TECHNICAL SPECIFICATION

LINEPIPE FOR USE IN OIL AND GAS OPERATIONS UNDER SOUR CONDITIONS
(AMENDMENTS/SUPPLEMENTS TO API SPEC 5L)

DEP 31.40.20.31-Gen.

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DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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TABLE OF CONTENTS

PART I INTRODUCTION

1.1 SCOPE

This DEP replaces Standard Specification L-3-2/3, dated November 1984 and gives minimum requirements for the purchase of seamless, electric welded or submerged arc welded linepipe for use in oil and gas operations under sour service applications. (For non-sour service applications, DEP 31.40.20.30-Gen. should be used).

This specification is based on API Spec 5L, fortieth edition, November 1992 and shall be read in conjunction with that document. Part II of this DEP gives amendments and supplements to clauses of API Spec 5L which are considered necessary to enhance pipeline integrity in accordance with Shell Group requirements.

All pipe specified to be in accordance with this DEP shall comply with the requirements of API Spec 5L, as amended and supplemented herein.

NOTE: Both API Spec 5L and this DEP adopt sampling as a method to determine batch compliance. Nevertheless, **all** pipes supplied shall meet **all** requirements of this specification.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors and Manufacturers/Suppliers nominated by them (i.e. the distribution code is "F", as described in DEP 00.00.05.05-Gen.).

This DEP is primarily intended to be used for oil and/or gas transmission pipelines and related facilities. It is intended for use by Exploration and Production, Manufacturing, Chemicals or Supply/Marketing companies which require the use of linepipe.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Defect (in NDT) - a discontinuity or group of discontinuities whose indication(s) do not meet specified acceptance criteria.

Flaw/discontinuity (in NDT) - an interruption, which may be either intentional or unintentional, in the physical structure or configuration of a pipe.

Indication (in NDT) - evidence of a discontinuity that requires interpretation to determine its significance.

Minimum operating temperature - the minimum temperature to which the pipeline or section of pipeline may be exposed during normal operational activities, including start-up and shut-down operations and controlled blowdown, but excluding abnormal situations such as pipeline ruptures.

Pipe bevel - the total weld preparation machined on the end of a pipe.

Plate or coil - the pipe material for welded pipe before forming into the shape of a pipe.

Purchaser - term used in API Spec 5L which has same meaning as Principal.

Radiological - term used in API Spec 5L which has the same meaning as radiographic. The term radiographic is used in this DEP.

1.4 ABBREVIATIONS

CE	-	carbon equivalent
CTOD	-	crack tip opening displacement
DN	-	diameter nominal
DWTT	-	drop weight tear test
EMT	-	electromagnetic testing
FBH	-	flat bottomed hole
GMAW	-	gas metal-arc welding
HAZ	-	heat affected zone
HFW	-	high frequency electric welding
HIC	-	hydrogen induced cracking
MT	-	magnetic particle testing
NDT	-	non-destructive testing
OD	-	outside diameter
Pcm	-	material cracking parameter
PT	-	liquid penetrant examination
RDH	-	radial drilled hole
RT	-	radiographic testing
SAW	-	submerged arc welding
SMLS	-	seamless
SPW	-	spiral welding
UT	-	ultrasonic testing

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (Part VI).

1.6 GUIDANCE FOR USE

The amendments to API Spec 5L given in Part II are directly related to equivalent sections in API Spec 5L. For clarity, the section and paragraph numbering of API Spec 5L has been used as far as possible. Where clauses in API Spec 5L are referenced within this DEP, it shall mean those clauses as amended by this DEP. Clauses in API Spec 5L that are not amended by this DEP shall remain valid as written.

1.7 INFORMATION TO BE SUPPLIED BY THE PRINCIPAL

There are a number of items within this DEP which require input from the Principal. Where these are mentioned within this DEP, they are identified by an annotation (A) in the left hand margin, indicating an action required by the Principal. The information which shall be supplied by the Principal to the Manufacturer at the time of order includes:

1. Minimum design temperature (Section 4.19 and Appendix E, SR5.1)
2. The requirements for Drop Weight Tear Tests (Appendix E, SR6.4)
3. The requirements for testing in the simulated heat treated condition (Section 4.2)
4. Type of pipeline, e.g. offshore line or onshore line (Section 6.5)
5. The requirements for pre-production welding procedure qualifications (Section 12.2)

PART II AMENDMENTS/SUPPLEMENTS TO API SPEC 5L

SECTION 1 SCOPE

1.1 COVERAGE

Replace first paragraph by:

This specification covers seamless and welded steel linepipe. It includes standard-weight plain-end, regular-weight plain-end, special plain-end, extra-strong plain-end, and double-extra-strong plain-end pipe.

Replace third paragraph by:

Grades covered by this specification are B, X42, X46, X52, X56, X60, X65 and X70. Pipe shall be ordered only to these grades; intermediate grades shall not be used.

Replace fourth paragraph by:

Higher grade pipe shall not be substituted for pipe ordered to a lower grade without the purchaser's approval, irrespective of strength level.

1.7 CERTIFICATION

Delete existing section and replace with the following:

The Manufacturer shall furnish to the Purchaser a certificate of compliance including the requirements of (Appendix E, SR15).

The certificate shall comply with ISO 10474 type 3.1.B. For tests witnessed by the Purchaser, type 3.1.C. certificates shall be issued. See appendix G.

Add new section:

1.8 QUALITY SYSTEM

The Manufacturer shall establish and maintain a quality assurance system in accordance with ISO 9001, or an approved equivalent. The Purchaser's nominated representative shall have the right to undertake such audits as he deems necessary to assess the effectiveness of the Manufacturer's quality system.

Add new section:

1.9 COMPLIANCE

This specification adopts sampling as a method to determine batch compliance. Nevertheless the manufacturer is responsible to ensure and certify that all pipes meet the requirements of this specification.

SECTION 2 PROCESS OF MANUFACTURE AND MATERIAL

2.1 PROCESS OF MANUFACTURE

a. Seamless Process

Delete second sentence of this clause and replace with the following:

Cold sizing and straightening of seamless pipe are permitted if the total strain does not exceed 3.0%.

b.1.(a) Continuous Welding

Add to the existing clause:

Pipe manufactured by this process is unacceptable.

b.1.(b) Electric-Welding

Add to the existing clause:

Only the high frequency electric welding process, having a minimum frequency of 150 kHz, shall be used.

b.2.(b) Gas Metal-Arc Welding

Add to the existing clause:

This process is only acceptable for tack welding pipes which will subsequently be welded by the SAW process.

c.2. Continuous Welded Pipe

Delete existing clause and replace with the following:

Pipe manufactured by this process is unacceptable.

c.3 Electric-Welded Pipe

Add to the existing clause:

Only HFW pipe manufactured from hot rolled coil is acceptable.

A normalising heat treatment of the weld and heat affected zone shall always be carried out, irrespective of grade and chemical composition. Full body normalising is also acceptable.

c.4. Longitudinal Seam Submerged-Arc Welded Pipe

Add to the existing clause:

The full length of the weld seam shall be made by automatic submerged arc welding, using run-on and run-off tabs. The welding procedure shall be approved by the Purchaser. Welding shall be checked at regular intervals to ensure that current, voltage and travel speed remain within the ranges of the welding procedure.

c.5. Gas Metal-Arc Welded Pipe

Add to the existing clause:

This type of pipe is unacceptable.

c.6. Combination GMAW and SAW pipe

Add to the existing clause:

GMAW is only acceptable for making a continuous tack weld in SAW pipe. This pipe is further considered as SAW pipe.

c.7. Double Seam SAW pipe

Add to the existing clause:

This type of pipe is unacceptable, unless specifically requested by the Purchaser.

c.8. Double Seam GMAW Pipe

Add to the existing clause:

This type of pipe is unacceptable.

c.9. Double Seam Combination GMAW and SAW pipe

Add to the existing clause:

This type of pipe is unacceptable unless specifically requested by the Purchaser, in which case the conditions of para 2.1.c.6 shall apply.

c.10 Helical Seam (SPW) Pipe

Add to the existing clause:

This type of pipe is unacceptable, unless specifically requested by the Purchaser, in which case all the requirements for SAW welding and inspection indicated in this specification shall be applied.

d.1. Electric-Weld

Add to the existing clause:

High frequency welding process, 150 kHz minimum, shall be applied.

d.4. Skelp End Weld

Add to the existing clause:

Skelp end welds are not acceptable, unless specifically agreed by the Purchaser.

d.5. Jointer Weld

Add to the existing clause:

Jointers shall not be supplied.

d.6. Tack Weld

Add to the existing clause:

Tack welds shall be made in accordance with a qualified tack welding procedure using automatic SAW, GMAW, gas shielded FCAW, or shielded metal arc welding using low hydrogen electrodes. When low hydrogen electrodes are used the diffusible hydrogen content of the resulting weldmetal shall not exceed 10 ml/100 g of deposited metal.

2.2 COLD EXPANSION

Delete existing section and replace with the following:

SAW pipe shall be mechanically cold expanded. Expansion between 0.8% and 1.5% shall be applied.

Non-expanded SAW pipe shall not be supplied unless explicitly stated on the purchase order together with any supplementary test requirements.

HFW pipe shall not be cold expanded.

2.3 MATERIAL

Add to the existing section:

The steel shall be made in a basic oxygen or electric arc furnace. It shall be fully killed and fine grained with a grain size of ASTM 7 or finer, as defined in ASTM E 112.

For quenched and tempered pipe, this grain size requirement shall not apply.

The steel shall be calcium treated and vacuum degassed.

2.4 HEAT TREATMENT

Delete existing section and replace with the following:

Seamless pipe shall be furnished in the hot formed, normalised, normalised and tempered or quenched and tempered condition. For hot formed pipe, the finishing temperature shall be greater than 780 °C. Pipe finished at a lower temperature than 780 °C shall be subjected to a further normalising heat treatment, with a minimum holding time of 30 minutes.

SAW pipe shall be furnished in the as-rolled, normalised, controlled rolled, controlled rolled plus accelerated cooled, or quenched and tempered condition.

HFW pipe shall be manufactured from hot-rolled coil and the entire weld plus HAZ shall be

normalised. Alternatively the pipe may be full body normalised, normalised and tempered or quenched and tempered. Details of heat treatment shall be agreed with the Purchaser prior to the start of production (Section 12.1).

The heat treating process shall be performed in accordance with a documented procedure. The Manufacturer shall also establish and follow procedures for maintaining heat and/or lot identity.

SECTION 3 CHEMICAL PROPERTIES AND TESTS

3.1 COMPOSITION

Delete existing section and replace with the following:

For each order the Manufacturer shall propose a chemical composition for the pipe to be supplied. This composition shall be contained in the manufacturing procedure specification and, as determined by product analyses, shall comply with the maximum allowable limits specified in Table 3.1. The limitations on heat and product analysis are those agreed following acceptance of the manufacturing procedure specification (Section 3.4.c).

Delete Table 3.1 and replace with the following:

Table 3.1 Chemical requirements for product analyses, percent

Element	Maximum Permitted Alloy Content, wt%			Maximum variation on agreed composition (see 3.4c)	Notes
	SAW	SMLS	HFW		
C	0.16	0.16	0.16	0.03	
Mn	1.30	1.40	1.30	0.30	1
Si	0.45	0.45	0.45	0.25	
P	0.015	0.015	0.015		
S	0.003	0.01	0.003		
V	0.08	0.08	0.08	0.02	2
Nb	0.05	0.05	0.05	0.02	2
Ti	0.04	0.04	0.04	0.02	2
Cr	0.20	0.30	0.20	0.05	3
Mo	0.10	0.35	0.25	0.05	3
Ni	0.35	0.40	0.35	0.10	3
Cu	0.40	0.40	0.40	0.10	3
Al	0.05	0.06	0.06	-	4
N	0.012	0.012	0.012	-	4
B	0.0005	0.0005	0.0005		
Ca	0.006	0.006	0.006	-	5
CE	0.39	0.41	0.39	-	6
Pcm	0.21	0.22	0.21	-	7

Notes:
1. For SAW pipes in X70 grade, the maximum Mn content may be increased to 1.4 wt%.
2. V+Nb+Ti shall not exceed 0.15%.
3. Cr+Mo+Ni+Cu shall not exceed 0.6%.
4. The total Al: N ratio shall not be less than 2 :1.
5. Calcium shall be 2 times Sulphur content, for Sulphur in the range 0.0015 - 0.003 %.
6. CE = C + Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15.
7. Pcm = C + Si/30 + (Mn + Cu +Cr)/20 + Ni/60 + Mo/15 + V/10 + 5B.

3.2 CHEMICAL ANALYSIS

b. Elements Analysed

Delete existing clause and replace with the following:

For Grade B pipe only C, Mn, Si, S and P levels shall be determined. For higher grades, analysis for other elements in the table shall also be performed.

3.4 PRODUCT ANALYSIS

b. Sampling Methods

Add to the existing clause:

Samples may be taken using any of the methods indicated in API Spec 5L provided they are taken from finished pipe. In this instance finished pipe shall be understood to mean pipe which has been formed and welded (if applicable) but before trimming to final pipe lengths.

c. Product Analysis Variation

Delete existing clause and replace with the following:

The Manufacturer shall propose a nominal product analysis in the manufacturing specification. The range of acceptable variations in the product analysis is given in Table 3.1. This shall be applied to the chemical composition proposed by the Manufacturer in the manufacturing specification. The maximum variation on agreed composition is allowed provided that the final maximum alloy content given in Table 3.1 is not exceeded.

SECTION 4 MECHANICAL PROPERTIES AND TESTS

4.1 MECHANICAL PROPERTIES

Delete existing section and replace with the following (Table 4.1 remains):

For all pipes, the ratio of body yield strength to tensile strength shall not exceed 0.90 when tested using flattened bar tensile specimens. For round bar and non-flattened rectangular specimens, the ratio of yield strength to tensile strength shall not exceed 0.93.

For steel grades X46 and higher the measured yield strength shall not exceed the minimum values indicated in column 2 of Table 4.1 by more than 150 MPa.

The required minimum tensile elongation shall be determined according to the formula given in footnote 1 of Table 4.1 but shall be not less than 20%.

Samples removed for the determination of tensile, toughness or microstructural properties shall be prepared by machining. Where thermal cutting has been used to remove pipe coupons from which test specimens are prepared, the full extent of the heat affected region shall be removed during machining of the specimens.

4.2 TENSILE TESTS

Delete existing section and replace with the following (Fig 4.1 and Fig 4.2 remain):

Tensile properties shall be determined from specimens removed from pipe which has been subjected to all mechanical and heat treatment operations. Where stress relieving of pipe will be performed, e.g. for field welding, additional tensile testing of parent metal and

(A) weldments shall be performed on stress relieved specimens. The Purchaser shall specify on the purchase order if this condition applies (Part I, Section 1.7).
The testing procedure shall be in accordance with ASTM A 370. Tensile test specimen orientation shall be as shown in Figure 4.1.

4.3 TENSILE TESTING

a. Frequency

Delete existing clause and replace with the following :

Tensile tests shall be performed on samples taken from two pipes per heat. For heats less than 100 tonnes, tests on only one pipe shall be required.

4.4 LONGITUDINAL TENSILE TESTS

Delete existing section and replace with the following:

Longitudinal tensile test specimens shall be either non-flattened rectangular or round bar specimens.

4.5 TRANSVERSE TENSILE TESTS

Delete existing section and replace with the following:

Transverse tensile properties shall be determined on flattened rectangular specimens. The ring expansion method shall only be applied after specific approval has been obtained from the Purchaser.

4.6 WELD TENSILE TESTS

Add to the existing section:

Weld tensile specimens shall be taken from the same part of the pipe used for preparing parent metal tensile specimens. The weld reinforcements shall be removed before tensile testing.

4.11 FLATTENING TEST ACCEPTANCE CRITERIA

Delete existing section and replace with the following:

No cracks or breaks shall occur in either weld or parent metal during flattening of the test specimen to 50% of its original OD. The specimen shall be further flattened to 1/3 of original OD without cracks or breaks other than in the weld.

4.19 FRACTURE TOUGHNESS TESTS

Delete existing section and replace with the following:

For all pipe, Charpy V-notch tests shall be performed on each test ring taken for tensile testing and tested in accordance with (Appendix E, Section SR5).

(A) If stress relieving is required for field welds, Charpy testing is also required in the simulated stress relieved condition. The Purchaser shall inform the Manufacturer at the time of enquiry/order of the need for testing in the stress relieved condition.

(A) For gas transmission lines with a pipe diameter of DN 400 (16 inch) or greater, DWTTs shall be carried out on one pipe from each heat of steel in accordance with the requirements of (Appendix E, Section SR6).

4.21 METALLOGRAPHIC EXAMINATION

Delete existing section and replace with the following:

Specimens for metallographic examination shall be extracted from HFW pipe such that the weld, complete heat treated zone and parent material on both sides of the weld are visible over the full wall thickness. A minimum of 3 specimens shall be microscopically examined from one pipe in each heat, or after each break in production, whichever is the more frequent. The examination shall determine the adequacy of microstructure and heat treatment.

Add new section:

4.22 HARDNESS TESTING

Hardness testing shall be performed in accordance with (Section 13.4). The hardness of weld, heat affected zone and base material shall not exceed 248 HV10.

SECTION 5 HYDROSTATIC TESTS

5.1 HYDROSTATIC TEST REQUIREMENTS

Delete existing section and replace with the following:

Each length of pipe shall withstand, without leakage, an inspection hydrostatic test to at least the pressure specified in Par. 5.3. Hydrostatic testing shall be performed after cold expansion.

The test pressure for all sizes and types of pipe shall be held for not less than 10 seconds.

5.3 TEST PRESSURES

Delete existing section and replace with the following:

The test pressure for all types and sizes of pipe shall be such that the hoop stress, calculated on the basis of the minimum specified wall thickness and including stresses from end loading, is at least 95% of the specified minimum yield strength.

If applied, the end load compensation factor as determined by the formula given in (Appendix E, Section SR14) shall be used.

SECTION 6 DIMENSIONS, WEIGHTS AND LENGTHS

6.1 GENERAL - DIMENSIONS AND WEIGHTS

Add to this section:

Measuring equipment for inspection and testing shall be selected such that it has a resolution and accuracy at least five times (5X) finer than the tolerance of the parameter being measured. Similarly, standards against which a piece of equipment is calibrated shall be at least five times as accurate as the equipment being calibrated.

Only measuring equipment which can be demonstrated to have been previously calibrated satisfactorily and still be within its documented calibration period (interval) shall be used for inspection and testing.

NOTE: These requirements apply to all inspections and tests performed to verify compliance with this specification (not only dimensions and weights).

6.2 DIAMETER

Delete existing section and replace with the following:

The diameter of the pipe shall be within the tolerances specified in Table 6.3, as amended below.

Table 6.3 TOLERANCES ON DIMENSIONS AND WEIGHTS

Replace the following sections of this table with the following:

Pipe body

The outside diameter of the pipe body, as determined by taping the circumference, shall not deviate by more than ± 3 mm from the value given in metric Table 6.2.

Pipe ends

For a length of 100 mm from each pipe end, the average internal diameter shall not deviate from the nominal internal diameter by more than ± 1.5 mm for welded pipe or ± 2.0 mm for seamless pipe.

The nominal internal diameter is defined as the outside diameter D (given in Metric Table 6.2) minus twice the nominal wall thickness.

The internal diameter shall be measured using an internal gauge or a measuring tape inside the pipe. The method and equipment used shall be approved by the Principal. For pipe of DN 200 (8 inch) and below, the internal diameter may be calculated by measuring the outside diameter with a circumference tape and subtracting twice the actual wall thickness from this value.

Out of Roundness

The ends of each pipe shall be tested for out of roundness using an internal ring gauge of diameter 5.0 mm less than the nominal internal diameter. The gauge shall pass freely into each end of the pipe when held normal to the pipe axis.

6.3 WALL THICKNESS

Delete existing section and replace with the following:

For all sizes of welded pipe the wall thickness at any place in the pipe measured during final inspection shall not deviate from the nominal wall thickness by more than the tolerances specified in the following table:

Wall thickness, t (mm)	Tolerance	
	Minus	Plus
$t \leq 7$	0.35 mm	10%
$7 < t \leq 10$	5%	10%
$t > 10$	0.50 mm	10%

For all sizes of seamless pipe, the wall thickness at any point shall not deviate from the nominal thickness by more than + 15% or - 10%.

6.5 LENGTH

Delete existing section and replace with the following:

(A) Unless otherwise indicated in the purchase order, pipe shall be supplied in the following lengths:

Onshore lines: A minimum of 95% of pipes shall be between 11 and 12.2 m in length.
No pipe shall be less than 8 m in length.

No pipe shall be greater than 12.5 m in length.

Offshore lines: The length of pipes in any one order shall average 12.2 m with a minimum of 95% of pipes between 11.9 and 12.5 m in length.
No pipe shall be less than 11.6 m in length.
No pipe shall be greater than 12.8 m in length.

NOTE: For heavy wall seamless pipe, where supply of the pipe lengths stated above may not be possible, the Principal and the Manufacturer shall agree an alternative pipe length.

6.7 JOINTERS

Delete existing section and replace with the following:

Jointers shall not be supplied.

SECTION 7 PIPE ENDS AND THREAD PROTECTORS

7.3 PLAIN ENDS

Add to the existing section:

The entire end bevel shall be machined and root faces shall not be brought into tolerance by filing or grinding.

SECTION 9 NON-DESTRUCTIVE INSPECTION

9.1 METHODS OF INSPECTION

Delete existing section and replace with the following:

All personnel performing NDT activities shall be qualified in the technique applied, in accordance with ISO 9712 or equivalent.

For UT at least one level III qualified inspector shall be available to the mill (on call) for overall supervision. A level II inspector is required for shift supervision, manual weld inspection and calibration of all systems (both manual and automated).

A level I inspector is acceptable for all other NDT methods. A level II inspector is acceptable for supervision of all other NDT methods.

All NDT shall be performed in accordance with written procedures. These procedures shall have the prior approval of the Purchaser.

NDT for acceptance of the pipe (final inspection) shall take place after all heat treating and expansion operations and, for welded pipe, after hydrostatic testing of the pipe. It may, however, take place before cropping, bevelling and end sizing.

9.1.a. Submerged arc welds shall be inspected over their entire length, for both longitudinal and transverse defects, using ultrasonic examination in accordance with (Sections 9.14 through 9.17). In addition, each end of the weld seam in SAW and SPW pipe shall be examined radiographically for a distance of at least 200 mm.

If skelp end welds are permitted for spiral welded pipes (Section 2.d.4), these shall be inspected by the same methods as used for the spiral weld.

9.1.b. HFW pipe welds shall be examined for longitudinal defects over their entire length by ultrasonic methods in accordance with Sections 9.14 to 9.17.

9.1.c. Lamination detection

Each plate or strip rolled shall be ultrasonically tested for laminations using an oscillating scanning pattern. The scanning coverage using this technique shall be a minimum of 12.5%. Alternatively, the scanning shall be executed along straight, evenly distributed parallel lines with a scanning coverage of at least 25%. Coil for HFW pipe may be tested after welding of the longitudinal seam by rotary ultrasonic testing of the pipe body. The coverage in this case shall be 100%.

In addition, the longitudinal edges of a plate or coiled strip shall be 100% ultrasonically tested, over a width of at least 25 mm from the trimmed plate/coil edge. This may be performed either before or after pipe forming. For HFW pipe subjected to 100% rotary ultrasonic testing of the pipe body, strip edge testing is not required.

9.1.d. Seamless Pipe

Ultrasonic lamination testing of each seamless pipe body shall be performed using a helical pattern with at least 25% scanning coverage of the pipe surface.

Ultrasonic thickness testing of the pipe body and ends of seamless pipe shall be performed by scanning along a helical or straight pattern in such a way that at least 10% of the pipe surface is covered.

The body and ends of all seamless pipe shall be 100% ultrasonically tested for inside and outside surface defects as well as transverse, longitudinal and inclined embedded defects.

EMT may be applied for nominal wall thicknesses less than 6 mm.

9.1.e. Pipe Ends

After bevelling, the complete circumference of the pipe end shall be tested ultrasonically from the inside for laminations (this inspection shall cover a width which includes the entire bevel). Alternatively the pipe may be tested from the outside prior to bevelling, in which case a band of at least 25 mm wide, to include the eventual bevelled area, shall be tested.

If UT has not been performed from the outside before cutting and if UT from the inside is

not feasible because of dimensional limitations, then MT or PT shall be applied to the bevel face in accordance with (Sections 9.19 through 9.21).

For pipes previously subjected to 100% rotary ultrasonic inspection, the above requirements shall not apply.

Each SAW pipe end shall be tested over the final 25 mm with UT to disclose axially aligned, through thickness cracks. The Manufacturer may perform this examination on the ends of the plate prior to forming/welding.

RADIOGRAPHIC INSPECTION

9.2 RADIOGRAPHIC INSPECTION EQUIPMENT

Delete existing section and replace with the following:

The radiographic examination shall be executed with X-ray equipment using fine-grain type film (e.g. Gevaert type D7 or equivalent) and lead intensifying screens.

For acceptance of the radiographic films, the technique used shall result in a sensitivity better than 2% of the thickness of the weld metal and in a relative film density of 2.0 to 3.5 in the weld metal.

The Manufacturer shall record on a review form accompanying the radiograph or within the mill computer system, the interpretation of each radiograph and disposition of the pipe inspected.

9.3 FLUOROSCOPIC OPERATOR QUALIFICATION

Delete this section

9.4 OPERATION CERTIFICATION

Delete this section

9.5 NDT REFERENCE STANDARDS

Delete existing section and replace with the following:

The penetrameter used shall be of the wire type in accordance with ISO 1027. The selection of penetrameter wire diameters shall be based on a sensitivity of 2% of weld metal thickness.

9.6 API STANDARD PENETRAMETER

Delete this section.

9.9 PROCEDURE FOR EVALUATING IN-MOTION OPERATION OF A FLUOROSCOPE

Delete this section.

9.14 ULTRASONIC AND ELECTROMAGNETIC INSPECTION EQUIPMENT

Delete existing section and replace with the following:

9.14.a Ultrasonic Equipment

The automatic ultrasonic equipment shall incorporate:

1. A device which monitors the effectiveness of the coupling.

   In the case where a zero degrees compression wave probe is used to monitor coupling, or where a through transmission technique is used for seamless or HFW pipe, loss of coupling exists when the sensitivity (echo height) decreases by more than 10 dB relative to the static calibration.

In the case where a through transmission technique through the weld seam is used for SAW linepipe, loss of coupling exists when the signal drops below the electronic noise level plus 10 dB at the position of the through transmission signal.

A clear acoustic warning system and an automatic paint spray system (or equivalent) shall be activated when loss of coupling occurs.

2. An automatic paint-spraying device, or equivalent system, which is activated when the received ultrasonic echo exceeds the preset acceptance limit. This alarm shall operate without any interference of the ultrasonic operator and shall be applied within 25 mm advancement past the detected defect. The reset time of the alarm system, after detection of a defect, to be again available for detection, shall be shorter than the time needed for 25 mm advancement in the scanning direction.

3. An automatic weld tracking system for correct positioning of the crystals/probes with respect to the weld centre of all welded pipe.

Entrance angles of shear wave probes shall be as follows:

Seamless pipe	: 45 (40 - 48) degrees
HFW pipe	: 45 (40 - 48) degrees
SAW and SPW pipe longitudinal defect detection	: 50 - 70 degrees
SAW and SPW pipe transverse defect detection	: 45 (40 - 48) degrees (on weld bead)
	: 50 - 70 degrees (X or K transmission)

Lamination testing may be performed in pulse echo or transmission mode; wall thickness only in pulse echo mode. The probe(s) used for wall thickness/lamination check should satisfy the following requirements:

- Twin crystal probes : The focal length should be 50% of the wall thickness.
- Single crystal probes in pulse echo mode : The near surface resolution should be better than 25% of the wall thickness, measured at the primary reference sensitivity level.

The transducer arrangement shall be such that the sound intensity in both the longitudinal and circumferential directions does not decrease by more than 3 dB at any point in the pipe wall, referred to the maximum sound intensity adjusted in the static calibration.

The equipment shall be checked with an applicable reference standard (test piece) as described in (Part III) at least every four hours and at the beginning and end of a batch in order to demonstrate the effectiveness of the inspection procedures and show that the equipment is functioning correctly.

In case discrepancies of more than 3 dB occur, then all pipes inspected since the previous check shall be reinspected. Proper functioning of the UT equipment and the linearity of the electronic instrumentation shall be checked at least once every six months or if a change is made to the equipment.

From each pipe under test, an automatic "on-line" record shall be made without operator intervention. For every pipe, a summary record shall be made showing pipe identification number, time and examination results, including re-examinations.

If parts of the ultimate pipe ends are not covered by an automatic UT system (untested area), manual ultrasonics shall be carried out using approved procedures for manual ultrasonic examination based on the requirements given above.

The complete circumference of seamless pipe ends or rotary tested HFW pipe ends, shall be tested manually over the length of the untested area plus 25 mm overlap of the automatically tested area.

9.14. b Electromagnetic Equipment

If permitted by the Purchaser, EMT methods such as eddy current testing or magnetic flux leakage testing may be applied for surface defect detection in seamless pipe.

EMT shall be performed in accordance with ASTM E 309 or ASTM E 570. Testing shall be performed by automatic equipment over the entire surface of the pipe.

If parts of the ultimate pipe ends are not covered by an automatic EMT system (untested area), then manual ultrasonics shall be carried out using approved procedures for manual ultrasonic examination based on the requirements given above. The complete circumference of the pipe ends shall be tested by manual UT, over the length of the untested area plus 25 mm overlap of the automatically tested area.

9.15 NDT REFERENCE STANDARDS

Delete existing section and replace with the following:

The reference (calibration) standard shall have the same specified diameter and thickness as the product being inspected and shall be of sufficient length to permit calibration of ultrasonic inspection equipment at the speed to be used in production. The reference standard shall also be of the same material type and have the same surface finish and heat treatment as the product to be inspected. It shall be free from discontinuities or other

conditions producing indications that may interfere with detection of the reference reflectors. The reference standard shall contain notches (N5 or N10) or radially drilled holes (3.2 mm) as shown in Figure 9.4, and/or flat bottomed holes. The type and location of the notches and drilled holes in the reference standard for welded pipe, shall be in accordance with (Part III, Figs. C and D).

The Manufacturer may use a type of reference reflector not specified above, provided he can demonstrate to the Purchaser that the examination is at least as sensitive as prescribed in this specification. In such cases, the Manufacturer shall obtain approval from the Purchaser.

The Primary reference sensitivity level shall be adjusted on the following reference reflectors:

Examination Type	Type of Pipe		
	SMLS	SAW/SPW	HFW
Lamination detection	FBH 6.3 mm	FBH 6.3 mm	FBH 6.3 mm
Surface defect detection	Notch N5		
Defect detection body and pipe ends	Notch N5		
Defect detection weld		RDH 3.2 mm	Notch N10
Defect detection plate and axial defect		Notch N5	

For all reference reflectors except for RDH 3.2 mm, the acceptance limit signal shall be equal to the primary reference sensitivity level, i.e. equal to the height of the signal produced by the reference reflector. For the RDH 3.2 mm reference reflector, the acceptance limit signal shall be 10 dB below the primary reference sensitivity level.

All sensitivity adjustments shall be carried out dynamically.

Flat bottomed holes for lamination detection shall be drilled to the midwall position.

9.16 ACCEPTANCE LIMITS

Delete existing section and replace with the following:

For all examination types, indications exceeding the acceptance limit signal are unacceptable.

For lamination detection in plate coil, seamless pipe body and pipe ends, the acceptance limits shall be based on the lamination size and frequency and be in accordance with the classification of SEL-072, as described below:

Location	SEL-072 Lamination Acceptance Levels
Plate/coil body Plate/coil edges	Table 1. Class 1 Table 2. Class 1
Seamless pipe body	Table 1. Class 1

9.19 MAGNETIC PARTICLE INSPECTION EQUIPMENT

Add to existing section:

MT shall be performed in accordance with the requirements of ASTM E 709.

Prior to the inspection, the surface to be examined and all adjacent areas within 25 mm shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil or other extraneous matter that could interfere with the examination.

SECTION 10 WORKMANSHIP, VISUAL INSPECTION AND REPAIR OF DEFECTS

10.1 VISUAL INSPECTION

Delete existing section and replace with the following:

The full body and welds (if applicable) of every pipe shall be examined, internally and externally, for surface defects. For internal examination of pipe DN 600 (24 inch OD) and larger, the inspector shall pass through the bore of the pipe. Adequate illumination shall be provided to enable proper inspection.

10.2 PURCHASER INSPECTION

Delete existing section and replace with the following:

The requirements of (Appendix G) shall apply.

10.3 WORKMANSHIP AND DEFECTS

a. Dents

Delete third sentence of existing clause and replace with the following:

All cold formed dents with a sharp bottom gouge and all sharp gouges (without dents) deeper than 1.0 mm shall be considered defects requiring rectification or rejection.

b. Offset of Plate Edges

Delete existing section and replace with the following:

The radial offset of plate edges (misalignment) for pipe with a nominal wall thickness of 10 mm or less shall be no more than 1.0 mm for SAW pipe and 0.5 mm for HFW pipe. For pipe with a nominal wall thickness greater than 10 mm, the maximum allowable radial offset shall be 1.6 mm for SAW pipe and 5% of the nominal wall thickness for HFW pipe.

d. Height of Outside and Inside Weld Beads - SAW

Add to existing section:

At pipe ends and other areas which are radiographed, the reinforcement of both inside and outside bead shall allow radiographic sensitivity requirements of (Section 9.2) to be met.

e. Height of Flash of HFW pipe

Delete second paragraph and replace with the following:

The inside flash of HFW pipe shall not extend above the prolongation of the original inside surface by more than [0.5 mm + 5% of nominal wall thickness].

f. Trim of Inside Flash of HFW Pipe

Delete existing clause and replace with the following:

In any case, the groove shall not cause the remaining thickness to be less than that allowed by Section 6.3.

g. Hard Spots

Delete first paragraph and replace with:

Any hard spot with a hardness greater than 22 HRC shall be rejected.

I. Other Defects

Add:

Local Irregularities of SAW Pipe Welds

The ends of each SAW pipe and two positions along the length shall be checked for out-of-roundness at the position of the longitudinal weld. Templates with a minimum chord length of 75% of the pipe internal diameter shall be used for measurement of local irregularity in profile. For pipes 16 inch OD and above, a template of 300 mm minimum chord length shall be used. The template profile shall have a radius equal to the nominal radius of the pipe outer or inner circumference for measurement of the outer or inner surface, respectively. The nominal inner radius shall be taken as the nominal outer radius minus the nominal wall thickness.

The template gauging surface shall have an appropriate cut-out to accommodate the weld bead of the pipe. The cut-out shall be at the centre of the gauging surface and shall have a width of less than 5 mm greater than the weld bead width. Any local irregularity shall be measured by a calibrated taper gauge inserted in any gap between the template and the pipe surface. The local irregularity shall not exceed 1.6 mm.

10.4 DISPOSITION OF DEFECTS

10.4.a

Add to existing clause:

In all cases where grinding repairs are made as a result of imperfections being disclosed by NDT, the part of the pipe containing such repairs shall be subjected to additional NDT using the same technique, and MT, after the grinding operation.

10.5 REPAIR OF DEFECTS BY WELDING

a. Seamless Pipe and Parent Metal of Welded Pipe

Delete existing clause and replace with the following:

Repair welding on seamless pipe and on parent metal of welded pipe is not acceptable.

b. Weld Seam of Welded Pipe

Delete existing clause and replace with the following:

Repair of the weld seam or heat treated region of HFW pipe is not acceptable.

Repair of the weld seam of SAW pipe is not acceptable within 200 mm of the bevel ends.

The nature of any weld defect indicated by non-destructive inspection shall be ascertained before any repair is performed. Where necessary, complementary ultrasonic and radiographic inspections shall be carried out to characterise the defect. Repair welding to rectify pipe welds containing cracks is not permitted.

Repairs to the weld seam shall be limited to three per pipe. The length of repair weld shall not exceed 5% of the total weld length on each pipe.

Weld repairs shall not be carried out after cold expansion or hydrostatic testing of a pipe.

10.6 PROCEDURE FOR REPAIR BY WELDING OF SEAMLESS PIPE AND PARENT METAL OF WELDED PIPE

Delete existing section and replace with the following:

Repair welding on seamless pipe and on parent metal of welded pipe is not acceptable.

10.7 PROCEDURE FOR REPAIR OF SUBMERGED ARC WELDS

Add new clause:

10.7.d

Repair welding shall be executed using qualified procedures and in accordance with the requirements of Appendix B.

The repaired area shall be non-destructively tested by RT, manual UT and MT.

10.8 PROCEDURE FOR REPAIR OF ELECTRIC WELDS

Delete existing section and replace with the following:

Repair welding of HFW welds is not acceptable.

SECTION 11 MARKING AND COATING

11.1 MARKING-GENERAL

Add to the existing section:

In addition to the marking specified on the pipes, the Manufacturer shall supply the Purchaser with lists of pipe produced stating pipe identification numbers, heat numbers, dimensions, weights of lots of pipes or individual pipe lengths, purchase order numbers, type of certificates issued, and any further items that may be indicated on the purchase order.

For pipes DN 100 and above, stencil markings required by this specification, shall be executed in white block capitals of minimum height 19 mm. For smaller pipe diameters, stencil marking height shall be a minimum 10 mm.

On HFW pipe, the Manufacturer shall apply a 50 mm wide daub of heat resistant white paint on the inside surface at each end of each pipe to mark the location of the weld line.

Marking of test pressures, size (diameter and wall thickness) and weight shall be in metric units.

11.2 LOCATION OF MARKINGS

Delete existing section and replace with the following:

Unless specified otherwise on the purchase order marking shall be located as follows. For pipe diameters DN 450 (18 inch OD) and larger, all paint markings shall be on the inside surface. For smaller pipe diameters the paint marking shall be on the outside surface.

11.3 SEQUENCE OF MARKINGS

Delete first sentence and replace with the following:

The following sequence of markings shall be applied - a, b, c, d, e, g, h, i. In addition the words "DEP 31.40.20.31-Gen." shall be included in the stencil area.

11.11 COATINGS

Delete existing section and replace with the following:

Unless otherwise stated on the purchase order, pipe shall not be coated. Protective coating or varnishing of the pipe identity markings is, however, permitted.

Add new section:

SECTION 12 MANUFACTURING PROCEDURE AND WELDING PROCEDURE

12.1 MANUFACTURING PROCEDURE SPECIFICATION

The Manufacturer shall produce a manufacturing procedure specification which shall be submitted for the purchaser's approval at least two weeks prior to the start of production. The manufacturing procedure specification shall include the following as a minimum:

Steel Supply

- Steelmaker
- Steel making and casting techniques including details of the following:
  - Details of steel making process, including deoxidation and desulphurisation practice, inclusion shape control method and the use of vacuum degassing.
  - Details of casting process, i.e. ingot or continuous casting, including casting speed, tundish superheat, segregation control measures.
  - Details of plate and strip manufacture, including slab reheating temperatures, start and finish rolling temperatures and reduction ratios.
  - Heat treatment details
  - Chemical composition:
    (a) Target chemistry;
    (b) Ranges for deliberately added elements;
    (c) Maxima for other elements specified in (Section 3.1).

Seamless pipe

- Pipe forming procedure
- Pipe heat treatment procedure
- Hydrostatic test procedure
- NDT procedures.

HFW pipe

- Strip manufacturing method including details of rolling, skelp splitting and any specialised cooling and heat treatment
- Strip NDT procedures
- Pipe making method including details of methods used for preparing the edge of the strip for welding and for control of misalignment of edges, and pipe shape
- Welding procedure including details of the following:
  - Methods to be used for heating plate edges and for the control and monitoring of power input in relation to the temperature of the pipe surface and to the speed of the pipe
  - Frequency (in kHz) of the welding power supply
  - Details of any protective atmosphere used for welding
  - Methods used to accomplish and control the upset forge-welding of the heated pipe edges
  - Method used for trimming of the weld bead
- Weld seam heat treatment procedure
- Hydrostatic test procedure
- NDT procedures.

SAW pipe

- Plate manufacturing method including details of specialised cooling and heat treatment
- Plate NDT procedures
- Pipe forming procedure
- Seam welding procedure including details of the following:

- Welding process
- Brand name, classification, size and grade of filler metal and flux
- Speed of welding
- Number of electrodes and polarity for each electrode
- Welding current for each wire
- Welding voltage for each wire
- Dimensions of welding preparation
- Number of weld passes
- Details of seam tracking system for both inside and outside welding and also the method for checking the set up of the system
- Limits on internal and external weld reinforcement
- Repair welding procedure

- Pipe heat treatment procedure (when appropriate)
- Hydrostatic test procedure
- NDT procedures.

12.2 WELDING PROCEDURE QUALIFICATION

(A) The seam welding procedure for welded pipe may be qualified by the first day production tests. If qualification prior to the start of production is required, the Purchaser shall notify the Manufacturer at the time of enquiry/order.

For qualification of the welding procedure, the following tests shall be executed on a full length test weld made in accordance with the manufacturing procedure specification.

12.2.1 UT

The weld seam shall be examined in accordance with (Sections 9.14 to 9.16). This shall be performed at least 48 hrs after completion of the test weld.

12.2.2 RT

The complete welded seam of SAW pipe shall be examined in accordance with (Sections 9.2 to 9.12).

12.2.3 PT or MT

The weld seam shall be subjected to PT or MT in order to check for surface defects in the weld material in accordance with (Section 13.2.4).

12.2.4 All Weld Tensile Tests (SAW only)

One specimen of the weld seam shall be subjected to an all-weld tensile test. Test results shall meet the minimum specified requirements of the plate with regard to yield, tensile strength and elongation.

12.2.5 Flattening Tests (HFW only)

The weld shall be subjected to flattening tests in accordance with (Sections 4.10 to 4.12).

12.2.6 Macrographic, Micrographic and Hardness Testing

A specimen shall be removed from the weld seam and subjected to macrographic, micrographic and hardness testing in accordance with (Section 13.4).

12.2.7 Fracture Toughness Testing

The weld shall be subjected to fracture toughness testing in accordance with (Sections 4.19, Appendix E, SR5 and SR6).

12.2.8 Weld Ductility Test (HFW only)

The welded pipe shall be tested as specified in Sections 4.17 and 4.18.

12.2.9 Witness

The preparation of the test weld and execution of the welding procedure qualification tests, shall be witnessed by the Purchaser if he so specifies.

Add new section:

SECTION 13 FIRST DAY PRODUCTION TESTS

13.1 GENERAL

Three of the completely finished pipes of the first day's production shall be selected at random for testing to verify that the submitted manufacturing procedure results in fully acceptable pipe. If more than one heat is used in the first day production pipes, at least two heats shall be represented by the test pipes. At the Purchaser's discretion, the Purchaser may make the selection. For orders of less than 50 tonnes, first day production tests are not required.

If the pipes have been made from coiled skelp, the pipes made from each end of the coil shall be tested in addition to the above pipes.

The pipes tested as above shall be considered to be test pipe(s) per heat, or per shift as required by this specification. The above first day production test shall be repeated after any change in the manufacturing procedure or interruption to the programme.

The Manufacturer shall submit to the Purchaser a report giving the results of all tests indicated below together with macrographs of the weld cross section, and micrographs confirming the microstructure of the plate and seamless pipe.

13.2 NON-DESTRUCTIVE TESTING

13.2.1 Visual examination

All pipes shall be examined visually for dimensional tolerances and for surface defects in accordance with (Sections 6 and 10) respectively.

13.2.2 UT

The weld seams of all pipes shall be examined by means of an automatic ultrasonic scanning device in accordance with (Section 9.14) and shall meet the requirements of (Section 9.16).

13.2.3 RT

The weld seams of all SAW pipes shall be radiographically examined throughout their full length in accordance with (Sections 9.2 to 9.12).

13.2.4 PT or MT

The weld seams of all welded pipes greater than or equal to DN 600 (24 inch OD) shall be submitted to PT or MT, throughout their full length both inside and outside, to check for longitudinal and transverse surface defects in the weld material. For pipe less than DN 600 (24 inch OD), the full length of the weld seam outside surface, plus the equivalent length of one pipe diameter each end of the internal surface, shall be examined. Seamless pipe shall also be submitted to PT or MT over the entire outside pipe body.

PT shall be in accordance with ASTM E 165.

Acceptance of discontinuities shall be in accordance with (Section 9.2.1). Cracks are unacceptable and their cause shall be investigated.

13.3 PHYSICAL TESTING

The physical properties of all pipes shall be tested as specified below. Test results shall meet the requirements for the specified grade and type of pipe.

13.3.1 Weld seam

The weld seam of all selected welded pipes shall be physically tested as required by (Section 4). For SAW pipe, in addition, an all-weld metal tensile test shall be made including the determination of tensile strength, yield strength and elongation. For determination of the

elongation value, the "Oliver" formula, as specified in ISO 2566-1 may be used. Results of the all-weld metal tensile tests shall meet the minimum specified requirements of the plate, from which the pipe is made. For SAW pipe, in addition, weld impact tests shall be carried out in accordance with (Appendix E, SR5).

13.3.2 Pipe material

Tensile tests shall be carried out on the two pipes made from each end of a coiled skelp, or on two pipes made from different heats, as required by (Section 4), except that for pipes greater than DN 200 (8 inch OD) tensile tests shall be performed in both the transverse and longitudinal directions.

13.3.3 Charpy impact test

Tests shall be carried out on all selected pipes in accordance with (Section 4.19 and Appendix E, SR5). In addition, full transition temperature curves shall be produced, showing impact energy (in Joules) and percentage shear (fibrous) of the fracture surface, plotted against temperature, over a temperature range sufficient to reproduce fracture appearance from 10% to 100% fibrous shear.

13.3.4 Drop weight tear test

For pipe to be used in gas transmission lines, drop weight tear tests shall be carried out in accordance with (Section 4.19 and Appendix E, SR6).

13.4 MACROGRAPHIC, MICROGRAPHIC AND HARDNESS EXAMINATION

13.4.1 HFW and SAW pipe

For SAW pipe, a specimen shall be extracted from one pipe at three locations along the weld.

These three specimens shall be cross-sectioned, polished and etched for macro-examination.

This examination shall provide evidence that proper fusion has been obtained throughout the full thickness of the joint, the extent of interpenetration and the alignment of internal and external weld passes.

For HFW pipe, a total of three specimens shall be taken from the selected pipes for microexamination, to provide proof that heat treatment of the weld zone has been adequate.

For SAW and HFW pipe, a series of Vickers hardness tests (HV10) shall be made on one of the etched specimens selected by the Purchaser. These series of readings shall extend from unaffected base metal on one side across the weld to unaffected base metal on the other side. Three traverses shall be made, one 2 mm from the outer edge, the second across the centre and the third 2 mm from the inner edge. The spacing between the hardness impressions shall be 0.75 mm. The location of the hardness impressions for SAW pipe is shown in Figure A. The hardness impressions nearest the fusion line shall be within 0.5 mm of the fusion line.

13.4.2 Seamless pipe

Three specimens from one pipe shall be extracted from locations 120° apart from a position chosen by the Purchaser, polished and etched for examination and checked for microstructure. A hardness survey shall be made on one of the above specimens selected by the Purchaser. Three traverses shall be made, one 2 mm from the outer edge, the second across the centre and the third 2 mm from the inner edge. A minimum of 12 readings shall be taken at 5 mm intervals.

13.4.3 Acceptance criteria

No hardness measurement shall exceed 248 HV10.

APPENDIX B REPAIR WELDING PROCEDURE

B.2.2. Mechanical Testing

Add new clause:

B2.2.6 Charpy V-Notch Impact Test

Charpy V-notch impact testing shall be performed on the repair welding procedure qualification test weld. Specimens shall be taken from the locations shown in Figure B. The test temperature and acceptance criteria shall be the same as those given for the pipe in Appendix E, SR5.

APPENDIX E SUPPLEMENTARY REQUIREMENTS

SUPPLEMENTARY REQUIREMENT SR5

SR5.1

Delete this section and replace with the following:

The fracture toughness of the pipes shall be determined by Charpy V-notch impact testing in accordance with ASTM A 370. The impact test temperature shall be lower than or equal to that specified in the table below.

Nominal wall thickness, wt (mm)	Test temperature (°C)	Maximum test temperature (°C)
wt ≤ 16.0	T	0
16.0 < wt ≤ 25	T-10	0
25 < wt ≤ 32	T-20	0
wt > 32	T-30	0

(A) T is the minimum design temperature, which shall be specified in the purchase order. If no minimum design temperature is indicated, it shall be taken as 0 °C.

SR5.4

Delete existing section and replace with the following:

Impact testing shall be carried out using 10 x 10, 10 x 7.5 or 10 x 5 mm cross section specimens. The largest possible specimen shall be used. Where the nominal pipe dimensions are insufficient to extract a 10 x 5 mm specimen, impact testing is not required.

For pipes of DN 250 (10 inch) or less, impact test specimens shall be taken parallel to the axis of the pipe (i.e. longitudinal specimens shall be taken).

For pipes greater than DN 250 (10 inch), impact test specimens shall be taken transverse to the axis of the pipe, except where the wall thickness prevents extraction of a 10x5 mm specimen, in which case longitudinal specimens shall be taken.

For weld centreline and HAZ impact tests, only transverse specimens shall be used.

SR5B.2

Delete existing section and replace with the following:

One set of three specimens shall be taken from the mid-thickness location in the pipe wall at the following positions (see also Figure B):

Seamless pipe	-	Pipe body
SAW pipe	-	Pipe body at 90 degrees to the weld
	-	Weld centreline
	-	Fusion line
	-	Fusion line + 2 mm
	-	Fusion line + 5 mm
HFW pipe	-	Pipe body at 90 degrees to the weld
	-	Weld centreline

SR5B.3

Delete existing section and replace with the following:

The minimum absorbed energy requirements for full size (10 x 10) specimens taken transverse to the pipe axis are given in the table below.

GRADE	MINIMUM AVERAGE VALUE (J)	MINIMUM INDIVIDUAL VALUE (J)

B	27	22
X42	27	22
X46	32	24
X52	36	27
X56	39	29
X60	41	31
X65	45	34
X70	48	36

For other specimen sizes and orientations, the values above shall be multiplied by the following factors:

Size	Orientation	Factor
10x10	Longitudinal	1.5
10x7.5	Transverse	0.75
10x7.5	Longitudinal	1.125
10x5	Transverse	0.5
10x5	Longitudinal	0.75

The shear area at the fracture surface of the test specimens shall be recorded. Each sample shall exhibit not less than 50% fibrous shear.

(A) The Charpy test requirements specified are based on crack initiation principles. For gas transmission and two phase lines higher absorbed energy requirements may be specified to avoid the risk of running fractures. In this case the Purchaser shall state the required values in the purchase order.

SUPPLEMENTARY REQUIREMENT SR6

SR6.1

Delete existing section and replace with the following:

Drop weight tear tests are required on pipes of DN 400 or (16 inch) and greater.

SR6.2

Delete existing section and replace with the following:

Two transverse DWTT specimens shall be taken from one length of pipe from each heat supplied in the order. The specimens shall be taken at the locations shown in Fig. SR6.1. Tests shall be performed at the minimum design temperature.

Full transition curves shall be established for one heat out of ten, with a minimum of one.

SR6.4

Delete existing section and replace with the following:

All specimens shall exhibit a minimum of 75% shear on the fracture surface.

SUPPLEMENTARY REQUIREMENT SR15

SR15.1

Add to first paragraph:

The Manufacturer's certificate shall state that the pipe complies with DEP 31.40.20.31-Gen.

APPENDIX G PURCHASER INSPECTION

Add to this section:

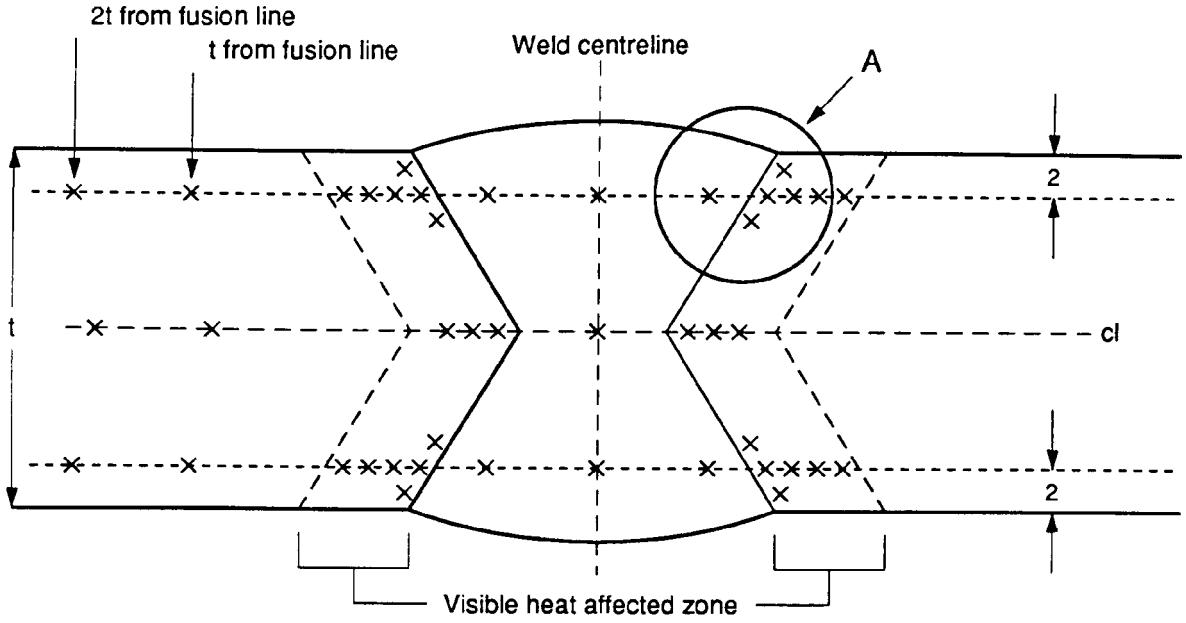
The Purchaser shall specify if, and to what extent, he will monitor the Manufacturer's production, quality control and inspection.

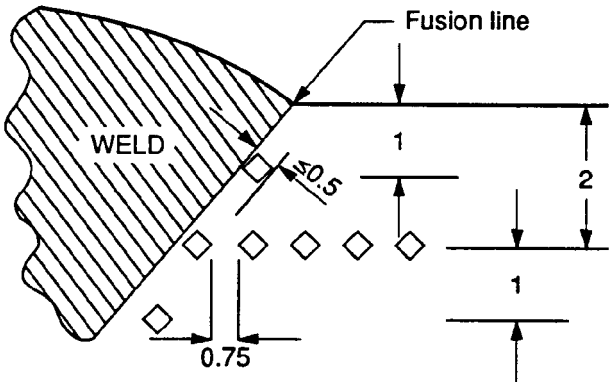
Sufficient fluorescent lighting both overhead and at pipe ends shall be provided at the inspection area. Facilities shall be provided for rolling each pipe joint for inspection. The Manufacturer shall make ultrasonic or other suitable equipment available for use by the Purchaser to check the remaining wall thickness where any defects have been ground out of the pipe.

If the Purchaser has to reject pipe repeatedly for any recurring cause, this shall be reason to refuse further pipes for final examination until the cause has been rectified.

FIGURE A LONGITUDINAL WELD HARDNESS SURVEY

FIGURE A LONGITUDINAL WELD HARDNESS SURVEY





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Enlargement of area A
(all dimensions in millimeters)

FIGURE B1 LOCATION OF CHARPY V NOTCH SPECIMENS IN SAW PIPE WELDS

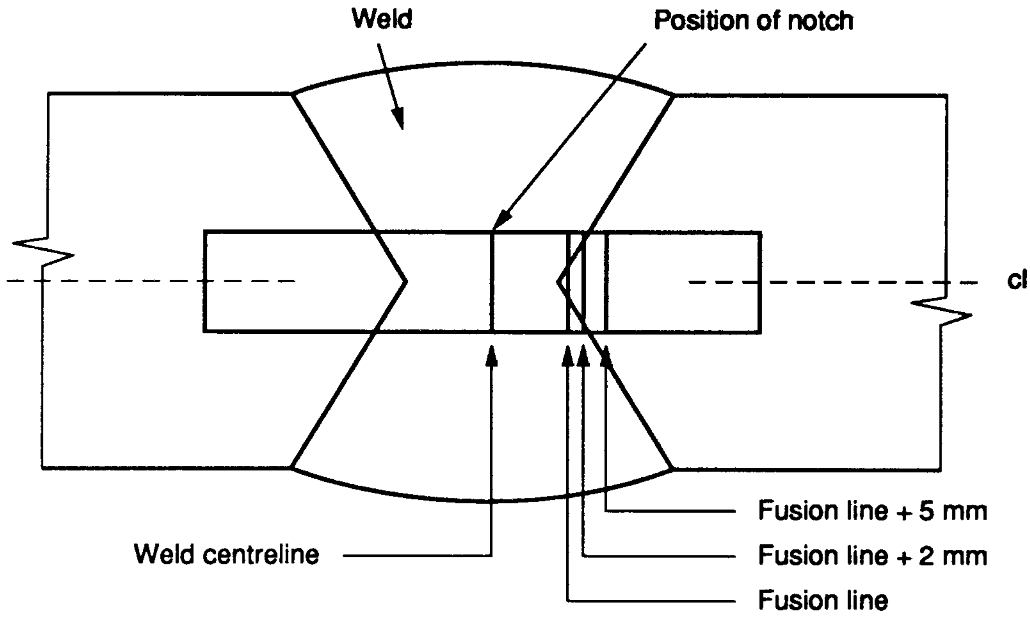
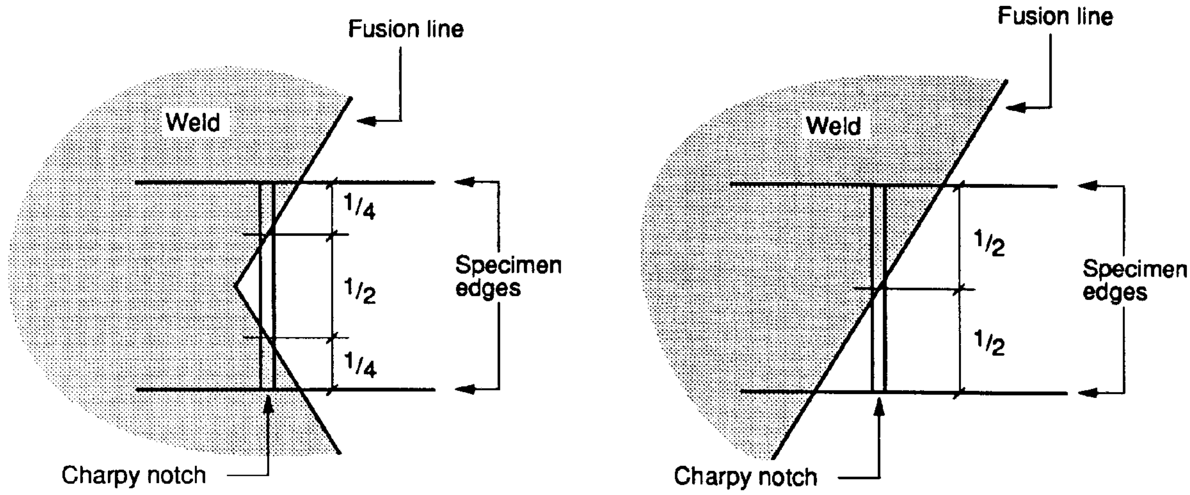


FIGURE B2 DETAIL OF FUSION LINE CHARPY NOTCH LOCATION



a) Symmetric weld

b) Asymmetric weld

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PART III REFERENCE STANDARD PIPE/PLATE FOR INSPECTION OF WELDS

Type and size of notches shall be as given in (Part II, Section 9.15).

FIGURE C TEST PLATE OR SECTION FOR SAW PIPE**

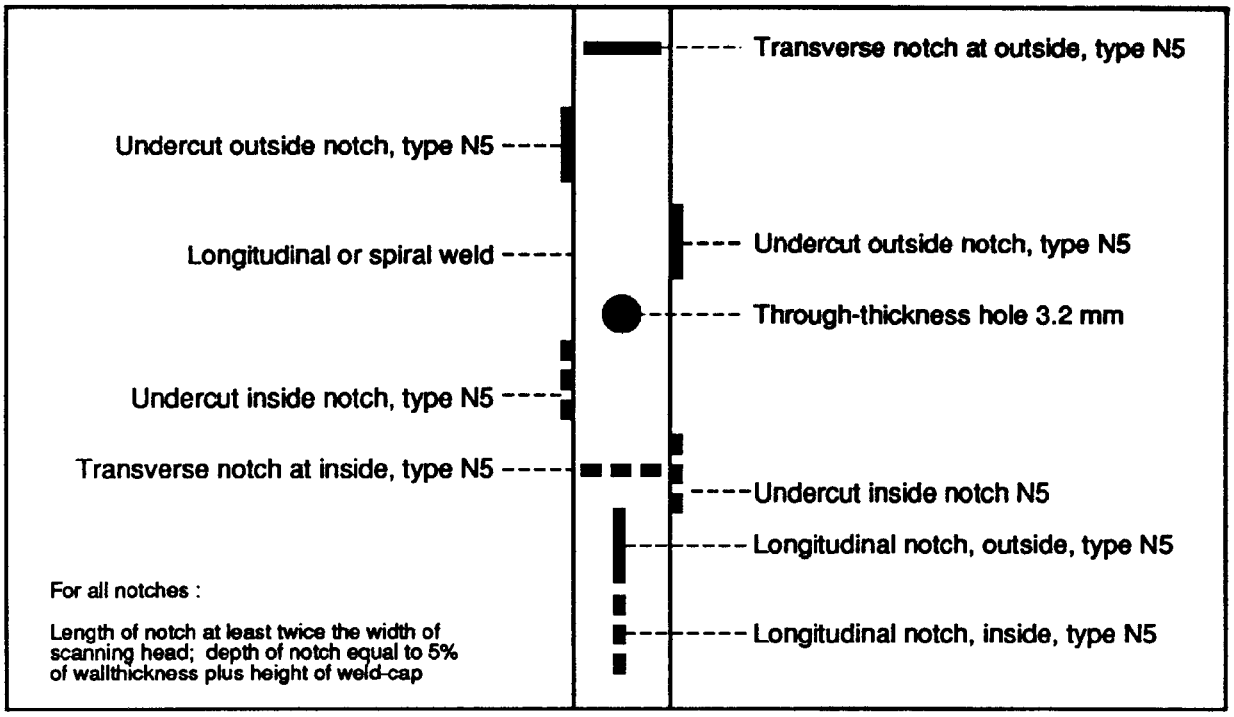
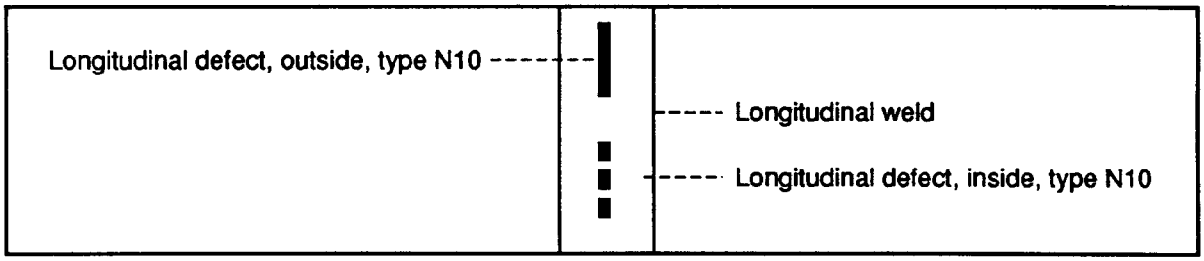


FIGURE D TEST PIPE OR SECTION FOR HFW PIPE**



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** The location of each reference standard may be at the manufacturer's option, provided that no interference will occur.

PART IV HYDROGEN INDUCED CRACKING SENSITIVITY TESTS

4.1 SELECTION OF SAMPLES

The Manufacturer shall perform HIC sensitivity tests. One pipe from each of the first three heats of pipe produced shall be tested. One pipe out of every subsequent ten heats shall be tested. The pipes for testing shall be selected by the Purchaser from the heats exhibiting the higher Sulphur contents. The test shall be witnessed by the Purchaser and the results submitted to the Purchaser. If a sample fails to pass the test, the situation shall be reviewed by the Purchaser, to decide on further testing to distinguish heats which are acceptable.

4.2 QUALIFICATION OF TEST METHOD

Before commencement of the order, the Manufacturer shall provide the Purchaser with a detailed procedure for the testing, metallographic preparation and evaluation of HIC specimens. The Manufacturer shall qualify his test method using samples from a steel of known crack sensitivity. All tests shall be witnessed by the Purchaser.

4.3 SAMPLING

4.3.1 Removal of test coupons

Welded Pipe

Two coupons, each to be sectioned into three specimens, shall be selected and tested for each pipe selected.

Coupon 1 - cut from the pipe opposite the weld seam and in a direction parallel to the rolling direction, see Figure E.

Coupon 2 - cut from the pipe transverse to the weld, see Figure F.

Seamless pipes

For seamless pipe, three specimens shall be removed from the test pipe as shown in Figure E. A curved specimen may be taken from pipe with thin walls or whose shape makes a flat specimen at least 5 mm thick impossible to remove.

An alternative coupon comprising three sets of three separate specimens taken radially, as shown in Figure J, may also be used.

4.3.2 Specimen Preparation

Three adjacent specimens shall be cut from each coupon with dimensions as shown in Figures E and F. The specimens shall firstly be rough ground on a belt grinder or by surface grinding. This shall be followed by final grinding to a 320 grit finish, using silicon carbide papers. They shall then be degreased in acetone. The effectiveness of degreasing shall be demonstrated by using the atomizer test of ASTM F 21. Thereafter, extreme care must be taken not to contaminate the coupons. They should only be handled with tongs or clean gloves. One set of specimens from both the seam weld and base pipe material shall be tested, without applied stress, in the test solution. Tests shall be carried out with specimens that are not coated in any way before exposure in the test environment.

4.4 TEST SOLUTION

The test shall be performed in the NACE TM0177 test solution, i.e. 0.5% acetic acid + 5% NaCl + H_2S. The testing shall be performed in glass vessels.

The solution shall be deaerated by bubbling nitrogen through it at a rate of 100 cc/l/min for one hour. The specimens shall be immersed in the solution with the face of 100 mm x 20 mm in the vertical position and the lower face raised from the cell bottom on bars of teflon or glass. When stacked, the specimens shall also be separated by similar bars, see Figure G.

Nitrogen bubbling shall be continued for a further one hour after which the solution shall be saturated by bubbling H_2S at the rate of 2 to 5 l/min for one hour through an open-ended tube with a 5 mm internal diameter. Upon reaching saturation, the H_2S flow rate may be reduced to 100 cc/min, for a 10 litre solution or pro rata, and maintained at this rate for the test period. The H_2S purity shall be 99.5 vol% or better.

A small positive pressure of H_2S should be maintained in the test cell by the use of an outlet trap to prevent oxygen contamination from the air. If at any time during the test, a white haze clouds the solution, the test shall be stopped and repeated after preparation of new specimens.

Test conditions shall be as follows:

Temperature	25 ± 3 °C
H_2S concentration	(2300-3500 ppm) saturated condition
pH value - initial	2.9 to 3.3
- final	3.5 to 4.0
Test period	96 hours

The pH value of the solution shall be measured at the beginning and the end of the test and the H_2S concentration in the solution determined at the end by iodometric titration.

4.5 EVALUATION OF BLISTERING AND HYDROGEN INDUCED CRACKING

4.5.1 Blistering

The tendency to blister shall be reported after visual examination. Photographs shall be taken of the two wide faces of each coupon to show any blistering. Where photography does not adequately show blisters a dimensioned sketch may be substituted.

4.5.2 Hydrogen induced cracking

Specimens taken with their long axis (100 mm) parallel to the rolling direction shall be sectioned transversely at three points, as shown in Figure H. Specimens containing the weld, cut from longitudinally welded pipe (Figure F), shall be sectioned as shown in Figure I. The intention of the above sectioning procedure is to examine for cracks, in each case on a plane transverse to the rolling direction.

The sections shall be mounted in epoxy resin, or an equivalent, and polished. To avoid the possible obscuring of fine cracks, the metallographic preparation shall entail polishing to a finish of 1 μm or less. Cracking shall then be estimated by micrographic examination at magnifications of X30 and X100.

4.5.3 Evaluation

For each crack observed, the length and extent of stepwise propagation (Figure K) shall be measured. For each section containing cracks, one photograph shall be taken showing one of the complete transverse sections with examples of cracking.

HIC is evaluated in terms of crack length ratio (CLR), crack thickness ratio (CTR) and crack sensitivity ratio (CSR).

These values shall be reported for each section examined and as the average of three sections per specimen. The results for each specimen, i.e. the average of the three sections examined, shall be used for evaluating HIC susceptibility. In this evaluation, cracks associated with surface blistering which have no part more than 1 mm from the specimen surface shall be disregarded.

4.5.4 Acceptance criteria

The following acceptance criteria shall be met:

CLR 15% maximum
CSR 1.5% maximum
CTR 5% maximum

The maximum individual crack length on any section shall not exceed 5 mm.

If any specimen fails to meet the above acceptance criteria, the heat of steel represented by the test shall be rejected.

4.6 REPORTING

The following information shall be supplied in a report together with the Test Certificates.

a. Results of cracking evaluation indicating CLR, CTR and CSR for each section and also averaged over 3 sections, and pass/fail.

b. Photomicrographs of the specimens showing cracking, together with photomicrographs of adjacent material structures:

   i) Unetched, showing the type of inclusions in the steel

   ii) Etched showing the parent material microstructure.

c. pH of H_2S saturated solution at the beginning and at the end of the test, the H_2S content and type of solution.

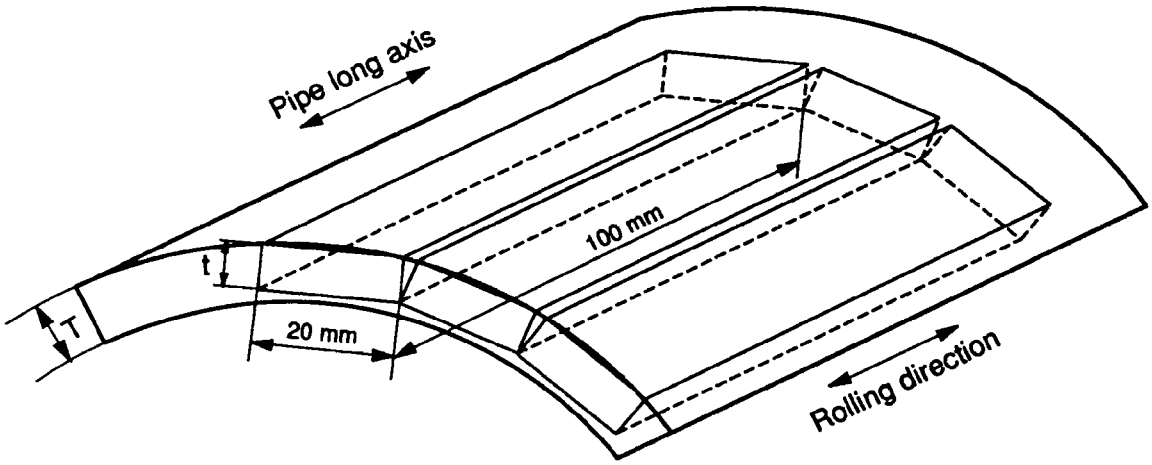
d. Photographs of specimens, showing any blisters, or alternatively dimensioned sketches.

e. Location and dimensions of specimens, and whether taken from pipe body or weld.

f. Full chemical analysis of material tested.

g. Mechanical properties of materials tested.

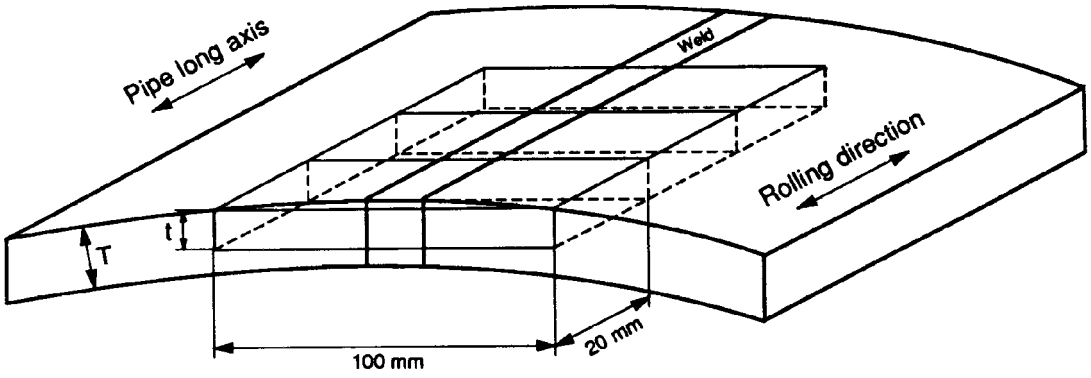
FIGURE E COUPON FROM PIPE PARENT MATERIAL



NOTE: i) t shall be as large as possible. If t cannot be greater than T minus 2.5 mm, coupons may be extracted from flattened specimens.

ii) For seamless pipe and fittings the specimens are 60 mm long x 20 mm wide.

FIGURE F COUPON FROM LONGITUDINALLY WELDED PIPE



NOTE: i) t shall be as large as possible. If t cannot otherwise be greater than T minus 2.5 mm, coupons may be extracted from flattened specimens.

FIGURE G SPECIMEN ARRANGEMENT IN CELL

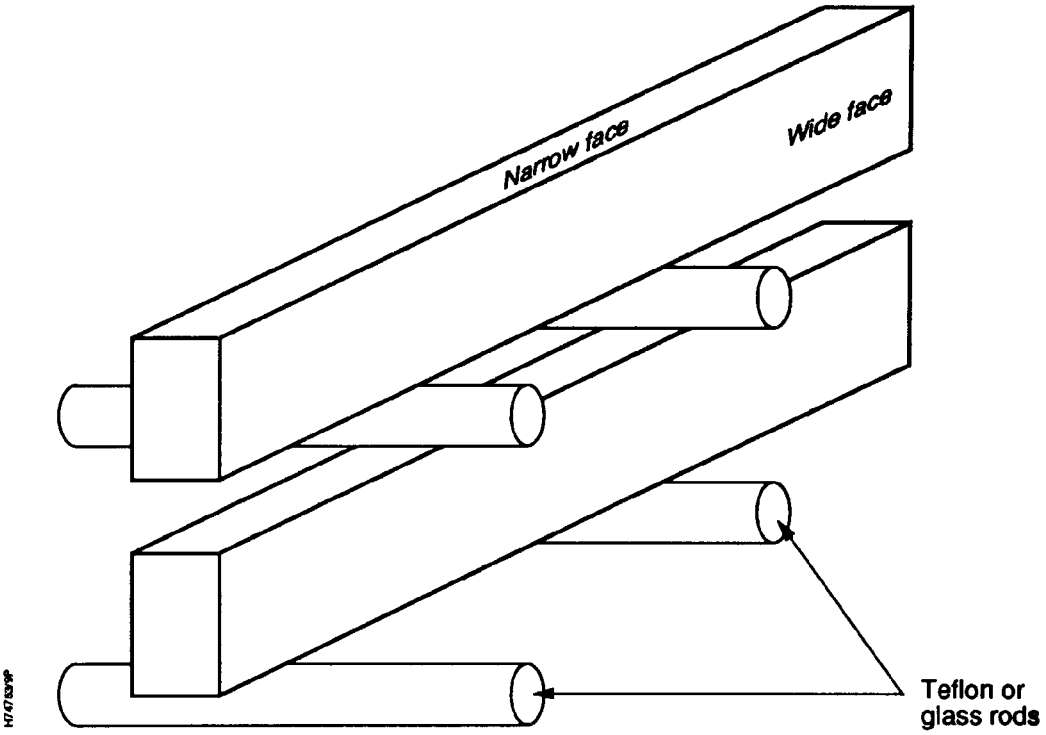


FIGURE H SECTIONING OF SPECIMENS FROM PIPE PARENT MATERIAL

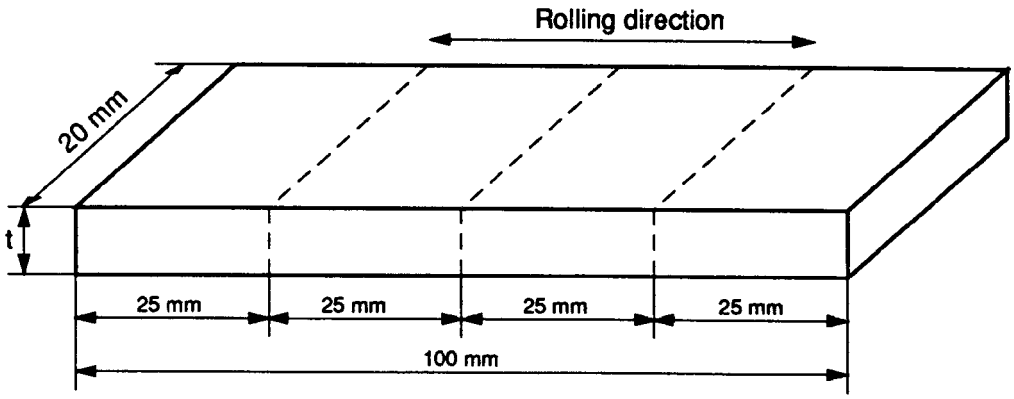


FIGURE I SECTIONING OF SPECIMENS FROM WELD SEAM

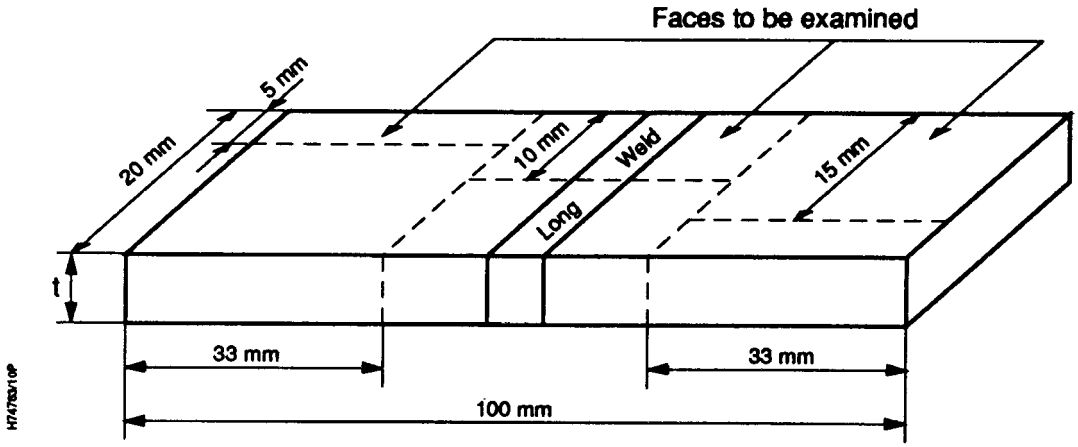


FIGURE J SECTIONING OF ALTERNATIVE SPECIMENS FROM SEAMLESS PIPE AND FITTINGS

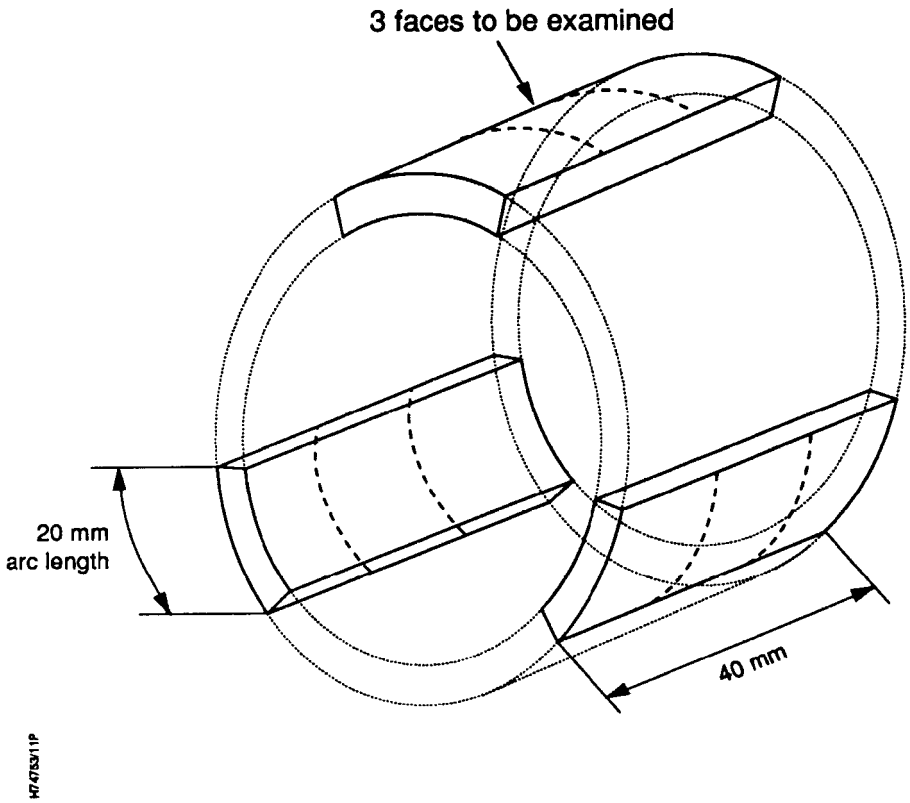
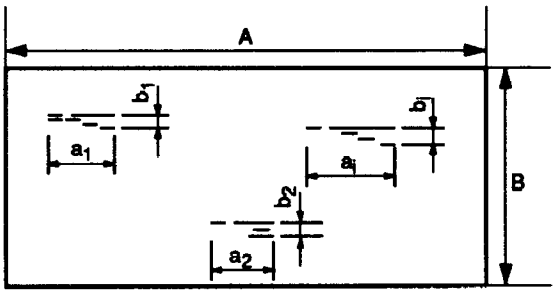


FIGURE K EVALUATION OF HIC

Cracks are evaluated according to crack length ratio (CLR), crack thickness ratio (CTR) or crack sensitivity ratio (CSR) by measuring the total crack length, extent of stepwise cracks or stepwise crack area respectively.



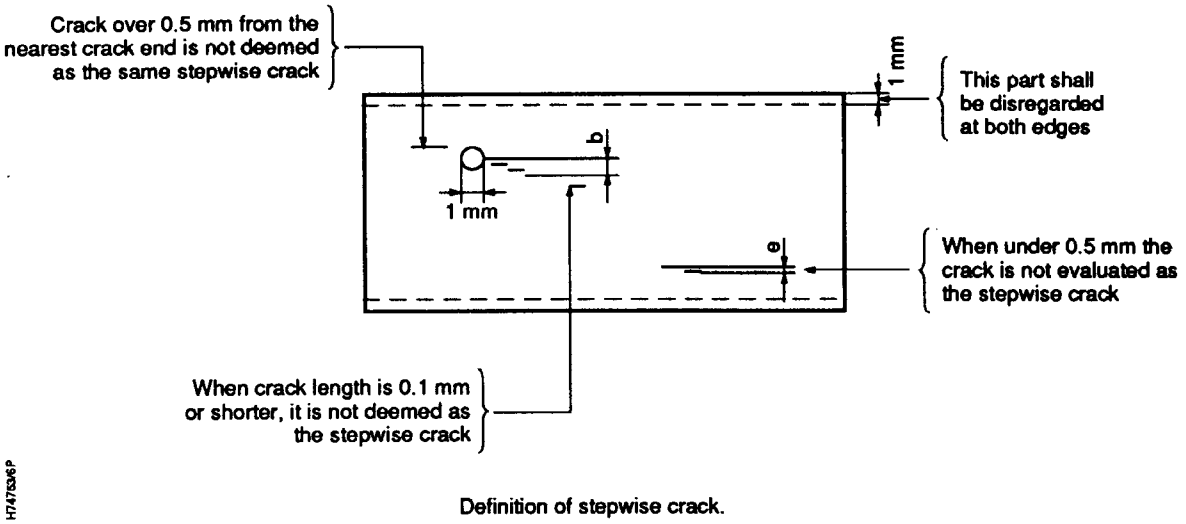
Length of stepwise crack: Σa_i
Extent of stepwise crack: Σb_i

CLR, CTR and CSR values can be calculated with the following equations.

$$CLR = \frac{\sum_{i=1}^{n} a_i}{A} \times 100\ (\%)$$

$$CTR = \frac{\sum_{i=1}^{n} b_i}{B} \times 100\ (\%)$$

$$CSR = \frac{\sum_{i=1}^{n} a_i.b_i}{A.B} \times 100\ (\%)$$



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Definition of stepwise crack.

PART V SUMMARY OF TESTING AND INSPECTION

Types of Test/Inspection	First-day Production Tests		During Production	
	Frequency	Remarks	Frequency	Remarks
VISUAL INSPECTION				
- dimensions	all pipes		all pipes	
- out of roundness at weld position	all SAW pipes		all SAW pipes	
- pipe end squareness	all pipes		2 pipes per shift	
- straightness	all pipes		random	
- surface defects	all pipes	external (plus internal ≥ DN 600)	all pipes	external (plus internal ≥ DN 600)
ULTRASONIC EXAMINATION				
- pipe ends	all pipes	25mm of pipe ends	all pipes	25mm of pipe ends
- welded pipe				
- plate/skelp	all plates/skelp	25mm of trimmed plate material	all plates/skelp	25mm of trimmed plate material
- weld seam	all pipes	SAW pipe ends shall be radiographed	all pipes	SAW pipe ends shall be radiographed
- seamless pipe	all pipes	25% of surface	all pipes	25% of surface
RADIOGRAPHY				
- weld seam	all selected SAW pipes	100% weld	all SAW welds	end 200mm
- weld repair areas on seam weld	all weld repairs		all weld repairs	
MT				
- seam weld	all selected pipes			
- seamless pipe body	all selected pipes			
- bevel faces	all pipes	only if ultrasonic testing is impossible	all pipes	only if ultrasonic testing is impossible

Types of Test/Inspection	First-day Production Tests		During Production	
	Frequency	Remarks	Frequency	Remarks
PHYSICAL TESTS				
- tensile test	two selected pipes		two pipes per heat	
- weld tensile test	all selected pipes	welded pipe only	as above	
- all weld tensile test	one pipe	SAW only		
- Charpy V-Notch	all pipes			
- at temperature in Part II, App.E.	all selected pipes		as required for tensile test	
- transition curve	one pipe			
- Drop Weight Tear Test				
- transition curve	one pipe		one pipe per ten heats	
- at minimum design temperature	all heats		all heats	
- flattening test				HFW only
- weld manipulation test			one pipe per 50 pipes	SAW only
- weld ductility test			one test per lot (see 4.17 API Spec 5L)	HFW only
- macro, micro plus hardness	one pipe (3 specimens) three pipes (3 specimens)	SAW & SMLS HFW	one pipe per heat or after each stop in production	HFW only

Types of Test/Inspection	First-day Production Tests		During Production	
	Frequency	Remarks	Frequency	Remarks
HYDROTEST	all pipes		all pipes	
CHEMICAL COMPOSITION - Ladle analysis - Check analysis	once per heat twice per heat		once per heat twice per heat	
HYDROGEN INDUCED CRAKING TEST	first three heats		one pipe per ten heats	

PART VI REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEPs and standard specifications	DEP 00.00.05.05-Gen.
Linepipe for use in oil and gas operations under non-sour conditions (Amendments/supplements to API Spec 5L)	DEP 31.40.20.30-Gen.

AMERICAN STANDARDS

Specification for Line Pipe	API Spec 5L, 40th Edition, November 1992

Issued by:
American Petroleum Institute
1220 L Street, Northwest
Washington DC 20005
USA.

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Standard Test Methods and Definitions for Mechanical Testing of Steel Products	ASTM A 370
Standard Test Methods for Determining Average Grain Size	ASTM E 112
Practice for Liquid Penetrant Examination	ASTM E 165
Standard Practice for Eddy Current Examination of Steel Tubular Products using Magnetic Saturation	ASTM E 309
Standard Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products	ASTM E 570
Practice for Magnetic Particle Examination	ASTM E 709
Standard Test Method for Hydrophobic Surface Films by the Atomizer Test (R 1989)	ASTM F 21

Issued by:
American Society for Testing and Materials
1916 Race Street
Philadelphia PA 19103
USA.

Laboratory Testing of Metals for Resistance to Sulphide Stress Cracking in H_2S Environments	NACE TM0177

Issued by:
National Association of Corrosion Engineers
1440 South Creek Drive
PO Box 218340
Houston, TX 77218-8340
USA

GERMAN STANDARDS

Ultrasonically Tested Heavy Plate; Technical	SEL-072

Delivery Specifications

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Burggrafenstrasse 6
Postfach 1107
D-1000 Berlin 30
Germany.

INTERNATIONAL STANDARDS

Radiographic Image Quality Indicator for Non-destructive testing	ISO 1027
Steel, conversion of elongation values Part 1 Carbon and low alloy steels	ISO 2566-1
Non-destructive testing; qualification and certification of Personnel	ISO 9712
Steel and Steel Products, Inspection documents	ISO 10474

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