



Exploration & Production

GENERAL SPECIFICATION

PIPELINES - RISERS

GS PLR 212

**Fabrication of longitudinally submerged arc welded
pipes for pipelines
(Intermediate and Severe Sour Service)**

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1. Scope

This specification defines the COMPANY's general requirements for the manufacture and supply of bare carbon steel pipes to be used in the construction of onshore or underwater pipelines, for crude oil, gas, multiphase or condensate effluents, operating in "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 longitudinally Submerged Arc Welded pipes (SAW) in Grade B and Grade X42 up to Grade X65 of **API Spec 5L** Specification, manufactured by the UOE process, the Press Bending Process or the Roll Bending process.

This Specification shall **always** be used in conjunction with a Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions of the Pipeline Project (see section 4 of this specification).

Requirements are also provided in this specification for line pipes with Wall Thickness in excess of 31.8 mm (e.g. topsides, risers, expansion loops, etc.), where the properties of Base Steel are to be ascertained after a Post-Weld Heat Treatment is made.

No deviation from the requirements stated in the present specification shall be permitted unless prior written approval has been obtained from the COMPANY. Refer to Section 17 of this specification.

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 are stated in paragraphs 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 the written approval of the COMPANY. Approval of equivalent standards will not, in any way, remove responsibility from the 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 fabrication, testing and 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 370	Mechanical Testing of Steel Products
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 E 112	Estimating the Average Grain Size of Metals
ASTM E 384	Test Method for Micro hardness of Materials
ASTM E 709	Magnetic Particle Examination
ASTM E 747	Test Method for Controlling Quality of Radiographic Examination Using Wire Penetrameters
ASTM G 39	Practice for Preparation and Use of Bent-Beam Stress-Corrosion Tests Specimens
ISO 148	Charpy impact test (V-notch)
ISO 643	Acier – Détermination micrographique de la grosseur de grain apparente
ISO 1027	Radiographic Image Quality Indicators for non-destructive testing.Principles and identification
ISO 6507	Hardness test - Vickers test - Part 1: HV5 to HV10
ISO 7539	Corrosion of Metals and Alloys – Stress Corrosion Testing
ISO 9001/9002	Quality systems: Model for quality assurance in production, installation and servicing
ISO 12096	Radiographic testing of longitudinal and spiral welds for the detection of imperfections
BS 5996	Methods for Ultrasonic testing and Specifying Quality Grades of Ferritic Steel Plate
EN 10204	Types of inspection documents
EN 462-1	Image Quality of Radiographs
EN 473	Qualification and certification of non-destructive testing personnel

Professional Documents

Reference	Title
API Spec 5L	Specification for Line Pipe
API RP 5L1	Railroad Transportation of Line Pipe
API RP 5LW	Transportation of Line pipe on Barges and Marine Vessels
API RP 5L3	Drop-Weight Tear on line pipe
NACE Standard TM-02-84	Evaluation of Pipeline Steel for Resistance to Stepwise Cracking
NACE Standard TM-01-77	Testing of Metals for Resistance to Sulphide Stress Cracking at ambient Temperatures
NACE Standard MR-01-75	Sulphide Stress Cracking resistant metallic material for oil field equipment
EFC Publication no. 16	Guidelines on materials requirements for carbon and low alloy steels for H ₂ S - containing environments in oil and gas production

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
ASME, Section V	Boiler and Pressure Vessel Code. Non-destructive Examination
ASME, Section II	Boiler and Pressure Vessel Code
ANSI/AWS A 5-1	Welding consumables

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 representatives or members from an Inspection Agency duly appointed by the COMPANY and thus notified to the SUPPLIER shall be referred to herein as the "Inspector".
- **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, shall be referred to herein as the "Mill".
- **Contract** The Purchase Order together with all material requisitions, specifications, etc. issued by the COMPANY and/or purchaser and attached to the contract or the purchase order shall be referred to herein as the "Contract".
- **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 its obligations to conform with the technical specifications, requisitions, etc. "approve", "approved" and "approval" shall be construed accordingly.
- **PPS** Used to designate the Project Particular Specification.

3.2 Quality Assurance/Quality Control

1. The SUPPLIER shall operate a Quality Assurance system in accordance with [ISO 9001](#) or [9002](#), or equivalent, approved by a recognized authority. The Quality Assurance Manual shall be submitted to COMPANY.
2. Three weeks prior to commencement of pipe manufacture, the SUPPLIER shall prepare and submit to COMPANY a written Quality Control Plan which describes the inspections to be performed during the supply of steel, plates and 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. Project Particular Specification (PPS)

The following informations shall be provided in the PPS:

1. Steel grade
2. Pipe nominal dimensions (O.D. x W.T.)
3. The sour service severity and pipeline effluent to clarify the H₂S test conditions (see Appendix 13 and Appendix 14).
4. If Mechanical tests are required on plates (see § 6.4)
5. If Press Bending process or Roll Bending process is accepted (see § 7.2)
6. If pipes shorter than 11.60 metres are acceptable (where necessary (see § 7.9.6)

7. Routine impact test temperature (see § 9.5.4)
8. Routine test temperature of DWTT (see § 9.5.7)
9. If welding tests results on similar pipe materials are required (see § 14.2)
10. If Pipe History System (PHS) is required (see § 14.2 and section 16)
11. If histograms are required (see § 14.3.a)
12. Number of originals and copies of Mill certificates and final production report (see § 14.3.b)
13. If PWHT test is required for WT less than 31.8 mm (where necessary) (see Appendix 7, Item 11)
14. If weldability tests are required (see § 7.1 and Appendix 7, Item 12)
15. If coloured painted band on pipe is maintained or is pending (see Section 11)
16. If a bar code system is required or, otherwise, acceptable (see Section 11)
17. If die stamping of pipe No. is required (see Section 11)
18. If bevel protectors are confirmed (where necessary) (see Section 11)

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

5. 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. At steel making mills, plate rolling 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.
5. 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,
 - plate input, pipe output, rejections status with causes, repairs,
 - any other information considered pertinent by the inspector for his monitoring.
 Computer, software environment compatible with the mill software, software interface where necessary for data exploitation with EXCEL and ACCESS shall be made available by the Supplier.
6. The Inspector shall ensure that materials and pipes are fabricated in accordance with all the specified requirements and COMPANY's approved procedures.

7. Inspection by the Inspector shall be carried out during pipe production in order to avoid any special or additional handling. Inspection will be 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 his inspection by the application of a special stamp (or indelible paint marking, when so previously agreed) on the accepted pipes. Die stamping is permitted only on the bevel surface.
9. The Inspector shall notify the COMPANY without delay of any difficulty, irregularity, problem or delay likely to occur during pipe production.
10. The COMPANY reserves the right to re-check tests carried out by the SUPPLIER. For this purpose, the COMPANY may request the delivery of samples or specimens for analyse in an independent laboratory chosen by the COMPANY.
11. The clause H.4 of Appendix H of **API 5L** Std shall fully apply.

6. Plate manufacture

6.1 General requirements

- 6.1.1** Steel shall be made to the Electric Furnace or Basic Oxygen Converter. Steel shall be fully killed and made to fine grain practice (grain size **ASTM no. 8** or finer according to **ISO 643** Std).

Grain size evaluation shall be made once at qualification of plate/pipe manufacturing procedure. Then, it shall be done only when a doubt arises about steel properties.

- 6.1.2** The steel making process shall result in the manufacture of steel plates/pipes having a high resistance to H₂S embrittlement and associated effects.

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

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

- 6.1.3** The SUPPLIER shall give full details about Mill control of sequential heats.

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

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

- 6.1.6** The SUPPLIER shall provide the COMPANY four (4) weeks minimum before commencement of production with a detailed plate Manufacturing Procedure Specification giving full details of all the characteristics of the proposed steel plates (see details in Appendix 6 relating to pipe manufacturing procedure).

- 6.1.7** The SUPPLIER shall provide the Inspector with the temperature measurements made at all important stages of the plate fabrication flow. For TMCP steel, this shall include the

temperatures and reduction ratios of the rolling steps, and temperatures at inlet and outlet of accelerated cooling facilities, with cooling rates.

- 6.1.8** The rolling records of each mother plate shall be made available for review at the plate Mill, on Inspector's request.
- 6.1.9** All calibration certificates of control devices, thermometers, recorders, shall be made available to Inspector's review prior to start the rolling campaign.
- 6.1.10** Except as otherwise previously agreed between the SUPPLIER and the COMPANY, all inspections and tests required for steel plate acceptance shall be carried out at the SUPPLIER's Mill.

6.2 Rolling technique/Heat treatment

Plates shall be manufactured by the Thermomechanical Controlled Process, including a subsequent accelerated water cooling method.

In all cases, steel plates shall show a homogeneous very fine-grained microstructure.

The rolling parameters shall be made available at pipe mill as well for Inspector review and selection of production test pipes.

Banded structure in terms of segregated bands of carbides shall not be acceptable.

Rolling ratio shall be equal to or above 3.5.

6.3 Chemical composition

- 6.3.1** Chemical composition of steel and its Carbon Equivalent (CE) and Pcm, as determined on each heat and product, shall be in accordance with Tables 1 and 2 (Appendix 1). However, the ruling composition shall be that proposed by the SUPPLIER and approved by the COMPANY **at the bid stage** (see § 6.1 above).

- 6.3.2** The SUPPLIER shall carry out ladle and product analyses for all specified elements (plus all other intentionally added elements, when applicable). Location of sampling shall be at midway between plate edges.

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

- 6.3.3** Test frequency shall be as follows:

- Ladle analysis: one per each heat. Residual elements shall be analysed only on the first heat produced and then every 20 heats
- Product analysis: at least one per each heat. Analysis of residual elements is not required on product. Product analysis may be carried out either on plates or on pipes, at the SUPPLIER's option. However, the selected option shall be clarified by the SUPPLIER at the bid stage.

6.3.4 Recheck analyses

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

6.4 Mechanical Properties and Tests (when so required in the PPS)

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

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

6.4.2 Testing procedures and specimens shall be as defined under § 9.5 for finished pipes.

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

6.4.4 Results from mechanical testing carried out on steel plates shall meet the working ranges stated by the SUPPLIER at the bid stage (see § 6.1 above and Appendix 2).

6.5 Visual, dimensional and ultrasonic inspections

Steel plates shall be subject to visual, dimensional and ultrasonic inspections on finished product. Visual and ultrasonic inspection may be carried out at the pipe mill. Wall thickness checking shall be made at both the plate rolling mill and the pipe mill.

6.5.1 Visual inspection

Steel plates shall be visually examined on both surfaces.

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

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

6.5.2 Thickness measurement

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

Any repair grinding shall initiate thickness checking.

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

Supplier shall provide histograms with the detail of the range min/max, the mean value (M) and the standard deviation (Sd) of wall thickness records for all measurements results irrespectively of the measurement location. Sd shall be conventionally calculated as follows:

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

6.5.3 Ultrasonic inspection

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

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

The acceptance limits of imperfections are specified in Appendix 3.

6.6 Repairs

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

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

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

6.7 Marking of plates

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

The following minimum indications shall be marked on each plate:

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

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

6.8 Mill Certificates

The SUPPLIER shall provide the COMPANY with 3.1.B Mill certificates according to [EN 10204](#) Std for plates, together with reports of all tests and inspections carried out on plates in accordance with the present specification:

- Results of heat and product analyses (see § 6.3)
- Results of mechanical tests (see § 6.4)
- Results of visual inspection (see § 6.5.1)
- Results of thickness measurements (see § 6.5.2)
- Results of ultrasonic inspection (see § 6.5.3).

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

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

7. Pipe manufacture

7.1 General requirements

7.1.1 Pipes shall be manufactured to 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 points not specifically mentioned or modified in the present specification.

7.1.2 HIC tests (as per Appendix 14) and SSC tests (as per Appendix 13) shall be required according to provisions of para. 9.6 and 9.7 of this specification. Weldability Tests (as per Appendix 15) are to be carried out only when so required in the PPS: refer to Appendix 7 of this specification.

7.1.3 The SUPPLIER shall guarantee the overall consistency of the pipe order (including chemical composition, dimensional, weldability, material traceability), especially if pipes are manufactured at different mills with the COMPANY's previous approval.

7.1.4 Except as otherwise previously agreed between the SUPPLIER and the COMPANY, all inspections and tests required for pipe acceptance shall be performed at the pipe manufacturing Mill.

7.1.5 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 bends).

7.2 Process of manufacture

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

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

7.3 Cold expansion

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

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

7.4 Base materials

The steel plates used in the fabrication of pipes shall meet the requirements defined under Section 6 of this specification.

7.5 Pipe Manufacturing Procedure Specification (MPS)

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

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

This detailed specification shall be submitted to the COMPANY four (4) weeks minimum before commencement of production.

7.6 Qualification of pipe manufacturing procedure

7.6.1 One finished pipe among the first pipes produced in each size, grade and steel source (first shift production) shall be subject to all the inspections and tests as described in Appendix 7 in order to qualify the pipe manufacturing procedure. This pipe shall be selected by the Inspector.

7.6.2 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 and signed by the Inspector who attended the tests.

7.6.3 The SUPPLIER is allowed to proceed with the pipe manufacture without waiting for the test results and the Inspector's approval, as long as the SUPPLIER is accepting the risk and responsibility of the consequences of any test failure, as stated here-after.

7.6.4 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 passed all the qualification tests laid down in this specification.

7.7 Chemical properties

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

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

Heat and Product analyses shall meet the requirements contained in Tables 1 and 2 of Appendix 1. However, the ruling composition shall be that proposed by the SUPPLIER and approved by the COMPANY at the bid stage (see § 6.3 above).

Number, type, location and frequency of tests shall be as defined under § 6.3.

7.8 Mechanical properties

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

Number, type, location and frequency of tests shall be as defined under § 9.5.

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

7.9 Dimensional and weight requirements

The following requirements shall be met on each finished pipe.

Frequencies of dimensional checking, measurement and recording shall be as described in § 9.2 and Table 5 of section 9 of present specification.

7.9.1 Diameters

a) Outside Diameter of pipe body

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

b) Inside Diameter of pipe ends

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

$$\text{Nominal ID} = \text{nominal OD} - 2 \times \text{nominal WT}$$

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

7.9.2 Out-of-roundness

a) Pipes with OD less than 20"

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

b) Pipes with OD 20" and larger

Out-of-roundness at pipe ends shall be checked using a rod gauge or a caliper gauge and measurement of actual major and minor inside diameters of pipe shall be made. The difference between maximum ID and minimum ID measured within 100 mm at each pipe end shall not exceed 0.80% of the specified nominal Inside Diameter, with a maximum of 5 mm. Nominal Inside Diameter is defined in § 7.9.1.b above.

7.9.3 Peaking

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

7.9.4 Wall thickness

a) Minimum wall thickness guarantee

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

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

Wall thickness shall be checked using a micro-meter, a limit gage, a calliper or ultrasonics.

The SUPPLIER shall guarantee the specified wall thickness along full length of finished pipe. However, random checking at mid-length of pipe shall be made by SUPPLIER at a frequency to be agreed (with a minimum of three times per shift), unless measurement and recording of plate wall thickness was made continuously at plate mill on both the strip longitudinal axis and one strip edge, as a minimum (refer to § 6.5.2 of this specification). Wall thickness print-outs shall be made available to the Inspector in that case, for review at the pipe Mill.

b) Particular requirement

When so required in the PPS and when the pipe item wall thickness Standard deviation has been found in plate mill in excess of 0.25 mm, the following shall apply:

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

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

7.9.5 Weight

Each pipe length shall be weighed individually.

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

7.9.6 Unit length

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

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

No pipes shall be shorter than 10.00 m.

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

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

7.9.7 Straightness

The deviation from a straight line (taut wire) shall not exceed 1.4 mm per metre of length. Straightness shall be checked according two planes, as a minimum, displaced by 90°. One of these planes shall include the longitudinal seam.

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

7.9.8 Squareness of pipe ends

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

7.9.9 Pipe end preparation

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

Bevelling shall be carried out by straight machining only. There shall be no internal taper.

- b) 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 of the Inspector.

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

7.9.10 Height of weld beads

The weld bead height above the prolongation of the original surface of the pipe shall be within 0.5 mm and 3.5 mm, whatever the wall thickness.

7.9.11 Offset of plate edges

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

7.9.12 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 1/4 of the diameter of the pipe. Any sharp bottom deformations shall be unacceptable.

7.10 Welding

7.10.1 Welding processes

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

Gas Metal Arc Welding (GMAW) process may be used for tack-welding only, provided that the weld is completely remelted by the Submerged Arc Welding process. Refer to § 7.10.5 of this specification.

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

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

7.10.2 Welding consumables

- a) The weld deposits obtained from the consumables shall satisfy the impact toughness and hardness requirements of this specification and shall have tensile properties that are equal to or slightly higher than those of the base metal. YS and TS of weld metal shall not exceed the specified maximum YS and TS of base metal shown in Table 3 of Appendix 2. YS to TS ratio of weld metal shall be reported for information only.
- b) The chemical analysis of weld deposit shall not include more than 1.0% Nickel and 0.5% Molybdenum.
- c) All welding consumables shall conform to [ASME, Section II Part C \(AWS\)](#) or approved equivalent. Manufacturer's data sheets shall be supplied to the COMPANY for information.
- d) Each heat, lot (or so called batch herein) of consumables shall be subject to inspection and approval by the Inspector. 3.1.b Mill test certificates from consumables manufacturers showing test results actually obtained on the said lot shall be submitted to the Inspector.

The lot and the level of testing are specified as per [AWS A5.01-93](#) as follows:

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

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

For SAW flux, additional diffusible hydrogen test and / or moisture test shall be required as per Appendix 5 of the present specification when "specification A" is proposed

- e) Coated electrodes shall be of the extra low hydrogen type (i.e. maximum specified hydrogen content of 5 ml per 100 grams of Weld Metal).
- f) Low hydrogen coated electrodes and welding fluxes shall be supplied in moisture guaranteed proof containers and used according to the recommendations of their manufacturers. If there are no written recommendations available from the manufacturers of consumables the following instructions shall be applied:
 - Low hydrogen coated electrodes conforming to [ANSI/AWS A 5.1](#) shall be oven dried for at least two hours between 350°C and 430°C. A lower temperature for a longer holding time is not acceptable. Immediately upon withdrawal from their hermetically sealed container or drying oven, the electrodes shall be kept in a holding oven at approximately 100°C before use. Electrodes withdrawn from the holding oven shall be used within two hours after withdrawal. If unused they shall be re-dried as above.
 - Fluxes procurement, packing, storage and use shall conform to the Appendix 5 of the present specification

- g) The SUPPLIER's consumables procedure for storing, handling, drying, recycling and traceability shall be approved by the Inspector before commencement of production welding.
- h) All welding consumables shall be submitted to inspection by the Inspector. The Manufacturer's test certificates for each batch and lot of consumables shall be available for that purpose. These documents shall certify that the consumables meet the requirements of the relevant standards for classification and grade.

7.10.3 Welding procedure qualifications

a) Longitudinal weld seam

The welding procedure for longitudinal weld shall be qualified together with the pipe manufacturing procedure (see § 7.6 and Appendix 7) based on the submitted WPS.

b) Repair welding

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

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

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

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

Each welding repair shall be qualified on a pipe section under realistic conditions to the satisfaction of the Inspector, in accordance with Appendix 12.

c) SSC tests

SSC tests shall be carried out on all qualification test welds (main welds and repair welds) according to test procedure stated in Appendix 13 of present General Specification.

For all kinds of test weld repairs, SSC tests shall be carried out at the two following locations: one test at repair start and one test at middle length of repair (refer to Appendix 12).

7.10.4 Qualification of manual welders

All manual welders shall be qualified as per Appendix C of **API 5L** and the following.

- Welders who have performed a satisfactory welding procedure qualification test are thereby qualified.
- Other welders shall be qualified by visual and radiographic examinations and side bend tests as follows:
 - 100% visual examination
 - 100% radiographic examination
 - Four guided side bend tests at locations selected by the Inspector.

No nick-break tests are required.

7.10.5 Production welding

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

b) Weld depressions at pipe ends:

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

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

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

However, the following variations shall be acceptable, always providing that variation of welding heat input shall be within $\pm 10\%$:

- Amperage: $\pm 10\%$
- Voltage: $\pm 7\%$ ($\pm 10\%$ for manual repairs)
- Travel speed: $\pm 10\%$ for automatic welding ($\pm 15\%$ for manual repairs)
- Preheating/interpass temperature: -0°C , $+50^{\circ}\text{C}$ (provided that max. interpass temperature of 280°C is not exceeded).

8. Mill hydrostatic testing

8.1 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

8.2 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% min. of MSYS as stated in the above formula.

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

8.4 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.

- 8.5** 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.
- 8.6** 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.

9. Inspection and testing

9.1 General requirements

- 9.1.1** The SUPPLIER shall bear full responsibility for the conformity of its 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.
- 9.1.2** The SUPPLIER shall develop a Quality Control Plan (refer to § 3.2 of this specification) for approval by the COMPANY and shall carry out all inspections and tests required by this specification.
- 9.1.3** 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.
- 9.1.4** If during the main production, more than 7% of the pipes are rejected in any day's production or re-routed for repairs or re-processing, then the Inspector shall have the right to ask the SUPPLIER to increase his Quality Control Programme to an appropriate level and to maintain it until the causes of defective quality are identified and eliminated. Where above rate attains 10%, the Inspector may require the main production to be stopped.
- 9.1.5** Only pipes fully meeting the requirements of this specification shall be presented to the Inspector for final acceptance.
- 9.1.6** The SUPPLIER shall provide office space and inspection facilities, as required by the Inspector, in the Mill. Free access shall be allowed to him at all 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 can carry out his own inspections on the finished pipes.
- 9.1.7** See also the provisions of section 5 of this specification, for information.
- 9.1.8** All finished pipes shall be submitted to production tests and inspections as defined in the following paragraphs.
- 9.1.9** 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...

9.1.10 All Non-Destructive inspection personnels shall be properly certified according to CSWIP scheme or [EN 473 Std](#), or equivalent COMPANY approved Std, and shall have also been approved by the Inspector before any involvement on the order. NDT operators shall be certified level 2, as a minimum. The SUPPLIER shall supply the Inspector with a list of inspection personnels working on the job, showing their scope of qualification and date(s) of qualifications.

9.2 Dimensional inspection

All specified dimensions (as per para. 7.9) shall be checked measured and recorded to the frequencies shown in Table 5, of present section, unless otherwise agreed at the bid stage.

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

Additional wall thickness measurements shall be carried out on ground areas (see section 10 of this specification), except for cosmetic grinding.

Note on definitions:

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

9.3 Visual examination/Workmanship

9.3.1 Visual examination

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

The bevels shall be smooth and free from tool marks.

The standards of acceptance shall conform to [API 5L](#), clause 7.8, with modifications as follows.

9.3.2 Workmanship and defects

The standards of acceptance shall conform to [API 5L](#), Clause 7.8, with modifications as follows: The provisions of Table 5 of present section shall apply.

a) Bulges, dents and flat areas

Refer to § 7.9.12 of this specification.

b) Offset of Plate Edges

Refer to § 7.9.11 of this specification.

c) Out-Of-Line Weld Bead

The offset between the centrelines of the internal and external weld beads shall not exceed 3 mm. The narrowest point of the weld bead cross-section shall not be less than one-fourth (1/4) of the nominal wall thickness of the pipe with a minimum of 4 mm (see Figures in Appendix 7). Checking for bead misalignment shall be performed on specimens prepared for hardness test (see § 9.5.5 of this specification).

d) Height of Weld Beads

Refer to § 7.9.10 of this specification.

e) Hard spots

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

f) Cracks and leaks

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

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

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

g) Laminations

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

h) Arc Burns

Repair by welding is not permitted.

i) Undercuts

Undercuts with a max. depth of 0.4 mm are acceptable in any length.

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

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

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

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

j) Surface condition of pipe

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

All those defects shall be removed by grinding. Thickness measurements shall be made on all areas where grinding has been carried out, except for cosmetic guiding. The final thickness after grinding shall not be less than the specified minimum wall thickness.



k) Other Defects

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

Table 5: Frequencies of visual and dimensional inspections

Inspection Items (3)	Mini. frequency Check (2)	Mini. frequency Measurement/Recording (1) (2)
WT (ends)	All pipes	ALL (4)
		20/shift (4)
- I.D. (ends) - Inside O.O.R (ends)	All pipes	20/shift
- Unit length - Unit weight	All pipes	All pipes
- Peaking (ends) - Peaking (mid-length)	All pipes 20/shift	20/shift 5/shift
- O.D. (ends) - O.D. (body) - Straightness - Squareness (ends)	5/shift	5/shift
- Bevel - Height of weld bead - Offset of plate edges	20/shift	5/shift
Bulges, dents, flat areas	All pipes (visual)	All pipes with anomaly
Surface condition (inside, outside) (arc burns, undercuts, surface imperfections, etc.)	All pipes (visual)	UT on ground areas (except for cosmetic grinding)
(1) Measurement/recording frequency shall be increased in mutual agreement with the COMPANY when dimensional histograms are required. (2) Definitions of “checking”, “measurement” and “recording” are stated in § 9.2. (3) All inspection items contained in above table shall be checked on each Press Bending pipes or Roll Bending pipe. (4) Refer to § 7-9-4-b		

9.4 Non-destructive inspection (Clause 9.8 of API 5L)

9.4.1 Ultrasonic Testing (UT)

Apart from the ultrasonic examination to be performed on the plates (refer to § 6.5.3 of this specification), all non-destructive inspections shall be carried out after completion of pipe manufacture, expansion (for UOE pipes) and hydrostatic test.

9.4.1.1 Inspection of longitudinal weld seam

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

a) Ultrasonic inspection equipment

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

b) Reference standards

The reference standard shall be made from a pipe manufactured for the order. However, with prior approval of the COMPANY, pipe production may start with a reference standard made from a pipe of same diameter and wall thickness having a longitudinal weld of same profile and width, always providing that the specified reflectors are included.

The reference standard shall be of sufficient length so as to permit the detection of the standard reflectors while the equipment is travelling at its normal inspection speed. The standard reflectors shall consist, as a minimum, of the following:

- One 1.6 mm (1/16") radially drilled hole (through thickness) in the weld centreline
- Four longitudinal N5 notches, two internal and two external of pipe, machined in the HAZ on both sides of weld
- Two weld centreline N5 notches machined longitudinally, one internal and one external of pipe
- Two N5 notches machined transverse to weld, one internal and one external of pipe
- Two 3 mm flat bottom holes drilled in weld centreline, half thickness depth, inside and outside.

The width of notches shall not exceed 1.0 mm.

The reference level shall be the lowest of the signals produced from any of the above specified reflectors and the trigger/alarm level shall be set on 100% of this reference level.

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

The reference pipe shall be re-run, for calibration purposes, as a minimum:

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

If during the calibration check, the standard reflectors do not produce signals of the required magnitude, the calibration shall be re-adjusted, and all pipes accepted since the previous successful calibration shall be re-examined.

c) Acceptance limits

Any imperfection which produces a signal of height exceeding the reference level defined above shall be considered an unacceptable defect, unless it can be demonstrated that the imperfection does not exceed the provisions of § 9.3 and 9.4.2 of this specification. Any imperfection found by the automatic ultrasonic system shall be further investigated by radiography. Automatic UT print-outs of calibration and production scanings shall be made available to Inspector for review.

9.4.1.2 Inspection of pipe ends

The full circumference of each pipe end after bevelling shall be ultrasonically checked for laminar imperfections over a band 50 mm wide with manual or automatic ultrasonic tester. This band width is extended to 60 mm when the inspection is made before bevelling.

Inspection procedure shall be according to [ASTM A 578](#) Std.

Any internal laminar imperfection exceeding an area of 60 mm² shall not be acceptable.

9.4.2 Radiographic inspection

- a) Radiographic inspection in accordance with [ISO 12096](#) Std shall be carried out on the longitudinal weld at each pipe end over a minimum distance of 240 mm and also on those parts of the weld not scanned by all probes in the automatic ultrasonic inspection, on all welding re-starts, repair welds, ultrasonic indications and welding procedure qualification test welds.
- b) Radiographic inspection shall be made by X-rays using fine grained high contrast direct films (AGFA-GEVAERT type D5, EASTMAN-KODAK type T, or equivalent), lead screens and a single wall/single image technique.

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

c) The following shall also apply:

- ISO wire penetrameter as per [ISO 1027](#), [ASTM E 747](#) or [EN 462-1](#).

Two (2) penetrameters shall be placed one at each extremity of each radiograph: one on the as-weld reinforcement and one on the ground reinforcement of weld.

- Maximum sensitivity across the weld, using a source side penetrameter, shall be as follows with regard to weld thickness T:

- $T \leq 10 \text{ mm}$: 2.0%

- $10 \text{ mm} < T \leq 20 \text{ mm}$: 1.8%

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

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

- Maximum geometrical unsharpness: 0.25 mm
- Image density: 2.2-3.5 with regard to the weld seam with reinforcement, but may be up to 3.9 on the ground portion or on pipe body. Density shall be measured and recorded on 10% of films of each shift, as a minimum.

d) Except as specified in § 9.3 above, the acceptance standards for radiography shall conform to **API 5L** and the following:

- Incomplete penetration and lack of fusion of any size are not acceptable
- Elongated slag inclusions shall not exceed 1.5 mm in width and 6.4 mm in length
- Circular slag-inclusions and gas-pockets shall not exceed 2.5 mm in diameter
- The cumulated length of all discontinuities in any 152.4 mm of weld length shall not exceed 12.7 mm
- Maximum area fraction of porosities, on the radiograph, shall not exceed 1% of any 50 mm of weld length
- Porosities and inclusions appearing on the radiograph within 50 mm of the pipe end shall be considered as unacceptable defects.

9.4.3 Magnetic Particle Inspection (MPI)

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

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

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

b) When pipe size is such that $O.D. \leq 25.WT$, then the pipe external shall be MPI tested on full body and weld at a frequency of one pipe per shift for the first ten shifts and if no defects are found once per ten shifts thereafter. Acceptance shall be to § 9.3.2 of this specification and **API 5L**, clause 9.7.5.3, except that repair by welding shall not permitted.

9.5 Production tests

- The following production tests shall be carried out on base material and weld seam in accordance of API 5L requirements and the following. The inspector will select a list of pipes to be preferentially tested, based on the review of the mother plate rolling parameters. The inspector reserves also the right to select the pipe to be tested for any other reason, justified to his opinion.

The inspector reserves the right to witness and stamp the test sampling, to require to keep his stamp traceable up to the testing and to witness the tests.

- Traceability of specimens shall be made by hard marking.
- Specimen cutting shall be made by sawing (flame cutting shall not be acceptable).

9.5.1 Product chemical analyses

A product analysis (refer also to § 6.3) shall be carried out on both the pipe selected for tensile test and on another pipe from same heat.

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

9.5.2 Tensile tests (base metal and weld)

a) Tensile tests in base material shall be transverse to pipe axis and located at 90° to the weld seam.

However, longitudinal tensile tests in addition to the transverse tensile tests are required for submarine pipelines. Specimens shall be cut at same location as above.

Strip specimens shall be used for longitudinal and transverse tests. Flattening procedure of pipe samples (before cutting transverse strip specimens) shall be submitted to the Inspector. Round bar specimens may be used where practicable for transverse tests, only when so previously agreed with the COMPANY. Round bar specimens shall then be machined directly in the formed sample without any flattening of the sample, as specified in [API 5L Fig. 4.2.G](#). In case of dispute, the results with round bar specimens shall prevail.

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

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

d) Transverse weld tensile tests shall apply regardless of diameter and shall record the transverse Tensile Strength and location of rupture.

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

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

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

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

g) According to the minimum levels of tensile properties obtained on plates, the Inspector reserves the right to select the pipes for production testing in order to check that the mechanical properties required for the pipes have been actually obtained with plates whose properties are at the minimum of the tensile range.

9.5.3 Guided bend tests

- Guided bend tests shall be conducted transverse to weld seam in accordance with the requirements of clause 9.8.3 of [API Spec 5L](#).
- One face-bend and one root-bend test, with weld reinforcement removed from both faces, shall be carried out for wall thickness of 12.7 mm and less. For wall thickness above 12.7 mm, these tests shall be replaced by two side bend tests having full pipe wall thickness and a width of 12.5 mm.
- Testing frequency shall be two bend specimens as above per each lot of 50 pipes or less per heat.

9.5.4 Charpy V-notch tests (base material and weld)

Three Charpy V-notch impact tests (one for base material testing and two for weld testing as indicated hereafter) shall be taken from the same pipe as that selected for tensile testing (see § 9.5.2 above). Each test shall consist of three specimens notched through the pipe wall thickness.

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

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

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

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

For acceptance, the results of energy absorption for the above notch locations shall not be less than the values stated in Table 4 of Appendix 2 for full size specimens (10 x 10 mm).

As far as possible, full size specimens shall be used. If sub-size specimens are found necessary due to pipe curvature and wall thickness, the required absorbed energy figures shall be those for full size specimens (see Table 3) multiplied by the corresponding factors given in the Table below.

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

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

9.5.5 Macrography/Hardness test

One specimen shall be extracted from the weld of the selected pipe for tensile tests (see § 9.5.2 above).

The specimen shall be polished and etched for macrographic examination. The weld cross-section shall be examined to ensure that weld profile is satisfactory as per para. 9.3.2 above and Appendix 8.

A VICKERS hardness survey shall then be carried out using a 5 kg load in accordance with Appendix 11. No individual hardness value shall exceed 250 HV 5 for Severe Sour Service and 280 HV 5 for Intermediate Sour Service. If any result exceeds this limit, all pipes from that lot/heat shall be rejected.

9.5.6 Micrography on base material.

One specimen of 30 mm long in the rolling direction, shall be extracted from base material, at 20 mm from the weld toe and at 180° to the weld seam. 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.

9.5.7 Drop Weight Tear Tests (DWTT)

In case of gas pipeline with 20" OD or larger, grade X52 or higher, wall thickness exceeding 8 mm, a pipe from each heat shall be tested by Drop Weight Tear Testing in accordance with SR-6 of API 5L Std and API RP 5L3 (or equivalent EN Std). The routine testing temperature shall be 0°C, unless otherwise stated in the PPS.

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

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

Relevant marking of pipes is not required.

DWTT applies to line pipes and riser pipes (including pipes of expansion loop). DWTT are not required on mother pipes to be used for bends.

9.5.8 Defective test specimens

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

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

9.5.9 Retests

Where a specimen fails to conform to the specified requirements, a retest may be accepted by the Inspector pending further investigation of the failure is made by the SUPPLIER. Where it is

thought that the failure can be an isolated case, then a retest on four (4) additional pipes from the same lot of pipes shall be carried out.

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

Should one (or more) of the retests give unacceptable results, then the complete lot of pipes 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, always providing that such individual tests shall not produce a rejection equal or superior to 50% of the pipes so tested. Should that be the case then all pipes of the said lot shall be rejected.

9.6 HIC tests

HIC tests shall be carried out per each steel source, pipe size, steel grade and manufacturing process using uncoated specimens on one test pipe from each of the first three heats (i.e. three test pipes to be tested) and then at a frequency of one test per 10 heats, or part thereof. The pipe selected for manufacturing procedure qualification shall be one of the three tested pipes. The procedure for determining HIC sensitivity and acceptance criteria shall be in accordance with Appendix 14.

In the event of failure to meet the acceptance criteria of Appendix 14 the COMPANY may accept to have four pipes of the same heat re-tested. If a re-test fails, the said heat shall be rejected and all heats of the said casting sequence shall be tested on two pipes minimum before release or reject of each individual heat of the sequence.

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

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

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

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

9.7 SSC tests

SSC tests as per Appendix 13 shall be carried out in weld seam and pipe material per each steel source, pipe size, steel grade and manufacturing process. SSC tests shall be performed during qualification of pipe manufacturing procedure (refer to para. 7.6 and Appendix 7) for 720 hours as stated in Appendix 13. Production tests shall then be carried out at 1/4th, 1/2th, 3/4th and end of pipe production, still according to provisions of Appendix 11, except that test duration shall be 360 hours only (15 days).

In the event of failure to meet the acceptance criteria of Appendix 13 in base material, the COMPANY may accept to apply to base material the re-testing procedure stated above in § 9.6 for HIC tests. However, when a test fails in weld metal or HAZ of weld seam, the re-testing procedure will be agreed between the SUPPLIER and the COMPANY based on a review of welding conditions to identify the lot of pipes to be further tested.

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

9.8 Residual magnetism

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

10. Repair of defects

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

10.1 Repair on base material

1. Repair by welding on pipe base metal shall not be permitted. This requirement applies also to welding repairs of any cavity resulting from removing of arc burns (see § 9.3.2).
2. Repair of dents and flat areas shall not be permitted.
3. Defects in the body of pipe shall be removed by grinding. A smooth curved surface shall be obtained. Thickness measurements shall be made on all areas where grinding has been carried out, except for cosmetic grinding. The final thickness after grinding shall be not less than the specified minimum wall thickness.

Measured thickness after grinding shall always be written (e.g. with chalk) on the pipe ground area. The marking shall be made in such a way to be readable by the Inspector when the pipes is presented at final bench.

4. Repair of bevels shall be made by full re-bevelling only.

10.2 Repair of longitudinal weld seam

1. Unacceptable defects in the longitudinal weld seam, except as specified below, may be removed by grinding and repaired by welding carried out by qualified welders (see § 7.10.4) and using a previously qualified welding procedure (see § 7.10.3).
2. No welding repair is permitted over a length of 200 mm from each pipe end.
3. Longitudinal weld seam containing cracks shall not be weld repaired. The section of pipe containing cracks shall be cut off. Then, acceptability of the remaining pipe shall be based on length requirements as per § 7.9.6.
4. For each pipe, the total length of manual welding repairs shall not exceed 5% of the pipe length and the number of repaired areas is limited to three maximum. Repairs shall be separated by at least one pipe OD of unrepaired weld.
5. Repair of a weld area previously repaired shall not be permitted.
6. Back to back repair shall not be permitted.
7. Each welding repair shall have a minimum length of 100 mm, even if the defect is of less extent.
8. The defect shall be completely removed by arc gouging and/or grinding and the resulting cavity shall be thoroughly cleaned. If the defect remains, the pipe shall be cut or rejected.
9. The external surface of the repair weld shall be subject to suitable grinding in order to obtain an uniform appearance and to merge smoothly into the base material.

10. Each repaired area shall be 100% inspected by manual ultrasonic testing, radiography and MPI tested according to § 9.4.2 and 9.4.3 of this specification.

11. Marking of pipes

- a) Each pipe shall be clearly identified by means of markings made with indelible white paint, and a circumferential coloured painted band 50 mm wide on the external surface of one pipe end at 200 mm approx. of pipe end. The colour shall be defined in the PPS or otherwise agreed with the SUPPLIER in due time.
- b) The quality of paint employed and its application shall be designed to provide inscriptions that shall be perfectly readable for a at 6 month after delivery on pipes exposed to outdoor weather conditions. The marking shall be designed also to withstand heating 200/250° C during the further coating stage. Marking and stamping will be protected by varnish.
- c) Marking (paint stencilling) shall begin at least 200 mm from the bevel and shall be made circumferentially using letters and figures of 25 mm minimum in height. Metric units shall be used to state pipe length. The marking position on the circumference shall be between 12 and 3 O'clock, the reference being the weld seam positioned at 6 O'clock.

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

- d) Unique pipe number shall be allocated sequentially and marked on the pipes.
- e) Stencilling shall be made at inside surface of both pipe ends as follows.

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

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

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

- f) The following shall be die stamped on the bevel surface at a point opposite to the longitudinal seam, at the pipe end where full stencilling as above has been made:
- The mark of the Inspector
 - The pipe number, when so required in the PPS.
- g) Marking shall be approved by the Inspector prior to pipe production.

12. Protection of bevels

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

13. Handling, transport and storage of pipes

13.1 General

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

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

13.2 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.

Pipes shall be stored with the weld seam located at 6 O'clock.

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

13.3 Transport

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

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

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

14. Documentation

The following documentation shall be delivered by the SUPPLIER.

14.1 Mill certificates

1. Unless otherwise stated in the PPS., the inspection test certificate required to support the delivered pipes shall be 3.2 according to [EN 10204](#) Std. Mill certificate shall be established by the pipe Manufacturer.
2. Mill certificates shall make reference to [API Spec 5L](#) together with the present General Specification and applicable PPS.
3. Mill certificates shall show the following:
 - Rolling technique/heat treatment of base material (e.g. normalized, TMCP with/without accelerated cooling, etc.)
 - Manufacturing process (e.g. UOE, Bending Roll, Press Bending)
 - Ladle analysis, including Carbon Equivalent and Pcm
 - Pipe no. with reference to heat no. (and slab no., where possible)
 - Mechanical test results and product chemical analysis (including CE and Pcm) with reference to pipe no.
 - Dimensional inspections with results
 - Non-Destructive Tests performed with results
 - Results of H₂S embrittlement tests
 - Any supplementary tests and inspections carried out
 - Certificate no. and date of issue.
4. Format of Mill certificates shall be agreed with the COMPANY prior to pipe production.
5. Refer to § 14.3 for number of originals and copies to be supplied and also for stamping and signing these certificates.

14.2 When the bids are submitted

- Manufacturer and mill names.
- A preliminary Pipe Manufacturing Procedure Specification (including plate manufacturing procedure specification) giving the main features and characteristics of proposed base materials and pipes. This MPS shall, however, include, as a minimum, all information required at items 1 through 10, and at items 12 13, 18 and 19 of Appendix 6 of this specification.
- Weldability test programme (when applicable)
- Description of the proposed bevel protectors (if any)
- Handling, transport and storage procedure for pipes (typical)
- Quality Assurance certification ([ISO 9002](#), [API Q1](#), etc.)
- Quality Control Plan (typical)

- Pipe supply track record as well as histograms of chemical and mechanical test (including impact tests on base metal and weld seam) results from previous orders of the same pipe grade and similar dimensions, as proofs of capability to produce pipes according to this specification
- Nominated laboratory for conducting the H₂S embrittlement tests.
- Past experiences of SUPPLIER and laboratory on HIC and SSC tests as per this specification (including the laboratory's typical procedures)
- Welding tests carried out by the SUPPLIER on similar pipe material and dimensions giving evidence of acceptable weldability as regard to applications defined in § 7.7 of this specification (when so required in the PPS).
- Details of offered fabrication Pipe History System (PHS), when required in the PPS
- At SUPPLIER's option, any other pertinent technical information relating to the proposed pipe supply
- The SUPPLIER's deviations/qualifications to present specification. Where no deviations are stated in the bid, then the potential SUPPLIER shall be considered as fully accepting the requirements of present specification.

14.3 Upon completion of pipe production

- a) A close-out production dossier shall be established by the SUPPLIER and submitted to the COMPANY. It shall include, but not be limited to, the information and documents stated hereafter:
- Steel making process and plate Manufacturing Procedure Specification
 - Non-Destructive Testing reports of steel plates
 - Mill test certificates of plates
 - Pipe Manufacturing Procedure Specification
 - Mill certificates of pipes
 - Reports of pipe manufacturing procedure qualification tests, including WPS and WPQR
 - Reports of HIC and SSC tests
 - Reports of NDT procedure qualification tests
 - Reports of production tests made on pipes
 - Reports of all dimensional and NDT made on pipes
 - Mill hydrostatic test certificate of compliance
 - Quality Control Plan
 - Report of weldability tests (if any) and SUPPLIER's recommendations or guidance for site welding of supplied pipes
 - List of heat numbers showing pipe numbers, individual length and weight, total length and weight produced per heat
 - Pipe list with sequential numbers of produced pipes related to heat numbers

- Pipe list of shipments
 - Histogram of production test results (chemical and mechanical) and dimensions of pipes (length, as a minimum),
 - Records of wall thickness as stated in § 7.9.4 b)
 - Fabrication Pipe History System (if any)
 - Compilation of concessions/deviations, if any, granted by the COMPANY.
- b) The PPS shall state the number of originals and copies of Mill certificates and the close-out production report which are to be supplied to the COMPANY.
- c) The Inspector shall stamp (rubber-stamp), sign and date the original documentation. The copies shall be stamped (as a minimum) by the Inspector.

14.4 Schedule

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

15. Storage of mechanical test specimens and radiographs

The SUPPLIER shall ensure preservation and storage of the following:

15.1 Mechanical test specimens

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

- Qualification tests = 5 working days
- Production tests = 2 working days

15.2 Radiographs

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

16. Fabrication Pipe History System (PHS)

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

- For each pipe number: Grade, OD, WT, Length, Weight, CE/Pcm with reference to heat number, mechanical properties (with reference to test no. and Mill 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 at the bid stage with the possible means of transmitting data (floppy disks, CD ROM, etc.).

17. Technical queries/Non-conformance reports

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

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

- 17.2** 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.
- 17.3** 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 - Ladle chemical composition⁽¹⁾ (% weight max.)

Steel grade	C	Si	Mn	P	S	V	Nb	Ti	Others	CE (4)	Pcm (5)
Pipes normalised/Normalising rolling											
B	0.14	0.40	1.20	0.015	0.003	-	-	-	(2) (3)	0.40	0.23
X42	0.14	0.40	1.40	0.015	0.003	-	-	-	(2) (3)	0.40	0.23
X46	0.14	0.40	1.45	0.015	0.003	0.06	0.05	-	(2) (3)	0.41	0.24
Pipes thermo-mechanically rolled											
X42	0.10	0.35	1.45	0.015	0.003	0.04	0.05	-	(2) (3)	0.38	0.22
X46	0.10	0.35	1.45	0.015	0.003	0.04	0.05	-	(2) (3)	0.38	0.22
X52	0.10	0.40	1.45	0.015	0.003	0.05	0.06	0.02	(2) (3)	0.38	0.22
X60	0.10	0.40	1.45	0.015	0.003	0.07	0.06	0.02	(2) (3)	0.38	0.20
X65	0.10	0.40	1.45	0.015	0.003	0.08	0.06	0.02	(2) (3)	0.39	0.21

Notes:

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

The maximum working percentages of residual elements shall be as follows (ladle and product check) for Grades X52 up to Grade X65:

$$\text{Sn} = 0.015$$

$$\text{Pb} = 0.005$$

$$\text{Sb} = 0.010$$

$$\text{As} = 0.015$$

$$\text{Bi} = 0.005$$

$$\text{B} = 0.0004 \text{ (i.e. no deliberate addition)}$$

(2) $\text{Cu} \leq 0.35$

$$\text{Al total} \leq 0.050$$

$$\text{Cr} \leq 0.25$$

$$\text{N} \leq 0.012$$

$$\text{Mo} \leq 0.25$$

$$\text{Al/N} \geq 2$$

$$\text{Ni} \leq 0.30$$

$$\text{O} \leq 0.0025$$

$$\text{for } S \geq 15 \text{ ppm : } \frac{\text{Ca}}{S} = 2 \text{ to } 5 \text{ with } \text{Ca} \leq 0.004$$

$$\text{for } S < 15 \text{ ppm : } 0.001 \leq \text{Ca} \leq 0.004$$

- (3) The total percentage of Nb + V + Ti + Cu + Mo + Cr shall not exceed 0.50%.

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

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

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

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

Appendix 2 Tensile and impact properties

Table 3 - Tensile properties of base metal and weld
API 5L Tensile test (strip or round bar specimen)

Grade (API 5L)	YS psi (MPa)		TS psi (Mpa) ⁽²⁾		$\frac{YS}{TS}$ maxi ⁽¹⁾	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
X42	42,000 (289)	60,000 (413)	60,000 (413)	79,000 (545)	0.88	
X46	46,000 (317)	64,000 (441)	63,000 (434)	82,000 (565)	0.88	
X52	52,000 (358)	70,000 (483)	66,000 (455)	88,500 (610)	0.88	
X60	60,000 (413)	78,000 (538)	75,000 (517)	98,000 (676)	0.90	
X65	65,000 (448)	83,000 (572)	77,000 (531)	100,000 (690)	0.92	

Notes:

- (1) Applicable to base metal only.
- (2) For transverse weld tensile test, only the mini. TS shall be met and recorded.

Table 4 - Transverse impact energy of base metal and weld - 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 Ultrasonic inspection of steel plates

1. General

The ultrasonic inspection of plates shall be carried out in accordance with [BS 5996](#) and the following, except that transverse scanning on plate body is not required. Scanning of transverse plate edges may be omitted provided that pipe ends are ultrasonically tested as per present specification.

The SUPPLIER is required to supply the COMPANY with an ultrasonic inspection procedure for prior approval.

2. Performance of the inspection

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

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

The automatic ultrasonic device shall be equipped with a warning system which must act in case of defect found or in case of lack of coupling with the plate, together with an automatic printer which can produce a printed cartography of laminar imperfections. Any other equivalent equipments may also be used providing that prior approval is obtained from the COMPANY at the bid stage.

The printed charts shall be made available to the Inspector for review at the pipe Mill.

3. Reference standards

Unless otherwise previously agreed, WT of the calibration plate shall be that or very close to that of the production plates to be examined.

The calibration of the ultrasonic equipment shall be carried out in dynamic condition using transverse rectangular notches with a width of 5 mm and 5mm flat bottom holes (FBH). Those notches and FBH shall be located within the body and the four edges of the reference plate. Notches shall have depths of 25%, 50% and 75% of plate WT, as a minimum. This shall also include reflectors located at a depth of 4 mm max. from both plate surfaces.

The reference level shall be the lowest of the signals produced from the notches.

Indications obtained at the automatic ultrasonic inspection shall be rechecked by manual UT according to [BS 5996](#) Std and the 20 dB drop method to determine the size of the laminar imperfections.

Frequency of calibration shall be as per [BS 5996](#) Std.

4. Acceptance standards (at manual UT examination)

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

(1) Within plate body:

Maximum acceptable area of single defect in mm ²	Maximum cumulated area in mm ² /m ²		Maximum frequency of acceptable imperfections	
	(*)	(**)	Locally (*)	Globally (**)
600	3,000	2,000	10 per m ²	5 per m ²

Notes:

(*) With respect to any area of 1 m² within the plate surface.

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

(2) Within plate edges:

Maximum acceptable area of single defect in mm ²	Maximum acceptable dimension of single defect in mm	Maximum frequency of acceptable defects per metre of plate length
60	6 x 10	3

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

Appendix 4 Automatic ultrasonic testing of longitudinal weld seam and subsequent investigations

1. Automatic ultrasonic inspection equipment

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

2. Reference standards

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

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

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

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

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

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

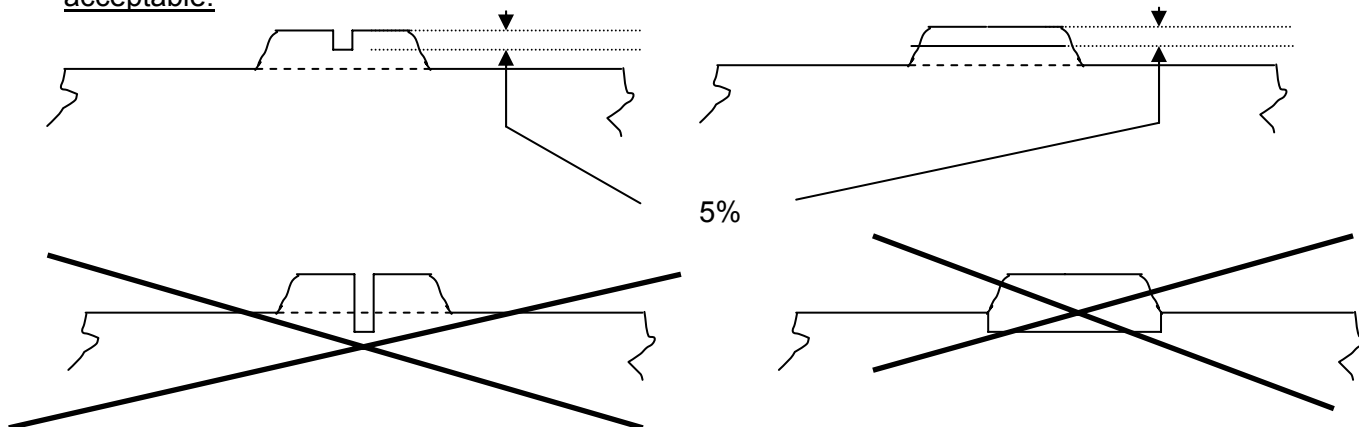
The standard reflectors shall consist, as a minimum, of the following:

- ◆ at 240 mm from each pipe end and at mid pipe length, one 1.6 mm radially drilled hole (through thickness) in the weld centreline
- ◆ within the scanning last 2 meters:
 - four longitudinal N5 notches, two internal and two external of pipe, machined in the HAZ on both sides of weld
 - two weld centreline N5 notches machined longitudinally, one internal and one external of pipe
 - two N5 notches machined transverse to weld, one internal and one external
 - for pipes of 16 mm wall thickness and above, a ceramic insert of 2 to 3 mm in height, 1 mm thick maximum and 10 mm long maximum, located at mid thickness of the weld and in the centreline

Notch profile standard reflectors:

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

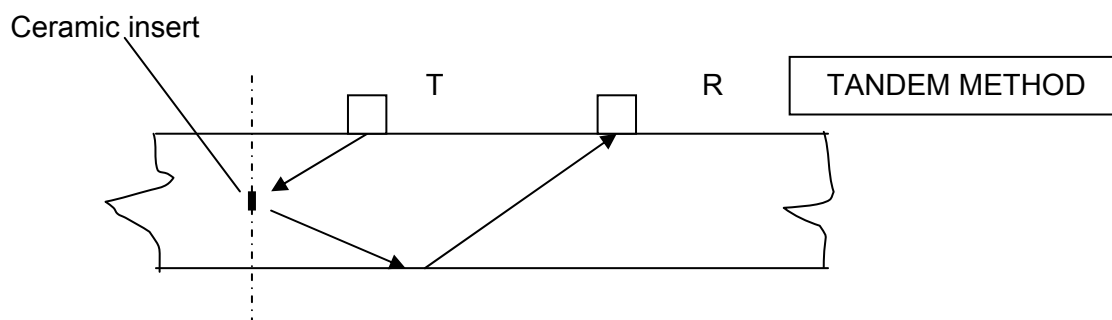
Notch (longitudinal or transversal), with a depth equal to weld reinforcement + 5% of w.t. is not acceptable.



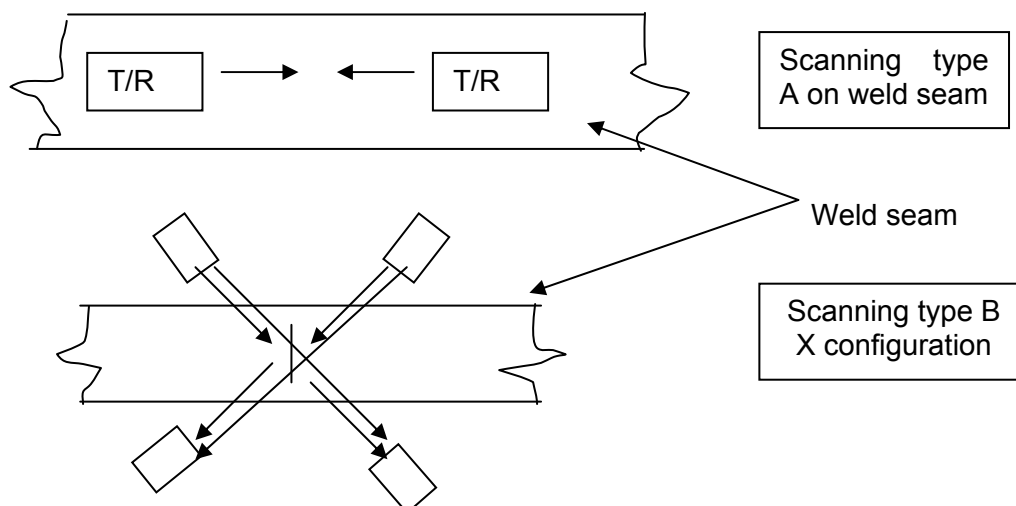
3. Particular probe arrangements and scanning techniques

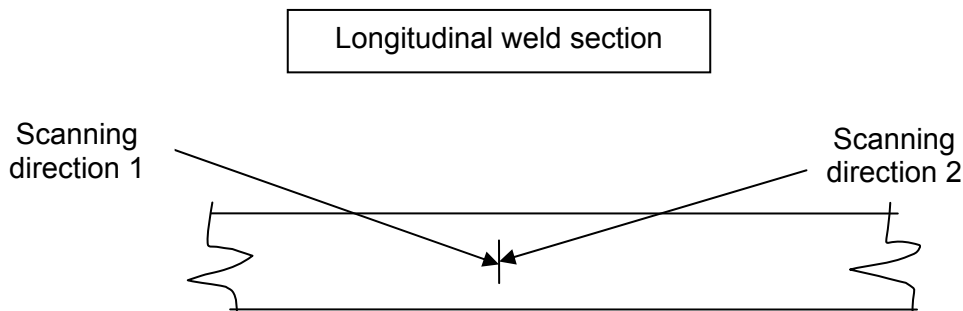
Unless otherwise designed and demonstrated efficient by supplier, the probe arrangement and the scanning techniques for the transverse and the longitudinal mid thickness scanning will be as follows:

3.1 scanning for longitudinal flaws at mid thickness



3.2 scanning for transverse flaws





Scanning in both 1 and 2 longitudinal directions is required.

Coupling control is required.

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

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

4. Calibration

4.1 Static calibration

- Reference level: in each channel, the reference level shall be the lowest of the signals produced from the relevant reflectors. It shall be set at 80% FSH.
- Detection thresholds: the detection trigger thresholds shall be set at 40% FSH.
- Coupling: A coupling type "go / no go" is not acceptable.

A coupling control by transmission shall be installed for each pair of symmetrical probes.

The reference level shall be the signal received on calibration pipe, in each coupling channel. The reference level will be set at the contractor option, but gains and levels shall be recorded.

Gains shall not be modified for production scanning.

The thresholds of "lack of coupling" detection shall be set at 8 dB drop maximum, below the reference levels.

When production scanning can not reasonably be achieved with a drop of 8 dB maximum, the following procedure will be considered:

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

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

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

- a comprehensive detailed list probes / channels, longitudinal/transverse, ID/OD/Mid, flaw detection/coupling
- in each channel, including coupling channels: gain, signal height, trigger threshold
- date, time, operator name and signature, inspector name and signature.

4.2 Dynamic verification (so called dynamic calibration)

- Definition

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

- Performance and frequency

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

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

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

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

- Acceptance criteria of dynamic calibration

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

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

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

The 3 dynamic print outs shall be checked, based on the table C/R criteria.

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

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

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

If the equipment requires re-calibration, the static and dynamic runs shall be repeated and all pipes tested since the last successful dynamic check shall be re-tested.

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

5. Production scanning

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

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

6. Investigation of AUT indications

6.1 Indications of coupling drops

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

6.2 Indications from flaw detection channels

Any imperfection which produces a signal of height exceeding the threshold level defined above, shall be considered an unacceptable defect, unless it can be demonstrated that the imperfection does not exceed the provisions of paragraph 9.3 and 9.4.2 of the specification. Any indication found by the automatic ultrasonic system, shall be further investigated by radiography.

Repair welds and welding re-starts locations shall be also investigated by manual UT and by radiography.

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

Supplier shall issue his own "decision tree" corresponding with his internal organisation. It shall be included in the procedures and working instructions to NDE operators.

6.3 Manual UT

Manual UT shall not consist of reproducing the AUT scanning.

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

Calibration shall be carried out on calibration pipe reflectors. For production scanning, 6 dB shall be added for detection.

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

Supplier shall submit to COMPANY approval the manual UT procedure.

The operator shall report the indication type, size, % FSH, and position in the weld section.

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

Note: when manual UT on weld seam is applied for the detection of chevron cracks, the attached relevant requirements shall apply.

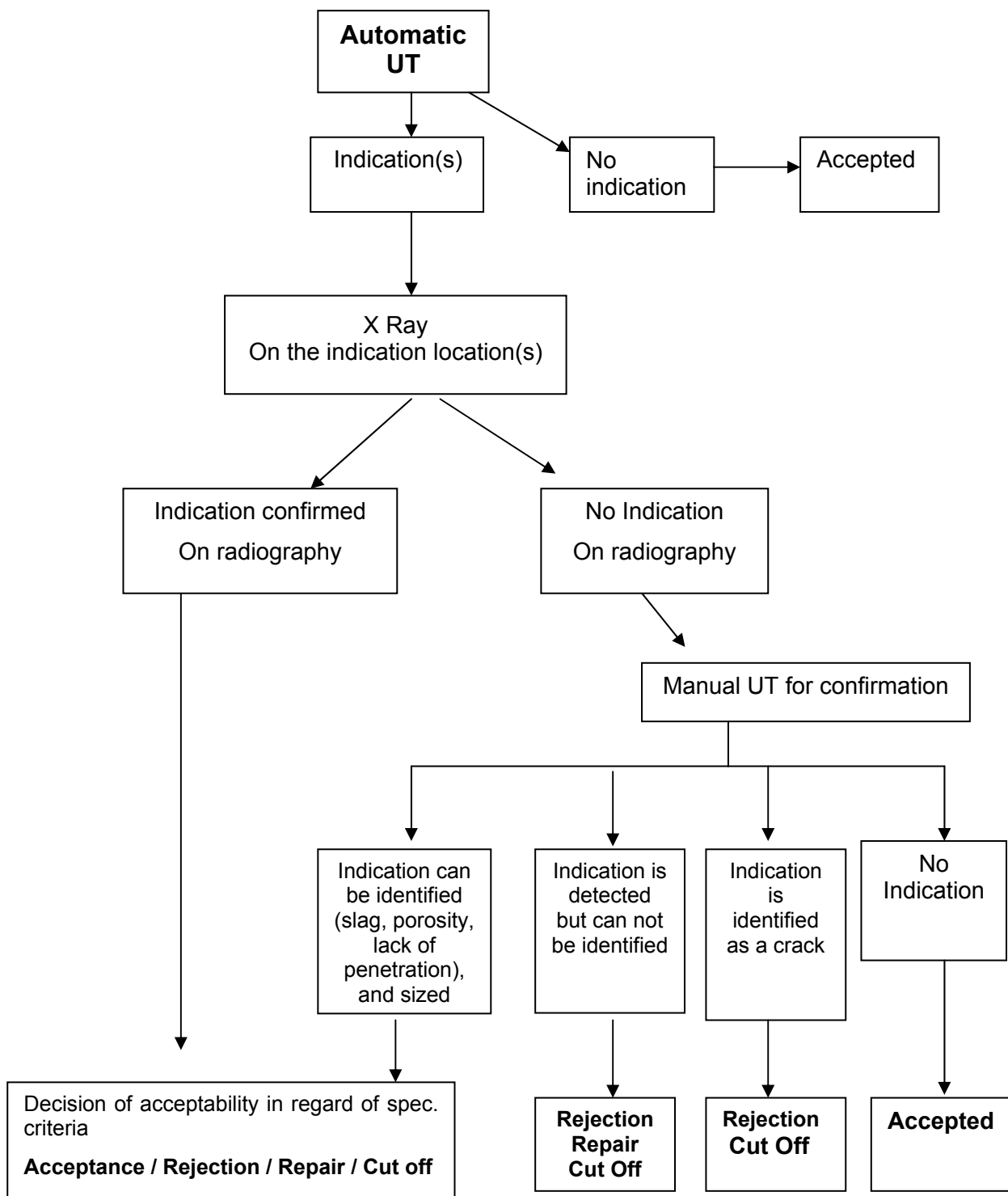


Table R/C

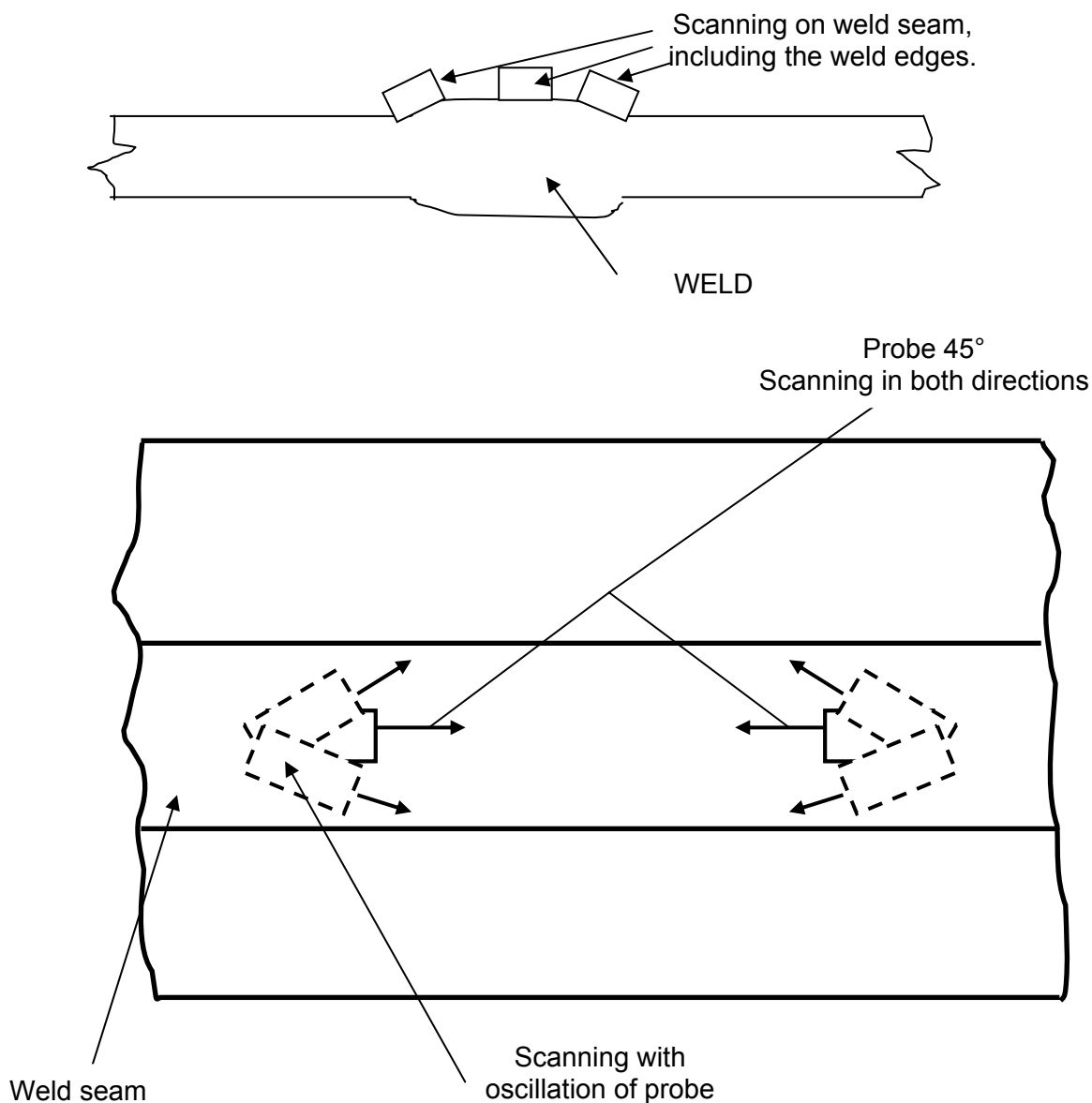
Scanning speed: -----

CHANNEL	L1 E/R	L2 E/L	L3 I/R	L4 I/L	L5 MW/R	L6 MW/L	T1 E	T2 I
REFLECTOR								
H 1.6mm center Scan start	x	x	x	x			x	x
H 1.6mm center Mid length	x	x	x	x			x	x
H 1.6mm center Scan end	x	x	x	x			x	x
Insert MW					x	x		
H 4 mm weld toe right	x		x					
H 4 mm weld toe left		x		x				
N5 longi center int			x	x				
N5 longi center ext	x	x						
N 5 toe int. Right			x					
N5 toe ext. Right	x							
N 5 toe int. left				x				
N 5 toe ext. Left		x						
N 5 trans. Ext.							x	
N 5 trans. Int.								x

Longitudinal weld seam inspection Decision tree



Recommendation for manual ultrasonic scanning on weld seam for the detection of chevron cracks in weld



MANUAL UT CALIBRATION :

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

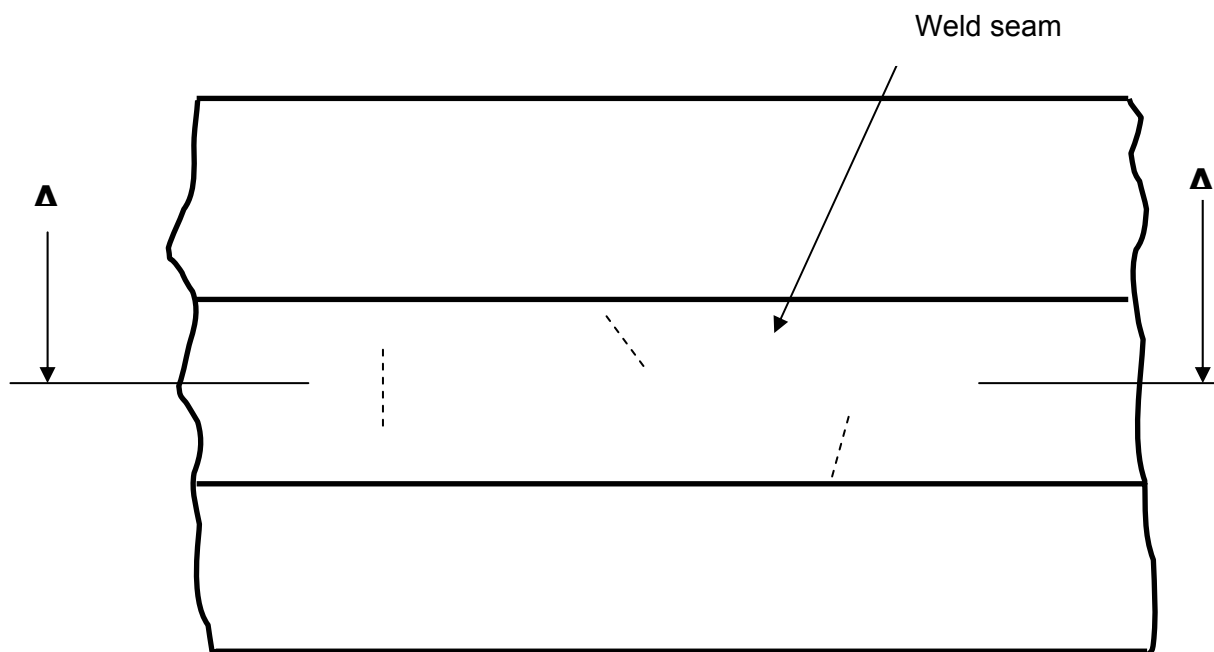
PRODUCTION SCANNING :

Add 12 dB for the detection in production scanning.

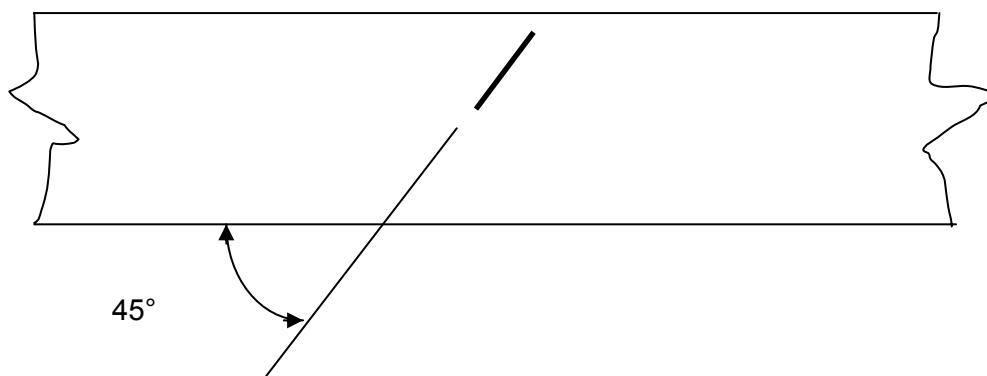
CRITERIA OF ACCEPTATION

40% FSH with the original calibration parameters.

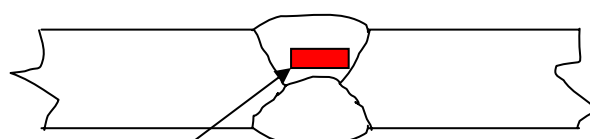
Location and orientation of cheron cracks in the saw weld seam



SECTION A - A



Transverse weld section



Cracks are usually located in the first pass of SAW

Appendix 5 Flux dryness

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

Specification A: (Originally a dry flux is packed in moisture proof sealed packing)

1 – Procurement of flux:

At the time of flux packing, the diffusible hydrogen content in SAW weld deposit shall be checked on a sample of the batch of flux and shall be lower than 5 ml / 100 g of weld deposit.

(This measurement may also be done through by the moisture content measurement, when evidence of correlation can be provided by flux manufacturer, based on previous comparative tests of diffusible Hydrogen versus flux moisture content. Otherwise, the acceptable maximum moisture content shall be 0.03 %. The “Karl Fisher” method shall be applied.)

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

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

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

Packing shall be of humidity proof type

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

2 – Storage of flux

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

3 – Use of flux

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

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

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

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

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



4 - Flux recycling

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

Specification B: (any other procedures)

Pipe mill shall demonstrate that its procedure allows to obtain dry flux at the welding point.

Flux shall be sampled at the welding point and checked at the start of production and then once per shift for inside welding and once per shift for outside welding, rotating among the welding machines. Inspector shall have the right to impose the time of sampling when it is justified to his opinion.

Check tests and results shall comply with the above paragraph 1.

Appendix 6 Pipe Manufacturing Procedure Specification

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

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



20. Pipe end ultrasonic testing procedure, with equipment, method and frequency of calibrating testing equipment.
21. Full details of radiographic testing procedure and equipment, including film type, brand and class.
22. Procedures for wet Magnetic Particle Inspection (pipe ends and weld repaired areas).
23. Methods, equipment and sensitivity proposed for pipe dimensional checking and measurement, including pipe wall thickness, peaking at the weld.
24. HIC test procedure.
25. SSC test procedure.

Appendix 7 Pipe manufacturing procedure qualification

- A.** At least one pipe of each size, steel grade, steel source and manufacturing process shall be subject to all of the inspections and testing required in section 9 of this specification and also in section 2 hereafter, this pipe representing one lot of pipes. Grouping of materials may be agreed with COMPANY.
- B.** The following additional inspections and tests shall also be carried out on the manufacturing procedure qualification pipe. Unless otherwise stated, all tests shall meet the requirements of this specification.
1. The longitudinal weld seam shall be X-radiographed along its full length.
 2. The pipe external shall be MPI tested on full body and full weld length. For diameters 24" and above the entire surface of internal weld shall also be inspected.
 3. Two longitudinal and two transverse (with respect to pipe axis) tensile strip specimens shall be cut in base material at one pipe end, at 90° from the weld seam. A second set of two longitudinal and two transverse tensile specimens shall also be cut as close as possible to the previous ones using round bar specimens as defined in § 9.5.2 of this specification.
 4. Two all-weld-metal (longitudinal) tensile test specimens shall be prepared: one from the inside weld bead and one from the outside weld bead. The YS and TS shall meet the requirements of the pipe base material. Elongation shall be as per [API 5L](#), Appendix D with a min. of 18%. Reduction of area and YS to TS ratio will be reported for information only. All the results shall meet the requirements of § 7.10.2 of this specification.
 5. A full chemical analysis shall be made on inside weld bead and outside weld bead. As a minimum, all the elements as per the composition requirement of the applicable consumable specification shall be analysed. The Nickel and Molybdenum contents shall also be reported.
 6. Weld macrosections for macrographic examination tests shall be taken at five positions at intervals of two metres along the pipe length. Three of them shall be selected by the Inspector for hardness tests. All the results shall meet the requirements of § 9.5.5, 9.5.6 and Appendix 8 of this specification.

For Press Bending or Roll Bending pipes, macrosections will be taken at both ends only.

7. At both ends of pipe, Charpy V-notch tests shall be cut in weld metal axis, Fusion Line + 2 mm and Fusion Line + 5 mm (including FL for single Vee weld), as shown in Figure of Appendix 9, and in pipe body at location 90° from weld seam. Each test shall meet the requirements of this specification at the test temperature stated in the PPS (i.e. routine test temperature). Among the two positions FL + 2 mm and FL + 5 mm, the one giving the lowest average value shall be selected for routine production test and shall be referred to in this specification as "Heat Affected Zone Charpy test".

All impact test specimens in weld area shall be etched before testing to check that notch location is correct.

8. Additional Charpy tests on weld metal axis, Heat Affected Zone (as defined above) and pipe body shall be carried out at temperatures 10°C and 20°C above and 10°C, 20°C and 30°C below the routine test temperature, for information only. Shear area shall be recorded in all cases, for information only. Results shall also be recorded by means of transition curves.

All impact test specimens in weld area shall be etched before testing to check that notch location is correct.

9. When the effluent in the pipeline is a gas, Drop Weight Tear Tests shall be conducted according to § 9.5.6.

Additional DWTT shall be conducted at temperatures 10°C and 20°C above and 10°C, 20°C and 30°C below the routine test temperature, for information only. Results shall be recorded by means of transition curves.

10. Strained Ageing tests

- a) For onshore pipelines, strain aged Charpy V-notch tests shall be carried out from samples located opposite the welded seam (i.e. at mid-distance of plate edges). Each sample shall be strained 3% longitudinally to pipe axis and one set of specimens extracted, the remainder of the strained sample shall then be heated for one hour at 250°C and a further set of specimens extracted. Each set shall comprise three specimens cut transverse to pipe axis.
- b) For all pipelines, when the percentage of permanent straining of base material due to pipe forming is 3% or above, strain aged Charpy V-notch tests shall be made from a pipe sample cut at location opposite to weld seam. The sample shall be aged for one hour at 280°C and then the Charpy specimens shall be cut transverse to pipe axis.

Impact tests shall be conducted at the routine test temperature stated in the PPS and also at a test temperature 10°C below this routine test temperature.

Only the tests made at the routine test temperature shall meet the impact energy requirements contained in Table 4 (Appendix 2).

11. Post Weld Heat Treatment tests

For pipes with wall thickness in excess of 31.8 mm, or for any other particular WT stated in the PPS, tensile tests and Charpy V-notch impact tests as per para. 9.5.2 and 9.5.4 of this specification shall be repeated after a simulated Post Weld Heat Treatment (PWHT) is made. These tests shall also be acceptance tests and test results shall meet the requirements of this specification. PWHT soaking temperature shall be basically 620°C ± 10°C for normalized steel and 580°C ± 10°C for controlled rolled steel, for one hour per 25 mm wall thickness. The PWHT procedure shall be agreed with the COMPANY.

12. Weldability Tests

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

The tests shall be carried out in accordance with Appendix 15.

When weldability tests are not required in the PPS, then the SUPPLIER shall produce, to the satisfaction of the COMPANY, a comprehensive documentation to support the weldability of the supplied pipes, such as in-house laboratory test results (e.g. implant tests), weldability test results from previous orders, welding recommendations, etc.

13. Hydrogen Induced Cracking tests (HIC tests) shall be carried out according to § 9.6 and Appendix 14 of this specification.

14. Sulfide Stress Cracking tests (SSC tests) shall be made in weld seam and base material in full compliance with § 9.7 and Appendix 13 of this specification.

15. Base metal metallurgical microstructure and grain size evaluation shall be carried out (refer to § 6.1) at mid-thickness. Photographs of microstructure shall be supplied.

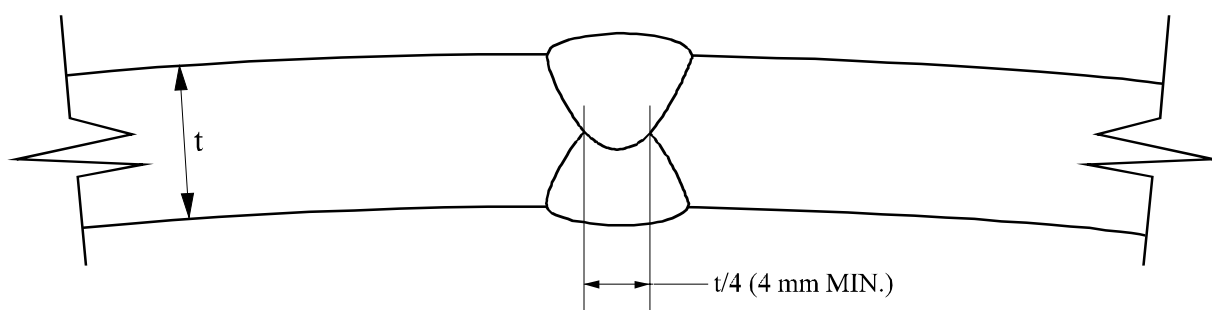
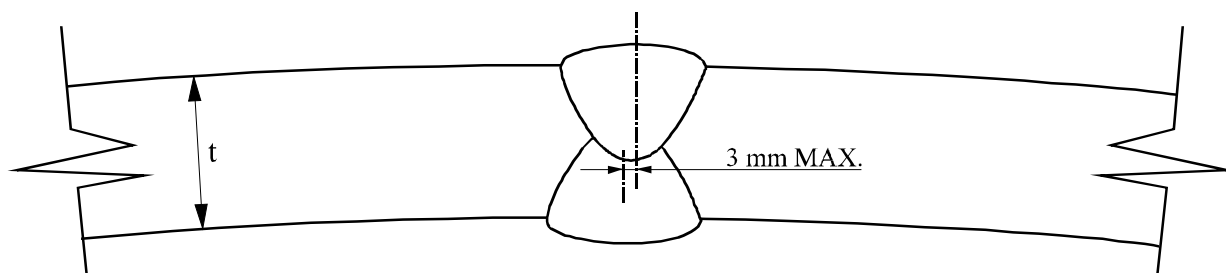


16. A micro analysis of weld shall be carried out by "Electron Probe Micro Analysis (EPMA)" or equivalent equipment. The fusion lines between weld and base metal, and between passes shall be particularly investigated.

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

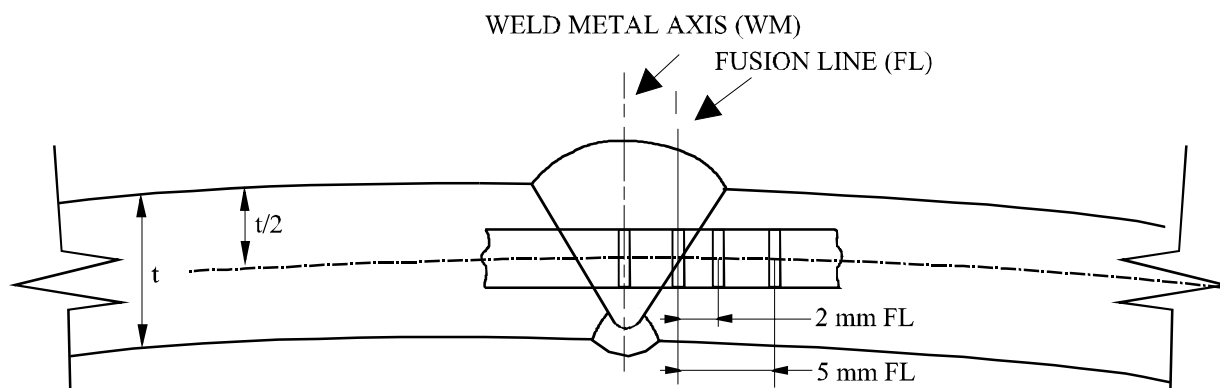
Any other significant peak of segregation shall be investigated and demonstrated not harmful for the pipe service.

Appendix 8 Weld bead alignment and interpenetration

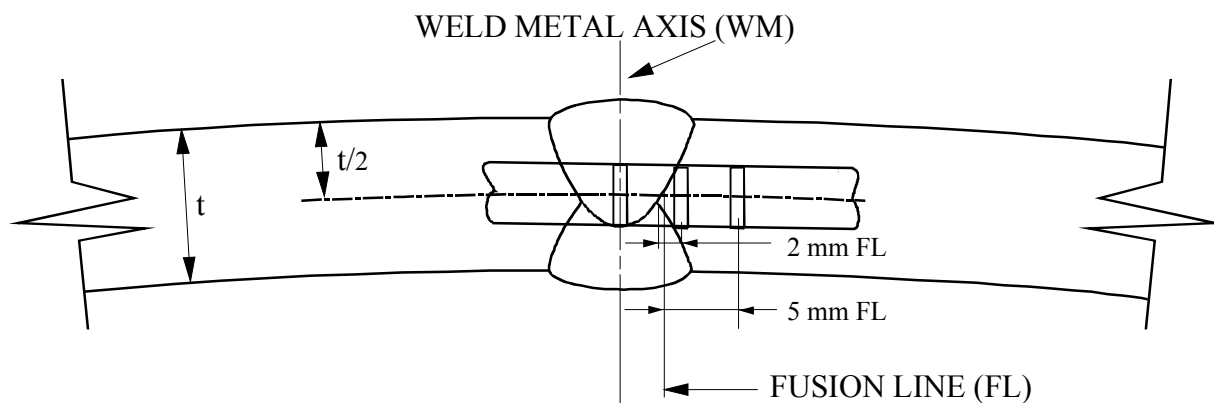


Appendix 9 Location of Charpy V-notch specimens

a) Single vee weld

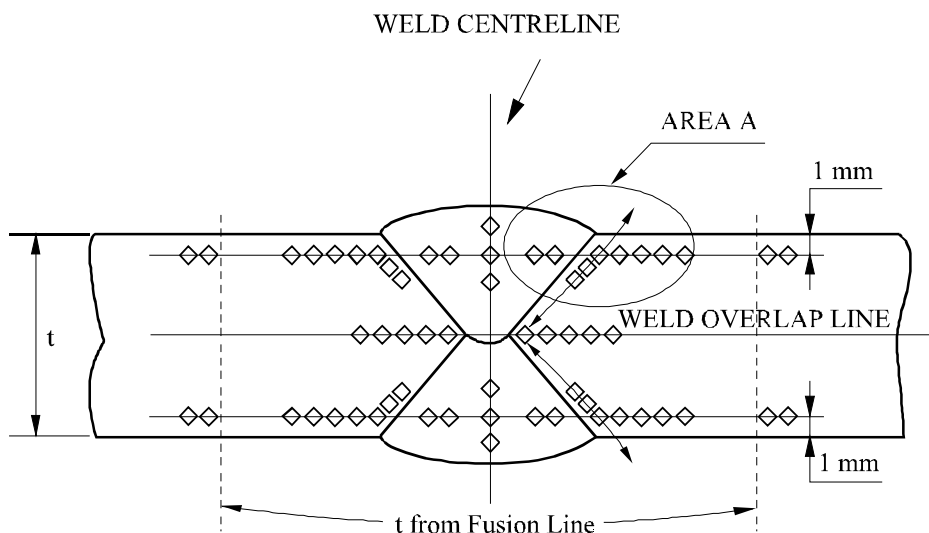


b) Double vee weld

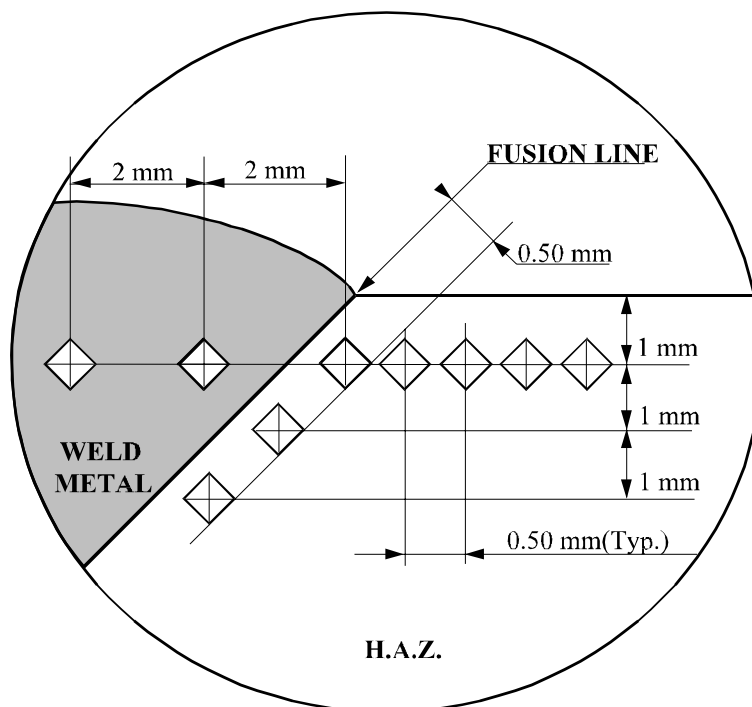


Appendix 10 Vickers hardness survey in weld for procedure qualification tests

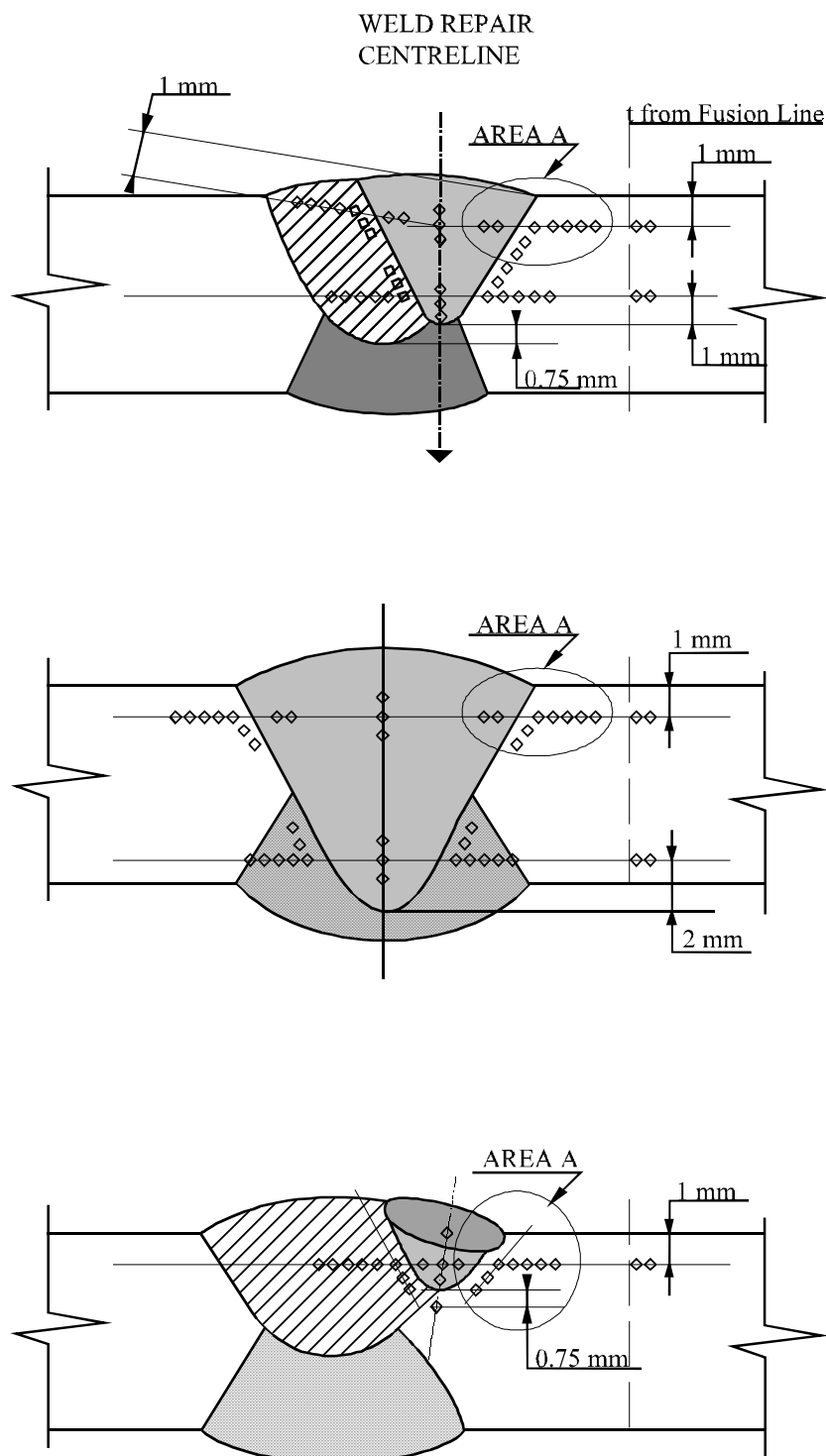
a) Longitudinal seam



Enlargement of area A (typical)

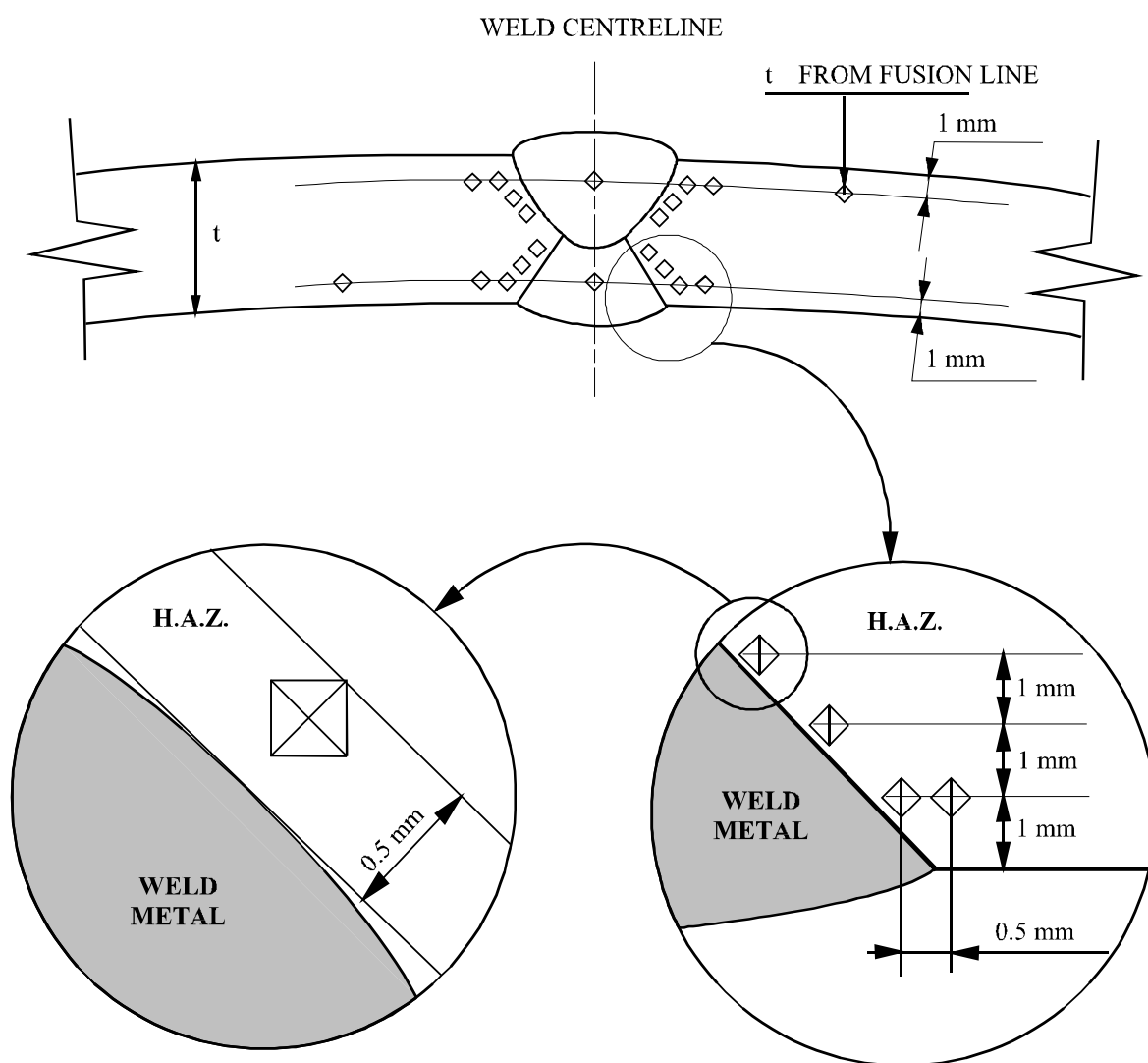


b) Repair welds



Appendix 11 Vickers hardness survey in weld for production tests

(longitudinal seam)



Appendix 12 Qualification of weld repair procedures

All weld repairs (including any re-welding using the automatic process with the same conditions as those used for main weld) shall be qualified by tests according to § 7.10.3 of this specification and the following.

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

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

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

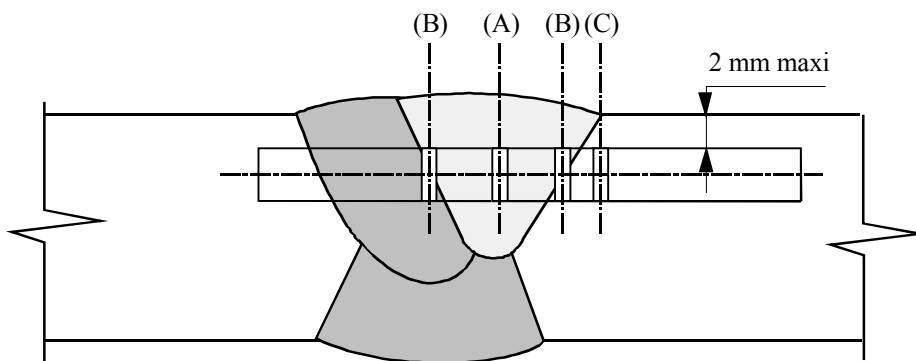
- 100% visual, X-rays and MPI as per § 9.3 and 9.4
- Two tensile tests transverse to weld as per § 9.5.2
- Two face/two root bend tests or four side bend tests as per § 9.5.3
- Four sets of Charpy-V tests as per Figure 1 in this Appendix 10 and § 9.5.4
- One macrography/hardness test as per § 9.5.5 and Appendix 8.
- SSC tests as per § 7.10.3.

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

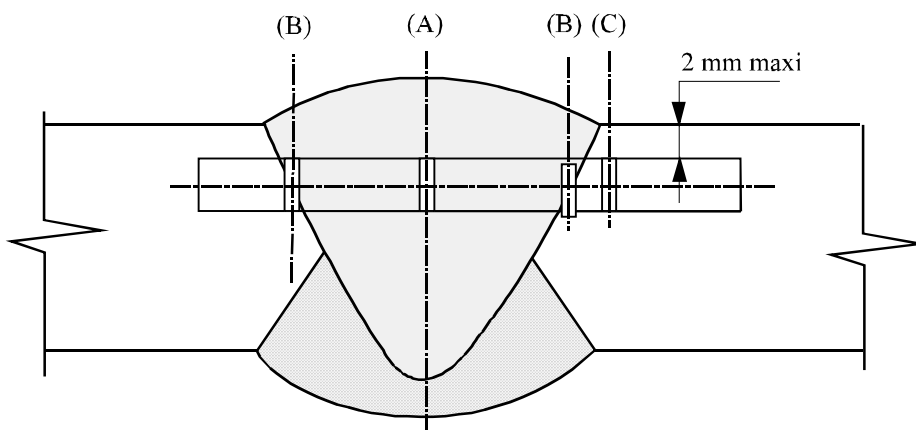
(See Figure 1 on next page)

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

a) Partial-thickness repair



b) Through-thickness repair



Notch specimen location:

- (A): Notch at centerline of repair weld
- (B): Center of notch located on fusion line
- (C): Centre of notch located 2 mm from fusion line

Appendix 13 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.

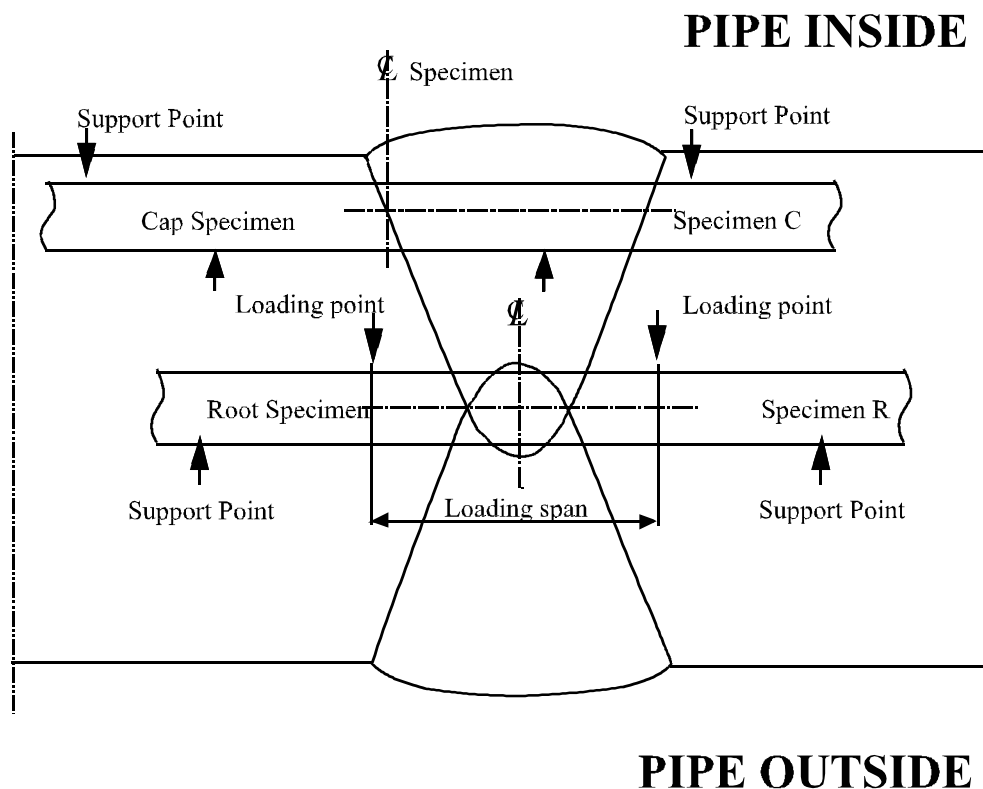


Figure 1 – Removal of specimens in weld

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 14 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

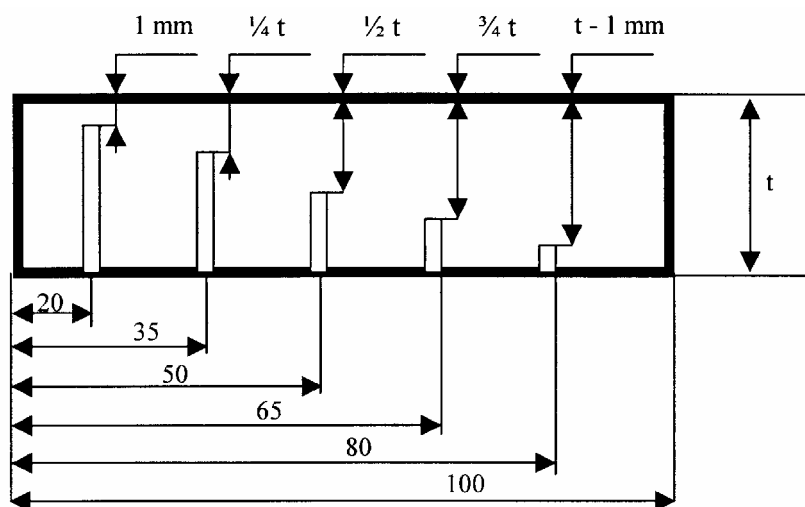
a) Calibration of time base

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 15 Weldability tests (SMAW and GMAW)

1. Purpose

To prove the weldability of the pipes produced, the SUPPLIER is required to carry out full scale weldability trials to ensure that the material supplied can be welded on a 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 welding process, welding parameters, etc.
- Proposals on pipe sample dimensions (width, length) so as to represent realistic welding conditions
- Full details of weld bevel geometries. 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

a) Radiography

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

b) Charpy-V notch Test

Specimens shall be cut at the 1 o'clock and 3 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.

c) Macrography

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

d) Vickers Hardness Survey

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

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

6. Acceptance criteria

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

- Maximum HV5 hardness shall 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 routine 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.

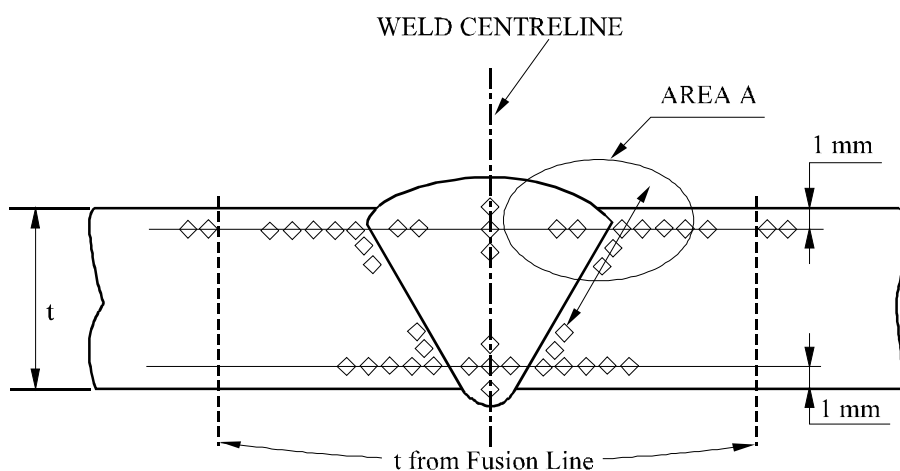


The final report shall include, as a minimum, the following:

- Welding 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)

Butt weld



Enlargement of area A (typical)

