



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 211

**Fabrication of seamless pipes for pipelines
(Intermediate and Severe Sour Service)**

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1. Scope

This specification defines the COMPANY's requirements for the manufacture and supply of bare carbon steel pipes to be used in the construction of onshore or underwater pipelines, for crude oil, gas, multiphase or condensate effluents, operating in "Intermediate Sour Service) or "Severe Sour Service" (i.e. corresponding respectively to areas 2 and 3 in design specification **GS COR 170**.

It applies to seamless pipes in steel Grade B and Grade X42 up to Grade X65 of **API Spec 5L**.

This specification shall be used in conjunction with a Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the design conditions of the pipeline project (see § 3.2 in this specification).

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

Requirements are also provided in this specification for pipes to be used in platform topsides, risers or expansion loops with Wall Thickness in excess of 31.8 mm, where the properties of Base Steel are to be ascertained after a Post-Weld Heat Treatment.

2. Reference documents

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

The order of precedence of the applicable documents shall be:

- The Purchase Order/Requisition
- The Project Particular Specification (PPS)
- The present General Specification
- The Codes and Standards in reference.

Applicable Codes and Standards which are to be used in conjunction with this specification shall be as stated hereafter.

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

Where this specification states no overriding requirements, the referenced Codes and Standards shall apply in full.

Standards equivalent to those referred to herein shall not be substituted without written approval from the COMPANY. Approval of equivalent standards will not, in any way, remove responsibility from SUPPLIER to meet the requirements of the standards referred to and amended herein, in the event of conflict.

The SUPPLIER shall equip himself with copies of all the reference specifications referred to in this specification and shall make them readily available to all inspection personnel involved on the work.

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

Standards

Reference	Title
ASTM A 578	Straight-beam ultrasonic examination of plain and clad steel plates of special application
ASTM E 23	Notched Bar Impact Testing of Metallic Materials
ASTM G 39	Preparation and Use of Bent-Beam Stress Corrosion Test Specimens
ASTM A 370	Mechanical Testing of Steel Products
ASTM E 384	Test Method for Micro hardness of Materials
ASTM E 709	Magnetic particle Examination
EN 473	Qualification and certification of NDT personnel
EN 10204	Types of inspection documents
ISO 148	Charpy impact test (V-notch)
ISO 6507	Hardness test - Vickers test - Part 1: HV5 to HV10
ISO 9002	Quality systems: model for quality assurance in production, installation and servicing
ISO 7539	Corrosion of Metals and Alloys – Stress Corrosion Testing

Professional Documents

Reference	Title
API Spec 5L	Specification for Line Pipe
EFC Publication no. 16	Guidelines on material requirements for carbon and low alloy steels for H ₂ S containing environments in oil and gas production
NACE TM-02-84	Evaluation of Pipeline Steels for Resistance to Stepwise Cracking
NACE TM-01-77	Testing of Metals for Resistance to Sulfide Stress Cracking at Ambient Temperature
NACE MR-01-75	Sulfide Stress Cracking Resistant Metallic Materials for Oilfield Equipment
API RP 5L1	Railroad Transportation of Line pipe
API RP 5LW	Transportation of Line pipe on Barges and Marine Vessels

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS COR 170	Materials for sour service. Specification for design
GS PLR 231	Induction bends for pipelines (Intermediate and Severe Sour Service)

3. General

3.1 Definitions

- Inspector**

The COMPANY's inspector(s) or the inspector(s) from an independent Inspection Agency duly appointed by the COMPANY to act on its behalf for the purpose of the Contract.
- Mill**

The plants, mills, workshops, laboratories or other locations where the fabrication, inspection and testing of steel and pipes are to be performed complete or in part.
- Contract Documents**

The material requisitions, material specifications, etc. issued by the COMPANY and attached to the Contract or the Purchase Order.
- Approval**

Authorisation in writing given by the COMPANY to the SUPPLIER on a procedure or to proceed with the performance of a specific part of the work without releasing in any way the SUPPLIER from any of his obligations or liabilities under the Contract or at law. The words Approve, Approved and Approval shall be construed accordingly.
- PPS**

Designates the Project Particular Specification

3.2 Project Particular Specification (PPS)

The following information shall be provided in the PPS:

- a) Steel grade
- b) Pipe nominal dimensions (O.D. x W.T.)
- c) Routine impact test temperature (see § 5.6.2.d)
- d) If weldability tests are required (see § 5.1 and 5.6.5)
- e) If PWHT test for WT less than 31.8 mm (where necessary) is required (see § 5.6.2.m)
- f) If a pipe is to be sandblasted and heated for qualification purposes (see § 5.6.2.n)
- g) The sour service severity and type of pipeline effluent to clarify the H₂S test conditions (see § 5.6.3, 5.6.4, Appendix 4 and Appendix 5).
- h) If pipes shorter than 11.60 meters are acceptable (where necessary) (see § 5.9.6)
- i) If coloured painted band on pipe is maintained or is pending (see § 9)
- j) If die stamping of pipe no. is required (see § 9)
- k) If bevel protectors are confirmed (where necessary) (see section 10)
- l) If histograms are required (see § 12.2)
- m) If Pipe History System (PHS) is required (see Section 14)
- n) Number of originals and copies of Mill certificates and final production report

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

3.3 Quality Assurance/Quality Control

1. The SUPPLIER shall operate a Quality Assurance system in accordance with [ISO 9002 Std](#), or equivalent, approved by a COMPANY recognised authority. The Quality Assurance Manual shall be submitted prior to the start of work.
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 shall set forth “witness”, “hold”, “review”, and “monitor” points.
3. Just before production starting, 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 supplier, signed by Inspector and enclosed with the final dossier.

4. Inspection by the COMPANY

1. All procedures shall have prior approval of the 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 stages.
4. The Inspector shall ensure that materials and pipes are fabricated 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 order manufacturing and inspection, shall be made fully available and comprehensible to Inspector reading. Where the mill country language is not English, all these information shall be written in double language, i.e. mill country language and English language.
6. It shall be made available in the inspector office, a free access to the mill computerised:
 - tracking system of production and inspection,
 - all data and results of mechanical tests, NDE 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 EXCEL and ACCESS shall be made available by the Supplier.
7. Inspection by the Inspector shall be carried out during pipe production in order to avoid any special or additional handling. Inspection will be made in such a manner to avoid delay in pipe production insofar as the pipes which are presented to him meet the specified requirements.
8. The Inspector shall finalise (when required) its inspection by the application of a special stamp (or indelible paint marking, when so previously agreed). Die stamping is permitted only on the bevel surface.
9. The Inspector shall notify the COMPANY without delay of any difficulty, irregularity, problem or delay likely to occur during pipe production.
10. The COMPANY 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 chosen by the COMPANY.
11. The clause H.4 of Appendix H of **API 5L Std** shall fully apply.

5. Pipe manufacture

5.1 General requirements

1. The pipes shall be manufactured to Product Specification Level 2 (PSL 2) and all the requirements of **API Spec 5L**, unless otherwise indicated in the present specification, i.e. **API Spec 5L** remains applicable for all matters not specifically mentioned or modified in the present specification.
2. HIC tests and SSC tests are required on a pipe selected by the Inspector at an early production stage (see § 5.6.3 and 5.6.4) and also as production tests (see § 7.2).
3. Except as otherwise agreed between the SUPPLIER and the COMPANY, all inspections and tests required for qualification and pipe acceptance shall be performed at the manufacturing Mill.

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 **GS PLR 231** for induction bends).
5. Pipe production shall not start without the approval of the COMPANY and until a pre-production meeting has been held between the COMPANY, the SUPPLIER, the manufacturer and the Inspector.

5.2 Process of manufacture

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 (the pilger mill process is not acceptable).

5.3 Billet manufacture

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 H₂S 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).

The COMPANY shall be provided with all ladle analyses (see § 5.7 of this specification).

2. 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 strand and sequential no.).
3. The SUPPLIER shall provide the COMPANY at the bid stage with a technical specification giving full details of all the characteristics of the proposed steel, the steel making process, the billet manufacturing process and the inspection procedures.

The SUPPLIER's specification shall include the following minimum information concerning the steel making process:

- Steel making process (Electric Furnace or Basic Oxygen Furnace)
- Killing/de-oxidisation method
- Special treatments for controlling residual elements and segregations
- Nominal weight of each heat
- Aimed chemical analysis, together with minimum and maximum working limits (ladle and check) selected for the order.

5.4 Pipe manufacture

Pipes furnished to this specification shall be manufactured by the hot rolling seamless process as stated in § 5.2 above.

Pipes shall be supplied Quenched and Tempered.

Pipe shall be sized, straightened and hydrostatically tested.

The SUPPLIER shall also refer to the provisions of § 5.9.11 of this specification for pipe surface condition.

A higher steel grade of API 5L Std shall not be substituted to the grade specified on the Purchase Order.

5.5 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
- Equipment for pipe rolling, sizing, straightening
- Heat treatment of pipes
- Aimed chemical analysis, minimum and maximum working limits (ladle and product)
- Typical metallographic structure of base metal with supporting documentation, such as microphotographs, grain size, definition of the microstructure, etc.
- Visual inspection
- NDT procedures
- Dimensional inspections with frequencies of execution
- HIC and SSC test procedures.

This document shall also mention the characteristics of equipment and procedures used to carry out these operations.

5.6 Qualification of pipe manufacturing procedure

5.6.1 General

1. One finished pipe among the first pipes produced in each size, 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. This pipe shall be selected by the Inspector.
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.

5.6.2 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 § 5.9).

Then, the said pipe shall be tested as follows. Note that tests according to para i) through l) hereafter are required only for pipelines to be laid by the reeling technique.

When the line pipes of the pipeline to be laid by the reeling technique are directly purchased by the installation contractor, then the impact tests and tensile tests under para. i) and l) hereafter shall be made on a full scale bending test simulating the successive bendings of pipeline from first spooling to final laying. The bending scheme and equipment shall be mutually agreed with the COMPANY.

- a) The entire pipe shall be ultrasonically examined and either electromagnetic or Magnetic Particle examined for longitudinal and transverse defects, and laminations.
- b) A chemical analysis shall be carried out on the pipe. At this stage, one cast shall be analysed for residual elements as shown at notes of Table 1. Results shall be in accordance with Table 1 of Appendix 1. However, the ruling composition shall be that proposed by SUPPLIER and approved by COMPANY at the bid stage (see § 5.3 above).
- 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 (see § 7.2.1).

The Yield and Tensile Strength plus percentage Elongation shall be determined according to **API 5L**. The Yield Strength (YS) to Ultimate Tensile Strength (TS) ratio shall be calculated. The results shall conform to Table 2 of Appendix 2 of this specification.

- 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 perpendicular to pipe surface. Required impact values are given in Appendix 2, Table 3. 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:
 - 25% for grades not exceeding X52 in WT not exceeding 15.9 mm
 - 50% in all other cases.

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 can be above 0°C.

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

- e) Charpy V-notch tests shall be conducted in the base metal to determine full Charpy energy and shear area transition curves to [ASTM A 370](#). 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 tests with test temperatures below the routine temperature test will be for information only. For pipeline to be laid by the reeling technique, transition curves shall be supplied for both the longitudinal and transverse directions.

Size of Charpy V-notch specimens shall be as per para d) above.

- f) Two macrosections shall be cut, one from each end of the pipe. They shall be polished and etched to show the metallurgical microstructure and to allow for grain size evaluation. Photographs of microstructure shall be supplied 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 macrosection, three Rockwell C or Vickers 10 kg Hardness measurements shall be carried out (one below outer surface and one below inner surface at 2.0 mm from surface, and one at mid-thickness of pipe). Hardness shall not exceed 22 rockwell C or 250 HV 10.
- g) Rockwell C or Vickers 10 kg Hardness measurements shall be carried out on pipe surface (where a slight grinding can be made) at each pipe end and at $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ length of pipe (two readings per location). Hardness shall not exceed 22 HRC or 250 HV 10.
- h) 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 at any location in pipe.

- i) (For reeling technique only) Strain-Ageing testing shall be carried out using Charpy V-notch specimens cut transverse (or longitudinally, when so agreed) to pipe axis. The test sample shall be strained to 5% and then aged for 30 minutes at 250°C. The SUPPLIER shall submit the procedure for Strain-Ageing testing to the COMPANY for prior approval.

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 tests with test temperatures below the routine test temperature will be for information only.

Where sub-size specimens are deemed necessary, specimen size and required absorbed energy figures shall be in accordance with § 5.6.2.d above.

- 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. They shall be bent through 180 degrees using a plunger with maximum diameter of four times the specimen wall thickness. There shall be no cracks on the outside surface of the bent portion of the specimen.

- k) (For reeling technique only) Ring flattening test

A section of cold 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 the following formula:

$$H = \frac{(1 + 0.07) t}{0.07 + t/D}$$

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 shall be performed on specimens removed from each pipe end. The specimens shall be successively deformed by uni-axial tension and compression in steps corresponding to those of the installation process. The plastic strain shall be, at least, equal to the plastic strain introduced during installation and service.

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

The testing shall include:

- Longitudinal tensile testing
- Hardness testing
- Charpy V notch testing on specimens cut longitudinally at 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 be as per 5.6.2.f above.

m) (For reeling technique only) 2 cycles of bending / straightening shall be simulated on a piece of pipe as specified in the PPS.

1. The 2 cycles shall be as follows: bending, wait 20 mn, straightening, wait 20 mn, bending, wait 20 mn, straitening.
2. When the straining conditions are not specified in the PPS, a straining of 3.5% shall be applied.
3. Then 2 SSC longitudinal specimens shall be taken in the most strained in tensile fibber and 2 longitudinal specimens in the most strained in compression fibber.
4. SSC test 720 hours shall be performed as per Appendix 4.

n) Post Weld Heat Treatment tests

For pipes with Wall Thickness in excess of 31.8 mm (or less when required in PPS), tensile tests (as per 5.6.2.c above) and Charpy-V notch impact tests (as per 5.6.2.d 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).

o) When so required in the PPS, the qualification pipe or another pipe of first shift production shall be fully sand-blasted and, then, heated at 180°C to check for the presence of unacceptable raised slivers or bristles of steel which could impair the subsequent coating.

5.6.3 SSC tests

SSC tests as per Appendix 4 shall be carried out in pipe material per each pipe size (diameter and W.T.), steel source, steel grade and manufacturing process. SSC tests shall be performed during qualification of pipe manufacturing procedure for 720 hours. Production tests shall then be carried out at $\frac{1}{4}$ th, $\frac{1}{2}$ th, $\frac{3}{4}$ th and end of pipe production, still according to provisions of Appendix 4, except that test duration shall be 360 hours only (15 days).

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

5.6.4 HIC tests

HIC tests shall be carried out per each each pipe size (diameter and W.T.) steel source, steel grade and manufacturing process 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 manufacturing procedure qualification shall be one of the three tested pipes. The procedure for determining HIC sensitivity and acceptance criteria shall be in accordance with Appendix 5.

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

5.6.5 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 6.

When weldability tests are not required in the PPS, then the SUPPLIER shall produce, to the satisfaction of the COMPANY, a comprehensive documentation to support the weldability of the

supplied pipes, such as in-house laboratory test results, weldability test results from previous orders, welding recommendations, etc.

5.6.6 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.

5.7 Chemical properties

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

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

Cast 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 § 5.3 and 5.5 above).

Number, type, location, and frequency of tests shall be as defined under § 7.2.

5.8 Mechanical properties

The supplied pipes shall meet the requirements stated in Tables 2 and 3 (Appendix 2) for tensile properties and Charpy V-notch test requirements respectively.

Number, type, location, and frequency of tests shall be as defined under § 7.2.

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

5.9 Dimensional, weight and surface condition

5.9.1 General

The following requirements shall be met on each finished pipe.

Dimensional checks and measurements/recordings shall be as stated in § 5.1 hereafter.

Note on definitions:

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

5.9.2 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 $OD \leq 12"$
- ± 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 mini. 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 $\pm 0.50\%$ of the specified nominal outside diameter.

5.9.3 Wall thickness

a) Minimum Wall Thickness Guarantee

Both ends of each pipe shall be checked for thickness with a limit gauge. Measurement shall be made using a micrometer, UT or any other approved device.

SUPPLIER shall guarantee the specified thickness along the length of finished pipe and random checking shall be made at a frequency to be agreed, unless the SUPPLIER's automatic ultrasonic testing is able to continuously make thickness measurement on full length of pipes.

The tolerance for the wall thickness shall be -10%, +15% of the specified nominal wall thickness.

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 found at each end shall be recorded and traceable in regard of pipe number and of end side.

The accuracy of measurements and records shall be of 0.1 mm, for example, 17.2 mm, 20.6 mm.

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

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: $Sd = (w.t. \text{ max} - w.t. \text{ min}) / 6$.

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

- w.t. maximum
- w.t. minimum
- w.t. the mean value (M)

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

5.9.4 Weight

The nominal weight of each pipe joint shall be calculated in accordance with clause 6.4 of **API Spec 5L**. The tolerance on weight of single joints of pipe shall be +5%, -3.5% of the nominal weight.

5.9.5 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 shall not exceed 1% of the specified nominal outside diameter.
- b) Out-of-roundness at the pipe ends shall also be checked using an internal ring gauge of diameter 3.2 mm less than the nominal Internal Diameter for $WT \leq 20$ mm and 4 mm less than the nominal internal diameter for $WT > 20$ 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 provided that 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.

5.9.6 Unit length

- a) Pipes shall be supplied in lengths of $12.20 \text{ m} \pm 0.60 \text{ m}$ and the average length of each item of the order shall be 12.00 m. 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.

All pipe lengths shall be recorded.

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

5.9.7 Straightness

The deviation from a straight line (taut wire) shall not exceed 1.4 mm per metre of length, with a max. of 12 mm per pipe length. Straightness checking and recording shall be carried out 20 times per shift, as a minimum.

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

5.9.8 Squareness of pipe ends

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

5.9.9 Pipe end preparation

Pipes shall be furnished with both ends bevelled to an angle of $30^\circ + 5^\circ$, $- 0^\circ$ with a root face of $1.6 \text{ mm} \pm 0.8 \text{ mm}$. Beveling shall be carried out by straight machining only. Internal taper is tolerated, 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.

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

5.9.10 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 deformations shall be unacceptable.

5.9.11 Surface condition

Pipes shall be free from unacceptable imperfections and shall have a workmanlike finish. Imperfections having a depth greater than 5% of the specified nominal wall thickness shall be considered unacceptable. Minor imperfections may be removed by grinding provided that a smooth curved surface is maintained and that the wall thickness is not decreased below the specified minimum.

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

5.9.12 Frequency of inspections

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

	Mini. frequency Check	Mini. frequency Measurement/Recording
• WT, ID, inside O.O.R.	All pipes	20/shift
• Unit length, unit weight	All pipes	All pipes
• OD, outside O.O.R.	1/20	3/shift
• Straightness	All pipes (visual)	20/shift
• Squareness	3/shift	-
• Bevel	20/shift	3/shift
• Bulges, dents, flat areas	All pipes (visual)	All pipes with anomaly
• Surface condition	All pipes (visual)	UT on ground areas (except cosmetic grinding)

6. Mill hydrostatic testing

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

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

P = Hydrostatic test pressure in bar

S = Minimum Specified Yield Strength in N/mm² or MPa

t = Specified nominal wall thickness in mm

D = Nominal outside diameter in mm.

2. When sealing against the end face of the pipe is made by means of a ram which produces a compressive longitudinal stress, the formula stated in Appendix K of **API 5L** shall not be used. However, an appropriate calculation may be produced by the SUPPLIER to prove that the actual hoop stress in the tested pipe is equal to 90% mini of MSYS as stated in the above formula.
3. The test pressure shall be held for a duration of not less than 10 seconds for each pipe.
4. 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. 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.
5. 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.
6. A Mill hydrostatic test certificate of compliance giving Mill hydrostatic test requirements (test pressure and duration) shall be established by the SUPPLIER and furnished to the COMPANY. The SUPPLIER shall certify that every length of pipes has been tested without any leak or sweat in accordance with the requirements of this specification.

7. Inspection and testing

7.1 General requirements

1. The SUPPLIER shall bear full responsibility for the conformity of his supply to all requirements of this specification. He shall, for this purpose, take all necessary measures, making use of suitable means, devices and qualified personnel, enabling him to ensure permanent and effective control at each stage of manufacture.
2. The SUPPLIER shall develop a Quality Control Plan for approval by the COMPANY and shall carry out, all inspections and tests required by this specification.
3. All inspections carried out by the SUPPLIER during pipe manufacture shall form the subject of constantly updated reports. These reports shall be available for consultation by the Inspector at any time.
4. 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.

5. Only pipes fully meeting the requirements of this specification shall be presented to the Inspector for final acceptance.
6. 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.
7. See also the provisions of section 4 of this specification.
8. 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" shall consist 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 shall check that the working instructions are complete and correct, that the procedure has been implemented as it is written, that the environment (e.g. lighting, access way) is suitable, that tools, equipment are convenient, that the procedure is fully efficient for the inspection purpose in view of specification requirements, that recording and traceability are satisfactory...

9. All NDT personnels shall be properly certified according to [EN 473 Std](#), or equivalent Std, and shall be approved by the Inspector before any involvement on the order. NDT operators shall be certified Level 2, as a minimum.
10. Heat treatment charts of pipes shall be made available to the Inspector for review at pipe mill.

7.2 Production tests

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

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

7.2.1 Tensile test

One tensile test specimen 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 8"5/8. Strip specimens shall be used for longitudinal and transverse tests. Round bar specimens may be used when practicable for transverse tensile tests. The test shall include Yield Strength, Tensile Strength and Elongation. The Yield Strength to Tensile Strength ratio shall also be reported. Test results shall meet the requirements of Table 2 in Appendix 2.

7.2.2 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.

Test shall conform to all provisions contained in § 5.6.2.d) of this specification and requirements (if any) of 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.

7.2.3 Hardness test

Rockwell C or Vickers 10 kg hardness measurements shall be carried out on external and internal original pipe surfaces (only a slight grinding may be performed on tested surfaces). The readings shall not exceed 22 HRC or 250 HV 10.

7.2.4 Micrography

One specimen of 30 mm long in the rolling direction shall be extracted. They shall be properly polished and etched. They shall be examined at 5 mm from the external and internal surfaces and at mid thickness, every 10 mm in the rolling direction, with a magnification of X 100. The microstructure shall not show banded structure in terms of segregated bands of carbides or carbide components.

7.2.5 Chemical analysis

A product analysis shall be carried out on the selected pipe.

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 P_{CM} . However, the ruling composition shall be that proposed by SUPPLIER and approved by COMPANY at the bid stage (see § 5.3 and 5.5 above).

The sampling method shall be in accordance with [API spec 5L](#).

Note: As said in § 5.7 hereabove, 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 documentation/certificates covering the related cast of steel.

7.2.6 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:

- OD less than or equal to 4"1/2 : 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.

7.2.7 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 will give acceptable results according to this specification will not be rejected.

Note: Re-heat treatment of pipe is accepted. 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).

7.2.8 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, it may be substituted by another test specimen with prior approval of the Inspector. 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.

7.2.9 SSC and HIC tests

SSC and HIC tests shall be made as production tests as stated in § 5.6.3 and 5.6.4 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 COMPANY.

7.3 Visual and NDT

7.3.1 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 § 5.9.11 of this specification.

7.3.2 Ultrasonic testing

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 ultrasonic examination. Manual UT may be replaced by MPI only for WT below 10 mm.

The inspection shall be efficient in detecting both axial defects and circumferential 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 10 mm, the pipes may be inspected by the flux leakage method, provided that the related inspection procedure is approved by COMPANY at the bid stage. However, scanning for laminations shall be maintained.

7.3.3 Electromagnetic testing

The SUPPLIER Shall produce 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 both the axial direction and the circumferential direction).

The SUPPLIER will supply the COMPANY with the equipment specifications, its location in the production line, the inspection procedure and the reference standards for calibration of sensitivity.

Both ultrasonic testing and electromagnetic testing are required.

7.3.4 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.

7.3.5 Acceptance criteria

- a) Any crack or suspected crack and any linear discontinuity shall be considered unacceptable defects.
- b) Any imperfection having a depth greater than 5% of the specified nominal wall thickness measured from the surface of the pipe, or any imperfection encroaching on the minimum wall thickness shall be considered as an unacceptable defect.
- c) Surface condition and surface defects shall also comply with the requirements specified in & 5.9.11 of this specification.
- d) The size of any lamination shall not exceed 5 mm x 10 mm within 50 mm of pipe ends, and 10 mm x 20 mm in pipe body, measured as circumferential x longitudinal.
- e) No defects shall be permitted on the bevel surface.
- f) Dimensional requirements shall be as stated in § 5.9.

7.4 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 five pipes checked per shift, using a calibrated Hall effect gauss-meter or other equipment approved by the Inspector.

7.5 Mill certificates

Mill test certificates shall be 3.2 according to [EN 10204 Std](#). Mill certificates shall be issued by the pipe manufacturer and signed, dated and stamped by the Inspector (refer to § 12.2).

Mill certificates shall make reference to [API 5L](#) 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 no. with reference to heat no. (and billet no. where possible)

- Mechanical test results and product chemical analysis (including CE and Pcm) with reference to pipe no.
- Results of dimensional inspections
- Non-destructive tests performed with results
- Results of H₂S embrittlement tests
- Any supplementary tests and inspections carried out.

8. Repair of defects

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

Defects shall only be removed by grinding provided that 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, 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-bevelling only.

9. 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 in the due time.
2. The quality of paint employed and its application shall be designed to provide inscriptions that shall be perfectly readable for a 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 $\geq 12"$, 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.

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

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 OD ≥ 12 " only:

- 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, when so required in the PPS.

7. Marking shall be approved by the COMPANY prior to pipe production.

10. Protection of bevels

All bevelled pipes shall be fitted with bevel protectors, unless otherwise stated in the PPS. Bevel protectors shall be submitted to the COMPANY with full details by the SUPPLIER at the bid stage.

11. Handling, transport and storage of pipes

11.1 General

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

All handling, loading and unloading shall be performed in such a way as to avoid mechanical damages 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.

11.2 Handling and storage

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

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

11.3 Transport

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

12. Documentation

The following minimum documentation shall be delivered by the SUPPLIER.

12.1 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 (heat treatment), typical metallurgical microstructure and grain size
- Name of pipe manufacturer and Mill
- A preliminary pipe Manufacturing Procedure Specification, which includes the main features of manufacturing process, heat treatment, dimensional and non-destructive testing procedures, including automatic UT procedure and stating if electromagnetic testing will be used or not used.
- Unit length of pipes offered, if different from that stated in § 5.9.6 (when applicable)
- Location of paint stencilling (on inside or outside of pipe)
- Quality Control Plan (preliminary)
- The nominated laboratory for conducting the H₂S 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)
- Quality Assurance certifications (**ISO 9002**, **API Q1**, etc.)
- Details of offered fabrication Pipe History System (PHS), when required in the PPS
- 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.

12.2 Upon completion of pipe production

A close-out production report which shall include, but not be limited to, the information and documents stated hereafter:

- Steel making process and billet manufacturing specification
- Pipe Manufacturing Procedure Specification (MPS)
- Quality Control 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 heat 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 heat numbers
- Records of wall thickness as stated in § 5.9.3b)
- Histograms of production test results (chemical and mechanical) and dimensions of pipes (length, as a minimum),
- Fabrication Pipe History (if any)
- 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.

12.3 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 without delay after completion of pipe production. The latest date of submission of this report shall be three weeks max. after dispatch of the pipes.

13. Storage of mechanical test specimens

The SUPPLIER shall ensure preservation and storage of the mechanical test specimens.

They shall be stored and made available for the COMPANY for the following minimum periods of time:

- Qualification tests = 10 days
- Production tests = 2 days

14. Fabrication Pipe History System (PHS)

When so required in the PPS, the SUPPLIER shall provide a computerised fabrication pipe history. 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 no. and Mill certificate).
- For each heat number: chemical analysis, individual weight, length of accepted pipes, pipe no.

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

15. Technical Queries/Non-Conformance Reports

1. Any SUPPLIER's requests for clarifications or deviations to COMPANY specifications shall be submitted to COMPANY only through Technical Queries (T.Q.), the format of which shall have prior approval of the COMPANY.

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

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

Appendix 1 Chemical composition

Table 1 - Chemical composition

Chemical Element (see note 1)	Grades B, X42 and X46	Grades X52 up to X65
	Ladle/Check Analysis % weight max.	Ladle/Check Analysis % weight max.
C	0.15/0.16	0.13/0.14
Mn	1.10/1.25	1.25/1.35
Si	0.40/0.45	0.45/0.50
Al total (see note 2)	0.060/0.060	0.060/0.060
Ca	0.006/0.006	0.006/0.006
S	0.005/0.008	0.005/0.008
P	0.020/0.025	0.020/0.025
Nb	0.05/0.05	0.05/0.05
V	0.06/0.06	0.08/0.08
V + Nb	-	0.10/0.10
Ni	-	0.30/0.30
Cr	-	0.20/0.20
Cu	0.30/0.30	0.30/0.30
Mo	-	0.25/0.25
Ti	-	0.04/0.04
N (see note 2)	0.012/0.014	0.010/0.012
CE (see note 3)	0.41/0.42	0.38/0.39
Pcm (see note 4)	(0.24/0.25)	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) for Grades X52 up to Grade X65:

- Sn = 0.015% As = 0.015%
- Sb = 0.010% B = 0.0005% (no intentional addition)
- Bi = 0.005% Ca = 0.006%
- Pb = 0.005%

(2) The soluble 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 5L tensile test (strip or round bar specimen)

Grade (API 5L)	YS psi (MPa)		TS psi (MPa)		$\frac{YS}{TS}$ max.	El % min.
	min.	max.	min.	max.		
B	35,000 (241)	48,000 (331)	60,000 (413)	80,000 (552)	0.85	As per API 5L
X 42	42,000 (289)	60,000 (413)	60,000 (413)	80,000 (552)	0.85	
X 46	46,000 (317)	64,000 (441)	63,000 (434)	83,000 (572)	0.85	
X 52	52,000 (358)	70,000 (483)	66,000 (455)	86,000 (593)	0.85	
X 60	60,000 (413)	78,000 (538)	75,000 (517)	95,000 (655)	0.88	
X 65	65,000 (448)	83,000 (572)	77,000 (530)	98,000 (676)	0.90	

Table 3 - Transverse impact energy of base metal - Charpy-V impact test -
Full size specimens 10 x 10 mm

ASTM E 23 (see impact test temperature in PPS)

Grade (API - 5L)	Minimum average Single value (joules)	Particular requirement for base material of gas transmission pipes Minimum average/single value (joules)
B	28 / 22	48 / 42
X 42	30 / 24	48 / 42
X 46	32 / 26	48 / 42
X 52	36 / 30	48 / 42
X 60	42 / 35	48 / 42
X 65	45 / 38	48 / 42

Appendix 3 Automatic ultrasonic testing

1. General

The automatic ultrasonic testing shall be in accordance with [API spec 5L](#), Supplementary Requirement SR4, unless otherwise stated hereafter.

2. Equipment

The ultrasonic system shall be capable of revealing axial imperfections 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 defined in this specification. It shall be checked as described in the following section 3.

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 and transverse to the longitudinal pipe axis and in rolling direction. Notches shall be as per API Spec 5L, but the maximum depth shall be 5% of nominal wall thickness. Additional flat bottom notches 4 mm wide x 12 mm long x half WT deep shall be used for detecting segregations and laminations.

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 coupling shall be controlled with a compression probe on the back wall echo. The drop shall not exceed 4 dB, based on the calibration pipe back wall signal as the reference.

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.

4. Acceptance limits

Any imperfection that produces a signal greater than the signal received from the reference standard shall be considered an unacceptable defect, unless it can be demonstrated by the SUPPLIER that the imperfection does not exceed the provisions of § 7.3.5 of this specification.

Appendix 4 Specification for Sulfide Stress Cracking tests (SSC Tests)

1. General

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

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

2. Specimen preparation

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

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

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

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

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

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

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

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

3. Test required

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

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

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

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

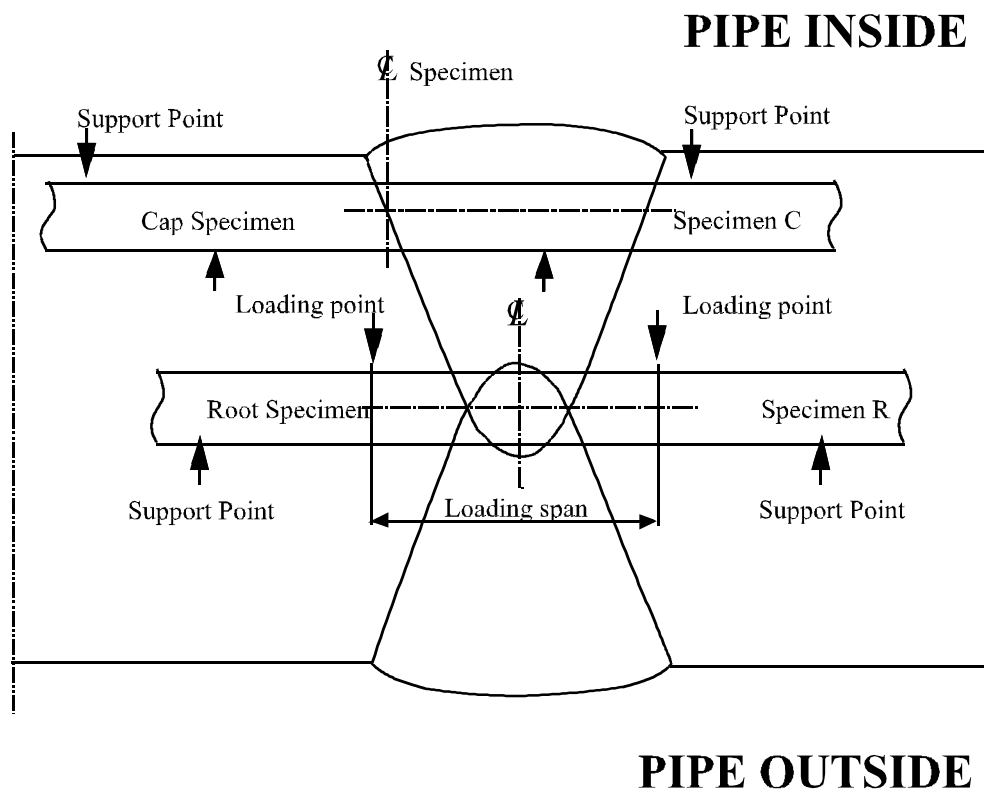


Figure 1 – Removal of specimens in weld

4. Test arrangement and test solution

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

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

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

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

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

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

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

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

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

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

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

H₂S gas purity shall be 99.5% minimum.

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

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

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

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

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

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

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

5. Specimen examination

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

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

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

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

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

6. Test acceptance criteria

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

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

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

7. Reporting

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

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

Appendix 5 Specification for Hydrogen Induced Cracking tests (HIC tests)

1. General

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

This specification shall be read in conjunction with [NACE Standard TM-02-84](#).

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

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

2. Tests specimens

2.1 Size, Number and orientation of specimens

Basically, six test specimens shall be taken from each test pipe as follows:

- Two specimens cut transverse to the longitudinal weld
- Two specimens cut in base material in a direction parallel to the rolling direction at each of the two following locations: at 90 degrees from weld and at 180 degrees from weld.

However, for WT above 30 mm, the specimens shall be staggered at each location as per "Pressure Vessel Plate" in [NACE TM-02-84-Std](#), with an overlap of 1 ± 0.5 mm between adjacent specimens.

Specimen dimensions shall be as follows:

- Length (L) = $100 \text{ mm} \pm 1 \text{ mm}$
- Width (W) = $30 \text{ mm} \pm 1 \text{ mm}$ (base metal) and $20 \text{ mm} \pm 1 \text{ mm}$ (weld area)
- 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 to prepare finish of specimen.

After machining, all specimen surfaces shall be ground and finished to 320 grit paper.

2.2 Preparation of cross-sections

The specimen cross-sections shall be ground dry employing a number of intermediate grinding steps to remove any prior metal deformation. The surface shall be finished by fine grinding with 800 grit paper or finer paper and then polished with diamond paste (grain size: 3 microns, 1 micron) and Al_2O_3 alumina paste or diamond paste (max. grain size: 0.25 micron). The consecutive steps of grinding and polishing shall be detailed in the HIC procedure. The surface shall finally be cleaned using water, alcohol and hot air.

Test solution, pH and H₂S partial pressure of test shall be as stated in the table below, according to sour service severity and type of pipeline effluent.

Pipeline ⁽¹⁾ Sour Service	Area ⁽¹⁾	Pipeline effluent	Test conditions	Mini H ₂ S concentration (ppm)
Intermediate Severe	2 and 3	Oil	EFC 16 solution B pH = 4.5 - PH ₂ S = 1 bar	2300
		• Gas • Multiphase systems • Condensates	EFC 16 solution A pH = 3.5 - PH ₂ S = 1 bar	2300
		•		
Note 1: Refer to definitions in specification GS COR 170 .				

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

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

H₂S gas purity shall be 99.5% minimum.

The ratio of solution volume to specimen surface area shall be a minimum of 5 ml/cm².

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

The solution shall be deaerated by bubbling nitrogen and then H₂S saturated as per **NACE TM 02 84** Std.

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

Hydrogen sulfide concentration in the solution shall be measured by the iodometric titration method. The minimum H₂S concentrations shall be as stated in Table of this paragraph. The pH shall be continuously recorded as said above. The H₂S concentration value shall be measured after initial hydrogen sulfide saturation and just prior to test termination, as a minimum. Test temperature shall be maintained at 25°C ± 3°C.

Test duration shall be 96 hours.

4. Evaluation of hydrogen induced cracking

4.1 Hydrogen Induced Cracking (HIC)

The specimens shall be first examined by automatic UT using compression waves and the immersion technique. The UT procedure shall comply with the provisions of para. 4.2 hereafter.

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

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.

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

Each of the specimens (base metal specimens and weld specimens) shall be sectioned transversely at the largest indication (if any) obtained at UT. For specimens in base material, the two other locations shall be:

- 25 mm apart if the largest UT indication is between 35% and 65% of specimen length,
- Or at a distance of 25 mm and 50 mm, if the largest UT indication is between 0% and 34% or 66% and 100% of specimen length.

When there are no indications at UT scanning, then the specimen shall be cut at three equispaced locations within the specimen length as per **NACE Std TM 02-84** (i.e. 25 mm apart). The sections shall be mounted in epoxy resin or equal and polished as described in para. 2.2 hereabove. Each section shall be suitably etched and microscopically examined for hydrogen induced cracking at magnification of X100.

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

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 one side of specimen with ultrasonic beam perpendicular to specimen surface.

Water path distance transducer/specimen shall be defined.

4.2.2 Ultrasonic Generator

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

4.2.3 Transducer

- Transducer shall have the following characteristics:
 - Mono or double transducer
 - Focalized or of cylindrical type ultrasonic beam
 - Frequency = 10 to 15 MHz.

- The following shall also be defined by the SUPPLIER:
 - Transducer type, characteristics, serial number
 - Active diameter.

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

4.2.4 Calibration

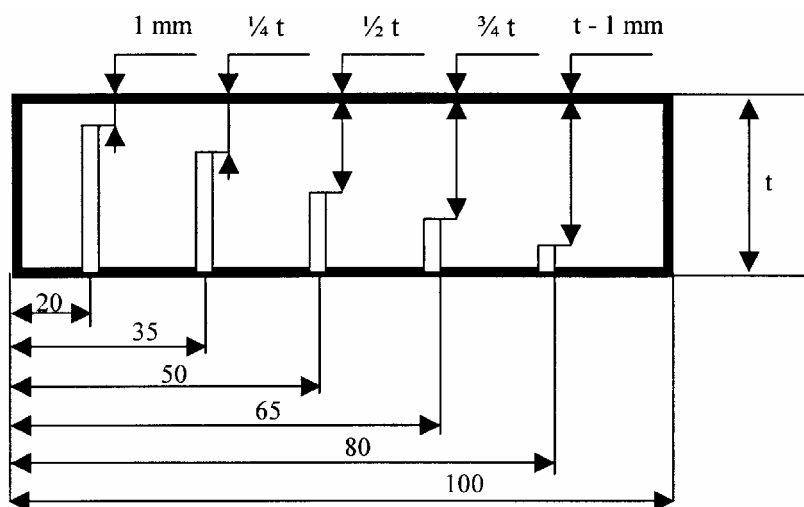
a) Calibration of time base

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

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

b) Calibration of sensitivity

It shall be made with a block of same dimensions as above which includes five transverse flat bottom notches 1 mm wide, with depths 1 mm, $\frac{1}{4} t$, $\frac{1}{2} t$, $\frac{3}{4} t$ and $t - 1 \text{ mm}$, as shown on sketch below:



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

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

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

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 stopping
- Speed less than 130 mm/second
- Scanning pitch so that to ensure an overlapping of 20% min. of transducer diameter.

4.2.6 Extent of UT inspection

Scanning shall cover 100% of specimen surface plus a peripheral 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 additionnal only.

The cartography shall give the sizing and location of detected cracks with an accuracy of ± 0.05 mm.

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

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

4.3 Acceptance Criteria

4.3.1 Ultrasonic examination of specimens

CAR = 5% max. of specimen area, per specimen (refer to definition of CAR in paragraph. 4.1 above). The CAR shall include all cracks and all laminations whatever they are associated or not associated with cracks.

4.3.2 Microscopic examination of cross-sections

CAR = 5% max. of specimen area, per specimen (Refer to definition of CAR in paragraph 4.1 above). The CAR shall include all cracks and all laminations whatever they are associated or not associated with cracks.

4.3.2 Microscopic examination of cross-sections

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

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

CLR, CTR and CSR shall be calculated and reported for each section and the average for each test specimen as per [NACE Std TM 02-84](#).

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

- Crack Length Ratio (CLR) : 15% maximum
- Crack Thickness Ratio (CTR) : 3% maximum
- Crack Sensitivity Ratio (CSR) : 1% maximum

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



5. Reporting

The following data shall be provided in the SUPPLIER's 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, with photographs of all unetched sections at X5 and X25 magnifications.
- d) Type of solution as per Table above of this Appendix. pH of solution at start and end of test and also at end of each day of test. H₂S concentration at start and end of test.
- e) Locations and dimensions of specimens in tested pipe
- f) Photomicrographs of typical micro-structures X 200 of weld and parent material, with definition of the microstructures
- g) Mill certificates of material tested showing full chemical analysis and mechanical properties

All pertinent explanations (where needed) and concluding comments. Any failure shall be analysed by the SUPPLIER and the causes of failure made clear to the COMPANY, before any re-tests or remedial actions are decided.

Appendix 6 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 § 6 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. For SMAW 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 downhill 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 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 6 o'clock position.

5.4 Vickers Hardness Survey

On the above macrographic cross-sections, a VICKERS hardness survey will be conducted under 5 kg load in accordance with Figure 1 of present Appendix 6.

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

6. Acceptance criteria

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

- Maximum HV5 hardness shall be as per Table below:

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

- 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 have been successfully completed.

7. Reporting

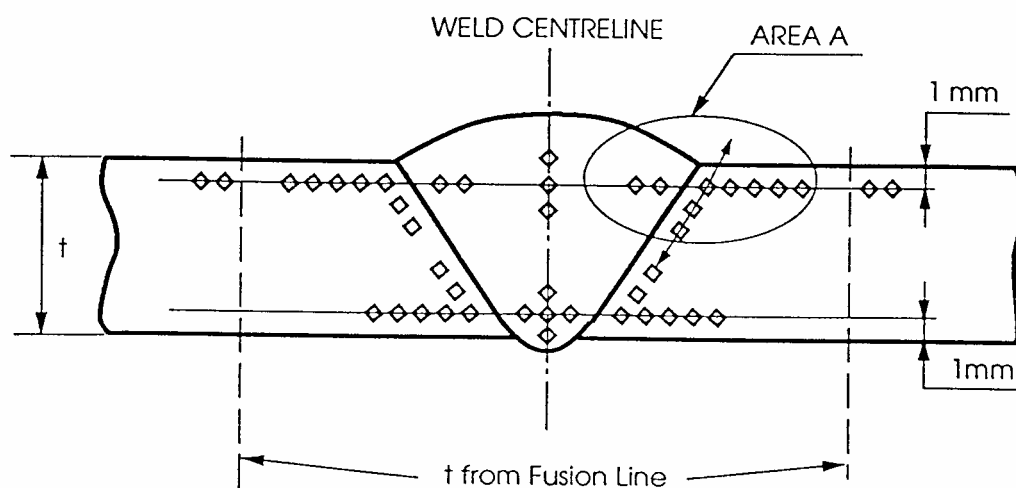
Following completion of the test programme, the results and final report from the SUPPLIER shall be submitted to the COMPANY.



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 test (typical)
(5 kg load)



ENLARGEMENT OF AREA A (TYPICAL)

