal OD - 2 x nominal WT.

Internal diameter shall be checked by internal circumferential tape (or diameter tape) or go-no-go gauge. Measurement shall be made using an internal diameter tape as above or a rod gauge. When a rod gauge is used, 4 equispaced diameters minimum shall be measured and the average value shall give the measured ID.

b) Dimensional tolerances on outside diameter of the pipe body shall not exceed ± 0.50% of the specified nominal outside diameter. Measurement of outside diameter to be made using a calliper or limit gauge.

7.4.9.3 WALL THICKNESS

a) Minimum Wall Thickness Guarantee

Wall thickness shall be controlled over the full pipe length (i.e. including pipe ends) by continuously operating measuring devices and shall cover at least 25% of full pipe surface.

The tolerance against the specified nominal wall thickness “t” shall be (acc. to DNV-OS-F101):

- For t < 25 mm:
  - -10%, +15%
- For t > 25 mm:
  - +0.1t or +3.7 mm (whichever is greater)
  - -0.1t or -3.0 mm (whichever is greater)

b) Particular requirement

When so required in the PPS, the wall thickness shall be automatically measured over 100 mm of each pipe end on the whole circumference area. The minimum and the maximum values found at each end shall be recorded and traceable concerning pipe number and pipe end side.

The accuracy of measurements and records shall be of 0.1 mm, (for example: 17.2 mm; 20.6 mm. etc.).

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 Microsoft Excel or other agreed formats.

The standard deviation (Sd) of wall thickness records for all measurements results irrespectively of the pipe number shall be calculated. Sd shall be conventionally calculated as follows:

Sd = (w.t. max - w.t. min) / 6.

The following data shall be transmitted to COMPANY and Contractor within 5 working days after the automatic measurement has been carried out on all pipes:

- w.t. maximum
- w.t. minimum
- w.t. mean value (M)
- Sd value
- The pipe(s) number(s) and end side(s) with w. t. = M + 2 Sd
- The pipe(s) number(s) and end side(s) with w. t. = M - 2 Sd.

7.4.9.4 WEIGHT

Each length of pipe in size 5.563” and larger shall be weighed individually. The nominal weight of each pipe joint shall be calculated either in accordance with clause 9.11.1.2 of API 5L / ISO 3183. The tolerance on weight of single joints of pipe shall be +10%, -3.5% of the nominal weight.

7.4.9.5 OUT-OF-ROUNDNESS

a) The difference between maximum outside diameter and minimum outside diameter checked within 100 mm at each pipe end using an external ring gauge or calliper, or limit gauge shall not exceed 1% of the specified nominal outside diameter.

b) Out-of-roundness (OOR) at pipe ends shall also be checked using an internal ring gauge of diameter 3.2 mm less than the nominal Internal Diameter for WT ≤ 25 mm and 4 mm less than the nominal internal diameter for WT > 25 mm. This gauge shall pass freely 100 mm into each end of the pipe when held normal to the pipe axis.

   A caliper gauge or rod gauge may also be used if actual major and minor inside diameters of pipe shall be measured. In that case, the permitted allowance shall be the same as for internal ring gauge above.

7.4.9.6 UNIT LENGTH

a) Pipes shall be supplied in lengths of 12.20 m ± 0.60 m and the average length of each item of the order shall be 12.00 m minimum. However, when so permitted in the PPS, 5% of the pipes may have an individual length between 9.00 m and 11.59 m, always providing that the average length of each item of the order is 12.00 m minimum. All pipe lengths shall be recorded.

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

7.4.9.7 STRAIGHTNESS

The deviation from a straight line (taut wire) shall not exceed:

- Maximum deviation over total pipe length shall not exceed 0.15%
- 3 mm on last metre checked by a reference straight line

Straightness checking and recording shall be carried out as per section 7.4.9.12.

The taut wire shall be positioned at 3 or 9 O'clock.

When necessary, cold straightening is allowed if the resulting permanent straining does not exceed 1.0%.

7.4.9.8 SQUARENESS OF PIPE ENDS

The pipe ends shall be cut perpendicular to the pipe longitudinal axis within 1.6 mm across any diameter.

7.4.9.9 PIPE END PREPARATION

Pipes shall be furnished with both ends bevelled to an angle of 30° +5°, -0° with a root face of 1.6 mm ± 0.8 mm. Bevelling shall be carried out by straight machining only. Internal taper is allowable, always providing that it does not exceed 1 in 7 (when measured in the pipe longitudinal axis, from base of root face to inside surface of pipe) and that radial height of taper does not exceed 2 mm, at any location around pipe end. When internal taper is intended to be machined, Supplier shall submit to COMPANY, a procedure for the checking of the remaining wall thickness at pipe ends after machining.

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

7.4.9.10 BULGES, DENTS AND FLAT AREAS

On the pipe body, deviations from the original contour of the pipe shall not exceed 3 mm depth, nor shall they extend in any direction greater than 1/3 of the diameter of the pipe. Any sharp bottom dents shall not be acceptable.

At pipe ends, bulges, dents and flat areas shall not be acceptable.

7.4.9.11 SURFACE CONDITION

Pipes shall be free from unacceptable imperfections and shall have a workmanlike finish.

Pipe surface must be substantially free from loose mill scales, scabs, pits, scores and laps as well as un-repaired tears, raised slivers, bristles of steel, sharp notches, scratches or mechanical marks.

Minor indications may be removed by grinding if a smooth curved surface is maintained and that the wall thickness is not decreased below the specified minimum. Pipes shall be re-checked on same type of NDT equipment to confirm indication has been removed.

- For line pipe not subject to fatigue loading, imperfections having a depth greater than 5% of the specified nominal wall thickness shall be considered unacceptable. ‘
- For line pipe subject to fatigue loading, any indication exceeding 0.4 mm indications in depth shall be considered unacceptable.

7.4.9.12 FREQUENCY OF INSPECTIONS

Checks and measurements/recordings shall be made at the frequencies stated in the following table:

	Minimum Frequency Check	Minimum Frequency Measurement/Recording
• ID, inside OOR	All pipes	20/shift
• WT	All pipes	All pipes
• Unit length, unit weight	All pipes	All pipes
• OD, outside OOR	3/shift	3/shift
• Straightness	All pipes (visual)	3/shift
• Squareness	3/shift	-
• Bevel	3/shift	3/shift
• Bulges, dents, flat areas	All pipes (visual)	All pipes with anomaly
• Surface condition	All pipes (visual)	WT by UT on ground areas (except for cosmetic grinding)
• Magnetism	3/shift	3/shift

7.5 MILL HYDROSTATIC TESTING

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

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

P Hydrostatic test pressure in bar

S Minimum Specified Yield Strength in N/mm^2 or MPa (as per Table 2 of Appendix 2)

t Specified nominal wall thickness in mm

D Specified Nominal outside diameter in mm

2. When DNV-OS-F101 is applicable, formula of section 7 § E102 of this Code shall apply to determine the test pressure.
3. Ram Additional Compressive stress: an appropriate calculation shall be produced by the Supplier to prove that the actual hoop stress in the tested pipe is equal to 90% minimum of MSYS 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
4. The test configuration shall permit bleeding of trapped air prior to pressurisation of pipe. The equipment shall be capable of registering a pressure drop of minimum 2% of the applied pressure (DNV-OS-F101, sec. 7, E100).
5. The test pressure shall be held for a duration of not less than 10 seconds for each pipe.
6. A certificate of calibration established less than 12 months before the pipe fabrication, by a recognised authority, shall be provided by the Supplier for the master gauge (or dead weight gauge). 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.
7. 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.
8. A Mill hydrostatic test certificate of compliance giving Mill hydrostatic test requirements (test pressure and duration) shall be established by the Supplier and furnished and filed in the final documentation. 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.

7.6 INSPECTION AND TESTING

7.6.1 GENERAL REQUIREMENTS

1. The production preventive measures and the inspections required in the present specification are stated as a minimum. The Supplier shall be responsible for the conformity of its supply to all requirements of this specification in terms of characteristics and soundness. The Supplier shall take all necessary measures such as additional inspections, metallurgical investigations, etc. and extend the inspection scope as required to ascertain the quality of the pipe. In addition, the Supplier shall also ensure the use of suitable means, devices and qualified personnel, for permanent and effective control at each stage of the manufacturing.

2. The Supplier shall develop a Quality Control Plan 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 feed back 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 manufacturing, their reports shall be constantly updated. These reports shall be made available for consultation by the Inspector at any time.

5. If during the main production, more than 10% 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 the defective quality are identified and eliminated. Where above rate attains 15%, 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 with Supplier

6. Only pipes fully meeting the requirements of this specification shall be presented to the Inspector for final acceptance.

   The Supplier shall provide reasonable office space and inspection facilities, as required by the Inspector, in the Mill. Free access shall be allowed to him, at all times, during manufacture and testing. A suitable working area shall be reserved for him at the end of the production line or at any other agreed location so that he may carry out his own inspections on the finished pipes.

   See also the provisions of section 7.3 of this specification.

7. All visual inspection, dimensional inspection and Non-Destructive inspection procedures shall have prior approval of the Inspector and shall be subject to qualification tests 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 review shall be carried out at the very start of production, to implement the approved written procedure in the presence of the Mill QA/QC representative and of the Inspector. The Inspector and the Mill QA/QC representative(s) shall ensure that:

(a) Relevant work instructions are complete and correct

(b) Procedures has been implemented satisfactorily

(c) Work environment (e.g. lighting, access ways) is suitable

(d) Correct tools and equipment are available and conveniently located

(e) Procedure is fully efficient for the inspection purpose in view of specification requirements

(f) Recording and traceability are satisfactory.

8. All Non-Destructive inspection personnel shall be properly certified according to CSWIP scheme or ISO 9712, or equivalent COMPANY approved Std (ASNT ‘’in- house’’ qualification is not acceptable, only qualification by an approved third party may be accepted). The Inspector before any involvement on the order shall have also reviewed them. NDT operators shall be certified level 2, as a minimum. The Supplier shall provide the Inspector with a list of inspection personnel working on the job, showing their scope of qualification and date(s) of qualifications.
9. Heat treatment charts of pipes shall be made available to the Inspector for review at Mill.

7.6.2 PRODUCTION TESTS

Finished pipes shall be submitted for production tests and inspections as defined below.

The Inspector reserves the right to select the pipes to be tested and to witness the laboratory tests.

The Inspector reserves the right to witness the test coupon sampling and to stamp it. His stamp shall be maintained traceable up to the testing.

Production tests may be sampled before pipe heat treatment subject to approval.

7.6.2.1 TENSILE TEST

One tensile test specimen (as per ISO 6892 or ASTM A370) using the proportional type gauge shall be removed from one end of the selected pipe. The test shall be transverse to pipe axis for OD equal to or greater than 8⅝”. Strip specimens shall be used for longitudinal and transverse tests. Round bar specimens may be used, when practicable, for transverse tensile tests. Sizing of round bar specimen shall be according to API Spec 5L / ISO 3183 Table 21. The test shall include Yield Strength, Tensile Strength, Elongation and Uniform Elongation (>8%). The Yield Strength to Tensile Strength ratio shall also be reported. Test results shall meet the requirements of Table 2 in Appendix 2.

7.6.2.2 IMPACT TEST (CHARPY V-NOTCH TEST)

One impact test (i.e. one set of three specimens) shall be cut at one end of the selected pipe.

When WT > 25 mm, the specimen location in the pipe wall shall be as specified in the above section 7.4.6.3 (e).

Test shall conform to ISO 148-1 all provisions contained in section 7.4.6.3 (d) of this specification and requirements (if any) of the PPS. Testing to ASTM A370 is acceptable only if agreed.

The test specimens shall be sampled 2 mm max from outer surface.

Full size test specimens shall be used whenever possible, otherwise Table 22 of API Spec 5L / ISO 3183 shall apply.

The routine test temperature shall be stated in the PPS.

Charpy tests are not required for nominal wall thickness less than 6.35 mm. In that case, a check of microstructure and grain size shall be made instead. Grain size of 8 minimum is required.

7.6.2.3 HARDNESS TEST

Vickers 10 kg hardness measurements shall be carried out as per section 7.4.6.3 (h). The readings shall not exceed 220 HV10.

7.6.2.4 MICROGRAPHY

One specimen of 30 mm long shall be extracted and tested as per section 7.4.6.3 (g). The microstructure shall not show any banded structure in terms of bands of minor or major segregation of carbon/carbides components.

7.6.2.5 CHEMICAL ANALYSIS

A product analysis shall be carried out on both the selected pipe and on another pipe from the same cast.

All results shall comply with the requirements of Table 1 of Appendix 1 for all specified elements and contents (plus all other intentionally added elements), as well as for the Carbon Equivalent (CE) and Pcm. However, the ruling composition proposed by Supplier and approved by COMPANY at the bid stage (see section 7.4.3 above) shall prevail over that of Table 1.

The sampling and testing shall be in accordance with API Spec 5L / ISO 3183…

Note: As said in section 7.4.7 here above, a ladle analysis shall be carried out for each cast of steel used in the manufacture of the pipes supplied in the order. The results shall be shown on all documentations/certificates covering the related cast of steel.

7.6.2.6 FREQUENCY OF PRODUCTION TESTS

The above production tests shall be carried out on one finished pipe selected from each lot of produced pipes as defined hereafter; except chemical analysis, which is to be made on two pipes per cast:

- OD less than or equal to 4½" : 200 pipes
- OD less than or equal to 16" : 100 pipes
- OD above 16" : 50 pipes

A lot includes only pipes of a same size and coming from a same cast. Any fraction of a lot shall be subjected to full testing.

Tests on mother pipes for bends shall include only micrography and chemical analysis here-above, unless these tests are made by the bend manufacturer.

7.6.2.7 RETESTS

Where one specimen fails to conform to the specified requirements, a retest on four (4) additional pipes from the same lot/cast 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 may be rejected unless each of the remaining pipes of the said lot is tested individually. The pipes, which gave acceptable results according to this specification, will not be rejected.

Note: Re-heat treatment of pipe is acceptable. However, no more than two additional heat treatments shall be permitted (in case of quenched and tempered pipes, heat treatment means both quenching plus tempering).

7.6.2.8 DEFECTIVE SPECIMENS

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

If any test specimen fails due to some defect in the material, another test specimen with prior approval of the Inspector may substitute it. The nature of the defect shall be made clear and the Inspector shall specify additional non-destructive testing to ensure that the defect is an isolated case.

7.6.2.9 SSC AND HIC TESTS

SSC and HIC tests shall be made as production tests as stated in section 7.4.6.4 and 7.4.6.5 of present specification.

In the event of failure to meet the acceptance criteria, the COMPANY may accept to have four pipes of the same heat retested. If a retest 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 the Inspector.

7.6.3 VISUAL AND NON-DESTRUCTIVE TESTS (NDT)

7.6.3.1 VISUAL EXAMINATION

Visual examination of the entire inside (as far as possible) and outside pipe surfaces shall be carried out on each pipe.

Refer to requirements in section 7.4.9.11 of this specification.

7.6.3.2 AUTOMATIC ULTRASONIC TESTING (AUT)

The Supplier shall produce the ultrasonic procedures (automatic and manual) he intends to use, including the equipment capabilities, the reference standards for calibration of sensitivity, and the acceptance criteria. These procedures shall be submitted at bid stage and shall be subject to qualification tests prior to production start.

Each finished pipe shall be 100% inspected along its entire surface area by automatic ultrasonic testing in accordance with Appendix 3. All pipe ends not scanned by the full automatic technique as above shall be either cropped or inspected by manual or semi-automatic ultrasonic examination. The length(s) of this dead zone at pipe ends shall be clearly defined by Supplier in its UT procedure. Manual UT may be replaced by MPI only for WT below 5 mm.

The entire pipe shall be ultrasonically examined for longitudinal and transverse defects including laminations. For offshore pipeline application, the entire pipe shall be also ultrasonically examined for oblique defects (in regard to parallel to rolling direction).

The inspection above shall be efficient in detecting defects, whatever they are located within the pipe thickness or at pipe internal or external surfaces.

Alternatively, when nominal wall thickness of pipes is less than 5 mm, these pipes may be inspected by the flux leakage method, if COMPANY approves the related inspection procedure at the bid stage. However, scanning for laminations shall be maintained.

7.6.3.3 ELECTROMAGNETIC TESTING (EMI)

The Supplier shall submit the procedure to use for electromagnetic testing (in addition to ultrasonic testing) on the full length of pipes for the detection of defects on the internal and external surfaces of the pipes (defects oriented in the axial direction and in the circumferential direction).

The Supplier shall supply the COMPANY with the equipment specifications, its location in the production line, the inspection procedure and the reference standards for calibration of sensitivity (Internal and external machined notches in the reference standard shall have a maximum depth of 5% of nominal wall thickness with a maximum of 1.5 mm and a minimum of 0.3 mm).

Both ultrasonic testing and electromagnetic testing are required.

7.6.3.4 MAGNETIC PARTICLE INSPECTION (MPI)

All bevel surfaces shall be checked by MPI using the wet method. The sensitivity of the method shall be checked using a recognised calibration block or using a pipe containing appropriate defects, to the satisfaction of the Inspector.

7.6.3.5 ACCEPTANCE CRITERIA

a) Defects (other than laminations)

- Any imperfection detected by AUT or by EMI shall be considered an unacceptable defect.
- After grinding repair, if any, the pipe shall be re-inspected by the same method, which had detected the original defect
- Unless due to lack of coupling or a failure occurs in the testing process/equipment during a pipe scanning, re-running inspection without pipe repair is not allowed and only two cycles of repair/re-inspection is allowed.

b) Laminations

The size of any lamination shall not exceed 5 mm x 10 mm (or 60 mm^2 whichever is larger) within 50 mm of pipe ends, and 6 mm x 12 mm (or 80 mm^2 whichever is larger) in pipe body, measured as circumferential x longitudinal/oblique, as applicable. The band of 50 mm at ends is extended to 100 mm when AUT on pipe laying girth welds is foreseen, refer to PPS when section 7.4.9.3 (b) is applicable.

c) AUT and EMI traceability and recording: The pipe NDT inspections shall remain fully recorded and traceable even after the order completion. As a minimum, the record of for AUT and EMI shall contain the pipe identification (pipe N°), even for those rejected, the first inspection result and, where any, the re-inspection run(s) result(s).

d) No imperfections shall be permitted on the bevel surface. Bevel shall be smooth.

e) The wall thickness shall be maintained as per requirements of section 7.4.9.3.

7.6.4 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 three pipes checked per shift, using a calibrated Hall effect gauss-meter, or other equipment provided that calibration procedure is demonstrated and approved by the Inspector.

7.6.5 MILL CERTIFICATES

Mill test certificates shall be Type 3.2 according to BS EN 10204. Mill certificates shall be issued by the pipe Manufacturer and signed, dated and stamped by the Inspector (refer to section 7.11.2).

Mill certificates shall refer to API Spec 5L / ISO 3183 together with the present COMPANY specification and applicable PPS.

Mill certificates shall state the following:

- As-delivery condition of pipes with heat treatment conditions
- Ladle analysis including Carbon Equivalent and Pcm
- Pipe number with reference to heat number (and billet number where possible)
- Mechanical test results and product chemical analysis (including CE and Pcm) with reference to pipe N^{o}.
- Results of dimensional inspections
- Non-destructive tests performed with results
- Results of H_2S embrittlement tests
- Any supplementary tests and inspections carried out.

7.7 REPAIR OF DEFECTS

Repair by welding on pipe base metal shall not be permitted.

Defects shall only be removed by grinding if the wall thickness is not reduced locally below the minimum specified wall thickness.

After grinding the pipe shall be inspected by the process, which detected the defect (UT or EMI), completed by wet MPI, to ensure that the defect is completely removed and that the repair is acceptable. Wall thickness measurements shall be made in the ground areas, except for cosmetic grindings.

Rectification of bevels shall be made by full re-machining only.

7.8 MARKING OF PIPES

1. Each pipe shall be clearly identified by means of markings made with indelible white paint, and a circumferential coloured painted band on the external surface of one pipe end. The colour shall be defined in the PPS or otherwise agreed with the Supplier.
2. The quality of paint employed and its application shall be designed to provide markings that shall be perfectly readable for at least three months on pipes exposed to outdoor weather conditions.
3. Marking (paint stencilling) shall begin at least 75 mm from the bevel. It shall be made at inside of pipe and circumferentially for OD ≥ 14”, otherwise, it shall be made on pipe outside surface.

   Letters and figures shall be min. 15 mm in height at pipe inside and 25 mm at pipe outside.

   Metric units shall be used to state pipe length and wall thickness.

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

   Marking shall be protected by a clear varnish.
4. Unique pipe numbers shall be allocated sequentially and marked on the pipes.
5. Marking may be made in a sequence convenient to the pipe Manufacturer and shall include the following minimum information.

   a) At one pipe end (full stencilling):

      - COMPANY’s name
      - Purchase Order Nº
      - Steel Grade
      - OD x WT
      - Heat number
      - Pipe number
      - Pipe length
      - Brand mark / logo of Mill.

   b) At the second pipe end (reduced stencilling) for offshore pipelines when OD ≥ 14”:

      - Pipe number
      - Pipe length.
6. The following shall be die stamped on the bevel surface at the end where full stencilling as above has been made:

- The mark of the Inspector
- The pipe number.

7. The Inspector shall approve the marking prior to pipe production.

7.9 PROTECTION OF BEVELS

All bevelled pipes shall be fitted with bevel protectors or end caps of the liftable type, unless otherwise stated in the PPS. The Supplier shall submit bevel protectors to the COMPANY with full details at the bid stage.

7.10 HANDLING, TRANSPORT AND STORAGE OF PIPES

7.10.1 GENERAL

The COMPANY specification 10008-STD-6-PLR-030, PEGS-0710-PLR-010 shall apply.

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 to prevent stresses which 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, provided that those operations are within the scope of the Supplier.

7.10.2 HANDLING AND STORAGE

All handling shall be performed with slings, pipe-shaped padded hooks or magnet cranes equipped with demagnetisation unit, approved by the Inspector.

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

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.

7.10.3 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 Supplier's procedure approved by the COMPANY. Rails cars, trucks, ships or other conveyances shall be cleaned of debris or any substances that might damage the pipes. Suitable timber and other dunnage shall be used to protect the pipes against damage during transit.

7.11 DOCUMENTATION

The following minimum documentation shall be delivered by the Supplier.

7.11.1 WHEN THE BIDS ARE SUBMITTED

- Name of billet manufacturer and mill
- Steel making process (electric furnace or Basic Oxygen Furnace)
- Nominal weight of each heat
- Billet casting method and weight
- Aimed chemical composition, together with minimum and maximum working limits (ladle and check chemical analysis of base steel) which are selected and guaranteed by Supplier for the order
- As-delivery condition of pipe base steel (quench and tempered), typical metallurgical microstructure and grain size
- Name of pipe Manufacturer and Mill
- A preliminary pipe Manufacturing Procedure Specification (MPS), which includes the main features of manufacturing process, heat treatment, dimensional and non-destructive testing procedures, including automatic UT procedure and electromagnetic testing procedure.
- Unit length of pipes offered, if different from that specified in section 7.4.9.6 (when applicable)
- Location of paint stencilling (on inside or outside of pipe)
- Quality Control Plan (preliminary)
- The nominated laboratory for conducting the H_2S embrittlement tests
- SSC and HIC test procedures (preliminary)
- Past experiences of Supplier and laboratory on HIC and SSC tests as per this specification (including the laboratory's typical procedures)
- Valid Quality Assurance certifications (ISO/TS 29001, API SPEC Q1, etc.)
- Details of offered fabrication Pipe History System (PHS),
- Weldability test specification (when applicable)
- Pipe supply track record as well as histograms of chemical and mechanical test results from previous orders of the same pipe grade and similar dimensions, as proof of capability to produce pipes according to this specification
- At Supplier's option, any other technical information related to the proposed pipe supply
- Description of the proposed bevel protectors (if any)

- The Supplier's deviations / qualifications to present specification. Where no deviations are stated in the bid, the potential Supplier shall be considered as fully accepting the requirements of present specification.

7.11.2 UPON COMPLETION OF PIPE PRODUCTION

A closeout production report, which shall include, but not be limited to, the updated information and documents stated hereafter:

- Steel making process and billet manufacturing procedure specification (MPS)
- Pipe Manufacturing Procedure Specification (MPS)
- Quality Control Plan or Inspection and Test Plan
- Record of pipe Manufacturing Procedure Qualification Test results
- HIC and SSC specifications and test reports
- Weldability test specification and reports, if any
- Mill hydrostatic test certificate of compliance
- Mill certificates of pipes
- Dimensional and NDT reports of pipes
- Records of NDT procedure qualifications
- Any other quality control reports or acceptance certificates
- List of cast numbers showing pipe numbers, individual length and weight, total length and weight produced per cast
- Pipe list with sequential numbers of produced pipes related to cast numbers
- Records of wall thickness as specified in section 7.4.9.3 (b)
- Histograms of production test results (chemical and mechanical tests) and dimensions of pipes (length, as a minimum - if required in PPS),
- Pipe Fabrication History
- Compilation of all concessions / deviations, if any, granted by COMPANY.

The PPS shall state the number of originals and copies of the Mill certificates and production report, which are to be supplied to the COMPANY.

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

7.11.3 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 immediately after completion of pipe production. The latest date of submission of this report shall be three weeks maximum after dispatch of the pipes.

7.12 STORAGE OF MECHANICAL TEST SPECIMENS

Qualification test and Production test specimens (including remaining parts of tested pipe rings) shall be properly identified, stored and made available to the COMPANY during the whole Contract processing time.

The end of Contract processing time shall be considered as when all pipes have been released and when related documentation has been delivered by Supplier and approved by COMPANY.

Those test pieces and materials may be used for any futher investigation or counter tests as addressed in this present specification.

7.13 PIPE FABRICATION HISTORY SYSTEM (PHS)

The Supplier shall provide a computerised pipe fabrication history using Microsoft Excel Software or other alternative means. Such a computer program will provide the minimum following information (unless otherwise detailed in the PPS):

- For each pipe number: Grade, OD, WT, Length, Weight, CE/Pcm with reference to heat number, mechanical properties (with reference to test N^{o} and Mill certificate)
- For each heat number: chemical analysis, individual weight, length of accepted pipes, pipe N^{o}

Full description of existing or proposed program will be provided by the Supplier with the possible means of transmitting data (DVD, potable hard drive, etc.).

7.14 TECHNICAL QUERIES/NON-CONFORMANCE REPORTS

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

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

(2) Approval given by the COMPANY specialist 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.

Any work performance or test results, which is found, 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 the submitted corrective action intended by the Supplier

8.0 APPENDICES

Appendix 1. Chemical Composition

Table 1 - Chemical composition

Chemical Element (see note 1)	Grades L290Q (X42Q) up to L485Q (X70Q) Ladle/Check Analysis % weight max.
C	0.13/0.14
Mn	1.25/1.40
Si	0.45/0.50
Al total (see note 2)	0.060/0.060
Ca	0.006/0.006
S	0.002/0.002
P	0.020/0.025
Nb	0.05/0.05
V	0.08/0.08
V + Nb	0.10/0.10
Ni	0.30/0.30
Cr	0.20/0.20
Cu	0.10/0.10
Mo	0.25/0.25
Ti	0.04/0.04
N (see note 2)	0.010/0.012
CE (see note 3)	0.38/0.39
Pcm (see note 4)	0.21/0.22

Notes:

1) The intentional addition of elements not specified in Table 1 above shall not be permitted without prior approval of the COMPANY.

   The maximum working percentages of residual elements shall be as follows (ladle and product check):

   Sn = 0.015% As = 0.015%

   Sb = 0.010% B = 0.0005% (no intentional addition)

   Bi = 0.005%

   Pb = 0.005%

2) Total aluminium to nitrogen ratio (Al/N) shall be at least 2.

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

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

Appendix 2. Tensile and Impact Properties

Table 2 - Tensile properties of base metal

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

Grade	YS Mpa (psi)		TS Mpa (psi)		YS/TS max.	El % min.
	min.	max.	min.	max.		
L290Q or X42Q	290 (42 100)	415 (60 200)	415 (60 200)	760 (110 200)	0.85	As per API Spec 5L/ ISO 3183
L320Q or X46Q	320 (46 400)	441 (64 000)	435 (63 100)	760 (110 200)	0.85	
L360Q or X52Q	360 (52 200)	483 (70 000)	460 (66 700)	760 (110 200)	0.85	
L415Q orX60Q	415 (60 200)	538 (78 000)	520 (75 400)	760 (110 200)	0.88	
L450Q orX65Q	450 (65 300)	572 (83 000)	535 (77 600)	760 (110 200)	0.90	
L485Q orX70Q	485 (70 300)	606 (88 000)	570 (82 700)	760 (110 200)	0.91	

Uniform Elongation shall be > 8% (see section 7.4.6.3 (c)) & 7.6.2.1)

Table 3 - Transverse impact energy of base metal –

Charpy-V impact test - Full size specimens 10 x 10 mm

ASTM E 23 or ISO 148-1 (see impact test temperature in PPS)

Grade (API Spec 5L)	Minimum 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) Average (Single)
L290Q or X42Q	40 / 30	42/31	85% (75%)
L320Q or X46Q	40 / 30	49/36	85% (75%)
L360Q or X52Q	40 / 30	49/36	85% (75%)
L415Q or X60Q	40 / 30	61/45	85% (75%)
L450Q or X65Q	54 / 40	69/51	85% (75%)
L485Q or X70Q	68 / 50	91/67	85% (75%)

1. Refer to section 7.1 of present specification and to PPS.
2. Percent of shear area and lateral expansion of broken specimen shall be recorded for information only.
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 (DNV-OS-F101)
4. The required KVL (Longitudinal direction specimens) values shall be 50% higher than those stated above

Appendix 3. Automatic Ultrasonic Testing

1. General

The entire pipe shall be 100% ultrasonically examined for longitudinal, oblique (parallelly to the resulting rolling process) and transverse defects, and laminations.

The automatic ultrasonic testing shall be in accordance with API Spec 5L / ISO 3183, unless otherwise stated hereafter.

2. Equipment

The ultrasonic system shall be capable of revealing axial, oblique and circumferential imperfections in the internal surface, external surface and inner material of pipe, including laminations and segregations.

The ultrasonic equipment shall have an automatic alarm device for the continuous checking of the acoustic coupling. It shall be equipped with an automatic alarm and an automatic marking of the pipe where the imperfection signal is beyond the acceptance level.

The equipment shall be of sufficient sensitivity to indicate unacceptable imperfections as definedin this specification. It shall be checked as described in the following section 5.

3. Reference standards

The reference standard shall be a pipe taken from production and of such dimensions as to allow static and dynamic calibration of the control system. The reference standard shall contain machined notches on both the internal and external pipe surfaces. Notches shall be oriented parallel, oblique and transverse to the longitudinal pipe axis. Notches shall be as per API Spec 5L / ISO 3183, but with a maximum depth of 5% of nominal wall thickness. The notches shall be of sufficient length to be detected by all the concerned probes in dynamic condition.

For laminations, the reference standard shall also contain flat bottom holes (FBH) of diameter 5 mm, the flat bottom being located at 3 mm from the ID and 3 mm from the OD surfaces, The FBH quantity and location shall be such that the concerned probes can detect, at least, one FBH in dynamic condition.

The reflectors shall be located on a portion of pipe where the WT is close to the nominal.

4. Calibration

The following requirements apply to each of all channels used for scanning.

Static calibration for flaw detection

- Reference level: in each channel, the reference level shall be the signal produced from the relevant reflector. It shall be set at 80% FSH.
- Detection thresholds: the detection trigger thresholds shall be set at 40% FSH maximum (i.e. N = 6 dB minimum)

All amplitudes, threshold levels and gains shall be recorded (i.e. N = 6 dB minimum. N dB being in the flaw detection channels, the difference between the reference signal(s) from reflector(s) and the detection threshold).

Gate opening: For ID and OD scanning, the gate shall cover, at least, from 0.25 skip to 1.25 skip (skip dimension/time being based on the signal received from reflectors located on a nominal wall thickness).

Coupling: Coupling shall be monitored through the back wall signal amplitude. A pipe from production shall be scanned for the back wall signal height. The minimum amplitude found shall be taken as the reference. Then the coupling warning threshold shall be set at the above reference amplitude minus N dB. N dB being in the flaw detection channels, the difference between the reference signal(s) from reflector(s) and the detection threshold.

Dynamic calibration: The dynamic calibration of the ultrasonic equipment with the reference standard shall be carried out under the same inspection conditions as for the pipes in normal production. The calibration print outs (or record) shall be evaluated to ensure that the response from each reflector in each channel is correct, i.e. not less than 3 dB (60% FSH) from the reference level (80% FSH).

The dynamic calibration shall be performed (as a minimum):

- At the beginning of each inspection shift
- At least once during each inspection shift
- Whenever any doubt arises on the ultrasonic efficiency, by mutual agreement between the Inspector and the Supplier.

If, during the calibration check, notches of the reference standard are not revealed, or if the signals caused by notches of the reference standard do not switch on the automatic alarm or marking device, all the pipes already checked since the previous calibration check shall be re-inspected. When the signal(s) have activated the automatic alarm and marking device but found lower than 60% FSH, the calibration of the concerned channel(s) shall be re-adjusted and the dynamic scanning re-performed. But in such a case, the re-inspection of pipes from the last scanning sequence is not required.

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

5. Paint spray maintenance

Every two hours, each paint spray, including those of coupling failure shall be manually activated in order to clean out the spray nozzle.

6. Acceptance criteria

Except for laminations where a manual UT investigation is necessary for the acceptability, any imperfection that produces a signal greater than the signal received from the reference standard shall be considered an unacceptable defect.

AUT and EMI inspections shall be fully recorded: pipe number, inspection result indication(s) or no indication.

A pipe passed successfully AUT and EMI without indication is acceptable.

A pipe with one (or more) AUT and/or EMI indication is rejected or ‘’on hold’’ till after repair (if any), the re-inspection shall be as defined in the above section 7.6.3.5, is indication free.

The automatic computerised records of AUT and EMI shall be the only judge to make the acceptability decision as stated above.

Any other organisation, not only based on computer automatic records is not acceptable.

7. AUT and EMI Documentation and Records

All scanning computer data in native format from AUT and EMI, showing clearly the inspection records as defined above, shall be copied on two CD Rom /DVD together with associated viewer, which allows data analysis.

One shall be handed over to Inspector and one shall be filed in the final dossier.

Appendix 4. Weldability Tests (SMAW and GMAW)

1. Purpose

To prove the weldability of the pipes produced, the Supplier is required to carry out weldability tests to ensure that the material supplied can be welded on a laybarge or onshore (where applicable) without significant or excessive precautions. The intent is that, during pipe installation welding, the hardness and impact requirements stated in section 8 of this Appendix can be met in the Heat Affected Zone (HAZ) of welds.

The requirements for performance of the weldability tests are stated in this Appendix. The Supplier may submit alternative proposals for review and discussion at the time of bidding.

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 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 bevel must be used).

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

4. Test welds

Two weld trials are required as follows.

The tests shall consist of butt welding together two pipe sections in the 5G vertical down-hill position using, on one case, SMAW and cellulosic 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 on plates 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 preheating of 100°C.

Maximum interpass temperature shall be 250°C.

5. Testing and inspection

5.1 Radiography

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

5.2 Charpy V-notch Test

Specimens shall be cut at the one o'clock and three o'clock positions and shall be located at mid-thickness. For each set, three specimens shall be cut and tested.

The notches shall be located as follows:

- In the Coarse Grain Zone (CJZ) 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.

5.3 Macrography

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

5.4 Vickers Hardness Survey

On the above macrographic cross-sections, a VICKERS hardness survey will be conducted under 5 kg or 10 kg load in accordance with Figure 1 in 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 hardness shall be 250 HV5 or HV10 in HAZ.
- Minimum Charpy V-notch impact energy at the required test temperature stated in the PPS shall be according to Table 3 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 from the Supplier shall be submitted to the COMPANY.

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

- Weld Procedure Specifications
- Weld Procedure Qualification Records giving details of the welding parameters for each pass, consumables used, bevel geometry, etc.
- Mill certificates of pipe materials used
- NDT and mechanical test results (including any failures)
- Any other testing agreed with the COMPANY
- Any necessary photographs, macrographs and micrographs (if any)
- The interpretation of the results and the conclusions of the Supplier, including his recommendations for welding the pipes at installation site.

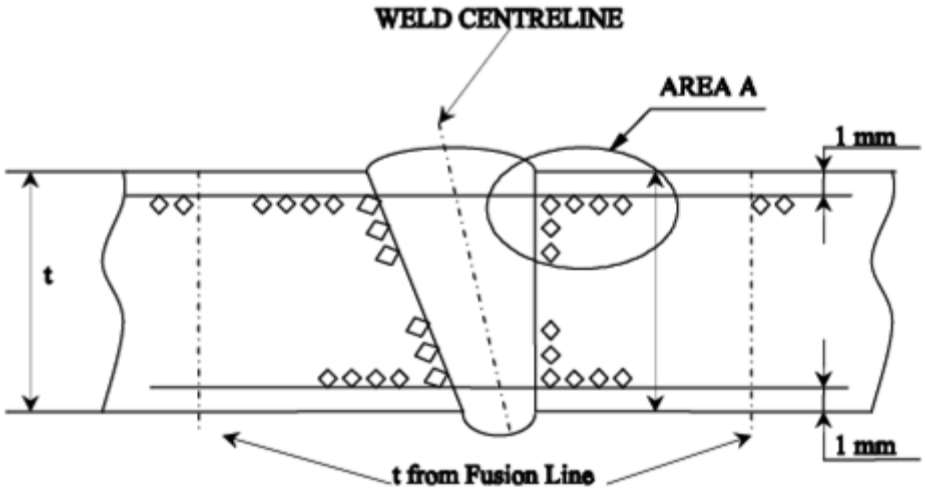
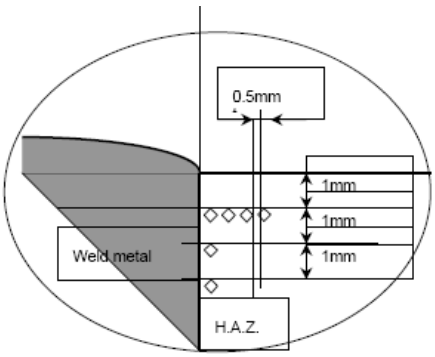


Figure 1 - Vickers hardness survey (5 kg load)

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

Enlargement of area A (typical)



Appendix 5. Applicable DNV Particular Requirements

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

NOTE: This PEGS is in line and meets the requirements of the DNV-OS-F101 except for few points where the DNV-OS-F101 Std is more stringent. Therefore when DNV-OS-F101 Std is applicable, the following modifications and/or additions to this COMPANY Specification shall apply.

Moreover, on a case by case basis, the pipeline Engineering company may require that one or several of the "Supplementary Requirements" in the DNV-OS-F101 section 7I shall apply. These "Supplementary Requirements", 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 – MPQT**

   - Number of pipes tested: DNV-OS-F101 section 7, section A803 shall apply.

     Two pipes (from two different heats) instead of one shall be tested.

     NDE and Destructive Testing shall apply to the 2 pipes as per COMPANY specification.

   - Acceptance criteria

     The acceptance criteria are those specified in the COMPANY specification except when a Supplementary Requirement applies and replaces the Company specification acceptance criteria.

   - Mill hydrostatic testing: test pressure to be calculated as per formula of DNV-OS-F101 section 7 section E102.

2. **Supplementary requirements (When required in the PPS)**

   - Supplementary requirement (F) - Fracture Arrest Properties DNV-OS-F101 section 7; I201 to I205 and Table 7-23 and 7-24 shall apply.
   - Supplementary requirement (P) - Line-pipe for Plastic Deformation (other than reeling) DNV Sec. 7; I301 to I309 and Table 7-25 shall apply with the following additional acceptance criteria:
     - section I303 the Uniform Elongation (UE) shall be measured and shall be minimum 8%
     - section I308 the Uniform Elongation (UE) shall be measured and shall be minimum 6%
     - **Note:** section 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-OS-F101 section 7, I401 and Table 7-26 shall apply.

- Supplementary requirement (U) - High Utilisation DNV-OS-F101 section 7, I501 to I512 shall apply.

Appendix 6. Specification for Sulphide Stress Cracking tests (SSC Test)

1. General

This specification shall apply to the testing of base material of seamless line pipe by means of sulphide stress cracking tests using the 4-Point Bending Test Method (Method B of EFC Publication No. 16). Apart from the type of specimen (no holes) and the Bending Method (4-Point Bending), all the provisions regarding Method B of NACE TM0177 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. The three specimens of each set shall be cut longitudinally to pipe axis at three equally spaced locations around the pipe circumference, at one pipe end as per Figure 2.

Whatever the pipe WT, one set of specimens shall be cut as close as possible to the pipe inside surface, with minimum depth of machining to obtain flat surfaces.

For pipe WT ≥ 16 mm, two sets shall be cut: one at pipe inside (as above) and one at pipe mid-thickness. All surfaces shall be ground smooth to 600 grit, minimum and degreased (acetone) following machining.

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

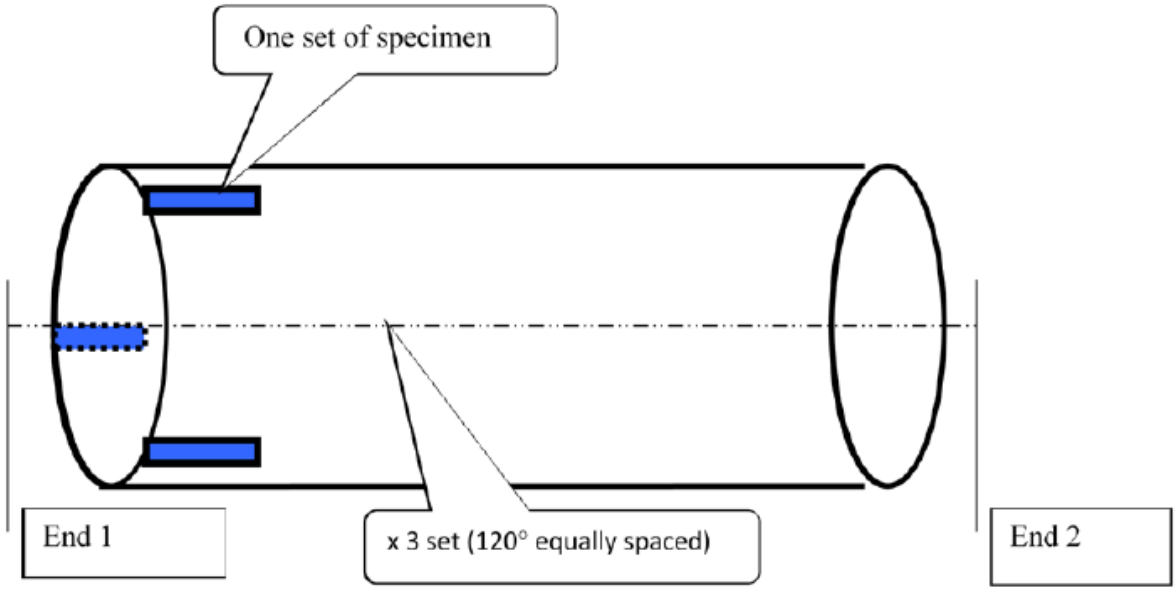


Figure 2 – Sampling of SSC test specimens

3. Test required

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

All SSC tests shall be conducted at the actual stress level of 80% or 90% (where applicable – refer to paragraph 4 here-after) of above actual Yield Strength of pipe base material. When loading the specimen in test jig, the load shall be monitored by the deflection at the center of the specimen using a dial gauge (accuracy of 0.01 mm) and the applied stress shall be adjusted and measured using electrical strain gauges. Personnel shall be certified for using electrical strain gauges.

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

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 G39 or ISO 7539-2. The procedure for strain gauge arrangement and specimen loading shall be submitted to COMPANY. The outer and inner rollers shall be made with materials that do not creep when subjected to the sustained loads (glass or ceramic rods) and avoiding galvanic coupling with the specimen.

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

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

(1) Option with NACE TM0177. Test solution A.

Pipeline [(1)] Sour service	**Region [(1)]**	**Pipeline effluent**	**Test conditions**	**Min. H_2S concentration (ppm)**	**Stress level (%actual YS)**
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 of Sour services in specification 10008-STD-6-COR-032, PEGS-0842-COR-032

NACE TM0177 solution A shall consist of 5% mass fraction NaCl +0.5% mass fraction CH_3COOH in distilled or deionized water.

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

Pipeline [(1)] Sour service	**Region [(1)]**	**Pipeline effluent**	**Test conditions**	**Min. H_2S concentration (ppm)**	**Stress level (%actual YS)**
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 • Condensates	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 • Condensates	EFC 16 solution A pH = 3.5 – PH_2S = 1 bar	2300	90

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

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

Throughout the test, pH shall be controlled and adjusted, using a calibrated pH-meter, to the above specified pH with an allowance of ± 0.1 by addition of HCl (or CH_3COOH) 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 flow meter.

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 as stated in the above tables.

Tests shall have duration of 30 days (720 hours) minimum. Counting starts after achieving 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 crack, polished and etched. All SSC cracks need to be examined and the metallurgical features at location of crack

shall be analysed (including definition of microstructure) and recorded with photomicrographs. Micro-hardness 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, minimum, following machining and visually examined for cracks as above at X5 magnifications.

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

6. Test acceptance criteria

No crack (or rupture) shall occur on any of the tested specimens within the 30-day period of test for tests carried out at the stated percentage of actual Yield Strength of base material.

For evaluation, only SSC cracks and Stress Oriented HIC (SOHIC) are to 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.

No untempered martensite or untempered bainite shall be present in the material.

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 photomicrographs, when applicable)

c) Type of solution used for the tests as per above tables 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.

Appendix 7. Specification for Hydrogen Induced Cracking tests (HIC tests)

1. General

This specification applies to the testing of the base metal of seamless line pipe by means of Hydrogen Induced Cracking tests (HIC tests).

This specification shall be read in conjunction with NACE TM0284.(including solution type)

Specimens shall be cut from pipes and immersed in the test solution prescribed hereafter. No applied stress is required. After 96 hours immersion under hydrogen sulphide saturation, damage due to hydrogen pressure induced cracking related features such as blistering, straight and stepwise cracks 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

Each test shall include three specimens cut longitudinally to pipe axis at three equispaced locations around the pipe circumference, at one pipe end. For WT above 30 mm, the specimens shall be staggered at each of 3 equispaced locations as per provisions for “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 ±1 mm
- 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 paper.

The test specimens shall not be flattened.

3. Test solution

Test solution A as per NACE TM0284 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 of Sour Services in specification 10008-STD-6-COR-032, PEGS-0842-COR-032

Test solution A shall consist of 5.0 weight % NaCl +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 a 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 TM0284.

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 the above table.

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 be cleaned (brush + detergent) and then examined by automatic UT using compression waves and the immersion technique. The UT procedure shall comply with the provisions of section 4.2 hereafter.

All personnel performing UT examination shall be qualified to 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 TM0284 (i.e. 25 mm apart). The sections shall be

mounted in epoxy resin or equal and polished as described in section 2 hereabove. Each section shall be unetched or slightly etched with 2% Nital and microscopically examined for hydrogen induced cracking at magnification of X100

In this evaluation, cracks that lie within 1.0 mm of internal or external surface of the test specimen shall be dis-regarded. 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 on 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 minimum, one of the two following adjustments:

- The Distance-Amplitude Correction (DAC)
- The equalization of heights of echos 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 of cylindrical type ultrasonic beam
- Frequency = 10 to 15 MHz.

b) The following shall also be defined by the laboratory:

- Transducer type, characteristics, serial number
- Active diameter.

The manufacturer’s datasheet of transducer shall be made available.

4.2.4. Calibration

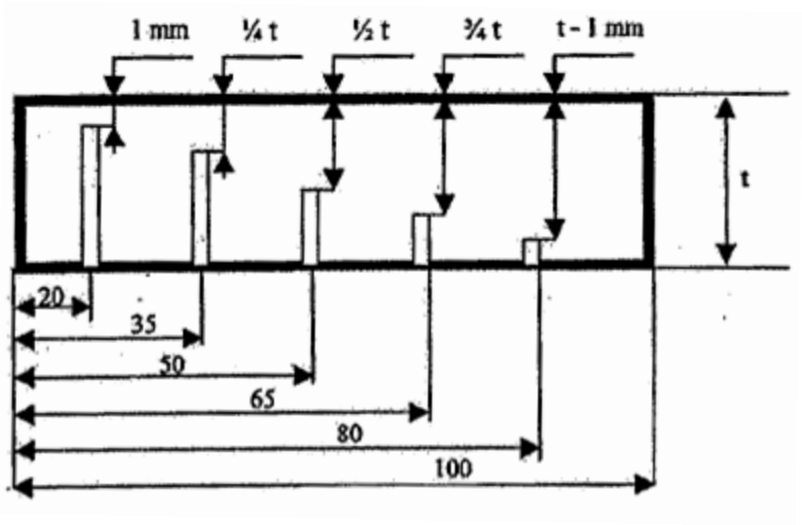
1. Calibration of time base

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/specimen interface echo and the first back wall echo, or between first and second back wall echo.

2. 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 TCG level (when applicable) shall be recorded.

Calibration shall be made once every 4 hours, or when there is an interuption of more than 30 minutes, or whenever there is a change in 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 transducer/specimen surface accurately adjusted, measured and recorded
- Smooth movement, without any stop
- Speed less than 130 mm/second

Scanning pitch so that to ensure an overlapping of 20% mini, of transducer diameter.

4.2.6. Extent of 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 colours.

Printouts shall be properly marked (specimen number, heat number, 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.

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

CAR shall be 5% maximum 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 exeeds the acceptance limit, the Laboratory may produce evidence by re-scanning and sufficient micrographics that non-cracked inclusions are on 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 (maximum 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 mentioned 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 dis-regarded. Cracks separated by less than 0.5 mm shall be considered as 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 TM0284.

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

- Crack Length Ratio (CLR): 10% 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 section 5 hereafter.

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 the above table in this Appendix. pH and H_2S concentration of solution at start (after initial H_2S saturation) and end of test.

f) Locations (using sketches), indentification and dimensions of specimens in tested pipe.

g) Photomicrographs of typical microstructures 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.

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