

Supplementary Specification to API Specification 5L and ISO 3183 Line Pipe

Public Review Draft

Revision history

VERSION	DATE	PURPOSE
1.1	November 2020	Issued for Public Review

Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2014).

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Public Review Draft

Introduction

The purpose of this specification is to define a minimum common set of supplementary requirements for procurement of line pipe to API Specification 5L 46th Edition 2018 including Errata 1 2018 and ISO 3183 4th Edition 2019 for application in the petroleum and natural gas industries.

This specification may also be applied to line pipe manufacturing for pipelines designed according to other design standards. It is the responsibility of the manufacturer to comply with the manufacturing requirements of the selected design code and this specification.

This JIP33 standardized procurement specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.



JIP33 Specification for Procurement Documents Supplementary Technical Specification

It is required to use all of these documents in conjunction with each other when applying this specification, as follows:

IOGP S-616: Supplementary specification to API Specification 5L and ISO 3183 Line Pipe

This specification is written as an overlay to API Specification 5L, following the clause structure of the parent standard (API Specification 5L), to assist in cross-referencing the requirements. Where clauses from the parent standard are not covered in this specification, there are no supplementary requirements or modifications to the respective clause. The terminology used within this specification follows that of the parent standard and otherwise is in accordance with ISO/IEC Directives, Part 2.

Modifications to the parent standard defined in this specification are identified as Add (add to clause or add new clause), Replace (part of or entire clause) or Delete.

IOGP S-616D: Line Pipe Material Data Sheet (LPMDS) for IOGP S-616

This document provides project specific requirements where the supplementary specification and its parent standard require the purchaser to define an application specific requirement. It follows the clause structure of the parent standard and this specification. It also includes information required by the purchaser for technical evaluation. Additional purchaser supplied documents are also listed in the data sheet, to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-616L: Information requirements (IRS) for Line Pipe

This document defines the information requirements, including format, timing and purpose, for information to be provided by the manufacturer. It also defines the specific conditions which must be met for conditional information requirements to become mandatory. The information requirements listed in the IRS have references to the source of the requirement.

IOGP S-616Q: Quality requirements (QRS) for Line Pipe

This document includes a conformity assessment system (CAS) which specifies standardized purchaser interventions against quality management activities at four different levels. The applicable CAS level is specified by the purchaser in the datasheet.

The LPMDS and IRS are published as editable documents for the purchaser to specify application specific requirements. The supplementary specification and QRS are fixed documents.

Unless defined otherwise in the requisition, the order of precedence (highest authority listed first) of the documents shall be:

- a) regulatory requirements;
- b) contract documentation (e.g. purchase order);
- c) user defined requirements (LPMDS, IRS, QRS);
- d) this specification;
- e) API Specification 5L and ISO 3183 Line Pipe.

1 Scope

1.1 Coverage

Replace section with

This supplementary specification is limited to seamless pipes and single seam welded pipes manufactured in accordance with product specification level 2 (PSL 2).

Any section within API Specification 5L or ISO 3183 that specifically relate to PSL1 line pipe, double seam welded pipes, jointers, intermediate grades, couplings, cast pipes and end welds are not relevant to the application of this specification and shall be considered as not applicable.

If line pipe is ordered to ISO 3183, the applicability of ISO 3183, Annex A for PSL 2 pipe ordered for European onshore natural gas transmission pipelines shall be specified in the LPMDS.

2 Normative References

Add to section

API Specification 5L:2018, *Line Pipe*

ISO 3183, *Petroleum and natural gas industries — Steel pipe for pipeline transportation systems*

NOTE At the time of publishing IOGP S-616, this fourth edition of ISO 3183 was not yet published. In the meantime, ISO DIS 3183:2018 may be used.

EFC Publication 16, *Guidelines on Materials Requirements for Carbon and Low Alloy Steels for H₂S-Containing Environments in Oil and Gas Production*

API RP 5L1, *Recommended Practice for Railroad Transportation of Line Pipe*

API RP 5LT, *Recommended Practice for Truck Transportation of Line Pipe*

API RP 5LW, *Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels*

ASME BPVC Section II Part C, *Boiler and Pressure Vessel Code*

ASME BPVC Section VIII, *Rules for construction of pressure vessel*

ASTM E9, *Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature*

ASTM E45, *Standard Test Methods for Determining the Inclusion Content of Steel*

ASTM E112, *Standard Test Methods for Determining Average Grain Size*

ASTM E1928, *Standard Practice for Estimating the Approximate Residual Circumferential Stress in Straight Thin-walled Tubing*

AWS A4.4M, *Standard Procedures for Determination of Moisture Content of Welding Fluxes and Welding Electrode Flux Coverings*

AWS A5.01/A5.01M, *Welding and Brazing Consumables - Procurement of Filler Materials and Fluxes*

AWS A5.1/A5.1M, *Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding*

AWS A5.5/A5.5M, *Specification for Low-Alloy Steel Covered Arc Welding Electrodes*

AWS A5.17/A5.17M, *Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding*

AWS A5.18/A5.18M, *Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding*

AWS A5.23/A5.23M, *Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding*

AWS A5.28/A5.28M, *Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding*

AWS A5.32/5.32M, *Welding Consumables—Gases and Gas Mixtures for Fusion Welding and Allied Processes*

BS 8701, *Full ring ovalization test for determining the susceptibility to cracking of linepipe steels in sour service - Test method*

DNVGL-ST -F101, *Submarine Pipelines Systems*

ISO 3690, *Welding and allied processes — Determination of hydrogen content in arc weld metal*

ISO 5817, *Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections*

ISO 14732, *Welding personnel — Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 17637, *Non-destructive testing of welds — Visual testing of fusion-welded joints*

ISO 17639, *Destructive tests on welds in metallic materials — Macroscopic and microscopic examination of welds*

ISO 17640, *Non-destructive testing of welds — Ultrasonic testing — Techniques, testing levels, and assessment*

NACE MR0175/ ISO 15156-1, *Petroleum and natural gas industries - Materials for use in H₂S containing environments in oil and gas production — Part 1: General principles for selection of cracking-resistant materials*

NACE MR0175/ ISO 15156-2, *Petroleum and natural gas industries — Materials for use in H₂S containing environments in oil and gas production — Part 2: Cracking-resistant carbon and low-alloy steels, and the use of cast irons*

NACE TM0316, *Four-Point Bend Testing of Materials for Oil and Gas Applications*

Add to section

3 Terms, Definitions, Symbols, and Abbreviations

3.1 Terms and Definitions

Add to section

3.1.66 inspector

The purchaser's representatives or members from an inspection agency duly appointed by the purchaser and thus notified to the manufacturer, and shall be referred to herein as the "inspector".

3.1.67 contract

The purchase order together with all material requisitions, specifications, etc. issued by the purchaser and attached to the contract or the purchase order shall be referred to herein as the "contract".

3.1.68 acceptance

Authorization given in writing by the purchaser to the manufacturer on a procedure or to proceed with the performance of a specific part of the work without releasing in any way the manufacturer from any of its obligations to conform to the technical specifications, requisitions, etc. "Accept", "accepted" and "acceptance" shall be construed accordingly. Acceptance of a deviation may override the technical requirement from the specification.

3.1.69 integrated mills

A steelworks which manufactures not only final pipe products but also their material of billets/slabs and starting material of plates/coils used for the pipe products.

3.1.70**systematic imperfections**

Imperfections that are not classified as defects but that are repeatedly distributed in the weld over the weld length to be examined.

3.1.71**coarse grain**

Area affected by welding exhibiting a grain growth.

3.2 Symbols

α_{fab}	fabrication factor
M	mean value
T _o	test temperature
T _{min}	minimum design temperature
S _d	standard deviation (of wall thickness)
AUT	automatic ultrasonic testing
AWMT	all weld metal tensile test
CAR	crack area ratio
CAS	Conformity Assessment System
CGHAZ	coarse grain heat-affected zone
CO	cut-off
CR	computed radiography
CCW	counterclockwise
CW	clockwise
DAC	distance amplitude curve
DBTT	ductile brittle transition temperature
DDA	digital detector array
DHC	delayed hydrogen cracks
DR	digital radiography
EMAT	electromagnetic acoustic transducer
EMI	electromagnetic inspection
FBE	fusion bonded epoxy
FBH	flat bottom hole
FL	fusion line
FL2	fusion line + 2 mm (0.08 in.)
FSH	full screen height
LPMDs	line pipe material datasheet (see IOGP S-616D)
MPfB	mother pipe for bends
MPQT	manufacturing process qualification testing
MPS	manufacturing procedure specification
MUT	manual ultrasonic testing

NCR	nonconformance request
PRG	primary reference gain
PQR	procedure qualification record
PRL	primary reference level
PWHT	post-weld heat treatment
pWPS	preliminary welding procedure specification
RCA	root cause analysis
RDH	radially-drilled hole
RT	radiographic testing
SAUT	semi-automated ultrasonic testing
SCR	steel catenary riser
SDH	side-drilled hole
SOHIC	stress orientated hydrogen induced cracking
S/N	signal/noise ratio
SS	scanning sensitivity
TC	transfer correction
TCG	time-corrected gain
ToFD	time of flight diffraction
UEL	uniform elongation

5 Compliance to this Standard

5.1 Quality

Replace section with

Add to section

The quality management system shall comply with API Q1, or ISO 9001 and ISO/TS 29001.

5.3 References to Annexes

Add to section

The following normative appendices shall address aspects not covered within API Specification 5L:

- welding consumables, see Appendix 1;
- weldability test, see Appendix 2;
- qualification of NDT at plate/coil and pipe mill, see Appendix 3;
- NDT procedure content, see Appendix 4.

7 Information to Be Supplied by the Purchaser

Add to section

In addition to Section 7, the LPMDS shall be used to clarify the information to be supplied by the purchaser.

7.2 Additional Information

Add to item b)

Items 1, 2, 4, 11, 12 and 15 shall apply and are mandatory.

Add to item c)

Items 10, 43, 44, 46, 50, 51, and 53 shall apply and are mandatory.

Items 23 and 39 are not permitted.

8 Manufacturing

8.2 Processes Requiring Validation

Add to section

Change to the essential manufacturing process parameters beyond the scope of qualification of the MPQT shall require requalification (see Annex B).

8.3 Starting Material

8.3.2

Delete item c)

8.3.3

Add to section

The manufacturer shall demonstrate that clean steel making practices are used and specific treatment to control inclusions size, shape and distribution are employed to produce the quality steel required to manufacture the pipes according to this specification.

For HFW inclusion content, control shall be tested on the first and last heat of each casting sequence.

For other product if specified, inclusion content control shall be tested on the first and last heat of each casting sequence.

If steel scrap is used, a procedure for scrap management shall be issued.

External scraps deliveries shall be checked for radioactivity.

Hydrogen control practice for billets and slabs shall be applied.

8.3.6

Replace section with

Lubricant or contamination on the weld bevel or the surrounding areas (minimum 100 mm (3.94 in.)) shall be removed before making the seam welds (tack weld and SAW weld).

The weld bevel shall be clean and dry.

Add new section

8.3.10

For integrated or non-integrated mills, reports of tests and inspections carried out on plates and coils in accordance with this specification shall be issued.

Add new section

8.3.11

Rolling mill edges shall be removed before welding.

Unless otherwise specified, rotary shearing shall not be permitted with the exception of:

- pipe of 8 mm (0.315 in.) wall thickness or less;
- with a pipe diameter of 273 mm (10 in.) or less;
- with a pipeline design temperature of not less than -10 °C (14 °F).

8.4 Tack Welds

Add new section

8.4.3

If not removed by machining, the tack weld shall be continuous and performed by an automatic welding process in compliance of Annex B.

For the repair of a tack weld by manual welding, the weld shall be ground down to the thickness of the automatic pass.

Manual welding is allowed but shall be restricted to pipe ends.

The tack welding process and the maximum thickness of the tack weld shall be specified within the welding procedure specification (WPS).

8.6 Weld Seams in SAW Pipe

Replace section with

Run-on and run-off tabs shall be grooved to match the seam weld groove geometry.

For longitudinal seam welds, the run-on and run-off tabs shall be removed.

If any of the following are true, the pipe ends shall be cropped:

- tabs are not used;
- tabs are not grooved to match pipe seam joint geometry;
- tabs are removed by mechanical breaking.

Cropping length shall be sufficient to remove arc starts, arc stops, portions of non-steady state arc regime, and imperfections and defects from mechanical breaking.

SAW:

- Welding equipment shall include a weld seam tracking system.

Flux coverage:

- Flux coverage of all arcs is mandatory. Visible arcs are not permitted.
- The flux shall meet the requirements specified in Appendix 1.

8.8 Treatment of Weld Seams in EW and LW

8.8.2 LW Pipe and PSL 2 HFW Pipe

Replace section with

For grades not subjected to quench and temper processing, the full thickness of the weld seam and HAZ shall be normalized above the upper critical transformation temperature of the steel.

The heat treatment area shall be extended to the base metal to the sides of the weld seam by, the greater of:

- 15 mm (0.60 in.);
- or,
- the pipe wall thickness as measured on the internal surface.

For pipe thicker 19.1 mm (0.750 in.) the width of the heat treatment area shall be by agreement.

Cooling by water shall be permitted when this area has a temperature of 250 °C (482 °F) or below, unless qualified to allow a higher temperature prior to water cooling.

Weld seam heat-treating equipment shall include a weld seam tracking system.

Heat treatment temperature shall be continuously monitored, recorded and available for review unless an alternative proposal is accepted.

Alarm and automatic pipe marking shall activate in the event of a failure or abnormal operation of the seam heat treatment equipment, including the seam tracking and heating elements.

Regions where the seam heat treatment temperature does not meet the control range shall be discarded.

8.9 Cold Sizing and Cold Expansion

Replace 8.9.2 with

8.9.2

The sizing ratio for cold-expanded pipe shall not be less than 0.003 or greater than 0.015.

The sizing ratio shall be recorded for three pipes per shift (at the beginning, middle and end of shift) and also on MPQT pipe used for qualification of the MPS.

Non-expanded pipes manufactured by press or roll bending processes shall have full body heat treatment.

8.12 Heat Treatment

Add to section

Furnace surveys shall be conducted at least annually in accordance with an industry recognized standard e.g. NORSOK, ISO, API, ASTM.

For austenitizing furnaces, temperature uniformity shall be $\pm 14^{\circ}\text{C}$ ($\pm 25^{\circ}\text{F}$).

For tempering furnaces, temperature uniformity shall be $\pm 8^{\circ}\text{C}$ ($\pm 15^{\circ}\text{F}$).

Furnaces shall be equipped with recording sensors that are calibrated at least quarterly.

For quenching facilities, the coolant temperature shall be continuously monitored and remain below 40°C (104°F).

Essential variables, including nozzle size, water flow rate and quenching conveyor speed, shall be controlled within agreed ranges for each production size.

8.13 Traceability

Add to section

If specified, the following heat identity properties shall be recorded as applicable:

- date of production;
- casting sequence number;
- heat number;
- casting strand number;
- billet/slab sequence number;
- mother billet/slab;
- daughter billet/slab;
- mother plate;
- daughter plate;
- test unit identity.

The pipe numbering shall be agreed.

9 Acceptance Criteria

9.1 General

9.1.2

Replace section with

An alternative grade to that ordered shall not be substituted.

9.2 Chemical Composition

9.2.2

Add to section

The following limits shall apply to product analysis unless lower limits are specified: $V \leq 0.08$ wt. %; $Nb \leq 0.05$ wt. %; $V + Nb \leq 0.10$ wt. %; $B \leq 0.0005$ wt. % (ladle analysis acceptable for B analysis).

Add new section

9.2.6

The manufacturer shall declare the target chemical composition and proposed range during the technical clarification stage.

The chemical composition allowable range shall be in accordance with Table 28.

Elements not intentionally added but listed in API Specification 5L Table 5 (including footnotes), S-616 section 9.2.2, and required for carbon equivalent formulas shall be reported in the pipe product analysis.

Product analysis shall be performed on a specimen extracted from a finished pipe and be performed by the pipe manufacturer or by a laboratory under the direction of the pipe manufacturer.

Add new table

Table 28—Chemical Composition Allowable Range (Weight Percentage)

Element	Allowable Range	Element	Allowable Range
C	0.040	V	0.030
Mn	0.200	Nb	0.020
P	N/A	Ti	0.014
S	N/A	Al	0.040
Ca	N/A	N	N/A
Si	0.300	O	N/A
Ni	0.100	B	N/A
Cr	0.100	H	N/A
Mo	0.100	CE_{IIW}^b	0.060
Cu	0.060	CE_{Pcm}^b	0.040
		CEN^a	Info

^a CEN shall be calculated for information

$$CEN = C + A(C) \left[\frac{Mn}{6} + \frac{Si}{24} + \frac{Cr + Mo + V}{5} + \frac{Cu}{15} + \frac{Ni}{20} + \frac{Nb}{5} + 5B \right]$$

$$A(C) = 0.75 + 0.25 \tanh [20(C - 0.12)]$$

^b For CEIIW and CEPcm the range shall be split equally around the agreed target value (allowable range: Target CEIIW $\pm$ 0.030 and CEPcm $\pm$ 0.020)

9.3 Tensile Properties

9.3.2

Add to section

For design temperatures above 50 °C (122 °F), tensile testing shall be performed at the maximum design temperature.

The acceptance criteria shall be as specified.

During cross weld tensile testing, the test piece shall break in the base metal.

9.4 Hydrostatic Test

Add new section

9.4.3

Pipes that fail the hydrostatic test shall be quarantined to an area for subsequent root cause investigation with results being made available.

9.6 Flattening Test

Replace section with

Acceptance criteria for flattening tests shall be:

- No cracks or breaks in the weld or parent metal to 50 % of the original outside diameter.
- Further flattened to 33 % of original outside diameter without cracks or breaks, other than in the weld.

9.8 CVN Impact Test for PSL 2 Pipe

9.8.2 Pipe Body Tests

9.8.2.1

Add to section

The test temperature (T_o) shall be calculated in accordance with Table 29 with a maximum of 0 °C (32 F).

Add new table

Table 29—CVN Impact Testing Temperature T_o (°C) as a Function of T_{min} (°C)

Specified Wall Thickness, t (mm)	Pipelines and Risers
------------------------------------	----------------------

$t \leq 20.0$	$T_o = T_{min}$
$20.0 < t \leq 30.0$	$T_o = T_{min} - 10$
$30 < t$	$T_o = T_{min} - 20$
NOTE A lower test temperature may be specified for gas service not covered by Annex G. This will be specified in the LPMS.	

9.8.2.2

Replace section with

If specified, for a set of three test pieces, the minimum average and individual shear fracture area for each test shall be at least 85 % and 75 % respectively, at the test temperature specified.

9.8.3 Pipe Weld and HAZ Tests

Replace section with

For a set of three test pieces, the minimum average absorbed energy for each pipe weld and HAZ test shall be in accordance with Table 8 of API Specification 5L, based upon full-size test pieces at the specified test temperature.

The minimum average and individual shear fracture area in the HAZ shall be in accordance with the values specified.

Replace section heading with

9.9 DWT Test for PSL 2 Pipe

9.9.1

Replace section with

Add to section

If specified, DWT testing shall be performed on seamless and welded pipes with $D \geq 406$ mm (16 in.).

The test shall be performed at the minimum design temperature specified for a full thickness specimen.

DWT temperature reduction for a reduced thickness specimen for a pipe thickness greater than 39.7 mm (1.56 in.) shall be by agreement with the purchaser.

The minimum average shear area of a set of two test pieces shall be 85 %.

9.10 Surface Conditions, Imperfections and Defects

9.10.1 General

9.10.1.1

Add to section

The external surface of all seamless pipes shall be free from scabs, laps, shells, slivers, burrs, metallurgical tears and sharp-edged discontinuities.

Add new section**9.10.1.4**

The pipe shall be free of loose scale on both the inner and outer surfaces.

9.10.2 UndercutsAdd to list

d) Undercuts which are coincident at the inside and outside welds are not permitted.

Replace section heading with**9.10.3 Arc Burns (Welded Pipes)****9.10.3.2**Add to section

Arc burns caused by arcing between copper-based materials (e.g. electrode holder, contact tip) shall be classified as defects and treated in accordance with API Specification 5L, C.3 b) or C.3 c).

9.10.5 Geometric Deviations**9.10.5.1**Add to section

Geometric deviations that exceed 25 % of pipe diameter or 300 mm (12 in.) in any direction, whichever is smaller, shall be treated in accordance with C.3 b) or C.3 c).

9.10.5.2Add new items to section

- c) the maximum length in any direction, the lesser of 0.25D or 300 mm (12 in.);
- d) cold formed dents without sharp bottom gouges, acceptable to a maximum depth of 3.2 mm (0.125 in.);
- e) dents > 1.6 mm (0.0625 in.) within 100 mm (4 in.) of pipe ends, or are on the pipe weld seam.

Add to section

Sharp bottom dents or sharp bottom gouges shall be rejected.

9.10.6 Hard SpotsReplace first sentence with

Any hard spot larger than 50 mm (2.0 in.) in any direction shall be classified as a defect if its hardness exceeds:

- a) for grade X70 and below, 275Hv10;
- b) for grade X80 and above, 325Hv10.

9.12 Finish of Pipe Ends

9.12.5 Plain Ends

9.12.5.2

Add to section

Beveling shall be carried out by machining only.

If the machined bevel requires repair by grinding, then re-beveling shall be done by machining.

Add new section

9.12.5.6

Outside and inside burrs shall be removed from the pipe ends, provided that the root face is not altered.

9.13 Tolerances for the Weld Seam

9.13.2 Height of the Flash or Weld Bead/Reinforcement

9.13.2.2

Add new items to list

- f) For SAWH/COWH weld beads, with the weld cap profile concavity of ≤ 1.5 mm (0.060 in.).
- g) When grinding seams, the transition between the weld seam to the pipe body is to be smooth without a visually noticeable step.
- h) A maintained outside pipe diameter contour, avoiding grinding flat.
- i) Grinding of the outside and inside weld beads at pipe ends may be performed after expansion but performed before hydrostatic testing.

9.13.3 Misalignment of the Weld Beads of SAW and COW Pipe

Add to section

For SAW pipes, the width of interpenetration overlap, measured with a straight line perpendicular to the radial direction, shall be the minimum of $\frac{1}{4}t$ or 5 mm (0.2 in.), whichever is less. Refer to Figure 4 d.

Add figure to section

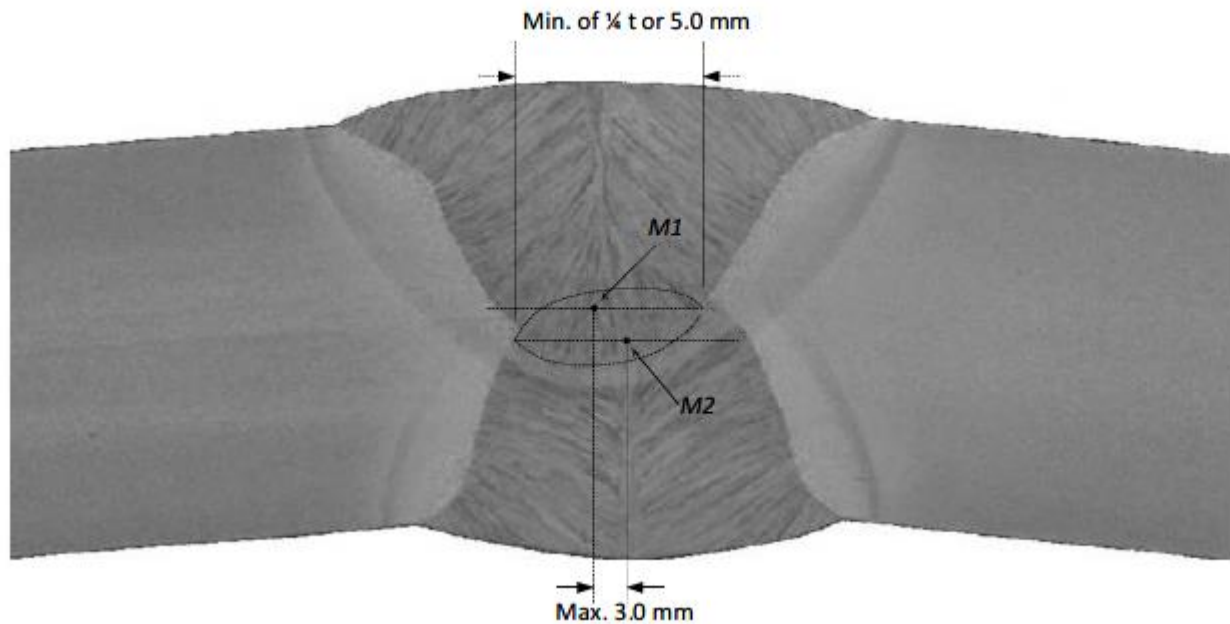


Figure 4.d—

Add new section

9.13.4 Peaking

Unless otherwise specified, peaking of the pipe at the weld location shall not deviate by more than 2.5 mm (0.10 in.) from the theoretical form, when measured transverse to pipe axis using inspector accepted inside and outside templates as per 10.2.8.4.

Add new section

9.13.5 Weld Toe Angle

The weld toe angle (re-entrant angle) for the OD and ID welds shall be greater than 120°.

Add new figure

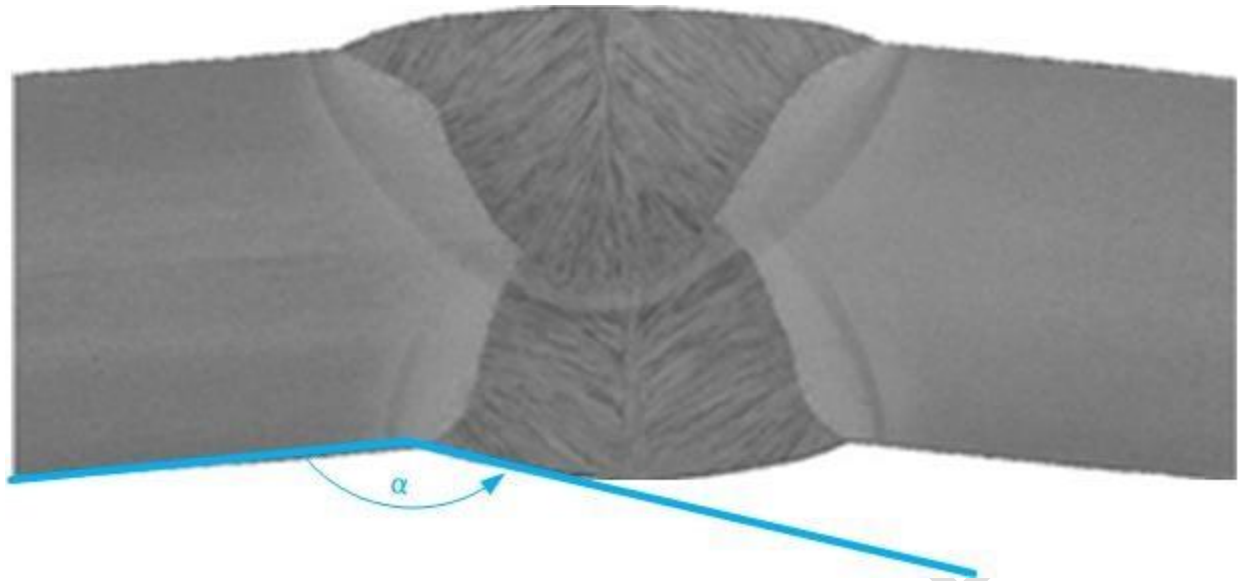


Figure 4.f—

Add new section

9.13.6 Welding related imperfections, visual examination

Arc burns, cracks, start/stop craters, poor restart and surface porosity shall not be permitted.

9.15 Weldability of PSL 2 pipe

Add to section

If specified, weldability tests shall be performed in accordance with Appendix 2.

If specified, simulated post weld heat treatment (PWHT) shall be conducted during MPQT.

Add new section

9.16 Fracture Toughness

CTOD value at the minimum design temperature shall be specified in the LPMDS.

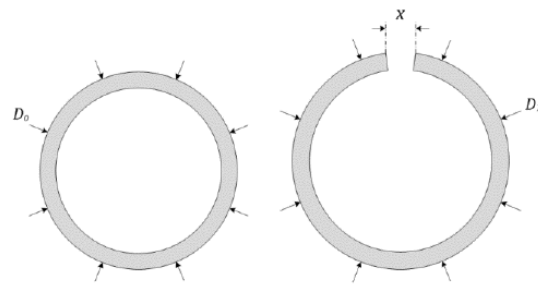
Add new section

9.17 Spring-back Ring Test

If specified, pipe shall be subject to spring-back testing.

The residual stress, as defined in Figure 10, shall not exceed ± 25 % of the specified minimum yield strength of the pipe unless otherwise specified.

Add new figure



$$\sigma = \frac{Et}{1 - \mu^2} \left(\frac{1}{D_o} - \frac{1}{D_1} \right)$$

Measured using diameter differences

[SOURCE: ASTM E1928]

$$\sigma = \frac{Et}{1 - \mu^2} \left(\frac{1}{D_o} - \frac{1}{\left[\frac{x}{\pi} + D_o \right]} \right)$$

Measured using the opening x

Where

σ is the residual stress;

μ is Poisson's ratio;

E is modulus of elasticity;

D_o is average outside diameter before splitting; and

D_1 is average outside diameter after splitting.

Figure 10—Spring-back Ring Test

Add new section

9.18 Hardness Survey

Finished pipes shall have a hardness level (HV10) not exceeding the values specified in Table 30 in IOGP S-616.

Add new table

Table 30 — Acceptance Criteria for Hardness Survey

Steel Grade	Base Metal	Weld & HAZ	Cap area
≤ L450 or X65	250	250	275
> L450 or X65	270	300	300

Add new section

9.19 Macrographic and Metallographic Examination

The macro and metallographic examination shall be documented by macro and micrographs at sufficient magnification and resolution to demonstrate that the base metal and the weld metal quality meets the requirements of this specification.

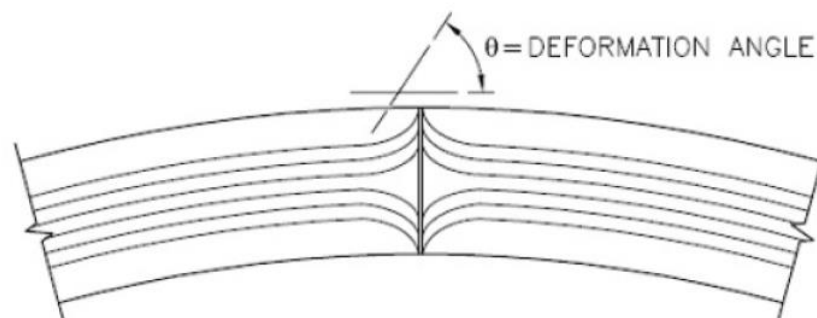
The macro section on an SAW/COW seam shall show the weld merging smoothly into the base material without weld defects, in accordance with ISO 5817 level C.

Weld and HAZ shall be free of martensite phase.

Additional requirements specific to HFW pipes shall be as follows:

- a) Metallographic examination of the HFW seam to demonstrate that no detrimental oxides, inclusions and martensite from the welding process are present.
- b) The recording of the following information by the manufacturer:
 - Width of heat-treated zone (unless full body heat treatment carried out);
 - Grain size (refer to ASTM E112) and microstructure of heat-treated weld area;
 - Deformation angle (i.e. the angle by which the material adjacent to the weld is displaced from the horizontal) or other means of assessment of deformation or squeeze pressure during welding.
- c) The acceptance criteria based on the results of manufacturing qualification tests or historical data of equivalent dimensions and grades:
 - These acceptance criteria applied in production to demonstrate that the entire weld heat affected zone has been heat treated over the full wall thickness and is free of defects;
 - The acceptance criteria to include assessment of the grain size, and general microstructure;
 - Metallographic examination to include an assessment of the level of deformation achieved during the welding operation, e.g. deformation angle (see Figure 11).

Add new figure



NOTE 1 Various techniques can be used for revealing and measuring metal flow distortion.

NOTE 2 Some methods that have proven successful individually or in combination include:

- saturated picric acid etchant in distilled water;
- specimens taken from a small pipe sample in which the seam has not been heat-treated;
- use of an optical comparator or profile projector.

Figure 11—Deformation Angle

10 Inspection

10.1 Types of Inspection and Inspection Documents

10.1.3 Inspection Documents for PSL 2 Pipe

10.1.3.1

Add to section

Final inspection reports shall be supplied in searchable electronic format e.g. PDF.

If specified, testing in which data curves are developed (e.g. tensile tests, compressive stress strain, CTOD) shall be supplied in native data formats that can be imported into a spreadsheet file. These data shall be provided at a frequency specified.

10.1.3.2

Add to 10.1.3.2

The reports shall include results of the following inspection and test performed on plate or coil:

- m) heat and product analysis;
- n) mechanical tests;
- o) through thickness metallographic examination;
- p) visual inspection;
- q) thickness measurements;
- r) ultrasonic inspection;
- s) Identity of heat and slab from which each plate or coil was produced.

Add new section

10.1.3.3

Inspection documents for plate/coils: except for integrated mills, the manufacturer shall issue a 3.1 inspection certificate in accordance with ISO 10474 or EN 10204.

10.2 Specific Inspection

10.2.1 Inspection Frequency

Replace section with

The inspection frequency shall be as given in Table 18.

10.2.1.2

Replace section with

All values shall be recorded and reported.

Macrographic, metallographic, and mechanical test results shall be available for review within three days after the test unit has been processed.

NOTE The intent is for the results to be available for review within the mill and not for a full final report to be provided.

Replace Table 18 with

Table 18—Inspection Frequency for PSL 2

Item No	Type of Inspection	Type of Pipe	Frequency of Inspection
1	Heat analysis	All pipes	One analysis per heat of steel
2	Product analysis	All pipes	Two analyses per heat of steel (taken from separate product items)
3	Tensile testing of the pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio ^{a c}
3a	If specified in the LPMDS, tensile testing of the pipe body in the longitudinal direction (if not already performed as per API Specification 5L, Table 20)	All pipes	Test shall be performed as part of MPQT. If required in the LPMDS, production test frequency shall be the same as transverse tensile test (item 3).
4	If specified in the LPMDS, tensile testing at elevated temperature	All pipes	Test shall be performed as part of MPQT. If required in the LPMDS, production test frequency shall be the same as transverse tensile test (item 3).
5	Tensile testing of the seam weld of welded pipe	HFW, SAW, COW	Once per test unit of pipes with the same cold-expansion ratio ^{a b c}
6	Macrographic and metallographic testing on of pipe body	All pipes	If specified in the LPMDS, MPQT
6a	Macrographic and metallographic testing of the of the seam weld of welded pipe	SAW, COW	Once per test unit of pipe with the same cold-expansion ratio ^{a b c}
6b	Macrographic and metallographic testing of the seam weld of welded pipe	HFW	Once per test unit of pipe with the same cold-expansion ratio ^{a b c} and at least once per shift.
6c	If specified in the LPMDS, macro hardness testing of the seam weld of welded pipe	HFW, SAW and COW	Once per test unit of pipe with the same cold-expansion ratio ^{a b c}
6d	If specified in the LPMDS, macro hardness testing of the pipe body	All pipes	Once per test unit of pipe with the same cold-expansion ratio ^{a c}
7	CVN impact testing of the pipe body of pipe with specified outside diameter and specified wall thickness as given in API Specification 5L, Table 22	All pipes	Once per test unit of pipes with the same cold-expansion ratio ^{a c}
7a	Longitudinal CVN impact testing of the pipe body	All pipes	MPQT pipes
8	CVN impact testing of the seam weld of welded pipe with specified outside diameter and specified wall thickness as given in API Specification 5L, Table 22	SAW, COW	Once per test unit of pipe with the same cold-expansion ratio ^{a b c}

Table 18 (continued)

Item No	Type of Inspection	Type of Pipe	Frequency of Inspection
8a	CVN impact testing of the seam weld of welded pipe with specified outside diameter and specified wall thickness as given in API Specification 5L, Table 22	HFW	Once per test unit of pipe with the same cold-expansion ratio ^{a b c} and at least once per shift.
9	If specified in the LPMDS, Spring-back test	SAW, COW, HFW	MPQT pipe
10	If specified in the LPMDS, DWT testing	All pipes	Once per test unit of pipes with the same cold-expansion ratio ^{a c}
11	Guided-bend testing of the seam weld of welded pipe	SAW, COW	Once per test unit of not more than 50 lengths of pipes with the same cold-expansion ratio ^{a b}
12	If specified in the LPMDS, CTOD of weld metal, HAZ and base material	All pipes	MPQT pipes
13	Flattening test of welded pipe	HFW	As per API Specification 5L, Figure 6
14	Hardness testing of hard spots in cold-formed welded pipe	HFW, SAW, COW	Any hard spot exceeding 50 mm (2.0 in.) in any direction
15	Hydrostatic testing	All pipes	Each pipe
16	Visual inspection	All pipes	Each pipe
17	Pipe diameter and out-of-roundness	All pipes	Unless otherwise specified in the LPMDS, at least once per 4 h per operating shift plus whenever any change of pipe size occurs during the operating shift.
18	Wall thickness measurement	All pipes	Each pipe (see API Specification 5L, 10.2.8.5)
19	Other dimensional testing	All pipes	At least once per 4 h per operating shift plus whenever any change of pipe size occurs during the operating shift
20	Weighing of pipe	All pipes	Each pipe
21	Length	All pipes	Each length of pipe
22	Non-destructive inspection	All pipes	In accordance with Annex E or Annex K as specified in the LPMDS
23	If specified in the LPMDS, etching of the longitudinal seam weld of welded pipe	SAWL, COWL	Each pipe shall be monitored and 5 pipes per shift shall be recorded (qualitatively)

The cold-expansion ratio (if applicable) is designated by the manufacturer, and is derived using the designated before-expansion outside diameter or circumference and the after-expansion outside diameter or circumference. An increase or decrease in the cold-expansion ratio of more than 0.002 requires the creation of a new test unit.

For mills with multiple welding lines, each welding machine used for pipe production shall be tested at least once per week.

Unless otherwise specified in the LPMDS, test unit is defined as a pipe lot coming from same size, same heat number, and consist of:

Max. 400 pipes for $D \leq 141.3 \text{ mm (5.563 in.)}$

Max. 200 pipes for $141.3 \text{ mm (5.563 in.)} < D < 323.9 \text{ mm (12.750 in.)}$

Max. 100 pipes for $D \geq 323.9 \text{ mm (12.750 in.)}$.

Max. 50 pipes for design temperature below $-10 \text{ }^{\circ}\text{C (14 }^{\circ}\text{F)}$: for all diameter.

10.2.3 Sample and Test Pieces for Mechanical Tests

10.2.3.1 General

Add to section

All mechanical test specimens shall be taken from pipe in the final condition, i.e. after heat treatment and cold expansion. A specimen may be sampled before cold end sizing.

Each specimen shall be prepared in a manner that does not intentionally enhance their mechanical properties.

10.2.3.2 Test Pieces for Tensile Test

Add to section

Transverse yield strength shall be determined using transverse flattened rectangular specimens or round bar specimens.

The same method shall be used for all pipe of a given wall thickness and grade.

Limitation on pipe diameter / wall thickness combination shall be in accordance with API Specification 5L and apply to annexes and appendices herein.

10.2.3.3 Test Pieces for the CVN Impact Test

Add new section

10.2.3.3.1 Welded Pipes

For SAW and COW pipe, an additional fusion line test shall be performed as follows:

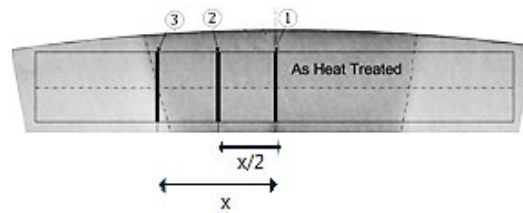
- a) The axis of the notch shall be taken at the fusion line (FL) that consists of 50 % weld metal and 50 % HAZ.
- b) The specimen shall be taken within 2 mm (0.08 in.) of the outer surface of the pipe.

If specified, an additional HAZ specimen shall be performed with notch at +2 mm from the FL.

For SAW and COW pipe with wall thickness equal to or greater than 25 mm (1 in.), additional testing [weld metal, fusion line as specified above and if specified FL+2 mm] shall be done as close as practicable to the ID surface of the pipe, i.e. within 2 mm (0.08 in.) of the inner surface of the pipe.

For HFW during MPQT Charpy testing shall be sampled in positions 1, 2 and 3 as shown in Figure 12 of IOGP S-616.

In production, only positions 1 and 2 shall be sampled.

**Key**

- ① On the weld line (± 0.25 mm (0.01 in.))
- ② On the midway of heat treated area
- ③ On the transition between base metal and heat-treated area after seam weld heat treatment

Figure 12—CVN Testing of HFW Weld SeamAdd new section**10.2.3.3.2 Seamless Pipes**

For test pieces taken from seamless pipes, the specimen's axis shall be aligned with the mid-thickness of the pipe.

For seamless line pipe with wall thickness greater than 20 mm (0.79 in.), Charpy impact testing shall be done on specimens taken from the ID and OD.

For seamless line pipe with wall thickness greater than 35 mm (1.38 in.), Charpy impact testing shall be done on specimens taken from ID, mid-wall and OD.

Coupons/specimens shall not be flattened.

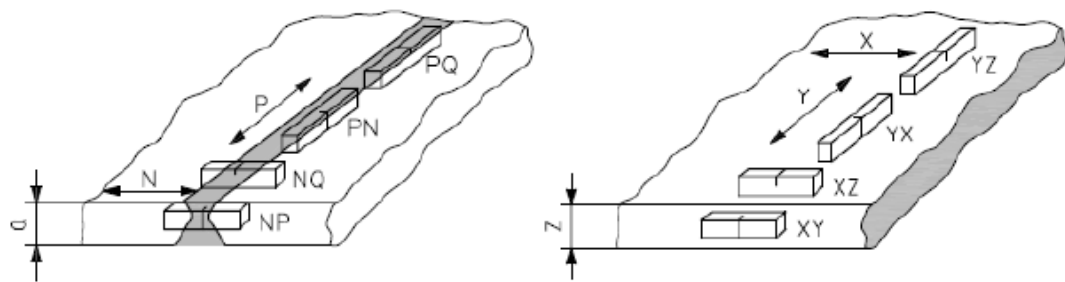
Add new section**10.2.3.8 Test Pieces for Fracture Toughness Test**

Test pieces for a CTOD test shall meet the requirements below:

- a) Test pieces to be taken from the weld metal, the HAZ and the parent metal.
- b) Test pieces to be prepared in accordance with ISO 12135 or ISO 15653.
- c) Test pieces to be Bx2B through thickness notched specimens.
- d) For weld metal testing, the notch axis to be located on the weld center line.
- e) For HAZ specimens, the notch axis to be located so as to sample the fusion line.
- f) The central 50 % portion of the specimen to be sampled in the HAZ.
- g) The outer portions of the specimen to be sampled in the weld metal.
- h) Test pieces for base metal to be taken at location 180° from the weld seam and have position YX as per Figure 13.
- i) Test pieces for weld metal and HAZ area to be taken from position NP as per Figure 13.

Three valid CTOD tests shall be required for each location.

Add new figure



Key

- X parallel to rolling direction
- Y transverse to rolling direction
- N normal to weld direction
- P parallel to weld direction
- Z weld thickness direction
- Q weld thickness direction

Figure 13—CTOD Orientation

Add new section

10.2.3.9 Test Piece for Spring-back Test

The length of the sample piece of tube should be at least three times the outside diameter and a minimum 150 mm (5.90 in.) long to avoid significant end effects.

Add new section

10.2.3.10 Test Pieces for Hardness, Macro and Metallographic Examination

Sampling for macro hardness testing shall be:

- a) For seamless pipe, two test pieces, 180° apart taken from the finished pipe.
- b) For welded pipe, test pieces (three) taken from the seam weld, and 90° and 180° from the seam weld.

The test pieces shall be prepared according to ISO 17639.

The surface to be examined shall be perpendicular to the pipe axis.

10.2.4 Test Methods

Add new section

10.2.4.9 Spring-back Test

Spring-back testing method shall be in accordance with ASTM E1928.

Add new section**10.2.4.10 Fracture Toughness Test**

CTOD testing shall be performed in accordance with ISO 12135 or ISO 15653.

10.2.5 Macrographic and Metallographic Tests**10.2.5.3**Add to section

For HFW pipe, metallographic examination of the weld seam shall be carried out at a magnification of at least X200.

Add new section**10.2.5.5**

Macro hardness testing shall be performed as per Figure J.1.

If specified in the LPMDS, hardness testing shall be performed in accordance with API Standard 2RD, Figure 1 or DNVGL-ST-F101, Figure B-10.

Macro hardness testing using the Vickers test shall be in accordance with ISO 6507-1 or ASTM E384.

For base metal (i.e. at 90° and 180°), a minimum of 12 indentations shall be made for below ID and OD surfaces, and at mid-wall thickness.

For welds, each of the hardness surveys, in each survey of ID, OD, and Midwall, shall include a minimum of three indentations at each of the following locations:

- a) in the deposited weld metal (SAW);
- b) fusion line (SAW) and bond line (HFW);
- c) HAZ's on both sides of the weld;
- d) heat treated zone for HFW on both sides of the weld;
- e) in the unaffected base material on both sides of the weld.

10.2.6 Hydrostatic Tests**10.2.6.1**Replace section with

Each length of pipe shall be hydrostatically tested for a duration of not less than 10 seconds.

The hydrostatic test shall be conducted at the end of the manufacturing process, including any repairs and heat treatments. See C.2 and E.3.1.3.

The water for testing shall be clean and free from any suspended or dissolved substance that is harmful to the line pipe material.

10.2.6.2Add to section

The test configuration shall permit bleeding of trapped air prior to pressurization of the pipe.

The equipment shall measure a pressure variation of a minimum of 2 % of the applied pressure.

Mill hydrostatic test pressure records shall show clearly the pipe number, date of test, applied test pressure and test duration for each pipe.

Paper or electronic copies of pressure records shall be available for conformance check at the mill.

The pressure shall not lead to stress in excess of the specified minimum yield strength.

Add new section**10.2.6.8**

Other test pressures may apply if specified.

10.2.7 Visual Inspection**10.2.7.1**Replace section with

The pipe seam weld shall be visually inspected according to ISO 17637, with an illuminance of at least 350 lx.

The inspection shall be over the entire external surface and as much of the internal surface as is accessible.

For pipe with $D \geq 609.6$ mm (24 in.), the entire internal surface shall be visually inspected.

When the seam tracking system associated is unable to follow the pipe rotation, the weld penetration shall be visually checked at both pipe ends on every pipe, by chemical etching on the machined weld sections.

10.2.8 Dimensional Testing**10.2.8.2**Add to section

Out-of-roundness of pipe ends shall be measured using a bar gauge, a caliper or a device that measures actual maximum and minimum diameters.

Add new section**10.2.8.8**

Straightness measurements shall be taken of the entire joint from end to end along the pipe measuring the greatest deviation.

Incremental methods shall not be used.

The length of the pipe shall be measured with tape or an automatic measuring device.

10.2.10 Nondestructive Inspection

Add to section

The requirements of Appendix 4 shall apply, unless specified otherwise.

10.2.11 Reprocessing

Add to section

The pipes subject to any reprocessing shall be treated as a new test unit.

For HFW pipes, reprocessing is not allowed. In case the retest fails, the entire test unit shall be rejected.

10.2.12 Retesting

Add new section

10.2.12.0 General

If specified, a retest on four pipes from the same test unit and same cold-expansion ratio shall be carried out.

Retesting allowances for failures of tests that are not specifically addressed in 10.2.12 shall be by agreement.

Add to section

10.2.12.9

If a set of CTOD test specimens fail to meet the acceptance criteria, the manufacturer shall elect to replace the test unit of material involved or conduct a set of tests from two more lengths from that test unit.

If the new tests meet the acceptance criteria, then each pipe in that test unit, with the exception of the original selected length, shall be considered to meet the requirement.

Failure of additional tests shall require testing of each length in the test unit for acceptance.

11 Marking

11.2 Pipe Markings

11.2.1

Add to section

The following shall be added to the marking requirement:

- purchaser's name;
- order number;
- pipe number;
- heat number; and
- length.

11.2.3

Add c) and d) to list

- c) The painted markings are to be readable for at least one year, for pipes exposed to outdoor weather conditions.
- d) Unique pipe numbers shall be assigned to each pipe.

11.2.5

Add to section

If specified, varnish type coating (hard drying) shall be used.

13 Retention of Records

Add to section

If specified, the manufacturing data and inspection records shall be retained for the period defined.

14 Pipe Loading

14.1 General

Add to section

Pipes shall be fitted with bevel protectors, unless specified otherwise.

Bevel protector details shall be submitted.

Pipe shall be free from contaminants, for example oil, grease, lacquer, antifreeze and chlorides, that adversely affect coating adhesion.

All pipe shall be handled, loaded and shipped in accordance with API RP 5L1, API RP 5LT and API RP 5LW, as applicable.

A procedure for handling, transport and storage detailing the proposed methods of handling, stacking during storage, method of preservation, and stacking and securing pipes for transportation and shipment shall be submitted.

Add new section

14.2 Shipping

When the manufacturer is responsible for handling or shipping:

- Review and comment of the loading instructions shall not relieve the manufacturer of responsibility for any damage during shipment.
- If in-transit fatigue cracks are detected after shipment, the purchaser shall reserve the right to reject the entire shipment until an absence of fatigue cracking is proven on the entire shipment, by an agreed-upon NDT method.
- The shipping procedures with a written method to prevent salt contamination of the pipe at the receiving facility shall be submitted.

- For transoceanic shipping, the ship's log shall be made available for review when the pipe is unloaded.
- The timing to submit loading instructions and diagrams for all pipe shipped shall be agreed during the PPM.
- All dimensional tolerances and pipe surface conditions specified shall apply to the pipe condition as received at the shipping destination.
- The manufacturer shall be responsible for any permanent deformations subsequent to mill acceptance and resulting from loading, storing, stacking, transportation or shipping, provided that these operations are within the scope.

Add new section

14.3 Handling

Unless hookable end caps are fitted, hooks shall not be used for handling of pipe.

Handling devices that contain copper or copper alloys shall not be used.

Add new section

14.4 Storage

No overstockage or deck loads shall be permitted.

The storage of pipe shall be elevated off the ground, sloped and not in contact with the other pipe.

Pipe shall not be nested one diameter inside another.

Handling, loading and unloading shall avoid magnetization, mechanical damage and prevent stresses that result in dents or out-of-roundness.

Annex B **(normative)** **Manufacturing Procedure Qualification for PSL 2 Pipe**

B.1 Introduction

B.1.3

Replace section with

Verification of the manufacturing procedure shall be by qualification in accordance with B.3, B.4 and B.5.

The MPQT shall be completed prior to the start of production.

If accepted, the MPQT requirement may be performed as first day production testing.

Other means of verification of the manufacturing procedure may be proposed for agreement.

B.2 Additional Information to be Supplied by the Purchaser

Replace section with

A comprehensive manufacturing procedure specification shall be submitted (as per B.3), an inspection and test plan (as per B.4), for acceptance prior to the start of production.

A manufacturing procedure qualification test in accordance with B.5 shall be carried out.

B.3 Characteristics of the Manufacturing Procedure Specification

Replace first paragraph with

The MPS shall be prepared for each mill to cover each type of pipe, delivery condition, nominal pipe diameter, grade and specified wall thickness.

The required information shall be included within the MPS or as a standalone document.

Before production commences, the summary information or identification of the control documents shall be supplied as it's applicable for both internally and externally sourced processes products and services, on the main characteristics of the manufacturing procedure.

This would include a plan and process flow description/diagram and at least the information required by Annex B and as follows:

Replace item a) 2) with

a) 2) equipment and process description including steelmaking method, heat size, deoxidation practice, control of slag physicochemical properties and slag removal, secondary/ladle refining, degassing and stirring practice, inclusion shape control practice and casting method;

Replace item a) 3) with

a) 3) the chemical composition maximum and minimum range and specific target, or aim value for all elements intentionally added and those elements listed in Table 5 and any Annexes specified;

Replace item a) 5) with

- a) 5) hydrogen control practice;

Add to item a) 6) with

Details of the casting sequences shall be recorded (e.g. casting strand, number of heats, tons, scrapping lengths) and available for review;

Replace item a) 8) with

a) 8) steelmaking and casting methods used to mitigate segregation and inclusions during the continuous casting process. The documentation shall include a description of the processes, quality control steps and tests to assure adequate quality of the final pipe. Control of steel cleanliness and centerline segregation, including the acceptance criteria;

Add new item a) 9)

- a) 9) control of steel scrap;

Add new item a) 10)

- a) 10) billets and slabs visual inspection and associated acceptance criteria.

Replace item b) 3) with

- b) 3) hydrostatic testing practices including calibration of equipment and records of the test;

Replace item b) 4) with

- b) 4). non-destructive inspection methods and practices including calibration practice and records of the test in accordance with Appendix 4;

Add to item b) 5)

- b) 5) the product analysis method and fully detailed corrosion test procedures (e.g. SSC, HIC) with drawings of test specimens, size location and orientation.

Replace item b) 8) with

- b) 8) pipe marking process and details (including freehand marking limitation, lettering height, distance from pipe ends, painted colored band);

Add to item b) 9)

- b) 9) identification and control of individual pipes throughout the heat treatment cycle

Replace item b) 11) with

- b) 11) pipe storage, handling (including pipe end protection), loading and shipping practices;

Add new item b) 12)

- b) 12) method for cold expansion/reduction/sizing/finishing, target and maximum sizing ratio

Add new item b) 13)

b) 13) control of intermediate heat treatment process if any (e.g. quenching or normalizing);

Add new item b) 14)

b) 14) control of final heat treatment process;

Add new item b) 15)

b) 15) heat treatment procedure including a sketch of the heat treatment facilities layout, showing furnaces and quenching bath relative to each other;

Add new item b) 16)

b) 16) calibration frequency of the thermocouples;

Add new item b) 17)

b) 17) loading temperature, heating and cooling rate, soaking temperature set-up and soaking time with associated tolerances and maximum transfer time;

Add new item b) 18)

b) 18) for continuous and semi-continuous furnaces: travel speed, minimum/maximum soaking time as a function of size, for example thickness, diameter, cross section, length.

Add new item b) 19)

b) 19) arrangement of pipes inside the furnaces including minimum distance between pipes, number of pipe layers in the furnace and location of the weld seam.

Replace item c) 2) with

c) 2) equipment and process description including slab reheating practices, minimum temperature, soaking time at slab reheating stage, rolling schedule and cooling practices;

Add to c) 7)

c) 7) qualified minimum crop lengths;

Add to Item e) 1)

e) 1) i) When slitting is performed, the details of slitting, including precautions taken to address adverse effects of segregations (e.g. additional metallographic investigation, macros, hardness including frequency);

Add new item e) 3) ii) c)

c) weld cap profile dimensions;

Replace item e) 3) i) b) with

e) 3) i) b) description and controls of welding and heat treating processes;

Add new item e) 3) ii) c)

e) 3) ii) c) The tack welding process and the maximum thickness of the tack weld to be specified within the welding procedure specification (WPS);

Add new item e) 5)

e) 5) preliminary welding procedure specification (pWPS) or previously qualified WPS (if available) including all essential variables from Table B.5 and Table B.6;

Add new item e) 6)

e) 6) welding equipment, including weld tracking system;

Add new item e) 7)

e) 7) The minimum tab length reported in the MPS and qualified during MPQT;

Add new item f) 3)

f) 3) equipment and process description including billet reheating practices, minimum temperature and soaking time at billet reheating stage, tube manufacturing stage and finishing stage;

Add new item f) 4)

f) 4) control of process parameters for reheating, tube manufacturing and finishing stage;

Add new item f) 5)

f) 5) end cropping practices.

Replace section heading with

B.4 Characteristics of the Inspection and Test Plan (ITP)

Add to section

j) each inspection activity and reference to the procedure for that activity.

Replace section heading with

B.5 Manufacturing Procedure Qualification Tests (MPQT)

Add new section

B.5.0

The MPS shall be validated through MPQT as described herein.

In the event of failed test in the MPQT, the MPS shall be reviewed and modified accordingly, and a complete re-qualification performed.

In the event of a failed test, retesting shall be permitted, if agreed.

In the event of SAW failed fusion line CVN tests (with reference to local brittle zone), retesting of a further two sets removed from the failed MPQT pipe (at the same position relative to wall thickness) shall be permitted.

In cases where the qualification test results do not comply with the requirements, the pipe tested and preceding pipes shall be rejected.

B.5.1

Add to section

Applicable annexes, appendices and the additional destructive tests specified in B.5.2 shall be carried out.

Replace section with

B.5.2

The MPQT pipes shall be single pipes from two different heats from the first pipes produced in each size, grade and steel source from the first shift production.

MPQT pipes shall be subject to the applicable inspections and tests.

If production consists of a single heat, the MPQT shall be carried out on a single pipe from that heat.

The MPQT pipes shall be selected by the inspector.

Add new section

B.5.2.1 Macrographic, Micrographic and Segregation Analysis on Slabs

For HFW, the first, middle and last slab from the first heat shall be subject to macrographic, micrographic and segregation analysis.

The analysis procedures shall be submitted.

- a) Macrographic methods shall be by macroetch (hot acid etch test) and magnetic particle testing.
- b) Micrographic methods shall be by optical microscope on the polished sample.
- c) Segregation analysis shall be carried out by cross-section chemical analysis at the surface of the slab, $\frac{1}{4}$ slab thickness and $\frac{1}{2}$ slab thicknesses (see Figure B.1).
- d) The chemical composition shall be within the tolerance of target chemical composition.

Add new figure

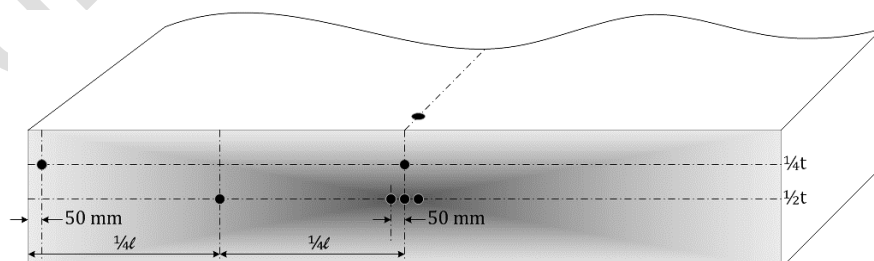


Figure B.1—Slab Macrographic, Micrographic Analysis Sampling

Add new section**B.5.2.2 Charpy Impact Tests**

If specified, a ductile brittle transition temperature (DBTT) curve, (in terms of energy, shear area and lateral expansion) shall be developed from a Charpy impact test, with test temperature 10 °C (18 °F) and 20 °C (36 °F) above routine test temperature, and 10 °C (18 °F), 20 °C (36 °F) and 30 °C (54 °F) below routine test temperature at the following location:

- a) seamless: DBTT shall be performed within the pipe body.
- b) HFW: DBTT shall be performed within the parent material and along the weld centerline within 0.25 mm (0.01 in.) from the fusion line).
- c) SAW and COW: DBTT shall be performed within the parent material at 90° from the weld seam, along the weld centerline and on the fusion line.

The temperature range for testing shall cover fully a transition curve showing the transition area.

Tests at temperatures below the routine test temperature will be for information only.

If specified, the transition curve shall be generated for finished and aged condition pipe.

Ageing shall be done by heating the specimen to a temperature of 250 °C (492 °F) with one-hour soaking time.

DBTT in terms of shear area shall not be required in the SAW weld metal location, but is required for HAZ, in accordance with 9.8.3.

Add new section**B.5.2.3 Tensile Tests**

Parent material and weld metal tensile tests shall record the full stress-strain curve up to maximum load at ambient temperature.

If specified, data shall be supplied in native data formats for importing into a spreadsheet file.

Two round bar all-weld tensile tests (one from inside and one from outside the weld bead) shall be performed.

For all weld tests, the minimum yield strength, minimum tensile strength and elongation shall meet the requirements of the pipe base material.

Reduction of area, Rt0.5/Rm ratio and uniform elongation shall be reported for information only.

If specified, elevated temperature tensile tests shall be made in the longitudinal direction for all pipe sizes and the transverse direction for pipes with an outside diameter greater than 219.1 mm (8.63 in.). See Table 20.

Acceptance criteria shall be as specified.

Add new section**B.5.2.4 Macrographic, Metallographic and Hardness Tests on Pipes**

Micrography and hardness tests shall be performed at both ends of the MPQT pipes at 0° (weld seam for welded pipe), and if specified, additional tests at 90° and 180°.

Test specimens shall be through-thickness, polished and etched to show the metallurgical microstructure.

Photographs of the microstructure shall be supplied at three locations minimum, i.e. at below the ID and OD surfaces, and at mid-thickness.

The inclusion rating shall not be higher than severity 2 in accordance with ASTM E45 (Method D).

If not evaluated on the slab (see B.5.2.1), the carbon/carbide segregation level shall be assessed and qualified.

Add new section

B.5.2.5 Guided Bend Test

For HFW, an additional root guided bend test shall be performed in order to test both pipe ends.

Add new section

B.5.2.6 Ageing Tests

When cold forming during manufacturing exceeds 5 % total accumulated strain after heat treatment, Charpy, tensile and hardness testing shall be performed on pipe specimens in the aged condition.

The total strain from cold forming shall take into account all operations on the steel, including but not limited to, levelling of plate, pipe forming and expansion.

The tests shall be performed on the actual pipe without straightening or additional deformation.

NOTE In most cases cold forming strain is less than 5 %. In exceptional cases where the D/t ratio is below 20, the requirement above applies only where no heat treatment is performed after final forming.

Add new section

B.5.2.7 Non-destructive Testing

In addition to standard production requirements:

- a) The weld seams of all SAW and COW pipes shall be radiographically examined throughout their full length.
- b) The weld seam shall be subjected to liquid penetrant or magnetic particle testing to check for surface defects in the weld, externally and internally along the accessible length. Inspection shall be 48 hours minimum after welding. For pipe with $D \geq 609.6$ mm (24 in.), the entire internal weld shall be MT inspected. Refer to E.6.4 for acceptance criteria.

Add new section

B.5.2.8 Surface Condition Test – Seamless Pipe

If required, a surface condition test shall be carried out according to the following:

- a) Blast clean and examine three seamless pipes during the manufacturing procedure qualification.
- b) Select the pipes at random and heat to a minimum of 70 °C (160 °F).
- c) Blast cleaned the outside surface of the pipe to a surface finish of SA2 ½ and then re-heat the pipe to 250 °C (482 °F).

- d) Examine each pipe visually over its entire surface for imperfections that could interfere with the FBE coating process which uses a grit blasting system can achieve a blast profile of 50 μm – 100 μm (0.002 in. – 0.004 in.).

B.5.2.9

Add new section

If specified, the effects of heating from coating application shall be tested in accordance with N.3.1.2.

B.5.3

Add to section

Essential variables that require new qualification shall be in accordance with Tables B.1 and B.2.

Replace B.5.4 with

B.5.4

Weldability test requirements shall be in accordance with 9.15.

If agreed, weldability tests may be undertaken separately to the MPQT.

Replace section with

B.5.6

Any change to the essential variables listed in B.5.7 shall require a new MPQT.

Add new section

B.5.7

Add new section

B.5.7.1 Welding Essential Variables

If requested, a preliminary welding procedure shall be submitted.

Qualification of the welding procedure specification shall be done in advance of each production, or from previously qualified procedures if agreed.

The WPS and supporting procedure qualification record (PQR) shall be submitted for acceptance.

During production, changes of any essential variable outside the ranges specified in the WPS, shall require requalification of the WPS.

Details shall be provided of how the welding essential variables are monitored and recorded.

For HFW, the mill shall operate a welding system where the control parameters are used to adjust the welding process automatically.

The system shall monitor, the voltage, current, frequency, power, travel speed, weld fusion point temperature and squeeze roll pressure or load.

These parameters shall be recorded at least every 10 milliseconds.

Welding records shall be available for review.

Information required in ASME IX WPS format shall be listed.

Public Review Draft

Add new table

Table B.1—Welding Essential Variable for SAW and COW Pipes

Essential variables	Changes that require new qualification	
	GMAW	SAW
1) Base metal	A change in API Specification 5L steel grade.	
	An increase in CEPCM greater than 0.02 as an essential variable.	
	An increase in CEIHW greater than 0.03 as an essential variable.	
	A change in pipe delivery condition.	
	A change in specified wall thickness by more than -10 % / +5 %.	
2) Bevel shape, angle	A change in bevel shape / groove type.	
	A change in root face by more than -1.5 mm / +1.5 mm (± 0.06 in.).	
	A change in root gap by more than -1.0 mm / +1.0 mm (± 0.04 in.).	
	A change in angle by more than -5° / +5°.	
3) Filler metal	A change in number of wires.	
	A change in nominal wire diameter.	
	Any change in brand name.	
	A change in wire classification.	A change from one flux wire classification to any other flux wire classification.
	A change in wire manufacturer.	A change in flux or wire manufacturer.
4) Position of welding point (for SAWH pipe)	A change in location and distance between strip-pipe meeting point to ID welding point.	A change in location and distance between strip-pipe meeting point to ID welding point.
		A change in location for OD welding.
5) Preheat /interpass temperature	Methods to be used for heating strip edges.	
	Decrease in qualified minimum preheating and/or interpass temperature.	
	Increase of qualified maximum preheating and/or interpass temperature by > 50 °C (122 °F).	
6) Equipment	Any change in make, type and model of welding equipment.	
7) Electrical characteristics	A change in welding position, type of current and polarity.	
	A change of ± 10 % in voltage, amperage, and wire feed speed for each wire.	
	A change of ± 10 % in travel speed.	
	A change of ± 7 % in welding heat input.	
	A change from constant voltage to constant current output.	A change of > 5 mm (0.2 in.) in longitudinal or lateral spacing of the arcs.
	A change in the mode of transfer.	
8) Weld pass	A change in number of weld passes.	
9) Shielding gas	A change in gas composition.	
	Decrease in gas flowrate.	
	Increase in gas flow rate by more than 10 %.	
10) Post weld heat treatment	Addition or deletion of PWHT.	
	A change in the PWHT temperature by more than ± 10 °C (50 °F).	
	A change of ± 10 % in soaking time.	

Add new table

Table B.2—Welding Essential Variables for HFW Pipes

Essential variables	Changes that require new qualification
1) Base metal	A change in API Specification 5L steel grade.
	An increase in CEPCM greater than 0.02 as an essential variable.
	An increase in CEIIW greater than 0.03 as an essential variable.
	A change in pipe delivery condition.
	A change in nominal wall thickness.
	A change in nominal pipe diameter.
	A change in the source of coil.
2) Transfer of welding current and the use of impeder	A change in welding current transfer mechanism (either by induction coils or contact tips).
	A change in dimension of induction coils/contact tip, material, coolant type and the contact tip force.
	A change in the use, dimension, material and location of impeder.
3) Equipment	Any change in make, type and model of welding equipment.
	Methods to be used for heating strip edges.
	Method to control and monitor power input in relation to the temperature of the pipe surface and the speed of the pipe.
4) Induction coil configuration (HFW only)	Any change.
5) Impeder configuration (HFW only)	Any change.
6) Electrical characteristics	A change of $\pm 5\%$ in qualified frequency (frequency shall be $\geq 150\text{KHz}$).
	A change of $\pm 5\%$ in welding heat coefficient, $Q = (\text{amps} \times \text{volts}) / (\text{travel speed} \times \text{thickness})$.
7) Roll pressure on welding/squeezing point, squeeze out and metal flow angle	A change in roll pressure location.
	A change of $> 5\%$ in roll pressure.
	Decrease in minimum qualified squeeze out [squeeze out shall be $> 4\text{ mm}$ (0.16 in.)].
	The metal flow angle shall be within the range $45^\circ - 60^\circ$.
8) Shielding gas and coverage area	A change in gas composition.
	Decrease in gas flowrate.
	Decrease in coverage area (as minimum beveled areas after induction coils/contact tip shall be protected).
9) Weld seam heat treatment and cooling system	A change of $> 5\%$ in qualified frequency.
	Decrease in soaking time.
	Decrease in qualified exit temperature by $> 10^\circ\text{C}$ (50°F).
	A change in cooling system.

Annex C (normative)

Treatment of Surface Imperfections and Defects

C.2 Treatment of Dressable Surface Defects

C.2.2

Add to section

The grinding processes shall be in accordance with those listed in Table C.1.

Add new table

Table C.1—Acceptable Grinding Processes

Manufacturing Stage	SMLS Pipe	Welded Pipe ^b
Before hydrostatic pressure	Grinding wheel or flap wheel	-
After hydrostatic pressure	Only flap wheels (cosmetic grinding ^a)	-
Before expansion	-	Grinding wheel or flap wheel
After expansion	-	Only flap wheels (cosmetic grinding)
^a Cosmetic grinding i.e. grain size disk # 100 or flap wheels. Wall thickness check is not required after cosmetic grinding. ^b Repairs to HFW weld line: external light grinding is permitted. Internal light grinding shall be limited to removing weld flash only. Wall thickness shall be checked after light grinding.		

C.2.3

Replace section with

After grinding, complete removal of defects shall be verified by wet or dry MT as per ASTM E709 or ISO 10893-5, and by the NDT method which detected the defect i.e. automatic UT (AUT) or electromagnetic inspection (EMI).

Following ID grinding, MT or liquid penetrant shall be used to verify complete removal of defects.

If MT or liquid penetrant cannot be performed on the ID, manual or automatic UT (and EMI as applicable) shall be used.

Any UT procedure for verification of removal of defects by ID grinding shall be submitted for review and acceptance.

Wall thickness measurements shall be made by UT in the ground areas and the results recorded.

The wall thickness in the ground area shall be in accordance with 9.11.3.2.

The minus tolerances for diameter and out-of-roundness (see 9.11.3.1) shall not apply in the ground area.

C.4 Repair of Defects by Welding

C.4.1

Add to section

Repair of a weld area previously repaired shall be performed in accordance with a dedicated welding procedure qualification and WPS.

Multiple repairs shall not exceed more than two consecutive repairs.

Unless defined in an agreed specific procedure or method statement, repairs of flux and wire stops in a restart area shall be by preapproved repair procedure.

Weld seams containing cracks shall not be weld repaired.

The section of pipe containing cracks shall be cut off.

Acceptability of the remaining pipe shall subsequently be based on length requirements.

When required, repairs inside the pipe shall only be performed when safe access procedures are in place.

Inside repairs shall be followed by visual inspection.

Inside arc stop/restart repairs for SAW shall be allowed if access for dressing, repair and visual inspection can be safely performed.

C.4.2

Add to section

Repairs shall be carried out before cold expansion (when required) and hydrostatic testing.

Complete removal of the defect shall be confirmed by magnetic particle inspection before the weld repair.

When arc-air gouging is used for defect removal, grinding shall be carried out for the removal of the decarburized zone.

C.4.3

Add to section after first sentence

Weld repairs shall be limited to a maximum of four per pipe with a maximum length of 350 mm (13.8 in.) each.

C.4.4

Replace section with

Repairs shall be separated by at least 200 mm (7.9 in.).

The repair shall be carried out with a minimum of two layers/passes over a length of at least 50 mm (2.0 in.).

No welding repair is permitted over a length of 254 mm (10.0 in.) from each pipe end.

C.4.5

Add to section

The properties of the weld repair shall meet the specification requirements of the longitudinal seam weld.

C.4.6

Replace section with

The external surface of the repair weld shall be subject to grinding to obtain a uniform appearance and to merge smoothly into the base material.

Each repaired area shall be 100 % examined by ultrasonic and MT testing and, if specified, by radiographic testing.

Annex D (normative) Repair Welding Procedure

D.1 General

D.1.2

Delete item b)

D.1.4

Replace section with

Test welds shall be made on pipe.

D.2 Repair Welding Procedure Qualification

D.2.1 General

D.2.1.1

Add to section

WPS for repair welding shall be qualified as follows:

- a) one partial repair (minimum of $\frac{1}{2}t$ repair), simulating a defect located on the fusion line;
- b) one shallow repair with two weld passes minimum, simulating a defect located at the weld toe;
- c) multiple repairs.

Through thickness repairs shall not be permitted.

Repair welding shall be qualified by simulating the repair situation to be qualified.

Repairs shall be preheated at 100 °C (212 °F), unless the qualification test has shown that a higher temperature is necessary.

Repairs to defects in the weld seam shall be carried out by qualified welders, using a previously qualified welding procedure.

D.2.2 Essential Variables

Add item to list

- c) 7) if agreed to have electrode under matching with respect to the strength of the base material: change in batch number of the electrode (each batch shall be individually tested).

D.2.3 Mechanical Testing

D.2.3.4 Charpy (CVN) Impact Test

Add new section

D.2.3.4.5

Sampling of CVN specimens shall be performed in accordance with Figure D.2 for a partial thickness repair.

Minor changes in the sampling location if agreed.

The test temperature and acceptance criteria shall be equal to those for unrepaired pipe weld and HAZ (see 9.8).

Add new figure

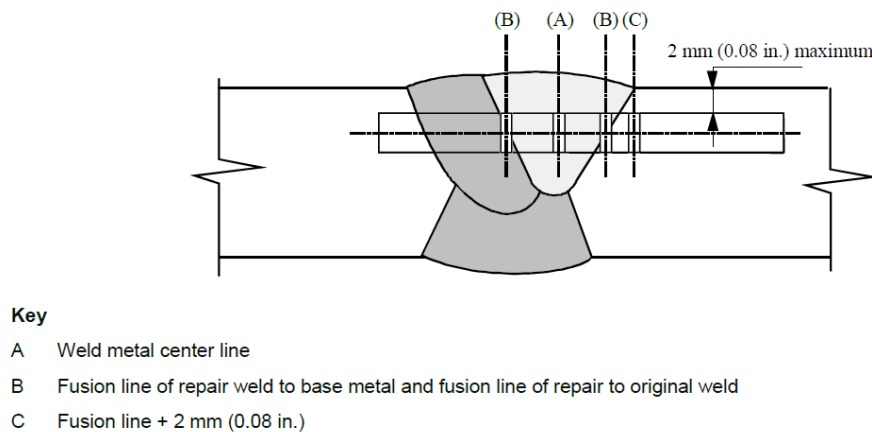


Figure D.2—Partial Repair Charpy Sampling Location

Add new section

D.2.3.5 Hardness Testing

If hardness testing (HV10) is specified for the longitudinal weld, hardness testing shall also be performed on any repairs to the longitudinal weld.

The number and position of the indentations shall be in accordance with Figure D.3.

Acceptance criteria shall be in accordance with 9.19, or applicable annexes and appendices if specified.

Add new figure

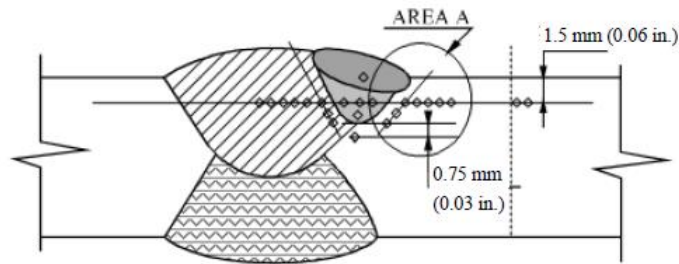


Figure D.3—Partial repair Hardness Indentation Location

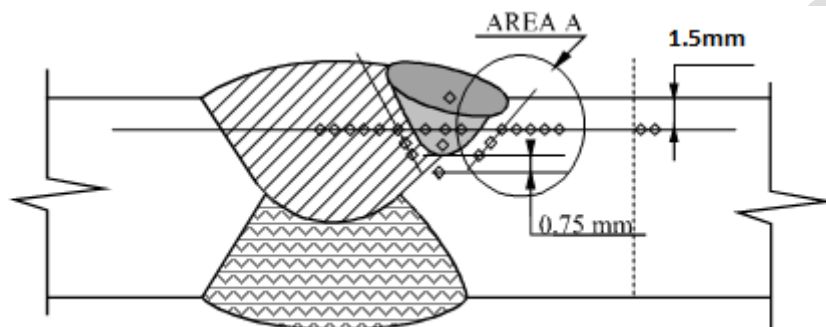


Figure D.4—Cap Repair Hardness Indentation Location

Add new section

D.2.3.6 CTOD Testing

For the qualification of a repair welds when CTOD testing has been specified, testing shall be performed using surface notched specimens (NQ) for the repair weld and the repair weld HAZ's.

Annex E **(normative)** **Nondestructive Inspection for Pipe Not Required** **to Meet Annex H, J or N**

E.1 Qualification of Personnel

E.1.1

Add to section

This requirement shall also apply to visual inspection.

NDT personnel shall be requalified for any method previously qualified if nondestructive inspection in that method has not been performed for a period exceeding six months.

If specified, a list of NDT personnel showing the scope and dates of their qualifications shall be provided.

If specified, the following shall be required:

- a) the qualifications of personnel performing NDT subject to acceptance;
- b) supplemental certification requirements for NDT personnel.

E.1.3

Replace section with

Level 3 personnel shall be responsible for all NDT activities.

The NDT UT Level 3 personnel shall be available during manufacture.

NDT specifications and procedures shall give evidence of the NDT Level 3 approval and the approval date.

If specified, the qualification number and expiry date of the NDT Level 3 individuals shall be provided.

Evaluations of indications shall be performed by a Level 2 or Level 3 personnel only.

E.3 Methods of Inspection

E.3.1 General

E.3.1.1

Replace section with

The weld seams and HAZs of welded pipes shall be inspected for longitudinal imperfections, over 100 % of the length through the full thickness and width, in accordance with Table E.1 and the following.

UT shall be performed in accordance with ISO 10893-11, as amended or supplemented by this annex.

UT shall be performed using automated equipment with conventional or phased array techniques.

UT procedures using time of flight diffraction (ToFD) and electromagnetic acoustic transducer (EMAT) equipment shall not be used unless otherwise agreed.

Unless otherwise specified, manual UT (MUT) shall not be permitted as a substitute or replacement for AUT.

If specified, full X-ray supplemented by MUT may be allowed for seam weld inspection.

Unless otherwise agreed, real-time (dynamic) radiography shall not be used.

Acceptance levels shall be in accordance with Table E.8.

Replace Table E.1 with

Table E.1—Pipe Weld Seam NDT

Weld seam type	NDT Method ^a		
	EMI ^b	UT	RT
HFW for $t < 6.4$ mm (0.25 in.)	One method or a combination of methods is required		Not applicable
HFW for $t \geq 6.4$ mm (0.25 in.)	Not applicable	Required	Not applicable
SAW and COW	Not applicable	Required	Required ^c
^a The weld seam at the pipe ends might require additional inspection (see E.3.2). ^b Acceptable EMI method shall be as specified. ^c Required as a minimum on pipe ends.			

E.3.1.2

Replace section with

Replace E.3.1.2 with

SMLS pipe shall be subject to automated NDT over 100 % of the length and circumference in accordance with Table E.2.

Replace Table E.2 with

Table E.2—SMLS Pipe Body NDT

Item	Thickness mm (in.)	NDT Method		
		EMI	UT	MT
PSL 2 pipe, any grade	≤ 6.4 mm (0.25 in.)	Either EMI or UT as specified		If specified
	≥ 6.4 mm (0.25 in.)	If specified	Required	

Replace E.3.1.3 with

E.3.1.3

NDT shall:

- a) for seamless pipe, if specified, be performed after hydrotesting.
- b) For welded pipe, NDT be completed after hydrostatic testing.
- c) For SAW pipe, NDT be done after hydrostatic testing and any sizing practice.

E.3.2 Pipe End Inspection – Welded Pipe

Add title to section

E.3.2.1 Non-inspected Ends

Replace section with

For the weld seam at the pipe ends, if an AUT or EMI inspection is applied to meet the requirements of E.3.1.1, the lengths of weld at the pipe ends that are not covered by the automated inspection, up to a maximum of 305 mm (12 in.), shall be inspected for defects using the same inspection parameters as specified in E.3.1.1, by:

- UT using an alternative AUT system or semi-automated UT (SAUT) system; or
- manual UT (MUT).

If agreed MUT shall only be used to inspect the untested ends of weld seams.

E.3.2.1.2

E.3.2.1.2.1

Scanning shall be performed in two opposing circumferential directions using shear wave probes.

E.3.2.1.2.2

The shear wave probe angle shall cover the full weld and HAZ.

Alternatively, the non-AUT-inspected pipe ends shall be cut off, with the following conditions:

- a) Non-AUT-inspected weld ends do not to exceed 305 mm (12 in.).
- b) Removal of non-AUT-inspected pipe ends does not remove the obligation to perform radiographic testing (RT) of the weld ends (see E.3.2.2).
- c) Removal of non-AUT-inspected pipe ends does not remove the obligation to perform UT of the pipe ends (see E.3.2.3 and E.3.2.4).
- d) Where more critical UT acceptance criteria applies to pipe ends than applies to the rest of the pipe, the more critical acceptance criteria shall be applicable to new pipe ends, after non-AUT-inspected pipe ends have been cut off.

Add title to section

E.3.2.2 RT of Welds at Pipe Ends

Add to section

The same area subject to RT shall also be inspected using UT (see E.3.2.1), which becomes the prime inspection method.

If a defect is detected by a NDT method, this shall be considered rejected.

The final acceptance shall be by UT.

E.3.2.2.3.1

RT shall not be used to accept defects detected by UT.

Radiography inspection shall be X-ray unless otherwise agreed.

Add new section

E.3.2.4 SAW & COW Pipe End Circumference

UT shall be carried out to verify that the 50 mm (2 in.) zone at each pipe end is free of axially aligned through thickness cracking.

Scanning shall be performed in both circumferential directions using 45° shear wave probes.

Axially aligned N5 notches on the inside and outside surfaces shall be used to set the reference and acceptance levels.

No cracks shall be allowed.

Add new section

E.3.2.5 MT of End Face

If specified, the end face (beveled or square cut) at each pipe end shall be magnetic particle inspected for the detection of laminar imperfections, in accordance with ISO 10893-5 or ASTM E709.

The end face shall be free of indications.

NOTE This inspection is generally only performed on beveled ends.

E.3.3 Pipe End Inspection – SMLS Pipe

Add title to section

E.3.3.1 Non-inspected Ends

Replace section with

The lengths of the pipe ends that are not inspected during AUT of the pipe body (see E.3.1.2), up to 305 mm (12 in.), shall be inspected for defects by an alternative AUT system or SAUT system using angle beam probes, and the same inspection parameters in accordance with E.3.1.2.

Scanning shall be performed in two opposing circumferential directions using 45° shear wave probes.

E.3.3.1.1.1

Scanning shall be performed in two opposing circumferential directions using 45° shear wave probes.

Alternatively, the non-AUT-inspected pipe ends shall be cut off, with the following conditions:

E.3.3.1.2.1

- a) Non-AUT-inspected pipe ends shall be defined and confirmed by a demonstration.
- b) Where more critical UT acceptance criteria are specified for the pipe ends than applies to the rest of the pipe body, the more critical acceptance criteria shall be applicable to the new pipe ends, after non-AUT-inspected pipe ends have been cut off.

E.4 Radiographic Inspection of Weld Seams**E.4.2 Radiographic Inspection Equipment****E.4.2.2**

Replace section with

The radiographic films used shall be:

- in accordance with ISO 11699-1, class C4
- used with lead screens.

Replace E.4.2.3 with

E.4.2.3

The density of the radiograph shall be between 2.0 and 3.0 in the weld seam and between 2.0 and 3.5 in the parent metal.

E.4.2.3.1

Film viewers (illuminator) shall be certified for the applicable density ranges.

Add new section

E.4.2.4

Where digital imaging methods (CR, DDA or DR) are used, the grey values and contrast achieved shall be controlled within limits specified in the procedures.

E.4.2.4.1

The grey values and contrast shall be sufficient to enable the required radiographic sensitivity to be achieved".

E.4.6 Defects Found by Radiographic Inspection

Add to section

Where suspect indications have been recorded by UT but have not been detected during retesting by RT, the area shall be subjected to further UT.

E.4.6.1

If the repeat UT confirms the indication as true and relevant (i.e. not due to geometrical features or coupling conditions), the UT indication shall be classed as a defect and rejected.

Add new section**E.4.8 Use of Filmless, Computed or Digital Radiography**

If agreed, the conventional RT film of the body weld seam and the weld seam at the pipe ends may be replaced by digital imaging methods, in accordance with ISO 10893-7, provided that the standard of the CR, DDA or DR is at least equal to the requirements for RT specified in this document.

The image quality during CR, DDA and DR shall comply with ISO 10893-7 Class B.

If a defect is detected by a NDT method, this shall be rejected.

The final acceptance shall be by UT.

E.4.8.4.1

RT shall not be used to accept defects detected by UT.

E.5 Ultrasonic and Electromagnetic Inspection**E.5.1 Equipment**Add title to section**E.5.1.1 Characteristics**

The AUT equipment shall record indications.

Add new section**E.5.1.1.1 General**

- a) The system is qualified in accordance with Appendix 3.
- b) Be capable of revealing the discontinuities specified and capable of revealing axial and circumferential imperfections (as applicable) in the internal surface, external surface and inner material of pipe, including laminations and segregations.
- c) If specified, be capable of detecting oblique imperfections.
- d) For automatic systems be equipped with robust (firm and stable) scanning systems.
- e) Be capable of registering or recording indications on paper or on a retrievable medium without any intervention from the ultrasonic operator.

E.5.1.1.1.5.1

All indications generating a signal above the recording level shall be recorded automatically.

Any indication above 50 % (-6 dB) of the primary reference level shall be recorded for investigation.

E.5.1.1.1.6.1

The primary reference level shall be below saturation level, and below 100 % full screen height (FSH) on systems capable of measuring amplitude up to 100 %.

Coupling shall be monitored for all probes, by use of consistent and reliable reference signals, e.g. the backwall echo, a through-transmitted signal (for probes arranged in pitch-catch) or the signal from the ultrasound entry surface.

E.5.1.1.1.7.1

The coupling monitor gate shall be set at 10 dB below the reference signal peak.

E.5.1.1.1.7.2

The reference signals and monitor gates shall be established and checked dynamically during equipment standardization.

Loss of coupling shall be recorded, and clear automatic audible alarm and acoustic warnings activated.

E.5.1.1.1.8.1

Areas identified with acoustic coupling loss during AUT inspection shall be evaluated manually, including the areas equal to one skip distance adjacent to the area identified, or may be reprocessed one time through the same automatic system used for initial inspection.

UT equipment shall satisfy the requirement for the signal/noise ratio (at least 12 dB).

Equipment shall be capable of automatic paint spray marking of defects or, if agreed, systems that record defect positioning with inspection maps may be accepted.

For systems with automatic paint spray systems, the system shall be activated every four hours to verify operation.

Add new section

E.5.1.1.2 Plate/Coil

If specified, scanning systems for AUT of plate or coil shall cover 100 % of the area, and full thickness of the material (see E.5.1.4)

If specified, indication above the recording level shall be presented in C-Scan format.

If specified, for HFW pipe, scanning of coil shall be by full body AUT.

E.5.1.1.2.1

If specified, indication above the recording level shall be presented in C-Scan format.

E.5.1.1.2.2

If specified, for HFW pipe, scanning of coil shall be by full body AUT.

Add new section

E.5.1.1.3 Pipe Weld Seam and Pipe Body

Scanning systems for AUT of the pipe weld seam or pipe body shall enable 100 % coverage in one continuous pass which is defined as a single uninterrupted pass along the full length and area under inspection. Coverage shall include the full depth and width of the seam and HAZs of welded pipe (HAZs shall be at least 3.0 mm (0.12 in.) wide) and the full thickness for pipe bodies. For AUT systems incorporating multiple scanning

carriages, this requirement shall apply to each carriage with sufficient overlap between carriages to assure 100% coverage of the full length and area under inspection.

For seamless pipes, coverage shall include the inside and outside surfaces and full thickness of the pipe.

For welded pipe, an automated weld tracking system for correct positioning of the probes with respect to the weld centerline shall be used, capable of a positional accuracy of ± 2 mm (0.08 in.) or better.

Any indication above the recording level shall be automatically marked on the pipe surface (see Table E.9).

If specified, UT equipment shall produce consistent responses within ± 25 % amplitude (or equivalent dB values as agreed) from each reference reflectors at both ends and the center of pipes or weld seams as defined in Tables E.7.1, E. 7.2, E.7.3 (as applicable) and as specified in Appendix AP3.2.2.2.3.

NOTE If the plate or coil body has been 100 % inspected at the plate or pipe mill in accordance with this specification, inspection is not required on the pipe body.

Add new section

E.5.1.1.4 Manual UT

MUT equipment shall only be used to:

- a) inspect non-AUT-inspected plate edges and plate ends;
- b) inspect non-AUT-inspected pipe ends or weld ends, if prior written acceptance has been obtained from the purchaser;
- c) verify indications recorded by AUT; and
- d) confirm the rejection or acceptance of indications.

Recording levels used during MUT shall be equivalent to those used during AUT.

E.5.1.1.4.2.1

The MUT scanning speed shall not exceed 150 mm/s (5.91 in./s).

MUT equipment shall be capable of detecting the minimum sizes of defects required by E.5.1.4.

The extent of laminar imperfection size shall be determined with the -6 dB method.

E.5.1.1.4.4.1

If the beam size is bigger than the imperfection size, the -20 dB method shall be used.

Add title to section

E.5.1.2 Weld seam coverage

Replace section with

For welded pipe, the equipment shall test the entire length of the weld seam (except for weld ends subject to separate AUT, SAUT or MUT) and the entire thickness of the weld seam for:

- a) EW and LW seams, the weld line plus at least 1.6 mm (0.063 in.) of adjacent parent metal on each side of the weld line (the HAZs);
- b) SAW and COW seams, the weld seam plus at least 1.6 mm (0.063 in.) of adjacent parent metal on each side of the seam (the HAZs).

The precision of the weld tracking device shall be included in determining the overall coverage of adjacent parent metal.

Add new section

E.5.1.3 Probes Used for AUT

Probes used for AUT shall:

- a) have the sensitivity and scanning coverage required;
- b) be provided with probe data sheets demonstrating the manufacturer, type, beam angle, dimensions, frequency distribution and focusing;
- c) for angle beam probes used for UT of weld seams be provided with data sheets that illustrate beam profile, or for phased array a simulation showing the -6dB beam profile for each virtual probe; and
- d) for 0° beam probes, be provided with data sheets that illustrate the lateral -6 dB beam profile.

Add new section

E.5.1.4 AUT Systems for Inspection of Plate/Coil and Pipe

For AUT systems used to detect laminar imperfections in plate/coil and pipe, the capability of the UT systems to record and reject the minimum sizes of defects required by the acceptance criteria, shall be demonstrated for all probe types to be used:

- a) Plate/coil: over the full body, at the plate edges and at the plate ends, 3 mm (0.12 in.) below the top surface and 3 mm (0.12 in.) above the bottom surface of the substrate.
- b) Pipe: over the full body and at the pipe ends, 3 mm (0.12 in.) below the top surface and 3 mm (0.12 in.) above the bottom surface.
- c) Weld edges: across the full area including at the pipe ends, 3 mm (0.12 in.) below the top surface and 3 mm (0.12 in.) above the bottom surface.

E.5.2 Ultrasonic and Electromagnetic Inspection Reference Standards

E.5.2.1

Add to section

The reference standards shall be from the production run, or from material of the same delivery condition, diameter and wall thickness of the production run material.

Reference standards for seamless or welded pipe shall include sufficient lengths for run-on and run-off, where applicable.

E.5.2.2

Replace section with

If specified, reference standards shall be full production length.

Replace E.5.2.3 with

E.5.2.3

Reference standards shall, as applicable, contain as a minimum, the reference reflectors stated in the following tables of this specification:

- a) HFW Seam: Table E.7.1
- b) SAW Seam: Table E.7.2
- c) SMLS pipe: Table E.7.3
- d) Plate/coil: Table E.7.4

Alternative or additional reflectors may be specified.

The surface profile of all scanning surfaces shall be within the product standard dimensional tolerances (thickness, shape, diameter and straightness) for the product being manufactured.

The test standard shall have a certification sheet, to document and certify the reference defects.

The test standard certification sheet shall include the following information:

- a) mechanical dimensions of each test notch, hole, and wall reduction (depth, length and width and/or diameter);
- b) acoustical characteristics for each reflector including drilled holes, being a maximum variation of 2 dB from all directions (e.g. left- and right-side and leading and trailing) for each reference reflector, unless otherwise agreed;
- c) photographs of test notch replicas or molds;
- d) remaining thickness, measured by manual ultrasonic testing or micrometer.

E.5.2.4

Replace note with

NOTE The term "reference reflector" is used in this annex to mean "reference indicator", "artificial defect" or "reference defect", e.g. flat bottom hole (FBH), radially-drilled hole (RDH), side-drilled hole (SDH) and N5 Notch.

E.5.2.5

Add to section

The reference standard shall be visually and dimensional inspected.

E.5.2.5.1.1

The results shall be included in a formal report or certificate, demonstrating compliance with the requirements of this specification and the applicable design.

E.5.2.5.1.2

NDT methods may be used to provide additional information

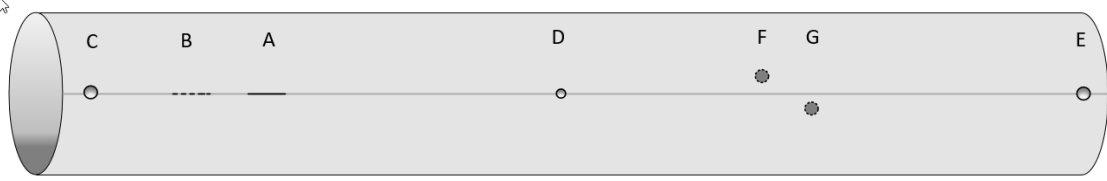
E.5.2.5.1.3

The following shall as minimum be included in the formal report or certificate:

- a) report identification, date, purchaser name, authorizing name and signature;
- b) reference standard: identification, length, diameter, thickness, material, weld procedure and weld profile (as appropriate), scanning surface profile, and reference reflector locations;
- c) N5 notches: length, width, depth, angle and cross-section;
- d) FBH (plate/coil): diameter, drilled depth, depth below surface, angles in two perpendicular planes, and confirmation of flatness and perpendicularity of end;
- e) SDH: diameter, drilled length, depth below surface, location, angles in two planes; and
- f) RDH: diameter, location, angles in two perpendicular planes.

Replace Table E.7. with Tables E.7.1, E.7.2, E.7.3 and E.7.4

Table E.7.1—HFW Seam: Reference Reflectors

Reference Reflectors ^{a b}				
WELD SEAM N5 NOTCHES ^c		RDH (SEAM) ^{d, e, f, g}		FBH ^{a, d}
OD	ID			
One	One	Three		Two
Reflector Identification				
A	B	C, D, E		F, G
				
Note This is an illustration and the drawing is not to scale.				

^a If specified, lamination check shall be performed with a 6.4 mm (0.250 in.) diameter FBH, drilled from the ID in radial direction located in the HAZ and/or parent metal on each side of the weld seam with a depth of 50 % wall thickness to satisfy the requirements of E.9.

^b Reference reflectors shall be sufficiently separated from each other and from any joints or edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically.

^c All notches shall be N5, rectangular section, longitudinal, at and parallel to the weld axis.

— Depth: 5 %*t*; minimum of 0.3 mm (0.012 in.); tolerance ±15 % of depth or ±0.05 mm (0.002 in.), whichever is greater.

— Length at full depth: maximum 25 mm (1.0 in.). Alternative notch length may be specified.

— Width: maximum 1 mm (0.04 in.).

— The weld body OD and ID notches shall be as close to the pipe center as practicable.^h

^d Drilled hole dimensions are based upon standard drill-bit sizes.

^e RDH – Seam: One 1.6 mm (0.06 in.) maximum diameter radially through drilled hole and centered on the fusion line for EMI acceptance criteria, and for detection purposes only for AUT.

^f RDH – Seam: Two 3.2 mm (0.125 in) maximum diameter hole at pipe ends to represent the maximum extent of automated NDT coverage of the length of the seam (also see E.3.2.1).

^g For AUT qualification (see Appendix 3), an additional 3.2 mm (0.125 in.) RDH shall be placed in the weld seam at the mid-length position. This hole and those listed in footnote f shall be used to demonstrate the axial consistency of the AUT system.

Table E.7.2—SAW Seam: Reference Reflectors

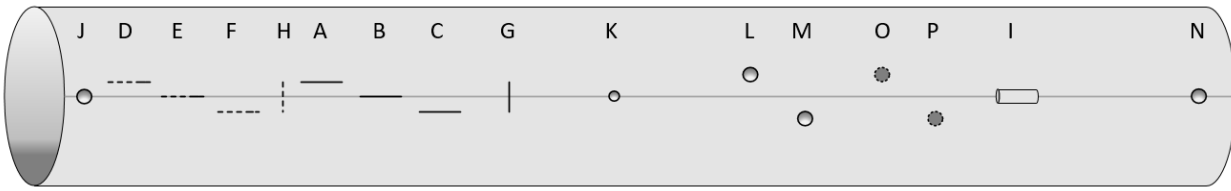
REFERENCE REFLECTORS ^{a, b}							
N5 NOTCHES ^c				SDH ^{f, g}	RDH ^{f, h, i, j, k}	FBH ^{a, f}	
Longitudinal ^d		Transverse ^e		Longitudinal	Vertical		
OD	ID	OD	ID	Embedded			
3	3	1	1	SDH per footnote ^g	5	2	
Reflector Identification							
A, B, C	D, E, F	G	H	I	J, K, L, M, N	O, P	
							
NOTE This is an illustration and the drawing is not to scale.							
^a If specified, lamination check shall be performed with a 6.4 mm (0.250 in.) diameter FBH, drilled from the ID in radial direction located in the HAZ and/or parent metal on each side of the weld seam with a depth of 50 % wall thickness to satisfy the requirements of E.9 ^b Reference reflectors shall be sufficiently separated from each other and from any joints or edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically. ^c All notches shall be N5, rectangular section: — Depth: 5 %<i>t</i>; minimum of 0.3 mm (0.012 in.), maximum 2.0 mm (0.08 in.); tolerance ±15 % of depth or ±0.05 mm (0.002 in.), whichever is greater. — Length at full depth: maximum 25 mm (1.0 in.). Alternative notch length may be specified. — Width: maximum 1 mm (0.04 in.). ^d N5 Notches, longitudinal, located in the HAZs parallel to the weld axis, one on each side of the weld, and one on the weld centerline. ^e N5 Notches - Transverse – perpendicular to the weld and on the weld centerline. If the weld is capped, the manufacturer may elect to grind both the internal and external weld reinforcements to match the pipe contour in the immediate area and on both sides of the notches. ^f Drilled hole dimensions are based upon standard drill-bit sizes ^g SDH: 3.2 mm (0.125 in.) maximum diameter hole, longitudinal, located along the weld centerline drilled parallel to the weld axis within ±1°. ^h RDH: Two 3.2 mm (0.125 in.) maximum diameter hole, center located at weld toes. For setting defect gate lengths/assuring coverage. ⁱ RDH: Two 3.2 mm (0.125 in.) maximum diameter hole, located on the weld centerline. One at each pipe end, representing the maximum extent of automated NDT coverage of the length of the seam. ^j RDH: One 1.6 mm (0.063 in.) maximum diameter, through drilled hole at weld centerline. This reflector is for detection only for AUT. ^k RDH: For AUT qualification (see Appendix 3), an additional 3.2 mm (0.125 in.) RDH shall be placed in the weld centerline at the mid-length position. This hole and those listed in footnote i shall be used to demonstrate the axial consistency of the AUT system.							

Table E.7.3—SMLS Pipe: Reference Reflectors

Reference Reflectors ^{a, b}						
N5 Pipe Body Notches ^c				RDH ^{e, f, g i}	Wall Reduction ^h	FBH ^{a, e}
Longitudinal		Transverse				
OD ^d	ID	OD	ID			
1	1	1	1	3	1	1
Reflector Identification						
A	B	C	D	E, F, G	H	I
						
NOTE This is an illustration and the drawing is not to scale.						

^a If specified, lamination check shall be performed with a 6.4 mm (0.250 in.) diameter FBH, drilled from the ID in radial direction with a depth of 50 % wall thickness to satisfy the requirements in Table E.8.1

^b Reference reflectors shall be sufficiently separated from each other and from any joints or edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically.

^c All notches shall be N5, rectangular section:

- Depth: 5 %t; not necessarily less than 0.3 mm (0.012 in.); tolerance ± 15 % of depth or ± 0.05 mm (0.002 in.), whichever is greater.
- Length at full depth: maximum 25 mm (1.0 in.). Alternative notch length may be specified.
- Width: maximum 1 mm (0.04 in.).

^d The pipe body OD longitudinal notch shall be parallel to the pipe axis and placed as close as practicable to the center of the pipe length.

^e Drilled hole dimensions are based upon standard drill-bit size.

^f RDH: One 1.6 mm (0.063 in.) maximum diameter hole in the pipe body for EMI acceptance criteria, and for detection purposes only for AUT.

^g Two 3.2 mm (0.125 in.) maximum diameter holes, one at each end representing the maximum extent of automated NDT coverage of the length of the pipe.

^h The pipe shall also contain an area of known/specified thickness [tolerance ± 0.01 mm (0.0003 in.)] for the calibration of pipe wall thickness measurement.

ⁱ For AUT qualification (See Appendix 3), an additional 3.2 mm (0.125 in.) RDH shall be placed in the pipe body at the mid-length position. This hole and those listed in footnote g will be used to demonstrate the axial consistency of the AUT system.

Table E.7.4—Plate/Coil: Reference Reflectors

REFERENCE REFLECTORS ^a					
Plate	FBH ^b	DEPTHS (mm) _{c,d,e}	EACH EDGE ZONE (Typ.) ^f	EACH END ZONE (Typ.) ^g	BODY ZONE
	Diameter: 6.4 mm (0.250 in.)	3	1 ^{h, i}	1 ^{h, i}	i, j
		t-3	1 ^{h, i}	1 ^{h, i}	i, j
Coil	FBH ^b	DEPTHS (mm) _{c,d,e}	EACH EDGE ZONE ^f	EACH END ZONE ^g	BODY ZONE ^h
	Diameter: 6.4 mm (0.250 in.)	3	1 ^{h, i}	n/a	i, j
		t-3	1 ^{h, i}	n/a	i, j

^a Reference reflectors shall be sufficiently separated from each other and from any edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically.
^b FBH shall be drilled from the back surface, opposite the scanning surface, perpendicular to the surface within $\pm 1^\circ$. Drilled hole diameter shall be stated as the standard drill bit diameter.
^c Depths are given as those below the UT scanning surface. Tolerance ± 0.5 mm (0.02 in.).
^d For $t > 6$ mm, one FBH at 3 mm (0.12 in.) below scanning surface and one at 3 mm (0.12 in.) above bottom of plate. For $t \leq 6$ mm, one FBH located at $t/2$.
^e Full coverage of the plate/coil thickness shall be demonstrated from 3 mm (0.12 in.) below the scanning surface to 3 mm (0.12 in.) above the backwall, using either the DAC or DGS method. Tolerance ± 0.5 mm (0.02 in.).
^f Each of the two edge zones shall run the full length of the plate/coil and from the line of the final edge cut to a distance of $[3.5t + 25 \text{ mm (0.98 in.)}]$ or 50 mm (2.0 in.), whichever is greater.
^g Each of the two end zones shall run the full width of the plate/coil and from the line of the final cut end to a distance of $[3.5t + 25 \text{ mm (0.98 in.)}]$ or 50 mm (2.0 in.), whichever is greater.
 — Longer scanning distance may be specified.
 — For continuous coil subject to in-line AUT before cutting to length, the end zone requirement may be omitted.
^h FBH shall be used to define the declared uninspected area.
ⁱ Each ultrasonic probe used shall be verified with the detection of a FBH. Probe overlap shall also be demonstrated.
^j In at least four positions over the plate width the depth coverages shall be demonstrated with the FBH at the two specified depths.
 1) For all equipment, the width of the reference standard or the number of scans shall be sufficient to comply with footnote i.
 2) Alternative arrangements shall only be permitted if agreed in writing by the purchaser at tender stage.
 3) For HFW manufacturing, full-body ultrasonic testing of the pipe for laminar imperfections is acceptable if coil edge ultrasonic inspection is unavailable.
 4) Where AUT is performed on HFW pipe body instead of coil, refer to Table K.2.1.

E.5.3 Instrument Standardization

E.5.3.1

Replace section with

A documented procedure shall be followed to achieve

- 100 % coverage of the application,
- establish sensitivity and recording,

— define reject thresholds for UT or EMI as applicable.

The reference reflectors given in Tables E.7.1 through E.7.4 (as applicable) shall be used to ensure full coverage of the pipe.

Reference reflectors defined in Tables E.7.1 through E.7.4 shall be used to establish sensitivity in accordance with Table E.9 and be detected under NDT operating conditions.

E.5.3.1.31

Sensitivity shall be demonstrated dynamically on-line using the same equipment used for production inspection, the same relative speeds between pipe and probe and the same scanning directions used for the production pipe.

E.5.3.2

Replace section with

For an automated NDT system, standardization shall be performed as follows.

Add new section

E.5.3.2.1 Static Calibration

Add new section

Static calibration shall be performed at the beginning of production and whenever there are any change in pipe dimensions, delivery condition or AUT system malfunctions.

The amplitudes of indications from each reference reflector shall be adjusted to a set reference amplitude between 50% and 80 % FSH and be within ± 5 % of the target reference amplitude.

Add new section

E.5.3.2.2 Dynamic Calibration

Dynamic calibration shall be performed after static calibration.

E.5.3.2.2.1.1

Amplitudes of indications from every reference reflector shall be adjusted to a set target reference amplitude between 50 % and 80 % FSH and be within ± 5 % of the target reference amplitude.

E.5.3.2.2.1.2

Final adjusted settings shall be verified by at least three consecutive dynamic runs.

E.5.3.3

Add to section

Sensitivity for AUT and EMI shall be established by use of the reference reflectors contained in the reference standard (see E.5.3.1 and Table E.9).

— A transfer correction (TC) shall be determined for every probe type (e.g. compression, shear) to adjust for differences > 2 dB between the reference standard and production plate/pipe.

E.5.3.3.1.1

Transfer correction checks shall be performed at the beginning of the production run and at a frequency of one per 400 pipes.

E.5.3.3.1.1.2

NOTE Transfer correction is the gain difference between the reference standard and the production pipe.

For EMI:

- PRG = gain setting used to establish an indication from the applicable reference reflector at an appropriate amplitude.
- Recording level = PRG = scanning sensitivity.

Add new section

E.5.3.5

Add new section

Dynamic verification shall be performed at the following periods:

- a) at the beginning of the operating shift;
- b) every four hours;
- c) at the end of the operating shift;
- d) whenever there is an equipment operator change-over; and
- e) whenever there is a mechanical malfunction or an electrical interruption (e.g. black-out).

End of shift verification may be combined with the start of next shift verification if both operators' shifts overlap.

The amplitudes of indications shall be within $\pm 5\%$ of the target reference amplitude.

E.5.3.5.3.1

For a channel where the signal amplitude falls outside the range, static and dynamic calibration shall be repeated.

E.5.3.5.3.2

In these instances, all pipes tested since the last satisfactory dynamic calibration or verification shall be retested.

Add new section

E.5.3.6

For UT and EMI, the coverage of the application shall be demonstrated for all applicable scans by the detection of all applicable reference reflectors.

Record of standardizations (calibrations), verifications and indications exceeding the threshold level shall be available for purchaser review.

E.5.5 Acceptance limits

E.5.5.1

Replace section with

The acceptance limit for indications produced by reference indicators shall be in accordance with Table E.8.

For HFW, alternative acceptance criteria may be specified.

Replace Table E.8 with Table E.8

Table E.8—Acceptance Limit, EMI, and UT Angled Beam Scans

Application	Acceptance Limit ^a		
	N5 NOTCH (AUT only)	SDH (AUT only)	RDH (EMI only)
HFW SEAM & HAZs	100 % PRL	n/a	100 % PRL 1.6 mm (0.063 in.)
SAW SEAM& HAZs	100 % PRL	100 % PRL 3.2 mm (0.125 in.)	n/a
SMLS PIPE	100 % PRL	n/a	100 % PRL 1.6 mm (0.063 in.)
All	Cracks are unacceptable, irrespective of amplitude		
^a Expressed as a percentage of PRL established using the applicable reference reflector.			

E.5.6 Disposition of defects found by Ultrasonic and Electromagnetic Inspection

Add to section

For SAW/COW pipe seams, all indications exceeding the recording level (see Table E.9) shall be evaluated in accordance with the flowchart in Figure E.1.

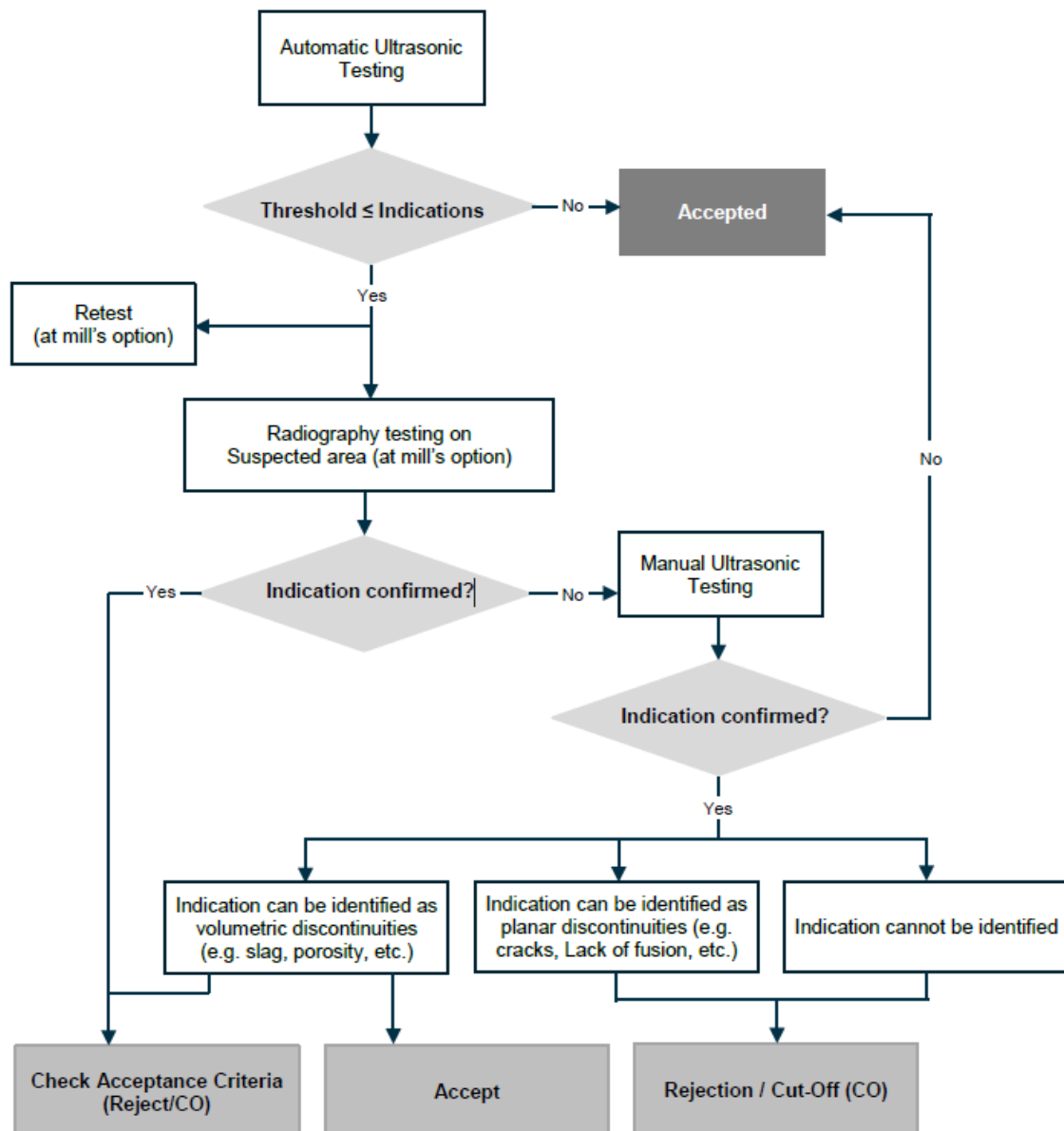
Add new table

Table E.9—UT Sensitivities

Technique	Application	Scans	Reference Reflector	PRG	PRL	SS	RL ^a
AUT	Plate/Coil, Pipe for laminations	Normal (0°) ^b	6.4 mm (0.250 in.) diameter FBH	100 % DAC/TC G	PRG+ TC	PRL	PRL- 6dB (50 % PRL)
	SAW Seam & HAZs	Angled Beam ^c	N5 Notch				
			3.2 mm (0.125 in.) SDH				
	HFW Seam & HAZs	Angled Beam ^d	N5 Notch				
	SMLS Pipe	Angled Beam	N5 Notch				
MUT	All	All	All as above			PRL+ 6 dB ^e	

^a All relevant recordable indications shall be evaluated against the acceptance limits (see E.5.5).
^b For plate and coil, sensitivity may be established using DGS system.
^c N5 notches and 3.2 mm (0.125 in.) SDH shall be used to establish sensitivity. For some scans, it might be necessary to establish the DAC/TCG using both types of reflector.
^d N5 notches shall be used to establish sensitivity.
^e For MUT, 6 dB shall be added for scanning but should be removed prior to evaluation of indications against the acceptance criteria. This requirement does not apply to E.5.9.
 All footnotes shall apply unless otherwise specified.

Add new figure



Note

Retest, if performed, shall consist of at least three scans and if the indication is detected by two out of three scans, it shall be considered confirmed.

Figure E.1—SAW/COW Seam Inspection Decision Tree

Add new section

E.5.8 Special Requirements for MUT Inspection for Delayed Hydrogen Cracks (Chevron Cracking) Detection

When specified, MUT inspection for delayed hydrogen cracking (DHC) shall be performed.

E.5.8.1.1.1

DHC inspection shall not be performed by AUT unless otherwise specifically agreed

E.5.8.1.1.2

AUT procedures and reference pipes shall be as agreed.

When AUT is applied, reference flaws shall be added to the reference standard, to assure 100 % coverage of the weld.

The inspection shall be restricted to SAWH and SAWL pipes.

Add new section

E.5.8.1 Coverage of the Inspection

One pipe per shift or 2 % of produced pipes per day, whichever is greater, shall be selected for inspection.

E.5.8.1.1.1

100 % of the weld seams shall be tested 48 hours after hydrostatic test.

The DHC testing shall sample equally, all welding lines.

The procedure for DHC detection shall also be applied on any indication detected by the AUT transverse channels.

Add new section

E.5.8.2 Probe Arrangements

Probe arrangements shall be:

- 45° probe in accordance with Figure E.2; or
- when UT from the weld cap is not practicable due to profile or roughness, by an agreed alternative scanning technique.

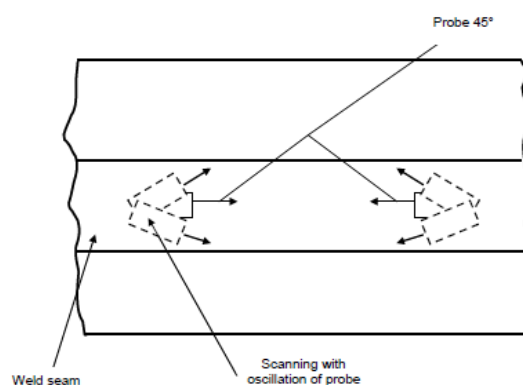


Figure E.2—MUT Probe Arrangements

Add new section**E.5.8.3 Calibration**

Calibration shall be carried out on a minimum of three side drilled holes of 1.6 mm (0.063 in.) in diameter covering the pipe wall thickness: mid-thickness and 4 mm (0.16 in.) (remaining ligament of 2 mm (0.08 in.)) from the ID and the OD.

The reference level for calibration shall be 80 % FSH.

For detection, 12 dB shall be added.

The UT procedure shall be in accordance with ISO 17640.

Add new section**E.5.8.4 Discontinuities Evaluation and Recording Criteria**

Indications ≥ 25 % of the DAC reference curve shall be evaluated.

Indications that exceed 50 % of the DAC reference curve shall be recorded and may be re-inspected by a different level 2 inspector.

E.5.8.4.2.1

Indications that exceed 50 % of the DAC reference curve shall be recorded and may be re-inspected by a different level 2 inspector.

Add new section**E.5.8.5 Discontinuities Rejection Criteria**

Indications with amplitude above 50 % of the DAC curve shall be rejected.

Add new section**E.5.8.6 Repairs**

Indications classified as DHC shall be reported or communicated immediately.

The welded joint shall be rejected.

In the event of a defective pipe, all pipes manufactured during the same, the previous shift and the following shift shall be inspected for DHC.

E.6 Magnetic Particle Inspection**E.6.2 Equipment**Add to section

Magnetization shall be carried out in two perpendicular directions for pipe bodies and in at least one direction (for circumferential defects) for pipe end bevels.

E.6.2.1.1

Magnetizing field strength shall be confirmed in the magnetizing direction using a strip-type (three slots) or shim-type flux (three rings) indicator.

E.6.2.1.2

For shim-type flux indicators, all lines on the indicators shall illuminate.

E.6.2.1.3

Pie-type indicators shall not be used to verify field strength.

E.6.2.1.4

If ISO 10893-5 is being applied, then the magnetic field strength shall be in the range from 2.4 to 4.8 kA/m, measured using a tangential field meter.

Add new section

E.6.4 SAWH and SAWL MT of Long Seam

Add new section

For the full seam weld of SAW pipes, one pipe per shift shall be inspected with 48 hours of welding.

E.6.4.1.2

For pipe with $D \geq 609.6$ mm (24 in.), the entire internal weld shall be MT inspected.

Indications > 3.2 mm (0.125 in.) in any direction shall be classified as defects. Cracks and crack-like indications of any size are not acceptable.

E.7 Residual Magnetism**E.7.2**

Replace section with

The longitudinal magnetic field shall be measured.

E.7.2.1

Measurements shall be taken on the root face or square cut face of finished plain-end pipe.

E.7.2.2

Measurements shall not be made on pipe in stacks.

E.7.6

Replace section with

Four readings shall be taken approximately 90° apart around the circumference at each end of the pipe.

E.7.6.1

The average of the four readings shall be ≤ 1.5 mT (15 Gs).

E.7.6.2

A single reading shall not exceed 2.0 mT (20 Gs).

E.8 Laminar Imperfections in the Pipe Body of EW, SAW and COW pipes**E.8.1**Replace section with

If specified, for HFW pipe, UT shall be used to verify that the plate/coil or pipe body is free of laminar imperfections.

E.8.1.1.1

UT shall be performed in accordance with E.5.1 and E.5.2 and:

- a) ISO 10893-9, if inspection is performed prior to pipe forming; or
- b) ISO 10893-8, if inspection is performed after seam welding.

E.8.1.1.2

Instrument standardization shall comply with Table E.9.

E.8.2Replace section with

If specified, for SAW and COW pipe, UT shall be used to verify that the plate or pipe body is free of laminar imperfections.

E.8.2.1.2

UT shall be performed in accordance with E.5.1 and E.5.2 and:

- a) ISO 10893-9, if inspection is performed prior to pipe forming; or
- b) ISO 10893-8, if inspection is performed after seam welding.

Standardization for pipe body zone shall comply with Table E.9.

E.9 Laminar Imperfections Along the Strip/Plate Edges or Pipe Weld Seam of EW, SAW, and COW PipeReplace section with

Inspection shall be performed along the entire edge up to a distance from the edge or the edge of the weld seam, of $[3.5t + 25 \text{ mm (0.98 in.)}]$ or 50 mm (2.0 in.), whichever is greater.

Add new section

E.11 Laminar Imperfections in the Pipe Body of SMLS Pipe

If specified for SMLS pipes, UT shall be used to verify that the pipe body is free of laminar defects in accordance with K.3.2.1.

Add new section

E.12 Thickness Measurement

Add new section

E.12.1 Seamless Pipes

For SMLS pipes, ultrasonic thickness measurements shall be carried out in accordance with ISO 10893-12.

E.12.1.1.2

Scanning coverage shall be at least 25 % of the area of the pipe.

The accuracy of measurements and records shall be to one decimal place.

If specified, pipe for AUT inspection (girth weld) shall be checked as follows.

The wall thickness shall be automatically measured over 100 mm (3.94 in.) of each pipe end on the whole circumference area.

E.12.1.3.1.1

The minimum and the maximum thickness measured at each end shall be recorded and traceable in regard to pipe number and end side.

E.12.1.3.1.2

The records shall be made available for review and shall be included in the final documentation as a native file, in a native data format that can be imported into a spreadsheet file.

The standard deviation (Sd) of wall thickness records for all measurement results, irrespective of the pipe number, shall be calculated.

E.12.1.3.3.1

Sd shall be conventionally calculated in accordance with Equation (E.1):

$$Sd = \frac{t_{max} - t_{min}}{6} \quad \text{E.1}$$

The following data shall be made available to the purchaser within the time specified:

- maximum wall thickness;
- minimum wall thickness;
- wall thickness mean value (M);

- STD value;
- pipe numbers and end sides with $t = M + 2 S_d$;
- pipe numbers and end sides with $t = M - 2 S_d$.

Add new section

E.12.2 Welded Pipes

Add new section

E.12.2.1 Steel Plate Wall Thickness Measurement

If specified, wall thickness checks shall be performed, as a minimum, on every five plates in the middle and edges of the plate.

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

Histograms shall be provided containing detail of the minimum/maximum range, the mean value (M) and the standard deviation (S_d) of wall thickness.

E.12.2.1.3.1

S_d shall be conventionally calculated in accordance with Equation (E.1).

Add new section

E.12.2.2 Pipe Wall Thickness Measurement

If specified, pipe suitable for girth weld AUT inspection shall be checked as follows.

When the pipe item wall thickness standard deviation (S_d) has been found in plate mill in excess of 0.25 mm (0.001 in.), see 6.8.2, the wall thickness shall be measured and recorded on 100 % of pipe ends, at two locations at each end, approximately 20 mm (0.79 in.) from one weld toe and on the opposite side to the weld (i.e. four measurements on each pipe).

E.12.2.2.1.1.1

The measurements shall not be carried out on ground areas;

E.12.2.2.1.1.2

A dial micro-meter shall be used for measurement. Its fingers (jaws) shall be sharp or round ended for a proper touch on the internal pipe surface;

E.12.2.2.1.1.3

The accuracy of measurements and records shall be to one decimal place;

E.12.2.2.1.1.4

The results shall be presented on a histogram and shall indicate the mean value (M) and the standard deviation (S_d).

The measured wall thickness versus the pipe numbers and the end sides shall be traceable.

E.12.2.2.1.2.1

The records shall be made available to the purchaser or pipe laying contractor for review and shall be included in the final documentation as a native file, that can be imported into a spreadsheet.

Add new section

E.14 Qualification of Mill NDT

NDT performed by plate/coil and pipe mills shall be subject to qualification in accordance with Appendix 3.

Annex G **(normative)** **PSL 2 Pipe with Resistance to Ductile Fracture Propagation**

G.1 Introduction

G.1.1

Add to section

For rich gas transmission and two-phase pipelines, one of the approaches in this annex shall be used by the Purchaser to determine the required absorbed energy to resist running fractures with the requirements as specified.

G.1.1.1

G.1.1.1.1

The Charpy test requirements given in 9.8 are based on crack initiation principles. Typically, for rich gas transmission and two phase pipe lines, higher absorbed energy requirements may be specified to avoid the risk of running fractures. In this case, one of the approaches in this annex would be used to determine the required absorbed energy. This shall be performed by the purchaser and the outcome requirements specified.

G.2 Additional Information to be Supplied by the Purchaser

G.2.1

Replace section with

The CVN minimum average absorbed energy value shall be based on full-size test pieces.

G.2.2

Replace section with

The CVN impact test temperature shall be the minimum design temperature or 0 °C whichever is colder.

The DWT test temperature shall be the minimum design temperature or 0 °C whichever is colder.

If CVN and DWT testing conducted in accordance with 9.8 and 10.2, meet the requirement of this annex, CVN testing is not required to be repeated.

G.6 Guidance for Determining CVN Absorbed Energy Values in Buried Onshore Gas Pipelines

Add to section

The CVN requirement shall be the higher of that stated in 9.8.2.1, determined by G.6.2, or by brittle fracture initiation in accordance with the pipeline design e.g. ASME B31.8 Clause 841.1.2, Fracture Control and Arrest.

Annex H (normative) Pipe Ordered for Sour Service

H.1 Introduction

General sour service requirements shall be in accordance with this annex. For specific applications, see H.4.8.

Material supplied according to this annex shall also comply with NACE MR0175/ISO 15156.

Where conflicting requirements arise, the most stringent requirement shall apply.

Pipe that has not been manufactured to be HIC resistant steel, even if passed subsequent HIC tests shall not be used.

H.2 Additional Information to be Supplied by the Purchaser

Replace section with

Information to be supplied and options within this specification shall be covered in Table H.5 and in the LPMDS.

Table H.5—Additional Information to be Supplier by the Purchaser

API Specification 5L, H.2 Item Number	Information Required	API Specification 5L Section or Table Number	Purchaser Requirements - (per this specification, as referenced below)
b)	Ultrasonic inspection of strip or plate for laminar imperfections	H.3.3.2.4	H.3.3.2.4
g)	Frequency of hardness testing of the longitudinal seam weld of EW or SAW pipe	Table H.3	Table H.3
j)	Photomicrographs of reportable HIC cracks	H.7.3.1.4	H.7.3.1.4
l)	Deviation from hardness test	H.7.3.3.2 and H.7.3.3.3	As per LPMDS
m)	Deviation from 4 hardness impressions	H.7.3.3.2 c)	As per LPMDS
n)	For pipe with $t \geq 5.0$ mm (0.197 in.), ultrasonic inspection for laminar imperfections within extended length of 100 mm (4.0 in.) at the pipe ends	K.2.1.3	K.2.1.3
o)	Supplementary end NDT lamination criteria	K.2.1.3 and K.2.1.4	K.2.1.3 and LPMDS
q)	Verification of lamination size/density	K.3.2.2	K.3.2.2
t)	Ultrasonic inspection of SMLS pipe for the detection of transverse imperfections	K.3.4.1	K.3.1
y)	Acceptance level U2/U2H for non-destructive inspection of the weld seam of HFW pipe	K.4.1	K.4.1
z)	Alternate ISO 10893-10 HFW weld seam UT acceptance criteria	K.4.1 b)	K.4.1

Table H.5 (continued)

API Specification 5L, H.2 Item Number	Information Required	API Specification 5L Section or Table Number	Purchaser Requirements - (per this specification, as referenced below)
aa)	Ultrasonic inspection of the pipe body of HFW pipe for laminar imperfections	K.4.2	K.4.2
bb)	Ultrasonic inspection of the strip/plate edges or areas adjacent to the weld for laminar imperfections	K.4.3	K.4.3
dd)	Use of fixed depth notches for equipment standardization	K.5.1.1 c)	Not applicable
ee)	Radiographic inspection of pipe ends (noninspected ends) and repaired areas	K.5.3 a)	K.5.3

H.3 Manufacturing

H.3.1 Manufacturing Procedure

Replace section with

H.3.1.1 General

Pipes shall be manufactured in accordance with a manufacturing procedure that has been qualified to the requirements of Annex B, supplemented with additional testing (refer to Table H.3).

Add new section

H.3.1.2 MPQT

H.3.1.2.1 Macrographic, Micrographic and Segregation Analysis on Slabs

Testing according to B.5.2.1 shall be performed on SAWL and HFW pipes.

H.3.1.2.2 Macrographic, Metallographic Analysis on Pipes

The base metal shall be examined and be free of a banded structure and martensite.

H.3.2 Steelmaking

Replace section with

H.3.2.2

Vacuum degassing or an alternative process to reduce the gas content of the steel shall be applied.

H.3.3 Pipe Manufacturing

H.3.3.1 SMLS Pipe

Replace section with

SMLS pipe shall be manufactured from continuously cast (strand cast) steel or when accepted prior to manufacture, ingot steel.

If the process of cold finishing is used, this shall be stated in the inspection document.

H.3.3.2 Welded Pipe

Replace H section with

H.3.3.2.1

Add to section

The pipe shall be SAWL or HFW.

SAWH shall not be permitted.

SAWL pipe for sour service shall be expanded unless otherwise agreed.

H.3.3.2.2

Replace section with

For HFW pipe, the abutting edges of coil or plate shall be machined or milled shortly before welding.

Final edge preparation shall not be performed by shearing.

Use of center slit coils shall be approved prior to use.

H.3.3.2.4

Replace section with

Coil and plate shall be inspected ultrasonically for laminar imperfections or mechanical damage in accordance with Annex K.

Complete body UT of HFW pipe after forming shall be permitted.

H.3.3.2.6

Replace section with

Intermittent tack welding (e.g. stitch welds, non-continuous) of the SAWL groove shall not be permitted.

Add new section

H.3.3.2.7

Welding consumables shall comply with Appendix 1.

Add new section**H.3.4 Cold Sizing and Cold Expansion**

The sizing ratio shall be recorded for ten pipes per shift, evenly distributed throughout production, or on one pipe per every ten pipes per shift, whichever is greater.

H.4 Acceptance Criteria**H.4.1 Chemical Composition****H.4.1.1**Replace first sentence with

For pipe with $t \leq 25.0$ mm (0.984 in.), the chemical composition shall be in accordance with the values specified in Table H.1, and modified by Table H.6, unless otherwise qualified and accepted.

H.4.1.2Replace section with

For pipe with $t > 25.0$ mm (0.984 in.), the chemical composition shall be in accordance with the requirements given in Table H1 and modified by Table H.6.

The chemical composition recorded for the pipes used in first-day production testing shall set the datum CE to CE_{IIW} or CE_{Pcm} .

The maximum percentages of residual elements shall be as follows:

- a) $Sn \leq 0.020$ %;
- b) $Sb \leq 0.010$ %;
- c) $Bi \leq 0.010$ %;
- d) $Pb \leq 0.010$ %;
- e) $As \leq 0.020$ %.

Residual elements shall be tested for on the finished product, unless a ladle analysis has been performed and certification has been issued.

Add new table

Table H.6—Chemical Composition for Pipe Ordered for Sour Service

	Weight Percentage	
Element	Seamless pipes	Welded pipes
Carbon (C)	0.040 - 0.110	0.025 - 0.100
Phosphorus (P)	0.0180 max	0.0150 max
Sulfur (S)	/	0.0030 max
Niobium (Nb)	0.010 max	0.040 max
Titanium (Ti)	0.0250 max	0.0250 max
Manganese (Mn)	1.65 max	/
Vanadium (V)	0.020 – 0.060 or Table H.1, whichever is lower	0.080 max or Table H.1, whichever is lower
CEPcm	0.190 max	0.210 max or Table H.1, whichever is lower
Other	The following alternative composition limits for niobium and vanadium are allowed: Nb: 0.035 % max. V: 0.010 % max. Higher limits may be proposed if there is a corresponding reduction in carbon equivalent.	Nb + Ti + V : 0.120 max
NOTE Weld procedures for offshore sour service are required to be qualified on the highest CEPcm that will be used for production.		

Add new section

H.4.1.3

Allowable ranges from the target chemical composition in the agreed MPS shall comply with Table H.7.

Add new table

Table H.7—Chemical Composition Allowable Range for Pipe Ordered for Sour Service

Element	Allowable Range Percentage	
	Welded pipes	Seamless pipes
C	0.02	0.02
Mn	0.15	0.2
Si	0.1	0.15
Ni	0.1	0.05
Cr	0.1	0.05
Mo	0.05	0.05
Cu	0.1	0.05
V	0.015	0.02
Nb	0.01	0.02
Ti	0.01	0.01
CEPcm	0.020 ^a	0.020 ^a
^a For CEPcm the range shall be split equally around the agreed target value (Allowable range: Target CEPcm $\pm$ 0.010)		

H.4.2 Tensile Properties

Replace section with

The tensile properties shall be in accordance with Table H.2.

The maximum yield strength shall be the specified minimum yield strength + 120 Mpa.

H.4.3 HIC/SWC Test

Add to section

If specified, the below shall apply:

- crack sensitivity ratio, crack length ratio and crack thickness ratio limits apply to each section or face, of each specimen;
- alternative acceptance criteria (to be specified) apply;
- crack area ratio (CAR) = 5 % maximum of the specimen area, per specimen. The CAR to include all cracks and all laminations whether they are associated with cracks or not.

Damage due to hydrogen pressure induced cracking related features for example, blistering, straight and stepwise cracks shall be measured and reported.

H.4.4 Hardness Test

Replace section with

Pipes ordered for sour service applications shall satisfy the hardness requirements in accordance with Table H.8.

Add new table

Table H.8—Acceptance Criteria for Hardness Test

Grade	Hardness on Pipe and Welded Seam (HV10)
All	230 for Base Material 245 for HAZ and Weld metal/Weld line

H.4.5 SSC Test

Replace section with

Test results shall be assessed in accordance with NACE TM 0316, Section 9.

The metallurgical features shall be documented with photomicrographs.

The test specimen shall not have cracks or ruptures within the 30-day period, for any of the tests.

Unbroken samples containing clearly identified welding defects that may have generated cracks with a length not exceeding 0.2 mm (0.008 in.) in the through thickness direction shall be acceptable.

Add new section

H.4.6 Fracture Toughness

Additional CTOD testing shall be performed in the environment specified.

CTOD testing procedure shall be submitted for review and acceptance.

Add new section

H.4.7 Macrographic and Metallographic Examination

Macro and metallographic examination shall be documented by macro and micrographs at sufficient magnification (e.g. X10, X100, and X400).

The base metal and weld quality shall be in accordance with ISO 5817 level C.

If specified, the base metal macrographs the inclusion ratings shall be in accordance with ASTM E45 method D and the severity level based on the service condition.

NOTE Severity level ½ or 1 may be considered.

If specified, metallographic examination shall be performed as below:

- a) The mid-thickness area of the base metal and the weld area (i.e. centerline of the weld and fusion lines between the base metal and weld metal and between passes) shall not show any indication of centerline segregation, more severe than qualified.

- b) The base metal at location $\frac{1}{4}t$ and $\frac{1}{2}t$ shall be examined for a banded structure (i.e. ferrite or pearlite/martensite). Acceptance criteria to be agreed.

Add new section

H.4.8 User Specific Sour Requirements (informative)

User specific sour requirements (if any) shall be specified and may include the following (the list is not exhaustive):

- a) Chemical composition: a different chemical composition may be specified (with no changes to the limits on CEIIW / CEPcm of this specification).
- b) Hardness: maximum value may be reduced and different HV load and indentations path may be specified.
- c) Corrosion testing: different testing methods, testing environment and/or more stringent acceptance criteria for HIC and SSC test may be specified (see H.7.3.1.3 and H.7.3.2.2) including:
 - 1) Full ring test may be required (see H.7.2.3.2).
 - 2) Additional SSC tests may be requested to be performed during qualification at simulated operating conditions if the maximum expected partial pressure of H₂S is higher than 1 bar (14.5 psi).
 - 3) Test method: 4 points bend according to NACE TM0177 Method B or TM0316.
- d) NDT: In case of pipes with delivery condition M (thermomechanical rolled or thermomechanical formed) it may be requested that plate surface is entirely inspected with suitable scanning tools for the detection of local surface areas with increased hardness according to the provisions of H.5.2.

H.5 Surface conditions, Imperfections and Defects

H.5.2

Add to section

If specified, NDT of plate surface hardness shall be performed in accordance with the provision of K.6.

When the plate mill performs NDT for surface hardness on the surface that is intended to form the pipe ID, identification of the surface tested shall be made.

H.7 Inspection

H.7.1 Specific Inspection

Add to section

The test unit shall be defined as a pipe lot coming from same size, same heat number, and consists of a maximum of 50 pipes.

Replace Table with

Table H.3—Inspection Frequency

Item No	Type of Inspection	Type of Pipe	Frequency of Inspection ^b
1	Hardness testing	SMLS, SAWL, HFW	Once per test unit of not more than 50 lengths of pipe with the same cold-expansion ratio a.
2	Hardness testing of hard spots in welded pipe	SAWL, HFW	Each hard spot found on the internal or external surface of the pipe.
3	If specified, hard spot / local surface areas with increased hardness inspection	SAWL	Each pipe, plate full surface.
5	Hardness testing of the longitudinal weld of welded pipe	SAWL, HFW	Once per test unit of not more than 50 lengths of pipe with the same cold-expansion ratio a.
6	Pipe diameter and out-of-roundness for pipe	SMLS, SAWL, HFW	First 10 pipes, then once per test unit of no more than 20 pipes but no less than once per 4-hour operating shift plus whenever any change of pipe size occurs during the operating shift.
7	Non-destructive inspection	SMLS, SAWL, HFW	In accordance with Annex K
8	HIC tests	SMLS, SAWL, HFW	Unless otherwise specified: one test for each of the first three heats; thereafter, not less than one test per each ten heats of steel.
9	If agreed, SSC tests	SMLS, SAWL, HFW	If specified, test shall be performed as part of MPQT testing. If specified, one test for each of the first three heats; thereafter, not less than one test per each ten heats of steel.
^a The cold-expansion ratio is designated by the manufacturer and is derived using the designated before-expansion outside diameter or circumference and the after-expansion outside diameter or circumference; an increase or decrease in the cold-expansion ratio of more than 0.002 requires the creation of a new test unit. ^b Unless noted otherwise all values/data shall be recorded. ^c Pipe produced by each welding machine shall be tested at least once a week.			

H.7.2 Samples and Test Pieces for Mechanical and Technological Tests

H.7.2.1 General

Add new section

H.7.2.1.3

These drawings shall define the specimen location along the length, around the circumference and in the pipe wall thickness.

Test reports shall identify the specimen location on the drawings.

H.7.2.2 Samples for HIC/SWC Tests

Add to section

If specified, for SMLS pipes, three sets of three specimens shall be taken from each test pipe as follows: one set cut in the base material in a direction parallel to the rolling direction at each of the three 120° location (i.e. 120° x 3 equally spaced = 9 specimens).

If specified, for welded pipes, three sets of specimens shall be taken from each test pipe as follows:

- a) One set of three specimens cut transverse to the longitudinal weld. For HFW, the set to be sampled parallel to the weld for the weld area of HFW line pipe. The weld to be approximately on the centerline of the test specimens.
- b) Two sets cut in base material in a direction parallel to the rolling direction: one at 90° and one at 180° from the weld, or at agreed locations.
- c) For MPQT testing, an additional two sets: one at each pipe end (head and tail of the mother plate) to be tested.

H.7.2.3 Samples and Test Pieces for SSC Tests

H.7.2.3.1

Add to section

If specified for SMLS pipes, three sets of three specimens shall be taken from each test pipe as follows: one set cut in the base material in a direction parallel to the rolling direction at each of the three 120° location (i.e. 120° x 3 equally spaced = 9 specimens).

If specified for welded pipes, three sets of specimens shall be taken from each test pipe as follows:

- a) One set of three specimens cut transverse to the longitudinal weld.
- b) For HFW, the set shall be sampled parallel to the weld for the weld area of HFW line pipe. The weld shall be approximately on the centerline of the test specimens.
- c) Two sets cut in the base material in a direction parallel to the rolling direction: one at 90° and one at 180° from the weld; and
- d) For MPQT testing, an additional two sets: one at each pipe end (head and tail of the mother plate) shall be tested.

H.7.2.3.2

Add to section

Test specimens shall be free of defects.

Specimens shall be cut adjacent to the surface in contact with the effluent containing H₂S, with the minimum depth of machining to obtain flat surfaces but leaving the area of interest intact.

With the exception of the surface of interest, surfaces shall be polished to 600 grit after machining.

The test specimens shall have the surface in contact with effluent in the original condition with no subsequent surface preparation.

SAW weld SSC specimens shall be machined square in accordance with Figure H.2 to remove the cap with minimal removal of the HAZ.

No more than 0.5 mm shall be removed from the weld toe area.

Add new figure H.2

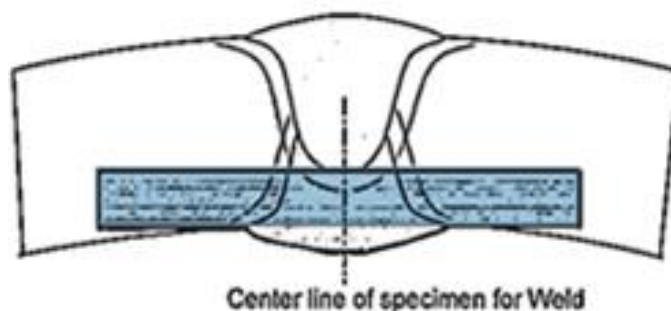


Figure H.2—Sampling Locations of SAW Weld SSC Specimens

Samples identification shall be performed on each specimen by an accepted method.

Unless otherwise specified, the specimen shall have the following dimensions:

- specimen thickness of 15 mm (0.6 in.) or full wall thickness whichever is less;
- the minimum width-to-thickness ratio to be 1.5:1; and
- the specimen length to test the area of interest and be a minimum of 115 mm (4.53 in.). The ratio of H/A is to be equal to 4 in accordance with TM0316.

If specified, full ring test sample and specimen reference shall be made in accordance with BS 8701.

H.7.2.4 Samples for Hardness Tests

Delete first paragraph

Replace Table H.4 with

Table H.4—Number, Orientation and Location of Test Pieces per Sample for Hardness Tests

Type of pipe	Sample location	Number, Orientation and location of Tests Pieces ^{ab}	
		Specified Outside Diameter D mm (in.)	
		< 508 (20.000)	≥ 508 (20.000)
SMLS	Pipe body	4T	4T
SAWL/HFW	Pipe weld	1W	1W
	Pipe body	3T	3T
^a Test Piece shall be spaced by 90° (all four quadrants of the selected pipe). ^b Refer to Figure 5 for an explanation of the symbols used to designate orientation and location.			

H.7.3 Test Methods

H.7.3.1 HIC/SWC Test

H.7.3.1.3

Add item d) to list

d) in an alternative medium as specified.

H.7.3.1.4

Add to section

In addition to the requirements of NACE TM 0284, the following data shall be provided in the manufacturer's report for each heat tested, for acceptance:

- a) the CAR percentage result for each specimen (If UT testing is specified);
- b) locations and dimensions of specimens in tested pipe;
- c) explanations and concluding comments, and
- d) magnified photographs of etched and un-etched sections, of any reportable crack.

Any failure shall be analyzed and the cause of failure made clear to the purchaser.

Add new section

H.7.3.1.5

If specified, prior to sectioning (i.e. after testing, scale and deposits removal), the test piece shall be tested using immersion AUT technique, in accordance with NACE TM0284, Appendix A.

Unless otherwise agreed, all narrow and wide faces shall be scanned.

The CAR of scanned surfaces shall be calculated and reported.

Additional sectioning shall be performed at the largest AUT indication.

Photographs shall be provided in the report, in accordance with H.7.3.1.4.

Crack sensitivity ratio, crack length ratio and crack thickness ratio shall be reported for each section.

The acceptance criteria shall also be applicable to this additional sectioning.

A HIC test procedure and AUT procedure shall be submitted for acceptance.

Add new section

H.7.3.1.6

Laboratory facilities for testing shall be accepted by the purchaser.

H.7.3.2 SSC Test

H.7.3.2.1

Replace first sentence with

Except as allowed by H.7.3.2.2, SSC tests shall be performed in accordance with H.7.3.2.1.1 to H.7.3.2.1.5.

Add new section

H.7.3.2.1.1 General

Sulfide stress cracking tests shall be performed using the 4-point bending test method of NACE TM 0316.

Add new section

H.7.3.2.1.2 Test Required for Determination of Actual Yield Strength

Three round bar tensile specimens shall be used for each set of SSC tests.

The tensile test specimens shall be taken adjacent to the place where each set of SSC specimens are taken.

Flattening shall not be permitted.

Tensile testing shall be in accordance with 10.2.3.2 using round bar specimens.

Tensile specimens shall be taken from the base metal and in the same direction as the SSC test.

Tensile test results shall be recorded.

The average yield strength value shall be taken as the reference for the actual yield strength for calculating the stress level of the SSC tests.

Add new section

H.7.3.2.1.3 Test Set-up

Test arrangements and loading of specimens shall be in accordance with NACE TM0316.

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

Stress applied to specimens shall be adjusted in accordance with H.7.3.2.1.4.

Add new section

H.7.3.2.1.4 Test Conditions

The test solution shall be the NACE test solution "A" (refer to NACE TM0177), unless otherwise specified.

Saturation shall be obtained within one hour.

Hydrogen sulfide concentration in the solution shall be measured by the iodine titration method at the start and at the end of the test.

The pH of the solution shall be recorded at the start and at the end of the test.

Partial pressure of H₂S shall be 1 bar.

The test pieces shall be stressed to a minimum of 80 % the actual yield strength.

For base metal tests, the measurement of applied stress shall be made using strain gauges or the deflection method.

If the deflection method is used, it shall be measured using a dial gauge with an accuracy of 0.01 mm (0.0004 in.).

Strain gauges shall be used for SSC test of welds.

If specified, additional SSC tests shall be performed at 90 % of actual yield strength.

The results of the tests shall be described and reported as pass or fail, for information only.

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

Add new section

H.7.3.2.1.5 Reporting

Test reports shall be provided in accordance with NACE TM0316 with the following additional information:

- a) individual results for each specimen tested per set, with photographs and photomicrographs (when applicable);
- b) actual dimensions of specimens;
- c) pipe number from which the SSC test specimens was extracted;
- d) testing procedure, and
- e) explanations and conclusions.

Test failure shall be analyzed and the cause of failure explained in the report.

H.7.3.3 Hardness Test

H.7.3.3.1

Add to section

An additional hardness indentation line shall be close to the surface in contact with the sour process fluid, for pipes formed from thermomechanically controlled processed plates and coils.

This shall be done using Hv0.5 (500 g), 0.25 mm (0.01 in.) from the surface.

Acceptance criteria shall be in accordance with H.4.4.

Individual readings shall not exceed the acceptance criteria specified in H.4.4.

H.7.3.3.2

Add item d) to list

- d) If specified, the hardness indentation shall be in accordance with API Standard 2RD Figure 1 or DNVGL-ST-F101 Figure B-10.

H.7.3.3.3

Add item d) to list

- d) If specified, the hardness indentation shall be in accordance with API Standard 2RD Figure 1 or DNVGL-ST-F101 Figure B-10.

H.7.5 HIC/SWC Retests

Delete first paragraph

Add to section

H.7.5.1

If any HIC/SWC test fails during production, the pipe shall be rejected and retests to be as follows:

- a) one retest to be taken on two different pipes from the same heat/test unit as the failed pipe;
- b) providing both these tests give acceptable results, the heat to be considered acceptable;
- c) if either or both pipes fail during retest, the test unit to be rejected and further testing defined in H.7.5.2 to be performed.

Add new section

H.7.5.2

The pipes manufactured before and after the discarded test units shall be tested per heat, or where there are multiple test units per heat, then testing to be performed for each test unit as following.

- a) Two pipes from every preceding consecutive test unit/heat to be tested, until two pipes pass for three consecutive test units/heats.
- b) For pipes manufactured after the discarded test units, two pipes from each subsequent test unit/heat to be tested until two pipes pass for three consecutive test units/heats.

When required, reprocessing shall be in accordance with 10.2.11.

If the RCA required by H.7.3.1.4 points to a raw material issue, retest frequency based on heat may be more appropriate. In this case, alternate testing frequency shall be proposed for acceptance.

Add new section

H.7.6 SSC Retests

When SSC has been specified as a production test (see Table H.3), the following shall apply:

- a) if any SSC test fails, the pipe is to be rejected and one retest taken on two different pipes from the same test unit;

- b) if both tests pass, the entire test unit is to be reviewed for acceptance;
- c) if the SSC test fails on one or both pipes during retest, all pipes produced prior to the failed SSC test but after the last successful test are rejected.

In case of failure, RCA shall be performed by means of microstructure/metallographic examination.

The affected slab/billet shall be identified.

Pipe manufactured from the affected slab/billet, produced before and after the test unit, shall be tested to release production.

This shall also apply to H.7.5.

Annex J (normative) PSL 2 Pipe Ordered for Offshore Service

J.2 Additional Information to be Supplied by the Purchaser

Replace section with

Information to be supplied by the purchaser and options within this specification are covered in Tables J.8 and in the LPMDS.

Add new table

Table J.8—Additional Information to be Provided by Purchaser – Offshore Pipe

API Specification 5L, J.2 Item Number	Information Required	API Specification 5L Section or Table Number	Purchaser Requirements (per this specification, as referenced below)
b)	Ultrasonic inspection of strip or plate for laminar imperfections	J.3.3.2.4	J.3.3.2.4
m)	Hardness test of the pipe body seam weld and HAZ of EW and SAW pipe	Table J.7	Table J.7
n)	Hardness testing of pipe body for SMLS pipe	Table J.6	Table J.6
o)	CTOD testing	J.8.2.2 and Table J.6	Table J.6 (Table 18)
q)	Additional longitudinal tensile testing for deep-water pipelay	Table J.6, footnote d	Table J.6 and J.4.2.1.1
r)	Deviation from hardness test	J.8.3.2.2 c) and J.8.3.2.3	As per LPMDS
s)	Deviation from location of hardness test	J.8.3.2.2.c)	As per LPMDS
t)	For pipe with $t \geq 5.0$ mm (0.197 in.), ultrasonic inspection for laminar imperfections within extended length of 100 mm (4.0 in.) at the pipe ends	K.2.1.3	K.2.1.3
u)	Supplementary end NDT lamination criteria	K.2.1.3 and K.2.1.4	K.2.1.3 and LPMDS
x)	Verification of lamination size/density	K.3.2.2	K.3.2.2
aa)	Ultrasonic inspection of SMLS pipe for the detection of transverse imperfections	K.3.4.1	K.3.1
ee)	Acceptance Level U2/U2H for non-destructive inspection of the weld seam of HFW pipe	K.4.1	K.4.1
ff)	Alternate ISO 10893-10 HFW weld seam UT acceptance criteria	K.4.1 b)	K.4.1

Table J.8 (continued)

gg)	Ultrasonic inspection of the pipe body of HFW pipe for laminar imperfections	K.4.2	K.4.2
hh)	Ultrasonic inspection of the strip/plate edges or areas adjacent to the weld for laminar imperfections	K.4.3	K.4.3
jj)	Use of fixed-depth notches for equipment standardization	K.5.1.1 c)	Not applicable
kk)	Radiographic inspection of the pipe ends (non-inspected pipe ends) and repaired areas	K.5.3 a)	K.5.3
mm)	For grades L625QO or X90QO, and L690QO or X100QO, a lower $Rt0.5/Rm$	Table J.2	J.4.2

J.3 Manufacturing

J.3.3 Pipe Manufacturing

J.3.3.1 SMLS Pipe

Replace first sentence with

SMLS pipe shall be manufactured from continuously cast (strand cast) steel.

When accepted prior to manufacture, ingot steel shall be an accepted alternative.

When the process of cold finishing is used, this shall be stated in the inspection document.

J.3.3.2.2

Replace section with

For HFW pipe, the abutting edges of coil or plate shall be machined or milled shortly before welding.

Final edge preparation by shearing shall not be permitted.

J.3.3.2.4

Replace section with

Coil and plate shall be inspected ultrasonically for laminar imperfections or mechanical damage in accordance with Annex K.

Full body UT of HFW pipe after forming shall be permitted.

J.3.3.2.6

Replace section with

Tack welding shall be in accordance with 8.4.

J.4 Acceptance Criteria

J.4.1

Add new section

J.4.1.3 Chemical Composition

Hydrogen content shall be no greater than 2 ppm (parts per million) by ladle analysis.

Add new section

J.4.1.4

The permissible ranges stated in Table 28 shall apply to pipe of all thicknesses.

Add to section

J.4.1.5

The maximum percentages of residual elements shall be as follows:

- a) $\text{Sn} \leq 0.020 \%$;
- b) $\text{Sb} \leq 0.010 \%$;
- c) $\text{Bi} \leq 0.010 \%$;
- d) $\text{Pb} \leq 0.010 \%$;
- e) $\text{As} \leq 0.020 \%$.

Residual elements shall be tested for on the finished product, unless a ladle analysis has been performed and certification has been issued.

J.4.2 Tensile Properties

J.4.2.1

Delete section

Add new section

J.4.2.1.1

The tensile properties shall be in accordance with Table J.2, with the following amendments:

- a) maximum yield to tensile ($R_{t0.5}/R_m$) ratio in the transverse direction to be 0.90 for grades up to X56, and 0.92 for grades X60/L415 and above, unless otherwise specified;
- b) ($R_{t0.5}/R_m$) ratio in the longitudinal direction not to exceed 0.93 unless otherwise agreed;
- c) a tensile test to be performed in the transverse direction (whenever pipe size allows it) and longitudinal direction;
- d) maximum yield strength to be the specified minimum yield strength + 120 MPa;

- e) actual yield strength range to be ≤ 100 MPa;
- f) for welded pipe, tensile properties in the longitudinal direction have the same acceptance criteria as required for the transverse direction, except that the minimum longitudinal tensile strength to be 95 % of the specified minimum transverse tensile strength.

The test frequency to be same as the transversal test (see table J.6).

Unless otherwise specified, a stress-strain curve shall be produced for the first five heats.

When specified, the data shall be supplied in native data formats for importing into a spreadsheet file.

The full stress-strain curve shall be reported.

Add new section

J.4.2.1.2

If specified, a circumferential compression test in accordance with ASTM E9 shall be performed to assess or confirm the σ_{fab} value (refer to DNVGL-ST-F101:2017, 5.3.3.7).

Testing shall be performed during MPQT and if required, as a production test with the same frequency as the tensile test production test.

A compressive stress-strain curve shall be developed.

The units used on each axis of each compressive stress-strain curve shall be clearly identified.

The compressive stress-strain curves shall cover a range of at least -2.0 % strain.

J.4.3 Hardness Test

Replace section with

Acceptance criteria shall be in accordance with 9.18.

J.4.4

Add new section

For a set of three test pieces, the minimum average absorbed energy for each pipe body test shall be in accordance with Table J.9, based upon full-size test pieces and a test temperature in accordance with Table 29.

Add new table

Table J.9—CVN Absorbed Energy Requirements for Pipe Body of PSL 2 Pipe

Specified Outside Diameter <i>D</i> mm (in.)	Full-size CVN Absorbed Energy, min KV J (ft·lbf)						
	Grade						
	≤ L415 or X60	> L415 or X60 to ≤ L450 or X65	> L450 or X65 to ≤ L485 or X70	> L485 or X70 to ≤ L555 or X80	> L555 or X80 to ≤ L625 or X90	> L625 or X90 to ≤ L690 or X100	> L690 or X100 to ≤ L830 or X120
≤ 508 (20.000)	54 (40)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)
> 508 (20.000) to 762 (30.000)	54 (40)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)
> 762 (30.000) to 914 (36.000)	54 (40)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)
> 914 (36.000) to 1219 (48.000)	54 (40)	60 (44)	60 (44)	60 (44)	60 (44)	60 (44)	68 (50)
> 1219 (48.000) to 1422 (56.000)	54 (40)	60 (44)	60 (44)	60 (44)	60 (44)	68 (50)	81 (60)
> 1422 (56.000) to 2134 (84.000)	54 (40)	68 (50)	68 (50)	68 (50)	81 (60)	95 (70)	108 (80)
NOTE Only one test piece is allowed to have an individual value less than the minimum average value.							

J.6 Tolerances for Diameter, Wall Thickness, Length and Straightness

J.6.1

Replace section with

Diameter and out-of-roundness shall be within the tolerances given in Table J.3.

For welded pipes, the out-of-roundness shall include the peaking effect.

If level A or level B is specified, Table J.10 shall apply.

If specified, the following requirements shall apply:

- Out-of-roundness and pipe end diameter shall be measured against the ID;
- Actual nominal ID shall be established, with measurements on the first 20 -100 production pipes;
- The OD out-of-roundness requirements at pipe ends shall be maintained.

J.6.2

Replace section with

The wall thickness shall be within the tolerances given in Table J.4 with the following amendments:

a) For SMLS pipe, the under tolerance shall be $-0.1t$

b) Table J.4 footnote "b" shall not apply.

If specified, Table J.11 additional restrictions shall apply.

Add new table

Table J.10—Premium Tolerances for Diameter and Out-of-roundness

Specified Outside Diameter <i>D</i> mm (in.)	Diameter mm (in.)				Out-of-roundness ^d mm (in.)	
	Pipe body ^a		Pipe end ^{b,c}		Pipe body ^b	Pipe end ^c
	SMLS	Welded pipes	SMLS	Welded pipes		
< 60.3 (2.37)	±0.5 (0.02) or ±0.0075 <i>D</i> , whichever is greater	±0.5 (0.02) or ±0.0075 <i>D</i> , whichever is greater, but max. ±3.2 (0.125)	Level A ^g ±0.5 (0.02) Level B ±0.5 (0.02) or ±0.005 <i>D</i> , whichever is greater, but max. ±1.2 (0.048) for SAW pipes ±1.0 (0.040) for SMLS and HFW pipes		Included in the diameter tolerance	
60.3 (2.37) ≤ <i>D</i> ≤ 610 (24.02)					Level A Welded pipes: 0.0075 <i>D</i> max 4 (0.156) Seamless pipes: 0.012 <i>D</i> Level B 0.015 <i>D</i> but max. 8 (0.31) ^f	Level A ^g Welded pipe: 0.005 <i>D</i> max 2.0 (0.079) Seamless pipes: Max 1 (0.040) Level B Welded pipes: 0.01 <i>D</i> but max. 4.5 (0.177) ^f Seamless pipes: 2 (0.079)
610 (24.02) < <i>D</i> ≤ 1422 (55.98)	±0.01 <i>D</i>	±0.005 <i>D</i> , but max. ±4.0 (0.156)	Level A ^{g)} ±0.5 (0.02) Level B ±1.2 (0.048) for SAW pipes ±1.0 (0.040) for SMLS and HFW pipes		0.01 <i>D</i> but max. 8 (0.31) ^f	0.0075 <i>D</i> but max. 5 (0.20) ^f
> 1422 (55.98)	To be agreed					

^a Dimensions of pipe body to be measured approximately in the middle of the pipe length.

^b For SMLS pipe, the tolerances apply for *t* ≤ 25.0 mm (0.98 in.), and the tolerances for heavier wall pipe shall be as agreed with the purchaser.

^c The pipe end includes a length of 100 mm (3.94 in.) at each of the pipe extremities

^d For welded pipes, the out of roundness shall include the peaking effect.

^e For expanded pipe with *D* ≥ 219.1 mm (8.625 in.) and for non-expanded pipe, the diameter tolerance and the out-of-roundness tolerance may be determined using the calculated inside diameter (the specified outside diameter minus two times the specified wall thickness) or measured inside diameter rather than the specified outside diameter (refer to API Specification 5L, 10.2.8.3).

^f For pipe with both *D* > 610 mm (24 in.) and *D/t* >75, the tolerances shall be agreed between the manufacturer and the purchaser.

^g Level A: Machining to achieve tolerances is acceptable.

Add to section

If pipe end machining is required, DNVGL-ST-F101:2019, 7.2.3.39 requirements shall be applied.

When required, pipe end rectification (e.g. cold end sizing - see section 8.9) shall be applied to achieve diameter and out-of-roundness tolerance, subject to review and acceptance of the rectification procedure.

NOTE Premium level tolerances are recognized to be stringent and generally specified for critical applications such as, fatigue sensitive risers and flowlines and deep water pipe lines.

Add new table**Table J.11—Premium Tolerances for Wall Thickness**

Wall Thickness t mm (in.)	Tolerances Level A mm (in.)	Tolerances Level B mm (in.)
SMLS Pipe		
≥ 25.0 (0.984)	+ 2.0 (0.079) - 2.0 (0.079)	+ 3.0 (0.120) - 3.0 (0.120)
SAW Pipe		
> 6.0 (0.236) to 10.0 (0.394)	± 0.6 (0.028)	± 0.6 (0.028)
> 10.0 (0.394)	± 1.0 (0.039)	± 1.0 (0.039)

Add new section**J.6.5**

There shall be no pitting nor imperfections with depth ≥ 0.7 mm on the outer surface of the pipe for a distance of 200 mm (8 in.) from each pipe end.

The visual surface finish of the pipe measured during the MPQT shall be the agreed surface finish for all production pipes.

J.7 Tolerances for the Weld Seam**J.7.1 Radial Offset of Strip/Plate Edges**Replace Table J.5 with**Table J.5—Maximum Permissible Radial Offset for SAW Pipe**

Specified Wall Thickness t mm (in.)	Maximum Permissible Radial Offset mm (in.)
≤ 15.0 (0.512)	1.3 (0.051)
> 15 (0.512)	1.5 (0.059)

J.7.3 SAWL Weld Seam

Add to section

The outside weld bead of SAWL pipe shall be removed for a distance of 200 mm (8.0 in.) from each pipe end by grinding.

The removal shall not extend above the adjacent pipe surface by more than 0.5 mm (0.020 in.).

For the remainder of the pipe length, the outside weld bead height above the prolongation of the original surface of the pipe shall be within 0.5 mm (0.02 in.) and 3.5 mm (0.14 in.), regardless of the wall thickness.

J.8 Inspection

J.8.1 Specific Inspection

Add to section

The test unit definition of Table 18 shall be amended to: "Unless otherwise specified, a test unit is defined as a pipe lot coming from same size, same heat number and consist of a maximum of 50 pipes".

Replace Table J.6 with

Table J.6—Inspection Frequency

Item No	Type of Inspection	Type of Pipe	Frequency of Inspection
1	Tensile testing of the pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio ^a
2	Tensile testing of the longitudinal or helical-seam weld of welded pipe	Welded pipes	Once per test unit of pipes with the same cold-expansion ratio ^{a, b}
3	CVN impact testing of the pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio ^a
4	CVN impact testing of the longitudinal or helical-seam weld of welded pipe	Welded pipes	Once per test unit of pipes with the same cold-expansion ratio ^{a, b}
5	Hardness testing of pipe body and of the longitudinal or helical-seam weld and HAZ of welded pipe	All pipes	Once per test unit of pipes with the same cold-expansion ratio ^{a, b}
6	Non-destructive inspection	All pipes	As per Annex K
7	Pipe diameter and out of roundness	All pipes	First 10 pipes, then once per test unit of no more than 20 pipes but no less than once per 4-hour operating shift plus whenever any change of pipe size occurs during the operating shift If specified, each pipes end shall be measured If specified, each pipe end measurement shall be recorded.
8	Wall thickness measurement	All pipes	Each pipe If specified, each pipe end measurement shall be recorded.
9	Pipe body dimensional testing, squareness, magnetism	All pipes	5 pipes per shift (recorded)
10	Straightness	All pipes	5 pipes per shift (recorded) If specified for fatigue services, straightness shall be measured and recorded on 100 % of pipes
^a Increase or decrease in the cold-expansion ratio of more than 0.002 requires the creation of a new test unit. ^b In addition, pipe produced by each welding machine shall be tested at least once per week. NOTE: Table J.6 modifies requirements of Table 18.			

J.8.3 Test Methods

J.8.3.1 CTOD Testing

Add to section

CTOD testing shall be in accordance with 10.2.3.8 and 10.2.4.10.

J.8.3.2 Hardness Test

Add to section

Hardness testing shall be in accordance with 10.2.5.5

Replace Table J.7 with

Table J.7—Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests

Type of Pipe	Sample Location	Type of Test	Number, Orientation, and Location of Test Pieces per Sample ^a		
			Specified Outside Diameter		
			D mm (in.)		
			< 219.1 (8.625)	≥ 219.1 (8.625) to < 508 (20.000)	≥ 508 (20.000)
SMLS, not cold-expanded [see API Specification 5L, Figure 5 a)]	Pipe body	Tensile	1L ^b	1L + 1T	1L + 1T
		CVN	3T	3T	3T
		Hardness	3T	3T	3T
SMLS, cold-expanded [see API Specification 5L, Figure 5 a)]	Pipe body	Tensile	1L ^b	1L + 1T	1L + 1T
		CVN	3T	3T	3T
		Hardness	3T	3T	3T
HFW [see API Specification 5L, Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1L + 1T180	1L + 1T180
		CVN	3T90	3T90	3T90
		Hardness	1T90 + 1T180	1T90 + 1T180	1T90 + 1T180
	Seam weld	Tensile	—	1W	1W
		CVN	3W + 3HAZ	3W + 3HAZ	3W + 3HAZ
		Hardness	1W	1W	1W
	Pipe body and weld	Flattening	As shown in API Specification 5L, Figure 6		
SAWL [see API Specification 5L, Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1L + 1T180	1L + 1T180
		CVN	3T90	3T90	3T90
		Hardness	1T90 + 1T180	1T90 + 1T180	1T90 + 1T180
	Seam weld	Tensile	—	1W	1W
		CVN ^c	3W + 6 HAZ	3W + 6 HAZ	3W + 6 HAZ
		Guided-bend	2W	2W	2W
		Hardness	1W	1W	1W
SAWH [see API Specification 5L, Figure 5 c)]	Pipe body	Tensile	1L ^b	1L + 1T	1L + 1T
		CVN	3T	3T	3T
		Hardness	1T90 + 1T180	1T90 + 1T180	1T90 + 1T180
	Seam weld	Tensile	—	1W	1W
		CVN ^c	3W + 6 HAZ	3W + 6 HAZ	3W + 6 HAZ
		Guided-bend	2W	2W	2W
		Hardness	1W	1W	1W

^a Refer to API Specification 5L, Figure 5 for an explanation of the symbols used to designate orientation and location.

^b Full-section longitudinal test pieces shall be used as far as possible.

^c Charpy HAZ testing to be as per 10.2.3.3 (HAZ= 1 set FL and 1 set FL2 with additional set for *t* > 25 mm (0.98 in.)).

Annex K (normative)

Nondestructive Inspection for Pipe Ordered for Sour Service, Offshore

K.1 Introduction

Add to section

This annex shall also apply to pipe that is ordered for fatigue service.

K.2 General Nondestructive Testing Requirements and Acceptance Criteria

K.2.1 Laminar Imperfections at the Pipe Ends

K.2.1.1

Add to section

If specified, laminar imperfections $> 3.2 \text{ mm}$ (0.125 in.) in any direction shall be classified as a defect.

Delete section

K.2.1.2

Replace K.2.1.3 with

K.2.1.3

Replace first paragraph with

For pipe with $t \geq 5.0 \text{ mm}$ (0.197 in.), UT shall be carried out at the pipe ends, in accordance with ISO 10893-8, to verify freedom from laminar defects.

Scanning shall be performed over a distance of $[3.5t + 25 \text{ mm}$ (0.98 in.)] or 100 mm (4.0 in.), whichever is greater, from the point where the outside surface meets the pipe end face or bevel.

Pipe end UT shall be performed before beveling.

Scanning shall be performed from the inside of the pipe if the end has been beveled.

If specified, a longer distance from the pipe ends shall be scanned.

K.2.1.4

Replace section with

The end face/bevel at each pipe end shall be magnetic particle inspected, in accordance with ISO 10893-5 or ASTM E709, for the detection of laminar imperfections.

The end face/bevel shall be free of indications.

K.2.2 Suspect Pipe

K.2.2.4

Replace section with

When dressing is carried out, complete removal of defects shall be verified by local visual inspection and by an NDT method in accordance with C.2.3.

Add new section

K.2.3 Acceptance Criteria, Inspection Reference Standards and Sensitivity

K.2.3.1 Acceptance Criteria

Acceptance criteria shall be in accordance with Tables K.1, Laminar Defects, and Table K.2, Angle Beam Scans.

For laminar defects, the Inspection Level shall be as specified.

K.2.3.2 Reference Standards and Sensitivity

Reference standards shall contain the reference reflectors stated in the following tables:

- HFW Seam: Table K.3.1;
- SAW Seam: Table K.3.2;
- SMLS Pipe: Table K.3.3;
- Plate/Coil: Table E.7.4.

Reference reflectors shall be used to establish sensitivity in accordance with Table K.4 and be detected under normal NDT operating conditions.

Add new table

Table K.2—Acceptance Limit, EMI, and UT Angled Beam Scans

Technique	Application	Acceptance Limit ^a			
		N5 NOTCH ^c	SDH ^d (AUT Only)	Perpendicular FBH ^{b, d} (AUT Only)	RDH ^e
AUT and EMI	HFW SEAM & HAZs	100 % PRL	n/a	If specified, 100 % PRL 3.0 mm (0.12 in.)	n/a
	SAW SEAM& HAZs	100 % PRL	100 % PRL 3.2 mm (0.125 in.)	If specified, 100 % PRL 3.0 mm (0.12 in.)	100 % PRL 1.6 mm (0.063 in.)
	SMLS PIPE	100 % PRL	n/a	n/a	100 % PRL 1.6 mm (0.063 in.) (for EMI only)
	All	Cracks are unacceptable, irrespective of amplitude			

^a Expressed as a percentage of PRL established using the applicable reference reflector.

^b As defined in Table K.2.1 and K.2.2.

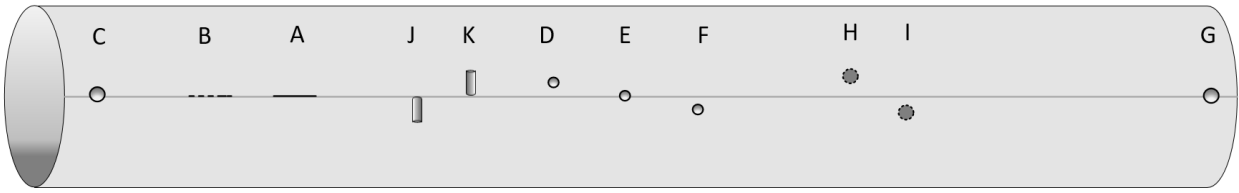
^c For Longitudinal and Transverse detection for SAWL and SMLS, and Longitudinal only for HFW.

^d For longitudinal detection.

^e For transverse detection.

Add new table**Table K.3.1—HFW Seam: Reference Reflectors**

Reference Reflectors ^b				
WELD SEAM N5 NOTCHES ^c		RDH ^{d, e, f, h}	RADIAL FBH ^{a, d}	PERPENDICULAR FBH (If specified) ^{d, g}
OD	ID			
One	One	Five	Two	Per Footnote ^g
Reflector Identification				
A	B	C, D, E, F, G	H, I	J, K



Note This is an illustration and the drawing is not to scale.

^a Lamination check shall be performed with a 6.4 mm (0.250 in.) diameter FBH, drilled from the ID in radial direction located in the HAZ and/or parent metal on each side of the weld seam with a depth of 50 % wall thickness to satisfy the requirements of K.4.3.

^b Reference reflectors shall be sufficiently separated from each other and from any joints or edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically.

^c All notches shall be N5, rectangular section. Longitudinal, at and parallel to the weld axis.

- Depth: 5 %*t*; minimum of 0.3 mm (0.012 in.); tolerance ±15 % of depth or ±0.05 mm (0.012 in.), whichever is greater.
- Length at full depth: maximum 25 mm (1.0 in.). Alternative notch length may be specified.
- Width: maximum 1 mm (0.04 in.).
- The OD and ID notches shall be as close to the pipe center as practicable.

^d Drilled hole dimensions are based upon standard drill-bit sizes.

^e RDH: Three 1.6 mm (0.063 in.) diameter radially drilled holes, one centered on the fusion line for confirmation purposes, and one on each side of the weld fusion line, within 3.2mm of the weld fusion line. If footnote g is applied, the RDHs on either side of the fusion line are not required but the RDH centered on the fusion line is required.

^f RDH – Seam: Two 3.0 mm (0.12 in.) at pipe ends to represent the maximum extent of automated NDT coverage of the length of the seam (also see E.3.2.1).

^g If specified or at the discretion of the supplier, 3.2 mm (0.125 in) diameter FBHs, drilled perpendicular to the weld fusion line (within ±1° of normal to the fusion line), end faces at the weld fusion line; one of each pair facing clockwise, one of each pair facing counterclockwise. Locations shall be per table below:

NOMINAL THICKNESS <i>t</i> mm (in.)	FBH
$t \leq 18$ (0.7)	One pair centered at 50 % of <i>t</i>
18 (0.7) $< t \leq 24$ (0.94)	Two pairs centered at 40 % and 60 % of <i>t</i>
$t > 24$ (0.94)	To be agreed with the purchaser in advance of NDT

^h For AUT qualification (See Appendix 3), an additional 3.0 mm RDH shall be placed in the weld seam at the mid-length position. This hole and those listed in footnote f will be used to demonstrate the axial consistency of the AUT unit.

Add new table

Table K.3.2—SAW Seam: Reference Reflectors

REFERENCE REFLECTORS ^{a, b}								
N5 NOTCHES ^c				SDH ^{f, g}	RDH ^{f, h, i, j, m}	RADIAL FBH ^{a, f}	FBH	
Longitudinal ^d		Transverse ^e		Longitudinal	Vertical		Longitudinal ^{f, k}	Transverse ^{f, l}
OD	ID	OD	ID	Embedded			Embedded	Embedded
3	3	1	1	SDH Per footnote ^g	5	2	Per footnote ^k	Per footnote ^l
Reflector Identification								
A, B, C	D, E, F	G	H	I	J, K, L, M, N	O, P	Q, R	S, T

Note This is an illustration and the drawing is not to scale.

^a If specified, lamination check shall be performed with a 6.4 mm (0.250 in.) diameter FBH, drilled from the ID in radial direction located in the HAZ and/or parent metal on each side of the weld seam with a depth of 50 % wall thickness to satisfy the requirements of K.5.2.2.

^b Reference reflectors shall be sufficiently separated from each other and from any joints or edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically.

^c All notches shall be N5, rectangular section:

- Depth: 5 %*t*; minimum of 0.3 mm (0.012 in.), maximum 2.0 mm (0.08 in.); tolerance ± 15 % of depth or ± 0.05 mm (0.002 in.), whichever is greater.
- Length at full depth: maximum 25 mm (1.0 in.). Alternative notch length may be specified.
- Width: maximum 1 mm (0.04 in.).

^d N5 Notches, longitudinal, located in the HAZs parallel to the weld axis, one on each side of the weld, and one on the weld centerline.

^e N5 Notches - Transverse – perpendicular to the weld and on the weld centerline. If the weld is capped, the manufacturer may elect to grind both the internal and external weld reinforcements to match the pipe contour in the immediate area and on both sides of the notches.

^f Drilled hole dimensions are based upon standard drill-bit sizes

^g SDH: all 3.2 mm (0.12 in.) diameter, longitudinal, located along the weld centerline drilled parallel to the weld axis within $\pm 1^\circ$. Number of pairs of reference reflectors, $N = ((t/8)-1) \uparrow$ (rounded up); evenly distributed through the weld depth. Depths are measured from pipe outer surface to SDH centerline. For example:

- Pipe Thickness, *t* = 12 mm (0.47 in.), Number of SDH, *N* = 1, Depth = 6 mm (0.24 in.).
- Pipe Thickness, *t* = 20 mm (0.79 in.), Number of SDH, *N* = 2, Depths = 6.7 mm (0.26 in.) and 13.3 mm (0.52 in.).
- Pipe Thickness, *t* = 30 mm (1.18 in.), Number of SDH, *N* = 3, Depths = 7.5 mm (0.30 in.), 15.0 mm (0.60 in), 22.5 mm (0.885 in.).

^h RDH: Two 3.2 mm (0.125 in.) diameter holes located at the weld toes. The RDH centerline shall be at least 1.6mm from the weld toe of the widest cap (i.e. the reflector should be the farthest away from weld centerline). For setting defect gate lengths/assuring coverage.

ⁱ RDH: Two 3.2 mm (0.125 in.) diameter, located on the weld centerline. One at each pipe end, representing the maximum extent of automated NDT coverage of the length of the seam. These shall also be used to demonstrate the accuracy and consistency of the alignment of the automated weld seam tracking system.

^j RDH: One 1.6 mm (0.063 in.) diameter, through drilled hole at weld centerline. Used for acceptance criteria.

^k If specified or at the discretion of the supplier, 3.2 mm (0.12 in.) diameter FBHs, drilled perpendicular to the weld fusion line (within $\pm 1^\circ$ of normal to the fusion line), end faces at the weld fusion line; one of each pair facing clockwise, one of each pair facing counterclockwise. Number of pairs of reference reflectors, $N = ((t/8)-1) \uparrow$ (rounded up); evenly distributed through the weld depth. Depths are measured from pipe outer surface to FBH centerline at end/SDH centerline. For example:

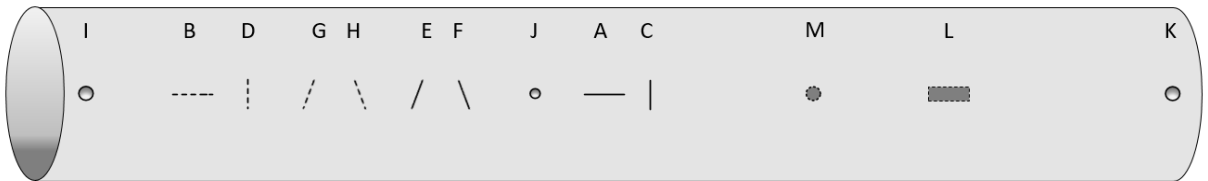
- Pipe Thickness, *t* = 12 mm (0.47 in.), Number of Pairs, *N* = 1, Depth = 6 mm (0.24 in.).
- Pipe Thickness, *t* = 20 mm (0.79 in.), Number of Pairs, *N* = 2, Depths = 6.7 mm (0.26 in.) and 13.3 mm (0.52 in.).
- Pipe Thickness, *t* = 30 mm (1.18 in.), Number of Pairs, *N* = 3, Depths = 7.5 mm (0.30 in.), 15.0 mm (0.60 in.), 22.5 mm (0.885 in.).

^l If specified or at the discretion of the supplier, 3.2 mm (0.125 in.) diameter FBH drilled from the ID at 45° to the weld axis (within $\pm 1^\circ$ in the radial/axial plane); one facing forward, one backwards. Drilled to 0.5 *t* depth.

^m For AUT qualification (See Appendix 3), an additional 3.0 mm RDH shall be placed in the weld seam at the mid-length position. This hole and those listed in footnote ⁱ will be used to demonstrate the axial consistency of the AUT system.

Add new table

Table K.3.3—SMLS Pipe: Reference Reflectors

Reference Reflectors ^b								
N5 Pipe Body Notches ^c						RDH ^{f, g, h, j}	Wall Reduction ⁱ	FBH ^{a, f}
Longitudinal		Transverse		Oblique ^{c, e}				
OD ^d	ID	OD	ID	OD	ID			
1	1	1	1	2	2	3	1	1
Reflector Identification								
A	B	C	D	E, F	G, H	I, J, K	L	M
								
Note This is an illustration and the drawing is not to scale.								

^a Lamination check shall be performed with two 6.4 mm (0.250 in.) diameter FBH, drilled from the ID in radial direction with a depth of 25 % and 50 % wall thickness to satisfy the requirements in K.3.2.1 and K.3.2.2.

^b Reference reflectors shall be sufficiently separated from each other and from any joints or edges in the reference standard such that indications from the reference reflectors can be properly identified, resolved and measured ultrasonically.

^c All notches shall be N5, rectangular section:

- Depth: 5 %t; not necessarily less than 0.3 mm (0.012 in.); tolerance ±15 % of depth or ±0.05 mm (0.002 in.), whichever is greater.
- Length at full depth: maximum 25 mm (1.0 in.). Alternative notch length may be specified.
- Width: maximum 1 mm (0.04 in.).

^d The pipe body OD longitudinal N5 notch shall be parallel to the pipe axis and placed as close as practicable to the center of the pipe length.

^e For OD and ID oblique pipe body N5 notches, one of each shall be included as follows:

- 1) One oblique angled in the positive direction to the pipe axis by the maximum rolling angle defined by the manufacturer.
- 2) One oblique angled in the negative direction to the pipe axis by the maximum rolling angle defined by the manufacturer.

If specified, the oblique angle shall be determined using notched billet.

^f Drilled hole dimensions are based upon standard drill-bit size.

^g RDH: One 1.6 mm (0.063 in.) diameter hole in the pipe body for EMI acceptance criteria, and for detection purposes only for AUT.

^h Two 3.2 mm (0.125 in.) diameter holes, one at each end representing the maximum extent of automated NDT coverage of the length of the pipe.

ⁱ The pipe shall also contain an area of known/specified thickness [tolerance ±0.01 mm (0.0003 in.)] for the calibration of pipe wall thickness measurement.

^j For AUT qualification, an additional 3.0 mm RDH shall be placed in the pipe body at the mid-length position. This hole and those listed in footnote g will be used to demonstrate the axial consistency of the AUT system.

Add new table

Table K.4—UT and EMI Sensitivities

Technique	Application	Scans	Reference Reflector	PRG	PRL	SS	RL a
AUT and EMI	Plate/Coil, Pipe for laminations	Normal (0°) ^b	6.4 mm (0.250 in.) diameter FBH If specified, 3.2 mm (0.125) diameter FBH	100 % DAC/TCG	PRG+ TC	PRL	PRL-6dB (50 % PRL)
	SAW Seam & HAZs	Angled Beam ^c	N5 Notch				
			3.2 mm (0.125 in.) SDH				
			If specified, 3.2 mm (0.125 in.) Perpendicular FBH				
			1.6 mm (0.063 in.) RDH ^e				
	HFW Seam & HAZs	Angled Beam ^d	N5 Notch				
			If specified, 3.2mm (0.125 in.) Perpendicular FBH				
MUT	SMLS Pipe	Angled Beam	N5 Notch	100 % DAC/TCG	PRG+ TC	PRL	PRL-6dB (50 % PRL)
			1.6 mm (0.063 in.) RDH (for EMI only)				
MUT	All	All	All as above			PRL+ 6 dB ^e	

^a All relevant recordable indications shall be evaluated against the acceptance limits (see E.5.5).
^b For plate and coil, sensitivity may be established using DGS system.
^c N5 notches and 3.2 mm (0.125 in.) SDH shall be used to establish sensitivity. For some scans, it might be necessary to establish the DAC/TCG using both types of reflector.
^d For MUT, 6 dB shall be added for scanning but should be removed prior to evaluation of indications against the acceptance criteria. This requirement does not apply to E.5.8.
^e For transverse scans only.
 All footnotes shall apply unless otherwise specified.

K.3 Nondestructive Inspection of SMLS pipe

Replace section K.3.1 title with

K.3.1 Ultrasonic Inspection for Longitudinal and Transverse Imperfections

Replace section with

SMLS pipe shall be subject to 100 % AUT in accordance with E.3.1.2 and ISO 10893-10.

K.3.2 Laminar Imperfections in the Pipe Body

K.3.2.1

Add to section

Ultrasonic inspection scanning coverage shall be 100% of the pipe surface.

K.3.2.2Add to section

The ultrasonic inspection scanning coverage shall be 100 % of the area of the pipe.

Replace Table K.1 with**Table K.1—Acceptance Criteria for Laminar Imperfections**

Service Condition	Maximum Individual Imperfection		Minimum Imperfection Size Considered			Maximum Population Density a
	Area mm2 (in.2)	Length mm (in.)	Area mm2 (in.2)	Length mm (in.)	Width mm (in.)	
Pipe Body (or strip/plate body)						
Level 1 : Offshore and longitudinal plastic strain capacity	1000 (1.6)	Not specified	300 (0.5)	35 (1.4)	8 (0.3)	10 [per 1.0 m (3.3 ft) ´ 1.0 m (3.3 ft) square] b
Level 2 : Sour	500 (0.8)		150 (0.2)	15 (0.6)	8 (0.3)	10 [per 500 mm (1.6 ft) ´ 500 mm (1.6 ft) square] c
Level 3 : Sour	100 (0.16)		30 (0.05)	5 (0.2)	5 (0.2)	5 [per 500 mm (1.6 ft) ´ 500 mm (1.6 ft) square] c
Strip/Plate Edges or Areas Adjacent to the Weld Seam d						
Sour, fatigue, offshore or longitudinal plastic strain capacity (Levels 1 & 2)	100 (0.16)	20 (0.8)	—	10 (0.4)	—	3 [per 1.0 m (3.3 ft) length]
Level 3: Sour	32 (0.05)	6.4		6.4		3 [per 1.0 m (3.3 ft) length]
NOTE 1 For an imperfection to be larger than the minimum imperfection size, each of the minimum area, minimum length and minimum width given for the pipe body (or strip/plate body) have to be exceeded.						
NOTE 2 For the purpose of determining the extent of a suspect area, adjacent suspect areas separated by less than the smaller of two minor axes of the areas shall be considered as one area.						
NOTE 3 Acceptance Level shall be as specified.						
a Number of imperfections smaller than the maximum and greater than the minimum imperfection size.						
b For pipe with <i>D</i> < 323.9 mm (12.375 in.) or strip/plate widths less than 1000 mm (39.4 in.), the maximum population density is referred to 1.0 m ² (10.8 ft ²).						
c For pipe with <i>D</i> < 168.3 mm (6.625 in.) or strip/plate widths less than 500 mm (19.7 in.), the maximum population density is referred to 0.25 m ² (2.7 ft ²).						
d The maximum imperfection area of edges is the product of the maximum imperfection length, where length is the dimension parallel to the material edge and the transverse dimension. An imperfection is considered to be larger than the maximum imperfection size if either the length or the transverse dimension is exceeded.						

K.4 Nondestructive Inspection of HFW Pipe

K.4.1 Nondestructive Inspection of the Weld Seam

Replace section with

HFW weld seams shall be subject to 100 % ultrasonic inspection.

K.4.2 Laminar Imperfections in the Pipe Body

Replace section with

The pipe or strip/plate body shall be ultrasonically inspected for the detection of laminar imperfections.

Ultrasonic inspection scanning shall be performed on 100 % of the surface area of the plate/coil or pipe body in accordance with the following:

- a) ISO 10893-9, if performed prior to pipe forming; or
- b) ISO 10893-8, if performed after seam welding.

Replace section K.4.3 title with

K.4.3 Laminar Imperfections on the Plate/Coil Edges or Areas Adjacent to the Weld Seam

Replace section with

For HFW pipes, ultrasonic inspection shall be used to verify that the zone along each side of the plate/coil edges or along each side of the weld seam is free of laminar imperfections.

Ultrasonic inspection shall be done along the entire edge up to:

- a) a distance from the edge, or
- b) the edge of the weld seam, of $[3.5t + 25 \text{ mm (0.98 in.)}]$ or 50 mm (1.97 in.), whichever is greater.

Ultrasonic inspection shall be performed in accordance with:

- a) ISO 10893-9, prior to pipe forming; or
- b) ISO 10893-8, after seam welding.

For HFW manufacturing, inspection for laminar imperfections shall be by coil edge ultrasonic inspection or full-body ultrasonic inspection.

Where ultrasonic inspection for laminar imperfections is performed on HFW pipe body instead of coil, the same edge criteria as above shall apply (see also Table K.1).

K.5 Nondestructive Inspection of SAW Pipe

K.5.1 Ultrasonic Inspection for Longitudinal and Transverse Imperfections in Seam Welds

K.5.1.1

Add to section

Ultrasonic inspection shall be carried out in accordance with E.3.1.1, with the following exceptions:

- a) Scanning to be performed for the detection of longitudinal and transverse imperfections.
- b) Scanning for longitudinal imperfections to be in accordance with Annex E.
- c) Scanning for transverse imperfections:
 - Scanning to be carried out in both axial directions (For = Forward, Rev = Reverse) using shear wave probes.
 - Scanning to be performed from the weld cap. where the roughness or profile of the weld cap prevents this, scanning may be carried out from the parent metal using probes in the K or X configuration. Where the presence of the weld cap prevents 100% coverage as required in E.3.1.1, the cap shall be dressed flush.

The manufacturer shall apply the provisions of E.5.6 to retest suspect areas.

K.5.2 Laminar Imperfections in the Pipe Body and on the Strip Edges

K.5.2.1

Replace first paragraph with

The pipe or strip/plate body shall be ultrasonically inspected for the detection of laminar imperfections in accordance with K.4.2.

K.5.2.2

Replace section with

For SAW pipes, ultrasonic inspection shall be used to verify the zone along each side of the plate/coil edges or the areas adjacent to the weld seam is free of laminar imperfections.

Inspection shall be in accordance with K.4.3.

Inspection shall be performed prior to pipe forming for SAWL.

K.5.3 Nondestructive Inspection of the Weld Seam at the Pipe Ends/Repaired Areas

Replace section with

For weld seams at the pipe ends that cannot be inspected by the automated ultrasonic inspection equipment or repaired areas of the weld seam (see C.4) shall be inspected by:

- a) AUT, SAUT or MUT for the detection of longitudinal and transverse imperfections using the same inspection sensitivity and parameters in accordance with K.5.1.1.

b) RT in accordance with E.4.

For SAW/COW pipe seams, indications exceeding the recording level (see Table K.4) shall be evaluated in accordance with the flowchart in Figure E.1.

Add new section

K.6 Plate Surface Inspection for Hard Surface Layer

If specified, the surface of thermo mechanically rolled plates for contact with the sour effluent, shall be inspected for the detection of surface hard layers.

Surface hard layer inspection equipment and procedures shall be subject to pre-production qualification trial that demonstrates ability to detect hard spots.

The procedure shall also address the following:

- Definition of blind zones;
- Inspection of blind zones in a grid pattern, or cropping of blind zones; and
- Grid dimensions.

A hardness increase due to cold forming and ageing, if applicable, shall be considered. This hardness increase shall be documented by the manufacturer and used to define the plate maximum acceptable hardness value. This surface hardness value measured on the plate surface shall not exceed 230Hv.

NOTE The qualification trial should include a statistical analysis of the frequency of hard spot occurrence and the NDE capability to detect it. Qualification of an NDE technique should show capability to ensure 100 percent of delivered thermo-mechanically controlled process (TMCP) steel plate is free of hard spots. Qualification of such a technique may vary and thus metallurgical and NDT specialists should be involved in this process.

Annex N (normative)

PSL 2 Pipe Ordered for Applications Requiring Longitudinal Plastic Strain Capacity

N.1 General

Replace first sentence

This annex specifies additional requirements for pipes ordered for applications with designs requiring longitudinal plastic strain capacity (resulting from single high strain event or accumulated strain) and reeled installations.

Add to section

These conditions apply to pipelines subjected to high strain, for onshore or offshore.

These requirements are additional to those specified for PSL 2 pipe for offshore service defined by ISO 3183, API Specification 5L, Annex J and this specification.

Replace note with

NOTE This annex does not contain guidance on the design of pipelines to withstand longitudinal strains (strain-based design); since the requirements for pipe and the required strain capacity for specific applications will vary the required properties are to be determined by the designer of the pipeline and unless the design mandates more stringent properties, the acceptance criteria stated in this annex shall apply; this annex provides a format for the purchaser of the pipe to specify properties that are known to affect the longitudinal strain capacity of pipelines.

N.2 Additional Information to be Supplied by the Purchaser

Replace section with

Information to be supplied by the purchaser and options within this specification are covered in Table N.8 and in the LPMDS.

Add new table**Table N.8—Additional Information to be Provided by Purchaser, Longitudinal Plastic Strain Capacity**

API Specification 5L, N.2 Item Number	Information Required	API Specification 5L Section or Table Number	Purchaser Requirements (per this specification, as referenced below)
b)	Ultrasonic inspection of strip or plate for laminar imperfections	N.3.3.2.4	N.3.3.2.4
h)	Requirements for longitudinal tensile properties	N.4.2.2	N.4.2.2
i)	Ageing conditions for longitudinal tensile test pieces and method of heating the sample	N.4.2.3	N.4.2.3
l)	Limit on the difference between the maximum and minimum values of actual longitudinal yield strength	N.4.2.6	N.4.2.6
p)	Use of inside diameter to determine diameter and out-of-roundness tolerances with $D \geq 219.1$ mm (8.625 in.)	Table N.2, Footnote c	N.6.1
q)	Hardness test of the pipe body of seamless, EW and SAW pipe and of the seam weld and HAZ of EW and SAW pipe	Table N.6	Table N.6 (ref Table J.6)
r)	CTOD testing	N.8.2.2 and Table N.6	J.8.3.1 (ref 10.2.3.8 and 10.2.4.10) and Table N.6 (ref Table 18)
t)	Alternatives to full-thickness strip test pieces for longitudinal testing of welded pipe	N.8.3.1	N.8.3.1
u)	The use of three hardness impressions at each through-thickness location	N.8.3.2.2 c)	As per LPMDS
v)	The use of an alternative distance from the weld line for parent metal hardness impressions for welded pipe	N.8.3.2.3 c)	As per LPMDS
w)	For pipe with $t \geq 5.0$ mm (0.197 in.), ultrasonic inspection for laminar imperfections within extended length of 100 mm (4.0 in.) at the pipe ends	K.2.1.3	K.2.1.3
y)	Ultrasonic inspection to verify conformance with the applicable requirements given in Table K.1	K.3.2.2	K.3.2.2
bb)	Acceptance Level L2/C or L2 for non-destructive inspection of the weld seam of HFW pipe	K.4.1	K.4.1
cc)	Ultrasonic inspection of the pipe body of HFW pipe for laminar imperfections	K.4.2	K.4.2
dd)	Ultrasonic inspection of the strip/plate edges or areas adjacent to the weld for laminar imperfections	K.4.3	K.4.3
ff)	Use of fixed-depth notches for equipment standardization	K.5.1.1 c)	Not applicable
gg)	Radiographic inspection of the pipe ends (non-inspected pipe ends and repaired areas)	K.5.3 a)	K.5.3

N.3 Manufacturing

N.3.1 Manufacturing Procedure

Replace section with

Add new section

N.3.1.1 Weldability Test

- e) If specified, weldability testing in accordance with AP2 shall also include toughness tests of the heat affected zone of girth welds.

NOTE Consider girth weld HAZ testing after strain and ageing.

Add new section

N.3.1.2 Welded Pipe

For welded pipes, longitudinal tensile and Charpy impact tests in the as-received condition, and after a heat treatment simulating thin-film coating shall be performed for the manufacturing procedure qualification.

The heat treatment shall consist of holding the temperature at 250 °C (480 °F) for a minimum of 10 minutes, unless otherwise specified.

Add new section

N.3.1.3 Strain Cycle Simulation – Application Other than Reeling

Excluding reeling applications, testing to qualify tensile and compressive strain capacity of the pipe by small-scale, medium-scale or full-scale testing shall be part of the qualification.

The samples shall then be artificially aged at 250 °C (480 °F) for one hour prior to testing, unless other artificial aging times and temperatures are agreed.

Add new section

N.3.1.4 Strain Cycle Simulation – Reeling

For reeling applications, accumulated straining simulation requirements shall be as follows:

- a) strain level 1: two cycles with ± 2.5 % plastic strain giving a total accumulated plastic strain of 10.0 %;
- b) strain level 2: two additional cycles, giving a total accumulated plastic strain of 20.0 %.

Two scenarios shall be tested independently.

The first straining cycle (strain level 1 + 2) shall start in tension and end in compression.

The second straining cycle (strain level 1 + 2) shall start in compression and end in tension.

The samples shall then be artificially aged at 250 °C (480 °F) for one hour prior to testing.

Simulation of reeling cycles shall be performed on full scale samples, or small scale specimens.

A detailed procedure shall be submitted to the purchaser.

Add new section

N.3.1.5 Additional Testing per MPQT Pipe

The following tests are applicable only for MPQT.

Add new section

N.3.1.5.1 Tensile Testing

A longitudinal and a transverse specimen shall be taken from each end of the pipe.

Samples shall be extracted from alternating ends and elongation recorded up to 8 % minimum on the stress-strain curve.

Add new section

N.3.1.5.2 Hardness Testing

One ring shall be extracted from each pipe end.

Hardness profile testing shall be done on each quadrant of each ring.

Add new section

N.3.1.6 MPQT additional testing after strain and ageing simulation (see N.3.1.3 and N.3.1.4).

The following tests are applicable only for MPQT.

Add new section

N.3.1.6.1 Tensile Testing

One all weld metal tensile test (AWMT) and two longitudinal tests shall be performed.

Longitudinal tensile test samples shall be extracted from alternating ends.

Unless otherwise specified, for base material testing:

- minimum yield strength and minimum and maximum tensile strength in accordance with API Specification 5L, Annex J.4.2;
- the $R_{10.5}/R_m$ ratio to be < 1.0 ;
- elongation to be 15 % minimum and uniform elongation 5 % minimum.

Unless otherwise specified, for AWMT testing the weld metal uniform elongation shall be $\geq 5\%$ and $R_m > R_{10.5}$ with elongation $\geq 15\%$.

If specified, a lower UEL for the strained and aged condition shall be accepted.

NOTE A lower UEL should conservatively reflect the strain level in the pipeline in operation and should not be lower than 2.5 %. For non-reeled applications, alternative strain levels and/or acceptance criteria based upon pipeline design may be considered.

Add new section**N.3.1.6.2 Charpy Testing**

Samples for longitudinal Charpy testing in the pipe body shall be extracted from alternating ends.

The seam weld shall be sampled as follows: one set in the weld metal (weld metal / weld line), one set on the FL and one set on the FL2.

Test temperature and acceptance criteria shall be in accordance with the unstrained tests in section 9.8.

In the longitudinal direction, acceptance criteria shall be 50 % higher than the specified criteria in the transverse direction.

The shear area shall be recorded for information.

Add new section**N.3.1.6.3 Hardness Testing**

For full scale testing, one ring shall be extracted from each pipe end.

Hardness profile testing shall be performed on each quadrant of each ring, including the weld seam area.

In case of small scale testing, hardness testing shall be performed on the body and weld seam samples at four locations, spaced at 90° apart.

Acceptance criteria shall be in accordance with Table N.9.

Add new table**Table N.9—Hardness Test Acceptance Criteria in Strained and Aged Condition**

Steel Grade	Base Metal, Weld & HAZ	Cap area
≤ L450 or X65	270	300
> L450 or X65	300	300
NOTE For sour service, Annex H is applicable		

Add new section**N.3.1.6.4 SSC and HIC Tests**

If specified, SSC and HIC testing shall be performed in accordance with Annex H.

Add new section**N.3.1.6.5 Fracture Toughness Test**

If specified, CTOD testing shall be performed in accordance with 10.2.3.8 and 10.2.4.10.

Add new section

N.3.1.6.6 Weld Seam Repairs

Repair welds in accordance with Annex D shall be qualified in the strained and aged condition.

Mechanical tests acceptance criteria in accordance with this annex for the original weld shall apply.

N.3.3 Pipe Manufacturing

N.3.3.2 Welded Pipe

Replace section with

N.3.3.2.2

For HFW pipe, the abutting edges of the strip or plate shall be milled or machined before welding.

N.3.3.2.4

Replace section with

Coil and plate shall be inspected ultrasonically for laminar imperfections or mechanical damage in accordance with Annex K.

Alternatively, full body UT of HFW pipe after forming is permitted.

Full body UT of HFW pipe after forming shall be permitted.

Replace section with

N.3.3.2.5

Intermittent tack welding of the SAWL groove shall not be permitted.

Add new section

N.3.3.2.6

If specified, HFW pipe intended for reeling shall be subjected to a heat treatment:

- a) full body quench and temper; or
- b) weld seam online quench followed by full body temper.

Add new section

N.3.3.2.7 Welding Consumables for SAW Pipes

Welding consumables for SAW pipes ordered for applications requiring longitudinal plastic strain capacity, shall have the deposited weld metal overmatching the maximum specified or actual yield strength of the base metal.

N.4 Acceptance Criteria

N.4.1 Chemical Composition

Add to section

Amendments in J.4.1. shall apply to Table N.1.

N.4.2 Tensile Properties

Add to section

The tensile properties requirements of J.4.2, shall apply for the tensile tests.

The additional requirements for longitudinal tensile properties specified in this annex shall apply.

N.4.2.2

Replace section with

Unless otherwise specified, additional requirements for longitudinal tensile properties shall be:

- a) the maximum yield strength is the specified minimum yield strength + 120 MPa;
- b) the maximum tensile strength is the specified minimum tensile strength + 150 MPa;
- c) the maximum ratio of $R_{10.5}/R_m$ in the longitudinal direction is not exceed 0.90;
- d) the minimum uniform elongation (U_{EL}) is 5 % and the total elongation for a minimum of 18 % for pipe body and all weld metal tests.

N.4.2.3

Replace section with

The MPQT shall be in accordance with N.3.1.3 and N.3.1.4.

N.4.2.6

Replace section with

The difference between the maximum and minimum values of actual longitudinal yield strength of produced pipe shall not exceed 100 MPa (14.5 ksi).

N.4.3 Hardness Test

Replace section with

The maximum hardness in the pipe body, weld and HAZ shall be in accordance with 9.18 for non-sour service or of Annex H for sour service.

Add new section

N.4.4 CVN Impact Test

The test temperature and acceptance criteria shall be in accordance with J.4.4 for unstrained tests.

In the longitudinal direction, the acceptance criteria shall be 50 % higher than the specified criteria in the transverse direction.

Add new section

N.4.5 Fracture Toughness

Unless otherwise specified, pipes shall have a CTOD value of 0.30 mm (0.01 in.) for the base metal, weld area, and HAZ area, tested at the minimum design temperature.

N.5 Other Surface Imperfections

Add new section heading before first paragraph

N.5.1 General

Add new section

N.5.2 Outer Diameter Grinding

Grinding shall be performed in accordance with accepted procedures.

Repair by stone wheel grinding shall not exceed 15 % of the pipe order.

Cosmetic repairs shall not be included in the repair percentage calculation.

Ground areas shall:

- a) not exceed more than 45 % of the circumference of a cross-sectional plane.
- b) be smoothly contoured to the surface of the pipe at a minimum 4:1 slope.
- c) not exceed an area of 10 % of the total surface area of each pipe.
- d) after grinding, the remaining wall thickness is to conform to the thickness tolerance requirements of this specification.
- e) have the final wall thickness measured by UT and be recorded (i.e. wall thickness and joint number).
- f) not interfere with nondestructive testing at the pipe mill.
- g) at pipe ends, comply with the requirements of E.2.2.2.
- h) not result in loss-of-signal or otherwise impede inspection verification required by C.2.3.

Pipe ends shall not be internally or externally machined nor ground by stone without prior acceptance.

Pipes that are repaired by grinding shall be identified with a green paint band, die stamped with the letter "R" on square cut face, and noted on the pipe tally list.

Add new section

N.5.3 Dents

Pipes shall not contain dents on a surface that cause visible distortion on the opposite surface.

Pipe shall not contain dents on the outside surface exceeding 2 mm (0.08 in.) for the pipe body or exceeding 1 mm (0.04 in.) within 150 mm (5.91 in.) from the pipe end.

Add new section

N.5.4 Surface condition

If the pipe surface quality rejection rate exceeds 15 %, then billets shall be scarfed or peeled prior to rolling unless a technical validation and resolution for the surface quality rejection rate is traced to source out with the billet quality.

N.6 Tolerances for Diameter, Wall Thickness, and Straightness

N.6.1

Replace section with

The diameter and out-of-roundness shall be within the tolerances specified in Table J.3 or Table J.9 for "premium" level A or B, as specified.

The diameter and out-of-roundness shall be within the tolerances specified in Table J.3 or Table J.9 for "premium" level A or B.

The tolerance shall refer to the internal diameter.

Actual nominal ID shall be established, with measurements on the first 20 to 100 production pipes.

ID and OD tolerances shall be measured and verified with calipers or a laser.

N.6.2

Replace section with

The wall thickness shall be within the tolerances specified in Table J.4 or Table J.10 for "premium" tolerances, as specified.

The wall thickness shall be within the tolerances specified in Table J.4 or Table J.10 for "premium" tolerances.

N.6.3

Replace section with

Geometric deviations in the pipe body and seam weld from the normal cylindrical contour of the pipe (e.g. flat spots and peaks) which exceed the lesser of:

- 0.005D or 1.5 mm (0.060 in.) measured as the gap between the extreme point of the deviation and the prolongation of the normal contour of the pipe; or
- 25 % of pipe diameter in any direction with a maximum length of 300 mm (11.8 in.), shall be considered a defect and treated in accordance with API Specification 5L, C.3 b) or C.3 c).

N.6.5

Replace section with

For seamless pipes, the eccentricity for pipe ends shall be:

$$\text{Eccentricity} = \frac{t_{\max} - t_{\min}}{t_{\max}} \times 100$$

where

$t_{\max}$ is maximum wall thickness

$t_{\min}$ is minimum wall thickness

- a) with an eccentricity tolerance less than or equal to 18 %;
- b) measurements to be made around the circumference on the same cross-sectional plane using callipers, laser or by other equivalent methods; and
- c) eccentricity within 152 mm (6 in.) of each end defined in the following equation:

N.8 Inspection

N.8.1 Specific Inspection

Replace section with

The frequency of inspection shall be in accordance with Table J.6, except as specifically modified in Table N.6.

Replace Table N.6 with

Table N.6—Inspection Frequency

No	Type of Inspection	Type of Pipe	Frequency of Inspection
1	Longitudinal CVN impact testing of the pipe body	All pipes	Once per test unit of pipe with the same cold-expansion ratio ^a
2	Pipe end eccentricity	SMLS	Each pipe Record frequency: 1 pipe at beginning of the shift then every 4 hours and 1 pipe at the end of the shift
NOTE When specified on the LPMDS, the frequency for HFW shall be one every 5 joints of pipe			
a The cold-expansion ratio is designated by the manufacturer and is derived using the designated before-expansion outside diameter or circumference and the after-expansion outside diameter or circumference; an increase or decrease in the cold-expansion ratio of more than 0.002 requires the creation of a new test unit.			

N.8.2 Samples and Test Pieces for Mechanical and Technological Tests

N.8.2.3 Samples for Hardness Tests

Replace section with

For the hardness testing, one ring shall be extracted from alternating ends.

The hardness profile testing shall be done on each quadrant of the ring. Including the seam weld for welded pipes.

Add new section

N.8.2.4 Samples for Charpy Tests

Samples for Charpy testing shall be extracted from alternating ends.

The sample location shall be in accordance with 10.2.3.3.

Replace Table N.7 with

Table N.7—Number, Orientation and Location of Test Pieces per Sample for Mechanical Tests

Type of Pipe	Sample Location	Type of Test	Number, Orientation, and Location of Test Pieces per Sample ^a		
			Specified Outside Diameter <i>D</i> mm (in.)		
			< 219.1 (8.625)	≥ 219.1 (8.625) to < 508 (20.000)	≥ 508 (20.000)
SMLS, not cold-expanded [see API Specification 5L, Figure 5 a)]	Pipe body	Tensile	1L ^b	1T + 1L	1T + 1L
		CVN ^c	3T + 3L	3T + 3L	3T + 3L
		Hardness	4T	4T	4T
HFW [see API Specification 5L, Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1L90 and 1T180	1L90 and 1T180
		CVN ^c	3T90 + 3L90	3T90 + 3L90	3T90 + 3L90
		Hardness	3T	3T	3T
	Seam weld	Tensile	—	2W	2W
		CVN ^c	3W + 3HAZ	3W + 3HAZ	3W + 3HAZ
		Hardness	1W	1W	1W
	Pipe body and weld	Flattening	As shown in Figure 6		
SAWL [see API Specification 5L, Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1L90 and 1T180	1L90 and 1T180
		CVN ^c	3T90 + 3L90	3T90 + 3L90	3T90 + 3L90
		Hardness	3T	3T	3T
	Seam weld	Tensile	—	2W	2W
		CVN ^c	3W and 6HAZ	3W and 6HAZ	3W and 6HAZ
		Guided-bend	2W	2W	2W
		Hardness	1W	1W	1W
SAWH [see API Specification 5L, Figure 5 c)]	Pipe body	Tensile	1L ^b	1L and 1T	1L and 1T
		CVN ^c	3T + 3L	3T + 3L	3T + 3L
		Hardness	3T	3T	3T
	Seam weld	Tensile	—	2W	2W
		CVN ^c	3W and 6HAZ	3W and 6HAZ	3W and 6HAZ
		Guided-bend	2W	2W	2W
		Hardness	1W	1W	1W

^a See API Specification 5L, Figure 5 for an explanation of the symbols used to designate orientation and location.

^b Full-section longitudinal test pieces may be used at the option of the manufacturer.

^c Charpy HAZ testing to be as per 10.2.3.3 (additional set required depending on wall thickness).

N.8.3 Test Methods

N.8.3.3 Longitudinal Tensile Tests

Add to section

The LPMDS shall specify the tensile test specimen type.

For non-proportional tensile specimens, 50 mm (2 in.) gauge length shall be used.

For the proportional type (in accordance with ISO 6892-1), the gauge length shall be equal to $5.65\sqrt{S_0}$, where S_0 is the original cross-sectional area of the specimen.

Add new Appendix 1

Appendix 1

Welding Consumables

AP 1.1 General

The manufacturer shall document the procedures concerning storing, handling, drying, recycling and traceability of consumables is subject to review and acceptance.

The manufacturer shall provide evidence of long and successful use of the proposed combination of welding consumables on similar applications, to the satisfaction of the purchaser.

Welding consumables shall be stored and handled in accordance with the supplier's written recommendations.

The welding consumables shall be procured according to AWS A5.01 or ASME BPVC Section II Part C SFA A5.01.

The level of testing shall be in accordance with Schedule I of AWS A5.01.

Unless otherwise specified, all welding consumables shall be individually marked and supplied with an inspection certificate type 3.1 according to EN 10204, obtained for the same batch.

Deposited weld metal shall not have diffusible hydrogen content higher than 5 ml per 100 g weld metal under production conditions, tested in accordance with ISO 3690.

The hydrogen content test and value, shall be done during packing and recorded in the certified material test report.

If specified, welding consumables and procedures shall not produce a weld deposit containing more than 1 % mass fraction nickel.

Weld deposits shall be in compliance with ISO 15156 for welding consumables for SAW pipes ordered for sour service applications.

AP 1.2 Consumables for GMAW

The solid electrode shall conform to the requirements of AWS A5.18 or AWS A5.28 and produced according to Lot Class S3 of AWS A5.01.

The gas shielding shall conform to the requirements of AWS A5.32.

AP 1.3 Consumables for SAW

The SAW consumables shall conform to the requirements of AWS A5.17 or AWS A5.23 and produced according to lot class S3 and lot class F2 of AWS A5.01 for solid electrode and flux, respectively.

The manufacturer shall provide a dedicated procedure for flux management, covering the steps from flux purchasing to the "ready-to-use" step (welding heads).

AP 1.3.1 Procurement of flux

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

Flux grain size shall be checked per batch when the flux is first received and comply with the recommendation of the flux supplier.

Acceptable packing shall be:

- metallic / stiff plastic drums with a rubber gasket for top tightness;
- double polymer top welded bags;
- PEHD-aluminium-PEHD top welded bags.

The packing shall not permit humidity absorption during storage for one year.

AP 1.3.2 Diffusible Hydrogen, Moisture Content Test

As required in AP 1.3.1 and AP 1.3.4, diffusible hydrogen measurement of deposited weld metal shall be performed.

Alternatively, diffusible hydrogen assessment may be done through moisture content measurement, when evidence of correlation for the flux intended to be used, can be provided by the flux supplier (previously established data is acceptable).

The maximum moisture content shall be 0.03 % unless a higher figure can be justified via the correlation curves based upon comparative tests of diffusible hydrogen versus flux moisture content.

AP 1.3.2.1 Test Condition

The moisture content shall be measured as per AWS A4.4M by the "Karl Fisher" method.

For diffusible hydrogen testing or for moisture measurement, pre-drying or any pre-heating of the flux sample shall be carried out before testing.

The moisture measurement test shall be carried out at $\geq 982\text{ }^{\circ}\text{C}$ (1800 $^{\circ}\text{F}$).

The carrier gas shall contain $\geq 10\%$ oxygen.

AP 1.3.2.2 Test Results

Results of diffusible hydrogen or moisture measurement shall be reported on the 3.1 flux certificate for each batch. The testing conditions as per this appendix shall be confirmed on the certificate.

AP 1.3.3 Flux Storage

Flux shall be stored in a room with controlled hygrometry and temperature.

Hygrometry and temperature shall be in accordance with the supplier's recommendation.

The maximum duration of storage shall be one year after the date of packing.

A check of the diffusible hydrogen / moisture content shall be required for material stored more than one year.

Flux that has been wet or damp shall not be used.

AP 1.3.4 Flux Handling and Transfer System

Drums/bags shall be checked before using the flux and be undamaged.

All flux shall be dried before use and poured in the welding machine hopper.

The temperature of the hopper shall be maintained between 120 °C (248 °F) and 150 °C (302 °F) unless a different temperature range is specified by the flux manufacture's procedure and the moisture content meets the requirements in AP1.3.2 and AP1.3.5.2.

Flux feeding shall be from:

- hopper by gravity, or
- flux conveying, using dry and oil-free pressurized air.

The manufacturer shall explain the flux management philosophy in case of an interruption or pause in welding. Unless the manufacturer can justify otherwise, in case of welding interruption:

- a) of more than two hours, the system of feeding downstream of the hoppers shall be drained off before recommencing welding;
- b) of more than 12 hours, the remaining flux stored in the hoppers shall be scrapped.

NOTE Flux is often stored in an intermediate oven at 150 °C (302 °F) to avoid a reduction of the flux temperature in the welding machine hopper during charging of the new flux.

AP 1.3.5 Flux Recycling

AP 1.3.5.1 Flux Recycling

When recycling flux, the manufacturer shall demonstrate that the mill has an appropriate flux recycling system:

- a) As a minimum, the flux recovery system to be equipped with vacuum suction to collect the excess unfused flux from the weld seam.
- b) The recovered flux to be processed with sieving and a magnetic separator.
- c) The size distribution of recovered flux to be within the specified defined tolerance range of the fresh batch.
- d) The frequency of flux size testing to be aligned with the moisture content check.
- e) The use of crushed or recycled slag, or blending crushed or recycled slag with fresh flux is not permitted.

AP 1.3.5.2 Moisture Content Check

The flux management system shall be demonstrated to supply dry flux at the welding point:

- a) Flux shall be sampled at each welding point and checked at the start of production and then once per week for both inside and outside welding. All welding lines shall be tested on an approximate evenly spaced schedule.
- b) If moisture content exceeds the established limit, sampling frequency shall be increased to once per shift per machine to verify corrections to the flux handling and drying processes are effective.

- c) The procedure shall include a scheme of flux management and shall specify the temperature of the ovens used for re-drying, if applicable.

AP 1.4 Consumables for SMAW

The covered electrodes shall conform to the requirements of either AWS A5.1 or AWS A5.5, produced according to Lot Class C5 of AWS A5.01 and shall be supplied in hermetically sealed containers.

Cellulose coated electrodes shall not be used.

Public Review Draft

Add new Appendix 2

Appendix 2 Weldability Test

AP 2.1 Introduction

The intent of the weldability test is to verify acceptable properties in the girth weld HAZ. The manufacturer should note that the weldability tests are acceptance tests for the pipes, and that pipes cannot be accepted until these tests have been successfully completed.

Weldability tests shall be performed by the pipe manufacturer or by an accepted supplier under their responsibility.

Where the purchaser allows data from previous weldability trials in lieu of testing, material used in the previous weldability trials shall be identical in grade and manufacturing procedure to the pipe to be supplied, and be of similar diameter, wall thickness and chemical composition (within the limits of applicable chemical composition and associated tolerances).

AP 2.2 Material for Weldability Test

The pipe material shall be qualified in accordance with the manufacturing procedure qualification (see Annex B) and within the limits specified (see B.5.).

Weldability tests shall be conducted for each steel grade, pipe size and steel source on pipes produced at the initial production stage.

Pipe size grouping of dimensions may be allowed subject to approval, the greatest wall thickness in the group shall be tested.

The material shall be taken from finished production pipes.

Selected pipes shall be subject to approval.

AP 2.3 Welding Procedure Specification (WPS)

Prior to welding, a pWPS shall be submitted and include:

- a) details of welding consumables, type of process, welding parameters, etc.;
- b) proposals on the pipe ring dimensions (length) so in order to represent realistic welding conditions;
- c) full details of weld bevel geometries. The proposed groove profile shall be such that the welding will result in a straight HAZ on one side of the bevel (i.e. half-V bevel or narrow gap bevel to be used);
- d) the welds to be single sided from the outer surface of pipe;
- e) welding positions, heat input range;

Welding test shall not be carried out until the manufacturer's pWPS has been accepted.

AP 2.3.1 Test Welds

At least one full butt weld shall be produced for each trial.

The welding processes for weldability tests, proposed by the manufacturer shall be in accordance with the method for pipe laying (e.g. GTAW, P-GTAW, P-GMAW, m-GMAW, STT, CMT, SMAW and SAW).

Test coupons shall be prepared with a single V-groove.

Test coupons shall have one side with 0° bevel angle.

The tests shall be carried out with two welding heat inputs as follows:

- a) low welding heat inputs ($0.45 \text{ KJ/mm} \leq HI \leq 0.75 \text{ KJ/mm}$) with a maximum preheat temperature of 50 °C (122 °F) and an inter-pass temperature not exceeding 250 °C (482 °F);
- b) high welding heat inputs ($1.5 \text{ KJ/mm} \leq HI \leq 3 \text{ KJ/mm}$) with a preheat temperature and inter-pass temperature not lower than 250 °C (482 °F)

The HAZ shall be considered straight when scribed marks for the machining of fracture toughness specimen notches sample at least 75 % of the scribe length in the central two thirds of the specimen thickness within 0.5 mm (0.02 in.) of the fusion line.

NOTE 1 The 75 % of the scribe length need not be continuous. The fusion line is considered part of the weld metal and need not be included in the determination of % HAZ sampled.

The time lapse between the root and hot pass shall be no longer than 15 minutes without maintaining preheating during that time.

NOTE 2 Weld bead placement techniques should be utilized such that within the central 60 % of the section thickness, 25 % of the weld metal adjacent to the fusion line on the square edge side of the weld groove is unrefined-columnar weld metal.

AP 2.3.2 Testing and Inspection

AP 2.3.2.1 Nondestructive Testing

The test weld shall be inspected by visual, magnetic particle and UT or X-ray radiography testing.

The weld shall satisfy the acceptance criteria of the specific project fabrication code prior to being sent for sampling.

Defects that lie entirely within the deposited weld metal shall be disregarded provided there are no adverse effects to the base metal HAZ properties and have no effect on the test sample preparation or results.

The project fabrication code shall be specified.

AP 2.3.2.2 Mechanical Testing

The test specimen failing due to welding defects shall be declared as invalid and retesting is permitted upon the purchaser's acceptance.

AP 2.3.2.2.1 Tensile Testing

A cross weld tensile test shall be carried out for information.

NOTE A failure located in the weld metal is not considered relevant. The intent of the test is to gather information on HAZ performance.

AP 2.3.2.2.2 Charpy Testing

For welding in position 5G, a set of specimens shall be cut at the 12 o'clock, 3 o'clock and 6 o'clock positions, transverse to the weld direction.

For alternative welding position (i.e. 1G or 2G), a sample of specimens shall be taken from two opposite locations.

Each set shall consist of three specimens.

The notches shall be located at mid-thickness of the welded side with 0° bevel in accordance with Figure AP2.1.

For welded pipes, a set of Charpy specimens shall be taken from the intersection of the longitudinal and circumferential weld seam with the notch location extended into the longitudinal seam side.

The impact test temperature and acceptance criteria shall be in accordance with 9.8. Alternative test conditions and acceptance criteria may be specified.

If specified, a transition curve shall be performed for each test location.

AP 2.3.2.2.3 CTOD Test

CTOD specimens shall be taken from the low and high welding heat input test coupons.

A set of specimens shall be cut at the 12 o'clock and 6 o'clock positions for the 5G welding position and located at mid-thickness.

For each set, three specimens shall be cut and tested.

For alternative welding positions (i.e. 1G or 2G), a sample of CTOD specimens shall be taken from one location only.

Specimens shall be SENB B*2B full thickness specimens or, if pipe dimensions do not permit B*2B, then B*B.

The notches shall be located on the welded side with 0° bevel in accordance with Figure AP2.1 and as follows:

- a) in the coarse grain HAZ (CGHAZ) - to be determined by metallography;
- b) at 2 mm (0.08 in.) from the fusion line - to be determined by metallography.

Following testing, sectioned CTOD samples shall be sampled with pre and post-testing macrographs to document that sampling requirements have been met.

CTOD testing shall be carried out in accordance with ISO 15653.

Test specimens for the HAZ areas shall have orientation NP in accordance with Figure 13.

The CTOD test temperature and acceptance criteria shall be as specified.

AP 2.3.2.2.4 Macrography and Vickers Hardness Survey

Three specimens shall be extracted, one at each of the 12 o'clock, 3 o'clock and 6 o'clock positions for the 5G welding position.

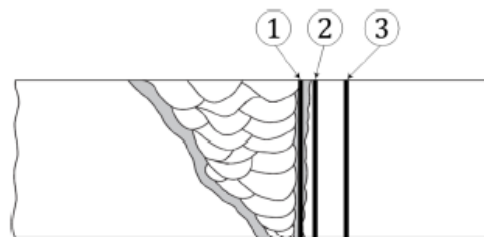
For alternative welding positions (i.e. 1G or 2G), a sample of macrography specimens shall be taken from two locations:

- a) 180° apart for pipe; and
- b) a minimum distance of 300 mm (12 in.) apart for plate.

Macrographic cross-sections for the above shall:

- have a HV10 hardness survey in accordance with Figure AP2.2.
- Indent spacing at 0.5 mm center-to-center, but not closer than the distance equal to 2.5 times the center-to-center length of the impression diagonal.

If not specified, the acceptance criteria shall be as per the applicable annex/appendix.



Key

- ① In the Coarse Grain HAZ (CGHAZ) – to be determined by metallography
- ② At 2 mm from the Fusion Line
- ③ At 5 mm from the Fusion Line

Figure AP2.1—Charpy Testing Locations

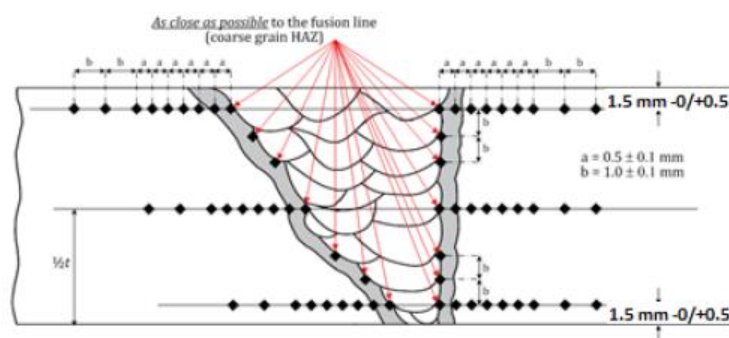


Figure AP2.2 —Hardness Indents Location

AP 2.4 Reporting

Following completion of the test program, the results and a final report from the manufacturer shall be submitted to the purchaser.

The final report shall include the following:

- a) welding procedure specifications;
- b) procedure qualification records;
- c) mill certificates of pipe materials used;
- d) NDT and mechanical test results (including failures);
- e) photographs, macrographs and micrographs (if applicable); and
- f) the interpretation of the results and the conclusions of the manufacturer, including the recommendations for welding the pipes at the installation site.

Add new Appendix 3

Appendix 3

Qualification of NDT at Plate/Coil and Pipe Mills

Qualification shall be subject to demonstration of the capability of the mill to satisfy the requirements of this specification, and all standards referenced herein.

The qualification shall remain valid for a period of four years unless there is a change to the equipment, including structural components, software or hardware.

The process for the qualification of pipe mill NDT equipment and practices shall be as follows.

AP 3.1 Prior to the Qualification Audit

The following information shall be submitted for review and agreement prior to the audit:

- a) Scope of the qualification required, as follows:
 - 1) Renewal of existing scope of qualification, extension to scope or new qualification;
 - 2) Service: whether "conventional", sour or offshore or multiple services, the audit is to be based on the most stringent requirement, based on the mill's capability;
 - 3) Pipe types (manufacturing methods e.g. SAW, HFW, SMLS), materials, grades;
 - 4) For each pipe type: ranges of pipe diameter and thickness for which qualification is sought;
 - 5) For plate/coil: materials, grades, and ranges of length, width and thickness;
 - 6) Applicable NDT methods, techniques and documented threshold settings.
- b) Written procedures for NDT including applicable methods, compliant with Appendix 4 and applicable to the scope of the audit;
- c) Design of UT and/or EMI reference standards;
- d) Report of visual and dimensional inspection for UT and EMI reference standards, demonstrating compliance with AP 3.1 c);
- e) Detailed description of the equipment design and any capability studies that the mill may have performed on the equipment.

AP 3.2 NDT Method-specific Requirements During the Qualification Audit

AP 3.2.1 General Requirements

The qualification audit shall include:

- a) Practical demonstration of each applicable NDT method and technique, performed on welds, pipes, plates/coils (as applicable).

- b) Calibrations, control checks and maintenance;
- c) Qualification and certification of NDT personnel; and
- d) Elements of the quality system/business management system related to NDT.

AP 3.2.2 Practical Demonstrations

For automated NDT systems, each carriage, combination of carriages, and configuration used for production shall be documented in standard operating procedures and qualified individually.

For HFW mills that perform full-body AUT, the coil AUT system shall be exempt from qualification.

Responses from each of the reference reflectors shall be recorded.

AP 3.2.2.1 AUT of Plate/Coil

The practical demonstration shall be carried out on one or more reference standards as agreed covering the manufacturing thickness range capability and shall include:

- a) Equipment set-up;
- b) Static standardization;
- c) Dynamic standardization (plate only);
- d) Gate positions for defects and coupling, S/N ratio;
- e) Extent of coverage;
- f) Detection of all required reference reflectors;
- g) Repeatability trial (plate only); and
- h) Documented threshold settings.

AP 3.2.2.1.1 Repeatability trials

The repeatability trial shall be carried out dynamically, using the same conveyor assembly and at the maximum scanning speed(s) (travel and/or cross-head) to be used during production.

Indications from all reference reflectors shall be set at a suitable amplitude to enable recording and subsequent height measurement, typically 50 % to 80 % FSH $\pm$ 5 % (i.e. where an AUT system can only measure amplitudes up to 100 % FSH, any indication greater than 100 % shall be invalid).

Ten test runs shall be carried out.

The results of a repeatability trial shall be considered acceptable when no reference reflector indication amplitude deviates from the average value by more than $\pm$ 2db (- 21 %, + 26 %).

The following data shall be recorded:

- 1) Written procedure;
- 2) Reference standard details and dimensions;

- 3) Equipment used, including probe types, frequencies and dimensions;
- 4) C-scan record, either paper or digital – as applicable;
- 5) For each channel: the probes used, scanning direction, reference reflector identities and locations, indication amplitudes (digitally recorded);
- 6) Indication amplitudes for all reference reflectors to be recorded as percentage of screen height or as percentage chart height (as applicable), or decibels, using an automated digital method such as a digital export feature, to at least one decimal point (e.g. 81.6 %, not rounded up to 82 %); and
- 7) Indication amplitudes for all channels and all reference reflectors to be entered into a spreadsheet supplied by the auditor for the calculation of the average values and the minimum and maximum deviations from the average values.

AP 3.2.2.2 AUT of HFW, SAW and SMLS Pipe

The practical demonstration shall be carried out on a full production length reference standards covering the manufacturing thickness and diameter range to include:

- a) Equipment set-up;
- b) Static (when applicable) and dynamic standardization;
- c) Gate positions for defects and coupling, S/N ratio;
- d) S/N ratio;
- e) Detection of reference reflectors in accordance with the tables in Annex E and Annex K, as applicable;
- f) Repeatability trial;
- g) Extent of coverage;
- h) Axial consistency;
- i) Accuracy and consistency of seam tracking system;
- j) Documented threshold settings.

AP 3.2.2.2.1

The number and dimensions of reference standard/pipe shall be for each carriage configuration:

- a) For wall thickness ≤ 12 mm (0.47 in.): one reference standard having the lowest wall thickness and smallest diameter to be qualified;
- b) For wall thickness > 12 mm (0.47 in.): one reference standard having the highest wall thickness and largest diameter to be qualified.

AP 3.2.2.2.2

For the repeatability trial, the following shall apply:

- a) The repeatability trial to be carried out dynamically, using the same conveyor assembly and bench, and be performed at the maximum scanning speeds (travel and/or cross-head) to be used during production.

- b) Indications from all reference reflectors to be set at a suitable amplitude to enable recording and subsequent height measurement, typically 80 % FSH ± 5 % (i.e. where an AUT system can only measure amplitudes up to 100 % FSH, any indication greater than 100 % will be invalid).
- c) Ten uninterrupted test runs, in the forward direction, without any adjustment of equipment or settings. Any interruption or adjustment will invalidate the results.
- d) For equipment with rotating head assemblies, 20 runs shall be completed in total, consisting of five runs at each pipe angular position (0°, 90°, 180° and 270°), the pipe being rotated after each series of five runs.
- e) The results of a repeatability trial is to be considered acceptable when no reference reflector indication amplitude deviates from the average value by more than ± 2 db (- 21 %, + 26 %).
- f) The following data is to be recorded:
 - 1) Written procedure;
 - 2) Reference standard details and dimensions;
 - 3) Equipment used, including probe types, frequencies and dimensions;
 - 4) Chart record, either paper or digital – as applicable;
 - 5) For each scan number: the channel, probes used, scanning direction, reference reflector identities and locations, indication amplitudes (digitally recorded);
 - 6) Indication amplitudes for all reference reflectors to be recorded as percentage of screen height or as percentage chart height (as applicable), or decibels, using an automated digital method such as a digital export feature, to at least one decimal point (e.g. 81.6 %, not rounded up to 82 %); and
 - 7) Indication amplitudes for all channels and all reference reflectors to be entered into a spreadsheet supplied by the auditor for the calculation of the average values and the minimum and maximum deviations from the average values.

AP 3.2.2.3 EMI of Welded or SMLS Pipe

The practical demonstration shall be carried out on the reference standards to include:

- a) Equipment set-up;
- b) Static (if applicable) and dynamic standardization;
- c) Gate positions for defects;
- d) S/N ratio;
- e) Detection of reference reflectors in accordance with the tables in Annex E or Annex K;
- f) Extent of coverage;
- g) Repeatability trial;
- h) Application to one or more production pipes, or substitute;
- i) Documented threshold settings.

AP 3.2.2.3.1

Two reference standards representative of the smallest and largest diameter, and of the maximum wall thickness range shall be qualified.

AP 3.2.2.3.2

For the repeatability trial, the following shall apply in one direction of the reference standard:

- a) Carried out dynamically, using the same conveyor assembly and at the maximum scanning speed(s) (travel and/or cross-head) to be used during production.
- b) Indications from all reference reflectors shall be set at a suitable amplitude to enable recording and subsequent height measurement, typically 50 % to 80 % FSH ± 5 % (i.e. where an EMI system can only measure amplitudes up to 100 % FSH, any indication greater than 100 % shall be invalid). Where EMI systems utilize voltage or alternative signal responses, readings above the vertical calibrated range shall not be permitted.
- c) Ten uninterrupted test runs, without any adjustment of equipment or settings. Any interruption or adjustment shall invalidate the results.
- d) The results of a repeatability trial shall be considered acceptable when no reference reflector indication amplitude deviates from the average value by more than ± 25 % (or equivalent dB tolerances).
- e) The following data shall be recorded:
 - 1) Written procedure;
 - 2) Reference standard details and dimensions;
 - 3) Equipment used, including probe types, frequencies and dimensions;
 - 4) Chart record, either paper or digital – as applicable;
 - 5) For each scan number: the channel, probes used, scanning direction, reference reflector identities and locations, indication amplitudes (digitally recorded);
 - 6) Indication amplitudes for all reference reflectors shall be recorded as percentage of screen height or as percentage of chart height (as applicable), using a consistent method, to at least one decimal point (e.g. 81.6 %, not rounded up to 82 %); and
 - 7) Indication amplitudes for all channels and all reference reflectors shall be entered into a spreadsheet supplied by the auditor for the calculation of the average values and the minimum and maximum deviations from the average values.

Add new Appendix 4

Appendix 4

Procedure Requirements for NDT

Written procedures shall be submitted for each NDT technique, describing the inspection equipment and processes to be applied.

Multiple NDT techniques shall not be combined within one procedure.

The procedures shall contain as a minimum, the details stated in the tables included in this appendix and be in English, for review and acceptance prior to production NDT.

Table AP4.1—Ultrasonic Testing (UT)

Scope (application)	Product form (e.g. plate/coil, pipe, pipe end, weld, etc.)
	Material grade and specification
	Dimensions (plate/coil: length, width, thickness; pipe: length, diameter, thickness)
	Coverage required; coverage limits
	Weld process (as applicable)
	Weld preparation (drawing showing weld preparation dimensions and angles)
	Reference to this specification and related standards
Personnel	Qualification requirements
	Performance demonstration - if specified
Stage of Manufacture	Stage at which UT is to be performed e.g. for longitudinally welded pipe seams - after hydrotest
Surface Condition	Condition and surface preparation of scanning surfaces
	Profile of scanning surfaces
Inspection techniques	Whether automated, semi-automated or manual
	Contact-, gap- or immersion-scanning
Equipment	Instrument/System: manufacturer type and designation, number of channels, computerized program identification and revision.
	Scanning frames descriptions and illustrations, with probe arrangement (layout and scanning directions)
	Probes: quantity, manufacturer, types, beam angles, frequencies, single- or twin-crystal, element dimensions, number and arrangement of elements in probes. Focusing. Probe data sheets.
	Reference standards: Identification, description, and plan and sectional drawings showing all dimensions and reference reflectors (types, dimensions, locations in plan and depth). Inspection certificates for the same. Acoustical properties of the reference reflectors
	Calibration blocks
	Couplant and method of irrigation
	Weld seam tracking
Calibration	Calibrations, control checks and maintenance

Table AP4.1 (continued)

Standardization	Range calibration
	Setting of sensitivity (PRG, transfer correction, PRL, scanning sensitivity)
	S: N ratio
	Recording levels (defect gate heights, start points and lengths
	Method of monitoring coupling (with coupling gate heights, start points, lengths
	Weld seam tracking and accuracy
Inspection parameters	Description of operation
	Guiding principle
	Scanning directions with respect to product axis
	Maximum permitted product travel speeds and probe traverse speeds
	Scan plans
	For HFW and SAW seams: scan plans for individual scans showing -6dB beam profile and probe offsets from datum – relative to reference reflector locations. Overall scan plan showing combination of scans. Scan plans shall be prepared using proprietary software and shall clearly demonstrate how 100 % coverage of depth and width is achieved.
Reference Table	Table coordinating:
	Scan and channel numbers
	Probe identifications, types and scan directions
	Reference reflector types, identifications and locations
Acceptance Criteria	Interpretation, evaluation and acceptance criteria
Reporting	Report shall include at least the following items:
	Procedure identification and revision
	Application: Identification, description and dimensions (see above)
	All equipment used
	Result: accept or reject
	For all scans, the primary reference level used
	Position, depth and size of all discontinuities exceeding the recording level and all defects
	Date and time of inspection
	Name of operator responsible for performing UT

Table AP4.2—Penetrant Testing (PT)

Scope (application)	Product form (e.g. weld, pipe end bevel, etc.)
	Material grade and specification
	Dimensions (pipe: length, diameter, thickness)
	Coverage required
	Weld process (as applicable)
	Reference to this specification and related standards
Personnel	Qualification requirements,
	Performance demonstration - if specified
Stage of Manufacture	Stage at which PT is to be performed
Surface Condition	Condition and surface preparation of surfaces requiring inspection
Inspection techniques	Method for cleaning
	Method of applying penetrant
	Method of removing excess penetrant
	Method of drying the surface
	Method of applying developer
	Whether color contrast or fluorescent
Equipment and consumables	Manufacturer type and designation of consumables (cleaner, penetrant, remover and developer).
	Requirement for certification of compliance for consumables (limits for sulfur and halogens)
	Light/UV-A meter, timers, sensitivity test blocks, timer, etc.
	Performance demonstration block – if specified
Calibration	Calibrations, control checks and maintenance
Inspection parameters	Description of process
	Permitted time periods for process stages
	Light or UV-A intensity ranges (for UV-A, also include background white light)
	Applicable temperature limits
	Adjustments to stage durations if lower or upper temperature limits are exceeded
Acceptance Criteria	Interpretation, evaluation and acceptance criteria
Reporting	Report shall include at least the following items:
	Procedure identification and revision
	Application: Identification, description and dimensions (see above)
	All equipment and consumables used
	Result: accept or reject
	Position and size of all defects
	Date and time of inspection
	Name of operator responsible for performing PT

Table AP4.3—Magnetic Particle Testing (MT)

Scope (application)	Product form (e.g. weld, pipe end bevel, etc.)
	Material grade and specification
	Dimensions (pipe: length, diameter, thickness)
	Coverage required
	Weld process (if applicable)
	Reference to this specification and related standards
Personnel	Qualification requirements,
	Performance demonstration - if specified
Stage of Manufacture	Stage at which MT is to be performed.
Surface Condition	Condition and surface preparation of surfaces requiring inspection.
Inspection techniques	Magnetizing techniques and magnetizing directions (with illustration showing these)
	Type/waveform and amperage of magnetizing current
	Whether color contrast or fluorescent
Equipment and consumables	Manufacturer, type and designation of magnetic field generator (DC Yokes are not permitted)
	Manufacturer, type and designation of consumables (cleaning liquid, magnetic particles (wet or dry) and contrast medium)
	Light/UV-A meter, tangential field meter, flux indicator and residual field meter
	Lift block for AC Yoke
	Performance demonstration block – if specified
Calibration	Calibrations, control checks and maintenance
Inspection parameters	Description of process
	Fill factors for rigid encircling coils
	Method for cleaning
	Method of magnetization and method of applying magnetic particles - and whether "continuous" or "residual"
	Light or UV-A intensity ranges (for UV-A, also include background white light)
	Tangential field strength range required (kA/m) - minimum and maximum
	Ink concentration range
	Applicable temperature limits
	Adjustments to stage times if temperature limits are exceeded
Acceptance Criteria	Interpretation, evaluation and acceptance criteria
Reporting	Report shall include at least the following items:
	Procedure identification and revision
	Application: Identification, description and dimensions (see above)
	All equipment and consumables used
	Result: accept or reject
	Position and size of all defects
	Date and time of inspection
	Name of operator responsible for performing MT

Table AP4.4—Electromagnetic Inspection (EMI)

Scope (application)	Product form (e.g. SMLS pipe, HFW pipe, HFW weld seam),
	Material grade and specification
	Dimensions (pipe: length, diameter, thickness)
	Coverage required; coverage limits
	Weld process (if applicable)
	Reference to this specification and related standards
Personnel	Qualification requirements,
	Performance demonstration - if specified
Stage of Manufacture	Stage at which EMI is to be performed
Surface Condition	Condition and surface preparation of surfaces requiring inspection
Inspection techniques	Mode of inspection: differential or absolute or combination
	Scanning mode: automated, manual
Equipment	Manufacturer, type and designation of EMI instrument and scanner
	Probe manufacturer, types, designations, sizes and arrangements)
	Reference standards: identification, description, illustration, including all reference reflectors
Calibration	Calibrations, control checks and maintenance
Standardization	Setting of sensitivity
	Recording levels (defect gate heights, start points and lengths)
Inspection parameters	Description of process
	Scanning direction with respect to product axis
	Frequencies, drive voltages and gain settings
	Minimum digitization rate
	Maximum permitted product travel speed and probe traverse speed
Acceptance Criteria	Interpretation, evaluation and acceptance criteria
Reporting	Report shall include at least the following items:
	Procedure identification and revision
	Application: Identification, description and dimensions (see above)
	All equipment used
	Result: accept or reject
	Scanning direction with respect to product axis
	Position and size of all defects
	Date and time of inspection
	Name of operator responsible for performing EMI

Table AP4.5—Radiographic Inspection (RT)

Scope (application)	Product form (e.g. pipe longitudinal weld seam; pipe weld seam ends)
	Material grade and specification
	Dimensions (pipe: length, diameter, thickness; weld thickness including root and cap)
	Coverage required
	Weld process
	Weld preparation (drawing showing weld preparation dimensions and angles)
	Reference to this specification and related Standards
Personnel	Qualification requirements
	Performance demonstration - if specified
Stage of Manufacture	Stage at which RT is to be performed e.g. for longitudinally welded pipe seams - after hydrotest.
Surface Condition	Condition and surface preparation of weld surfaces
Inspection techniques	Conventional film RT or digital (e.g. DR, DDA, CR)
	Single-wall/double-wall; source inside/outside; film/detector outside/inside
	Film processing: automated or manual
	Arrangement of equipment – description, with illustration
Equipment	X-ray set: manufacturer, type and designation. Maximum kV and amperage. Focal spot size(s)
	X-ray generator: manufacturer, type and designation. Maximum kV.
	Film: brand, designation and sizes
	Film processor: manufacturer, type and designation
	Source/film/detector manipulation system
	Intensifying screens
	Digital detector: manufacturer, type and designation, dimensions, number of pixels
	Imaging plate (IP): types, dimensions, resolution
	Imaging plate scanner: manufacturer, type and designation. Resolution
	Film viewer: Sizes, maximum readable densities
	Digital viewers/monitors: manufacturer, type, designation, size. Capabilities in terms of brightness, shades of grey, light intensity ratio, number of pixels
	Image quality indicators
Calibration	Calibrations, control checks and maintenance
	For digital RT: as required by ISO 10893-7, plus routine checking of image archiving
Inspection parameters	Source-film/detector distance, object-film/detector distance, geometric unsharpness (Ug)
	Angle of beam centerline relative to weld centerline
	Maximum kV permitted relative to penetrated thickness
	Overlap of consecutive exposures
	Location of film/detector/IP, IQIs, identification letters

Table—AP4.5 (continued)

Inspection parameters (continued)	For digital RT: image quality class; permitted ranges for grey values and contrast; requirements for basic spatial resolution and signal-to-noise ratio
	IQI location and sensitivity
	Storage conditions for unexposed and exposed films. Digital image archiving
Acceptance Criteria	Interpretation, evaluation and acceptance criteria
Reporting	Report shall include at least the following items:
	Procedure identification and revision
	Application: Identification, description and dimensions (see above)
	All equipment used
	Result: accept or reject
	Position and size of all defects
	Date and time of inspection
	Name of operator responsible for performing RT/interpreting images

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