International Association of Oil & Gas Producers

SPECIFICATION

IOGP S-616

August 2022

Version 2.0

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

JIP33 JOINT INDUSTRY PROGRAMME

Revision history

VERSION	DATE	PURPOSE
2.0	August 2022	Second Edition
1.0	January 2019	First Edition

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).

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 2020).

This second edition cancels and replaces the first edition published in January 2019.

Due to technical writing requirements and structure amendments leading to extensive changes:

— this second edition should be treated as a new document;

— there is no redline version (Version 2.0 to Version 1.0) available.

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Introduction

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

This 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

This specification is to be applied in conjunction with the supporting procurement data sheet, information requirements specification (IRS) and quality requirements specification (QRS) as follows.

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

This specification defines the technical requirements for the supply of the equipment and is written as an overlay to API Specification 5L and ISO 3183, following the API Specification 5L and ISO 3183 clause structure. Clauses from API Specification 5L and ISO 3183 not amended by this specification apply as written to the extent applicable to the scope of supply.

Modifications to API Specification 5L and ISO 3183 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: Procurement Data Sheet for Line Pipe

The procurement data sheet defines application specific requirements, attributes and options specified by the purchaser for the supply of equipment to the technical specification. The procurement data sheet may also include fields for supplier provided information attributes subject to purchaser's technical evaluation. Additional purchaser supplied documents may also be incorporated or referenced in the procurement data sheet to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-616L: Information Requirements for Line Pipe

The IRS defines the information requirements, including contents, format, timing and purpose to be provided by the supplier. It may also define specific conditions which invoke information requirements.

IOGP S-616Q: Quality Requirements for Line Pipe

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the data sheet or in the purchase order.

The terminology used within this specification and the supporting procurement data sheet, IRS and QRS follows that of API Specification 5L and is in accordance with ISO/IEC Directives, Part 2 as appropriate. The procurement data sheet and IRS are published as editable documents for the purchaser to specify application specific requirements. The supplementary specification and QRS are fixed documents.

The order of precedence (highest authority listed first) of the documents shall be:

a) regulatory requirements;

b) contract documentation (e.g. purchase order);

c) purchaser defined requirements (procurement data sheet, IRS, QRS);

d) this specification;

e) API Specification 5L and ISO 3183.

1 Scope

1.1 Coverage

Replace first paragraph with

This specification specifies requirements for the manufacture of product specification level PSL 2 of seamless and welded steel pipe for use in pipeline transportation systems in the petroleum and natural gas industries.

Replace second paragraph with

Any section within API Specification 5L or ISO 3183 that specifically relate to PSL 1 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 procurement data sheet (IOGP S-616D).

2 Normative References

API Standard 2RD , *Dynamic Risers for Floating Production Systems (TLPs)*

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

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

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

ASME BPVC, Section II, Part C, *Boiler and Pressure Vessel Code Section II-Materials-Part C-Specifications for Welding Rods, Electrodes, and Filler Metals*

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 E384, *Standard Test Method for Microindentation Hardness of Materials*

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 Electrodes for Shielded Metal Arc Welding*

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

ASME BPVC-IX, *Welding, Brazing, and Fusing procedures; welders, brazers and welding, brazing and fusing operators*

EN 10204, *Metallic products - Types of inspection documents*

ISO 27913, *Carbon dioxide capture, transportation and geological storage - Pipeline transportation systems*

ISO 10005, *Quality management — Guidelines for quality plans*

BS PD 8010-1, *Pipeline systems – Part 1: Steel pipelines on land – Code of practice*

API Recommended Practice 1111, *Design, Construction, Operation, and Maintenance of Offshore Hydrocarbon Pipelines (Limit State Design)*

API Specification Q2, *Specification for Quality Management System Requirements for Service Supply Organizations for the Petroleum and Natural Gas Industries*

ASME B31.4, *Pipeline Transportation Systems for Liquids and Slurries*

ASME B31.8, *Gas Transmission and Distribution Piping Systems*

ISO 29001, *Petroleum, petrochemical and natural gas industries — Sector-specific quality management systems — Requirements for product and service supply organizations*

ISO 9001, *Quality management systems — Requirements*

ISO 13623, *Petroleum and natural gas industries — Pipeline transportation systems*

3 Terms, Definitions, Symbols, and Abbreviations

3.1 Terms and Definitions

Add new term

3.1.66
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 their obligations to conform to the technical specifications, requisitions, etc.

NOTE "Accept", "accepted" and "acceptance" can be construed accordingly. Acceptance of a deviation may override the technical requirement from the specification.

Add new term

3.1.67
coarse grain heat affected zone
Area of grain growth experienced during welding cycles.

Add new term

3.1.68
contract
Purchase order together with all material requisitions, specifications, etc. issued by the purchaser and attached to the contract or the purchase order.

Add new term

3.1.69
inspector
Purchaser's representatives or members from an inspection agency duly appointed by the purchaser and thus notified to the manufacturer.

Add new term

3.1.70
integrated mill
Steelworks that manufactures, in addition to final pipe products, their source material of billets/slabs and starting material of plates/coils used for pipe products.

Add new term

3.1.72
tab
Extensions plates connected to each pipe end on pipe to be longitudinal welded.

NOTE The welding starts and stops on tabs. Tabs are removed after welding.

3.2 Symbols

αfab	fabrication factor
M	mean value
To	test temperature
Tmin	minimum design temperature
Sd	standard deviation (of wall thickness)

3.3 Abbreviations

AUT	automatic ultrasonic testing
AWMT	all weld metal tensile test
CAR	crack area ratio
CAS	conformity assessment system
CCW	counterclockwise
CGHAZ	coarse grain heat-affected zone
CR	computed radiography
CW	clockwise
DAC	distance amplitude curve
DBTT	ductile brittle transition temperature
DDA	digital detector array
DGS	distance grain size
DHC	delayed hydrogen crack
DR	digital radiography
EMAT	electromagnetic acoustic transducer
EMI	electromagnetic inspection
FBH	flat bottom hole
FL	fusion line
FL2	fusion line + 2 mm (0.08 in.)
FSH	full screen height
MPQT	manufacturing process qualification testing
MPS	manufacturing procedure specification

MUT	manual ultrasonic testing
PRG	primary reference gain
PPM	parts per million
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
RL	recording level
RT	radiographic testing
S/N	signal/noise ratio
SAUT	semi-automated ultrasonic testing
SDH	side-drilled hole
SS	scanning sensitivity
TC	transfer correction
TCG	time-corrected gain
ToFD	time of flight diffraction
UEL	uniform elongation

5 Compliance to This Specification

5.1 Quality

Add to section

The quality management system shall comply with the requirements of API Specification Q1 for API Specification 5L manufacture or of ISO 29001 for ISO 3183 manufacture.

5.3 References to Annexes

Add to section

The following normative annexes address aspects not covered within API Specification 5L or ISO 3183:

— welding consumables (see Annex Q);

— weldability test (see Annex R);

— qualification of nondestructive testing (NDT) at plate/coil and pipe mill (see Annex S);

— procedure requirements for NDT (see Annex T);

— HFW welding qualification (see Annex U).

7 Information to Be Supplied by the Purchaser

Add to section

7.1 General Information

Add to section

In addition to Section 7, the procurement data sheet (IOGP S-616D) shall be used to clarify the information to be supplied by the purchaser.

7.2 Additional Information

b) Items that apply as prescribed, unless otherwise agreed:

Move list items 1), 2), 4), 11), 12) and 15) to 7.2. d)

c) Items that apply, if agreed:

Move list items 10), 43), 44), 46), 50), 51) and 53) to 7.2 d) Move list items 23) and 39) to 7.2 e)

Add new list heading d) to section

d) Items that are mandatory:

Move list items 7.2 b) 1), 7.2 b) 2), 7.2 b) 4), 7.2 b) 11), 7.2 b) 12) and 7.2 b) 15) to this list section d) Move list items 7.2 c) 10), 7.2 c) 43), 7.2 c) 44), 7.2 c) 46), 7.2 c) 50), 7.2 c) 51) and 7.2 c) 53) to this list section d)

Add new list heading e) to section

e) Items that are prohibited:

Move list items 7.2 c) 23) and 7.2. c) 39) from 7.2 c) to this list section e)

8 Manufacturing

8.2 Processes Requiring Validation

Add to section

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

8.3 Starting Material

8.3.2

Delete list item c)

8.3.3

Add to section

Clean steel making practices and specific treatment to control inclusions size, shape and distribution shall be used to produce the quality steel required to manufacture the pipes in accordance with this specification.

Add to section

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

Add to section

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

Add to section

External scraps deliveries shall be checked for radioactivity.

Add to section

Hydrogen control practices 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 (i.e. tack weld and SAW weld).

Add to section

The weld bevel shall be clean and dry.

Add new section

8.3.10

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

Add new section

8.3.11

8.3.11.1

Rolling mill edges shall be removed before welding.

8.3.11.2

Rotary shearing shall only be permitted on the following:

a) pipes with WT ≤ 9.5 mm (0.375 in.);

b) pipes with diameter ≤ 273 mm (10 in.);

c) pipelines with design temperature ≥ -10 °C (14 °F).

8.4 Tack Welds

Add new section

8.4.3

8.4.3.1

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

8.4.3.2

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

8.4.3.3

Repair of tack welds shall be recorded and reported to the purchaser.

8.4.3.4

A dedicated repair ratio shall be maintained for the repaired tack weld.

8.4.3.5

Manual welding shall be restricted to pipe ends.

8.4.3.6

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

8.6 Weld Seams in SAW Pipe

Add to section

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

Add to section

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

Add to section

When tabs are removed by mechanical breaking or not used, the pipe ends shall be cropped.

Add to section

The cropping length shall remove arc starts, arc stops, portions of nonsteady state arc regime, and imperfections and defects from mechanical breaking.

8.8 Treatment of Weld Seams in EW and LW Pipe

Add new section heading 8.8.0 before 8.8.1

8.8.0 Control Systems for Weld Seams in HFW Pipe

8.8.0.1

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

8.8.0.2

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

8.8.0.3

The system shall identify in real time and subsequently segregate any material produced with essential variables outside of their agreed range.

8.8.0.4

Parameters defined in 8.8.0.2 shall be recorded at least every 500 milliseconds.

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.

Add to section

For pipes with WT ≤ 19.1 mm (0.750 in.), the width measured on the internal surface of the heat treated area on each side of the bond line shall be minimum of 12.7 mm (0.500 in.) or one nominal wall thickness, whichever is greater.

Add to section

For pipes with WT > 19.1 mm (0.750 in.) the width of the heat treatment area shall be by agreement.

Add to section

The heat treatment area shall entirely encompass the HAZ and the weld seam.

Add to section

Cooling by water shall be permitted when this area has a temperature of 300 °C (572 °F) or below, unless qualified to allow a higher temperature prior to water cooling.

Add to section

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

Add to section

The heat treatment temperature shall be continuously monitored, recorded and available for review.

Add to section

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

Add to section

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

8.9 Cold Sizing and Cold Expansion

8.9.2

Replace section with

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

Add to section

The sizing ratio shall be recorded for three pipes per shift at the beginning, middle and end of shift.

Add to section

Nonexpanded SAWL pipes shall have full body heat treatment.

8.12 Heat Treatment

Add to section

For pipe forming and heat treatment furnaces, furnace surveys shall be conducted at least annually in accordance with an industry recognized standard (e.g. NORSOK, ISO, API, ASTM).

Add to section

For austenitizing furnaces, temperature uniformity shall be ±14 °C (±25 °F).

Add to section

For tempering furnaces, temperature uniformity shall be ±8 °C (±15 °F).

Add to section

Furnaces shall be equipped with recording sensors.

Add to section

Recording sensors for furnaces shall be calibrated at least quarterly.

Add to section

For quenching facilities, the coolant temperature shall be continuously monitored.

Add to section

For quenching facilities, the coolant temperature shall remain below 40 °C (104 °F) unless qualified for higher temperatures.

Add to section

Essential variables (e.g. 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

The following heat identity properties shall be recorded as applicable:

a) date of production;

b) casting sequence number;

c) heat number;

d) casting strand number;

e) billet/slab sequence number;

f) mother billet/slab;

g) daughter billet/slab;

h) mother plate;

i) daughter plate;

j) test unit identity.

Add to section

The unique pipe numbering shall be agreed.

9 Acceptance Criteria

9.1 General

9.1.2

Replace section with

The specified grade shall not be substituted by a pipe manufactured as another grade.

9.2 Chemical Composition

9.2.2

Add to section

The following limit shall apply to product or ladle analysis: B ≤ 0.0005 weight %.

Add new section

9.2.6

9.2.6.1

The target chemical composition and proposed range shall be declared during the technical clarification stage.

9.2.6.2

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

9.2.6.3

Elements not intentionally added but listed in Table 5 and 9.2.2 and required for carbon equivalent formulas shall be reported in the pipe product analysis.

9.2.6.4

Product analysis shall be performed on a specimen extracted from the parent material.

9.2.6.5

Product analysis shall performed by the pipe manufacturer or by a laboratory under the direction of the pipe manufacturer.

Add new Table 28

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	—	Ti	0.014
S	—	Al	0.040
Ca	—	N	—
Si	0.300	O	—
Ni	0.100	B	—
Cr	0.100	H	—
Mo	0.100	CEIIW [b]	0.060
Cu	0.060	CEPcm [b]	0.040
		CEN [a]	Info

[a] CEN shall be calculated for information as follows.

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

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

[b] For CEIIW and CEPcm the range shall be split equally around the agreed target value (allowable range: Target CEIIW ± 0.030 and CEPcm ± 0.020).

9.3 Tensile Properties

Add new section

9.3.3

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

Add new section

9.3.4

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

The acceptance criteria shall be as specified.

9.4 Hydrostatic Test

Add new section

9.4.3

Pipes that fail the hydrostatic test shall be quarantined to an area where a root cause investigation is to take place.

Add new section

9.4.4

The root cause investigation, including inspection and reporting of the failed pipe, shall be open to the purchaser's participation.

Add new section

9.4.5

The purchaser shall be permitted to inspect the failed pipe and participate in the root cause investigation.

9.6 Flattening Test

Replace section with

Acceptance criteria for pipe flattening tests shall be no cracks or breaks in the weld or parent metal to 50 % of the original outside diameter.

Add to section

When pipe is further flattened to 33 % of the original outside diameter, acceptance criteria for flattening tests shall be crack or break free, other than in the weld.

Add to section

Acceptance criteria for flattening tests shall have no evidence of lamination / burnt metal during the entire test before opposite walls of the pipe meet.

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 29

Table 29—CVN Impact Testing Temperature To (°C) as a Function of Tmin (°C)

Specified Wall Thickness *t* mm	Pipelines and Risers
$t \leq 20.0$	TO = Tmin
$20.0 < t \leq 40.0$	TO = Tmin - 10
$40.0 < t$	TO = Tmin - 20
NOTE A lower test temperature may be specified for gas service not covered by Annex G. This is specified in procurement data sheet IOGP S-616D.	

9.8.2.2

Replace section with

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 first paragraph and list with

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

Add to section

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

Replace section 9.9 title with

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1

Replace first sentence with

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

Replace second sentence with

DWT temperature reduction for a reduced thickness specimen for a pipe thickness greater than 39.7 mm (1.56 in.) shall be subject to purchaser's agreement.

Delete NOTE 1

Delete NOTE 2

9.10 Surface Conditions, Imperfections, and Defects

9.10.1 General

9.10.1.1

Add to section

The external surface of 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 the inner and outer surfaces.

9.10.2 Undercuts

Add new list section d)

d) Undercuts of any dimension that are coincident at the inside and outside welds shall not permitted.

Replace section 9.10.3 title with

9.10.3 Arc Burns (Welded Pipes)

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 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).

9.10.5.2

Add new list item c)

c) maximum length in any direction, the lesser of 0.25D or 300 mm (12 in.);

Add new list item d)

d) cold formed dents without sharp bottom gouges, acceptable to a maximum depth of 3.2 mm (0.125 in.);

Add new list item e)

e) dents with depth greater than 1.6 mm (0.0625 in.) within 100 mm (4 in.) of pipe ends or located on the pipe weld seam.

Add new section

9.10.5.3

Sharp bottom dents and sharp bottom gouges shall not be permitted.

9.10.6 Hard Spots

Replace first sentence with

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

a) for grade X70 and below, 275Hv10;

b) for grade X80 and above, 325Hv10.

Add new section

9.10.8 Welding Related Imperfections and Visual Examination

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

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.

Add to section

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

Add new section

9.12.5.6

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

Add new section

9.12.5.7

Removal of burrs shall be by light grinding.

9.13 Tolerances for the Weld Seam

Replace Figure 4 d) with

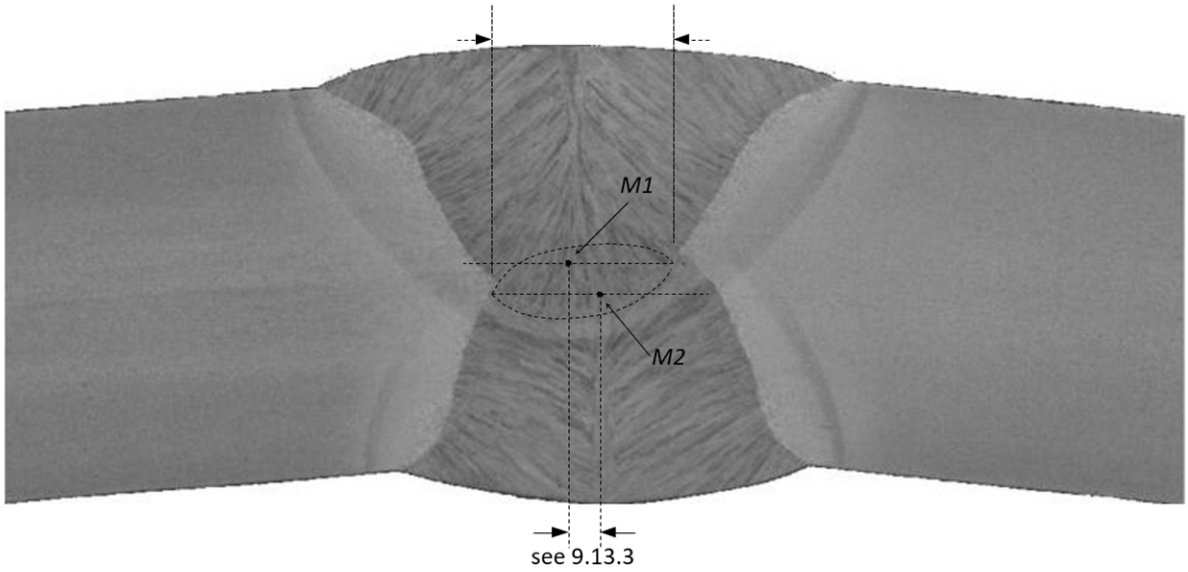


Figure 4—Dimensional Deviations of the Weld Seam
d) Misalignment of Weld Beads of SAW Pipe

9.13.2 Height of the Flash or Weld Bead/Reinforcement

9.13.2.2

Add new list section f)

f) For SAWH/COWH weld beads including the weld cap profile concavity shall be less than or equal to 1.5 mm (0.060 in.).

Add new list section g)

g) When grinding seams, the transition between the weld seam to the pipe body shall be smooth without a visually noticeable step.

Add new list section h)

h) Maintain the OD contour of the pipe, any flat areas caused by grind removal of the weld cap shall be less than 0.8 mm (0.032 in.) of the OD contour of the pipe.

Add new list section i)

i) Grinding of outside and inside weld beads at pipe ends shall be performed before final NDE.

NOTE Grinding of outside and inside weld beads at pipe ends may be performed after expansion.

Add new list section j)

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

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 ¼ *t* or 5 mm (0.2 in.) minimum, whichever is less [see Figure 4.d)].

Add new section

9.13.4 Peaking

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 inside and outside templates in accordance with 10.2.8.4.

Add new section

9.13.5 Weld Toe Angle

For OD and ID welds, the weld toe angle, also known as re-entrant angle, shall be > 120° [see Figure 10)].

Add new Figure 10

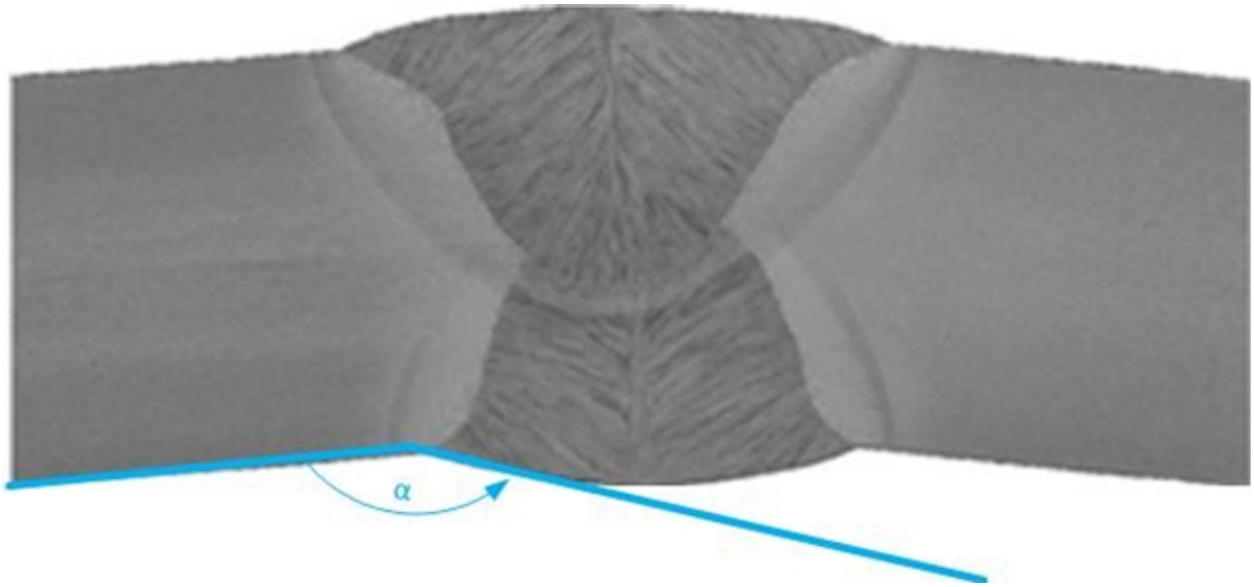


Figure 10—Re-entrant Angle Definition

Add new section

9.13.6 Pock Marks

Pock marks with depth less than 0.2 mm (0.008 in.) shall be accepted.

9.15 Weldability of PSL 2 pipe

Add to section

If specified, weldability tests shall be performed in accordance with Annex P.

Add new section

9.16 Fracture Toughness

The CTOD value at the minimum design temperature shall be specified in the procurement data sheet (IOGP S-616D).

Add new section

9.17 Spring-back Ring Test

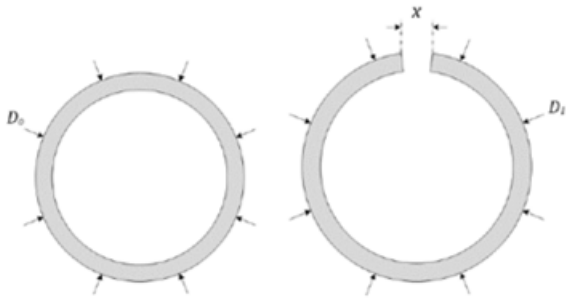
9.17.1

If specified, the pipe shall be subjected to spring-back testing during MPQT.

9.17.2

The residual stress caused by cutting in the base material as shown in Figure 11 shall not exceed ±25 % of the specified minimum yield strength of the pipe.

Add new Figure 11



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

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

Key

σ residual stress

μ Poisson's ratio

E modulus of elasticity

D_o average outside diameter before splitting

D_1 average outside diameter after splitting

Figure 11—Spring-back Ring Test for Measurement of Residual Stresses

Add new section

9.18 Hardness Survey

Finished pipes shall have a hardness level, HV10, not exceeding the values specified in Table 30.

Add new Table 30

Table 30—Acceptance Criteria for Hardness Survey

Steel Grade	Base Metal	Weld and HAZ
≤ L483 or X70	250	270
> L483 or X70	270	300

Allowance given in J.8.3.2.1 shall apply.

Add new section

9.19 Macrographic and Metallographic Examination

9.19.1

The macrographic and metallographic examination shall be documented by macrographs and micrographs.

9.19.2

The macrographic and metallographic examination shall be at a magnification and resolution to demonstrate that the base metal and the weld metal quality meets the requirements of this specification.

9.19.3

The macrographic 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.

9.19.4

Weld and HAZ shall be free of martensitic phases when inspected at a magnification of X400.

9.19.5

Additional requirements specific to HFW pipes shall be as follows:

a) Metallographic examination of the HFW seam that demonstrates no detrimental oxides, inclusions and martensite from the welding process are present.

b) Recording of the following information by the manufacturer:

   1) OD and ID surface width of heat-treated zone (unless full body heat treatment carried out);

   2) grain size (see ASTM E112) and microstructure of heat-treated weld area;

   3) 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.

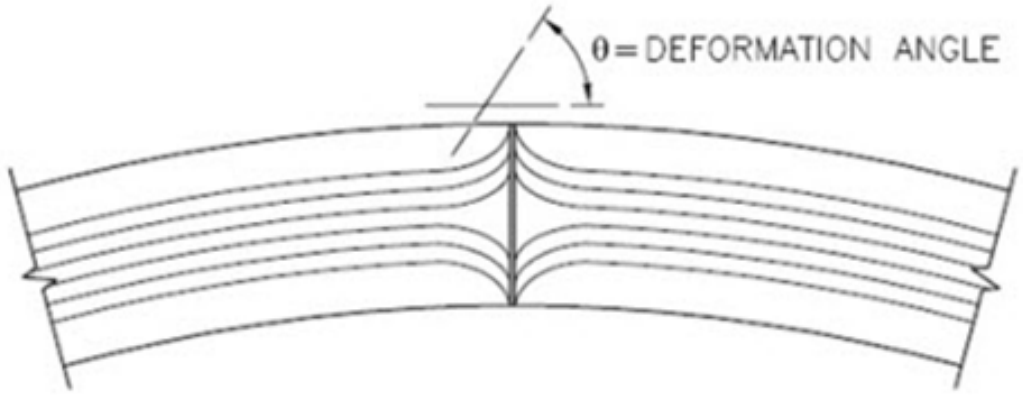
c) Acceptance criteria based on the results of manufacturing qualification tests or historical data of equivalent dimensions and grades:

1) 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;

2) these acceptance criteria to include assessment of the grain size, and general microstructure;

3) metallographic examination to include an assessment of the level of deformation achieved during the welding operation (e.g. deformation angle) [see Figure 12].

Add new Figure 12



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 12—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).

Add to section

Data curves developed from testing (e.g. tensile tests, compressive stress strain, CTOD) shall be supplied in native format compatible with spreadsheets.

10.1.3.2

Add to section

In addition, for plate and coil, the following information, when applicable, shall be provided for each order item:

a) through thickness metallographic examination acceptance;

b) visual inspection acceptance;

c) thickness measurements;

d) ultrasonic inspection acceptance.

Add new section

10.1.3.3

Except for integrated mills, the manufacturer for plates and coils shall issue a 3.1 inspection certificate in accordance with ISO 10474 or EN 10204.

10.2 Specific Inspection

10.2.1 Inspection Frequency

10.2.1.1

Replace section with

The inspection frequency shall be as given in Table 18.

10.2.1.2

Add to section

Values shall be recorded and reported in accordance with Table 18.

Add new section

10.2.1.3

Macrographic, metallographic and mechanical test results shall be available for review within timeframe established in ITP/MPS 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.

Table 18—Inspection Frequency for PSL 2 Pipe

Replace Table 18 with

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 pipe body $D \leq 141.3$ mm (5.563 in.)	All pipes	Once per test unit of 400 pipes maximum with the same cold-expansion ratio [a, c]
4	Tensile testing of pipe body $D > 141.3$ mm (5.563 in.) and $D \leq 323.9$ mm (12.750 in.)	All pipes	Once per test unit of 200 pipes maximum with the same cold-expansion ratio [a, c]
5	Tensile testing of pipe body $D > 323.9$ mm (12.750 in.)	All pipes	Once per test unit of 100 pipes maximum with the same cold-expansion ratio [a, c]
3a	If specified, tensile testing of pipe body $D \leq 141.3$ mm (5.563 in.) in the longitudinal direction (if not already specified as per Table 20)	All pipes	Once per test unit of 400 pipes maximum with the same cold-expansion ratio [a, c]
4a	If specified, tensile testing of pipe body with $D > 141.3$ mm (5.563 in.) and $D \leq 323.9$ mm (12.750 in.) in longitudinal direction (if not already specified as per Table 20)	All pipes	Once per test unit of maximum 200 pipes with the same cold-expansion ratio [a, c]
5a	If specified, tensile testing of pipe body $D > 323.9$ mm (12.750 in.) in longitudinal direction (if not already specified as per Table 20)	All pipes	Once per test unit of 100 pipes maximum with the same cold-expansion ratio [a, c]
3b	If specified, tensile testing at elevated temperature of pipe with $D \leq 141.3$ mm (5.563 in.)	All pipes	Once per test unit of 400 pipes maximum with the same cold-expansion ratio [a, c]
4b	If specified, tensile testing at elevated temperature of pipe with $D > 141.3$ mm (5.563 in.) and $D \leq 323.9$ mm (12.750 in.)	All pipes	Once per test unit of 200 pipes maximum with the same cold-expansion ratio [a, c]
5b	If specified, tensile testing at elevated temperature of pipe with $D > 323.9$ mm (12.750 in.)	All pipes	Once per test unit of 100 pipes maximum with the same cold-expansion ratio [a, c]
6	Tensile testing of seam weld of welded pipe with $D > 219.1$ mm (8.625 in.) and $D \leq 323.9$ mm (12.750 in.)	HFW, SAW, COW	Once per test unit of 200 pipes maximum with the same cold-expansion ratio [a, b, c]
7	Tensile testing of seam weld of welded pipe with $D > 323.9$ mm (12.750 in.)	HFW, SAW, COW	Once per test unit of 100 pipes maximum with the same cold-expansion ratio [a, b, c]
8	Tensile testing of the coil/plate end weld of welded pipe	SAWH or COWH	Not applicable
9	CVN impact testing of pipe body of pipe with specified outside diameter and specified wall thickness as given in Table 22	All pipes	Once per test unit of pipes with the same cold-expansion ratio [a, c]
10	CVN impact testing of seam weld of welded pipe with specified outside diameter and specified wall thickness as given in Table 22	HFW	Once per test unit of pipe with the same cold-expansion ratio [a, b, c] and at least once per shift

Table 18 *(continued)*

No	Type of Inspection	Type of Pipe	Frequency of Inspection
11	CVN impact testing of seam weld of welded pipe with specified outside diameter and specified wall thickness as given in Table 22	SAW, COW	Once per test unit of pipe with the same cold-expansion ratio [a, b, c]
12	CVN impact testing of coil/plate end weld of welded pipe	SAWH or COWH	Not applicable
13	If specified, DWT testing of pipe body for pipe with $D \geq 406$ mm (16 in.)	All pipes	Once per test unit of 100 pipes maximum with the same cold-expansion ratio [a, c]
14	Guided-bend testing of seam weld of welded pipe	SAW, COW	Once per test unit of 50 lengths of pipes maximum with the same cold-expansion ratio [a, b]
15	Guided-bend testing of coil/plate end weld of welded pipe	SAWH or COWH	Not applicable
16	Flattening test of welded pipe	HFW	As shown in Figure 6
17	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
18	Hydrostatic testing	All pipes	Each pipe
19	Macrographic and metallographic testing of seam weld of welded pipe	SAW, COW	Once per test unit of pipe with the same cold-expansion ratio [a, b, c] and at least once per shift
20	Macrographic and metallographic testing of 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, plus whenever excursions from operating heat treatment conditions are encountered
20a	If specified, macrographic hardness testing of seam weld of welded pipe	HFW, SAW, COW	Once per test unit of pipe with the same cold-expansion ratio [a, b, c]
20b	If specified, macrographic hardness testing of pipe body	All pipes	Once per test unit of pipe with the same cold-expansion ratio [a, c]
21	Visual inspection	All pipes	Each pipe
22	Pipe diameter and out-of-roundness	All pipes	At least once per 4 hours per operating shift plus whenever any change of pipe size occurs during the operating shift
23	Wall thickness measurement	All pipes	Each pipe (see 10.2.8.5)
24	Other dimensional testing	All pipes	At least once per 4 hours per operating shift plus whenever any change of pipe size occurs during the operating shift
25	Weighing of pipe with $D < 141.3$ mm (5.563 in.)	All pipes	Each pipe
26	Weighing of pipe with $D \geq 141.3$ mm (5.563 in.)	All pipes	Each pipe
27	Length	All pipes	Each length of pipe
28	Nondestructive inspection	All pipes	In accordance with Annex E or Annex K
29	If specified, etching of longitudinal seam weld of welded pipe	SAWL, COWL	5 pipes per shift at both ends

[a] 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.

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

[c] Unless otherwise specified, test unit is defined in 3.1.60 with the additional restriction of maximum 50 pipes for design temperature below -10 °C (14 °F).

10.2.3 Sample and Test Pieces for Mechanical Tests

10.2.3.1 General

All mechanical test specimens shall be taken from pipe in the final manufacturing condition.

Add to section

The specimen shall be prepared in a manner that does not enhance its mechanical properties.

10.2.3.2 Test Pieces for Tensile Test

Add to section

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

Add to section

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

Add to section

Limitation on pipe diameter / wall thickness combination shall be in accordance with API Specification 5L and this specification.

10.2.3.3 Test Pieces for the CVN Impact Test

Add new section

10.2.3.3.1 Welded Pipes

10.2.3.3.1.1

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 FL and sample 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.

10.2.3.3.1.2

If specified, an additional HAZ specimen shall be performed with notch at FL2.

10.2.3.3.1.3

For SAW and COW pipe with $t \geq 25$ mm (1 in.), additional testing specified above and if specified FL2 shall be done within 2 mm (0.08 in.) of the inner surface of the pipe.

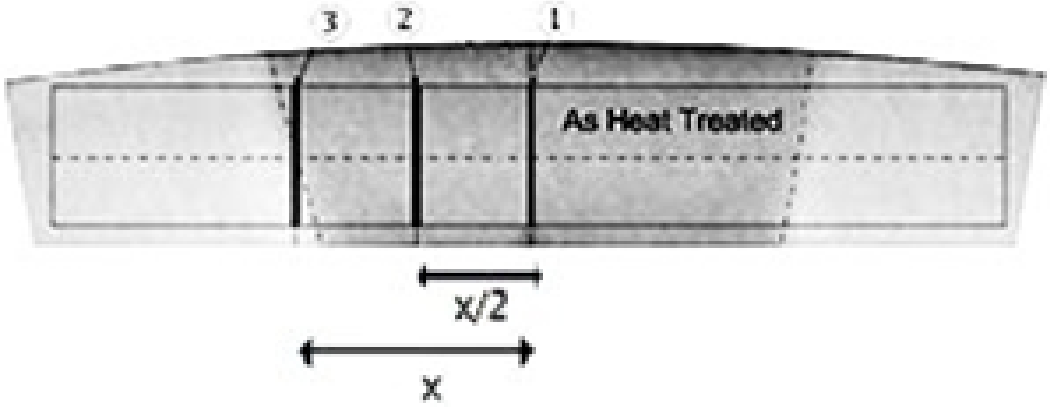
10.2.3.3.1.4

For HFW, during MPQT, the manufacturer shall obtain Charpy testing samples from positions 1, 2 and 3 as shown in Figure 13.

10.2.3.3.1.5

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

Add new Figure 13



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 13—CVN Testing of HFW Weld Seam

Add new section

10.2.3.3.2 Welded Pipe Body and Seamless Pipe

10.2.3.3.2.1

For seamless line pipe with wall thickness less than 25 mm (1.0 in.), the axis of the specimen shall be aligned with the mid-thickness of the pipe.

10.2.3.3.2.2

For seamless line pipe with wall thickness greater than 25 mm (1.0 in.), Charpy impact testing shall be done on specimens taken from the ID and OD.

10.2.3.3.2.3

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

10.2.3.3.2.4

Coupons/specimens shall not be flattened.

Add new section

10.2.3.8 Test Pieces for Fracture Toughness Test

10.2.3.8.1 Test Pieces

10.2.3.8.1.1

Test pieces for a CTOD test shall be taken from the weld metal, the HAZ and the parent metal.

10.2.3.8.1.2

Test pieces for a CTOD test shall be prepared in accordance with ISO 12135 or ISO 15653.

10.2.3.8.1.3

Test pieces for a CTOD test shall be Bx2B through thickness notched specimens.

10.2.3.8.1.4

Test pieces for a CTOD test for base metal shall be taken at location 180° from the weld seam and have position YX as per Figure 13.

10.2.3.8.1.5

Test pieces for a CTOD test for weld metal and HAZ area shall be taken from position NP as per Figure 13.

10.2.3.8.1.6

For test pieces for weld metal testing in position NP, the notch axis shall be located on the weld center line.

10.2.3.8.1.7

For HAZ specimens in SAW pipe in position NP, the notch axis shall be located so as to sample the fusion line.

10.2.3.8.1.8

For HAZ specimens in SAW pipe in position NP, the central 50 % portion of the notch shall be located in the HAZ.

10.2.3.8.1.9

For HAZ specimens in SAW pipe in position NP, the outer portions of the notch shall be located in the weld metal.

Add new section

10.2.3.8.2

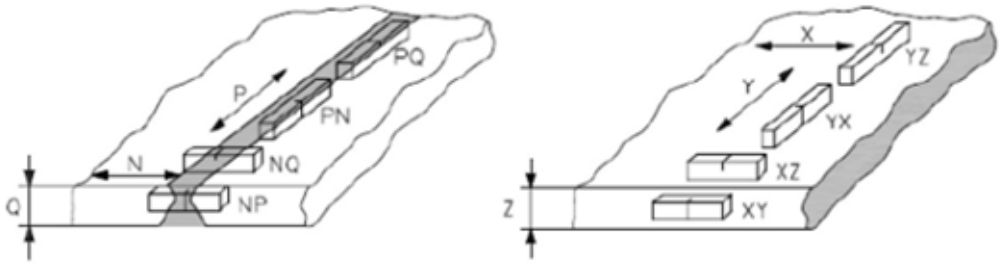
Three valid CTOD tests shall be required for each location.

Add new section

10.2.3.9 Test Piece for Spring-back Test

The length of the sample piece of pipe shall be a minimum of 305 mm (12 in.) with consideration of end effects.

Add new Figure 14



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 14—CTOD Orientation

Add new section

10.2.3.10 Test Pieces for Hardness, Macrographic, and Metallographic Examination

10.2.3.10.1

Sampling for macrographic hardness testing shall be as follows:

a) for seamless pipe, two test pieces, 180° apart taken from the finished pipe;

b) for welded pipe, two test pieces taken from the seam weld and at a location that is of either 90° or 180° from the seam weld and that is determined based on the location with the highest hardness from MPQT.

10.2.3.10.2

The test pieces shall be prepared in accordance with ISO 17639.

10.2.3.10.3

The surface to be examined shall be perpendicular to the pipe axis for seamless pipe and perpendicular to the welding direction for welded pipe.

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 to section

For HFW, the deformation angle as defined in Figure 12 shall be 50° to 80° or within the qualified range.

Add new section

10.2.5.5

10.2.5.5.1

If specified, hardness testing shall be performed in accordance with Figure J.1.

10.2.5.5.2

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

10.2.5.5.3

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.

10.2.5.5.4

The hardness test locations for SMLS pipe shall be in accordance with Figure J.1 a), excluding the following:

a) for pipe with $t < 4.0$ mm (0.156 in.), it is necessary to carry out only the mid-thickness traverse;

b) for pipe with 4.0 mm (0.156 in.) $\leq t < 6$ mm (0.236 in.), it is necessary to carry out only the inside and outside surface traverses.

10.2.5.5.5

Hardness locations for welded pipe shall include the weld cross-section.

10.2.5.5.6

Indentations in the weld cross-section shall be made in the parent metal, in the original HAZ, and at the weld centerline, in accordance with Figure J.1 b) or Figure J.1 c) or Figure J.1 d), excluding:

a) for pipe with t < 4.0 mm (0.156 in.), it is necessary to carry out only the mid-thickness traverse;

b) for pipe with 4.0 mm (0.156 in.) ≤ t < 6.0 mm (0.236 in.), it is necessary to carry out only the inside and outside surface traverses.

10.2.6 Hydrostatic Test

10.2.6.1

Replace first sentence with

Each length of pipe shall be hydrostatically tested for at least 10 seconds.

Replace second sentence with

The hydrostatic test shall be conducted in the final manufacturing condition after repairs, except for cosmetic grinding as per C.2 or grinding of weld cap as per 9.13.2.2 f). In addition, see E.3.1.3.

Replace third sentence with

Hydrostatic testing water shall be neutral fresh water.

Delete fourth sentence

10.2.6.2

Add to section

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

Add to section

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

Add to section

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

Add to section

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

Add to section

The pressure shall not lead to the stress exceeding the specified minimum yield strength.

Add to section

The hydrostatic test pressure gauges shall be validated against a deadweight tester or compatible device just prior to the start of production, at least once a week during production and after any production interruption.

10.2.7 Visual Inspection

10.2.7.1

Replace first sentence with

The pipe seam weld shall be visually inspected in accordance with ISO 17637 with an illuminance of at least 350 lx.

Replace second sentence with

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

Add to section

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

Add to section

The weld penetration shall be visually checked 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 the actual maximum and minimum diameters.

Add new section

10.2.8.8

10.2.8.8.1

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

10.2.8.8.2

Incremental methods shall not be used.

10.2.8.8.3

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 Annex T shall apply.

10.2.11 Reprocessing

Add to section

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

Add to section

In case of test unit failure for HFW pipes, reprocessing shall not be performed.

10.2.12 Retesting

Add new section 10.2.12.0 before section 10.2.12.1

10.2.12.0 General

10.2.12.0.1

Retesting allowances for failures of tests that are not specifically addressed in 10.2.12 shall be submitted for the purchaser's approval.

10.2.12.0.2

When a test fails for HFW pipe, the entire test unit shall be rejected.

Add new section

10.2.12.9

If a single CTOD test specimen from a set of three CTOD test specimens fails to meet the acceptance criteria, the manufacturer shall test and pass a set of three specimens from the same joint and an additional set of three specimens from a separate joint in the same heat.

11 Marking

11.2 Pipe Markings

11.2.1

Add to section

The marking requirements shall include the following:

a) purchaser's name;

b) order number;

c) pipe number;

d) heat number;

e) length (with units).

11.2.3

Add new list section c)

c) The markings shall be coated with a clear varnish type coating (hard drying).

Add new list section d)

d) Unique pipe numbers shall be assigned to each pipe.

14 Pipe Loading

Add new section after NOTE

14.1 General

14.1.1

Pipes shall be fitted with bevel protectors.

14.1.2

The product data sheet for the bevel protectors shall be supplied.

14.1.3

Pipes shall have no visible contaminants (e.g. oil, grease, lacquer, antifreeze and chlorides) that adversely affect coating adhesion.

14.1.4

Pipes shall be handled, loaded and shipped in accordance with the applicable sections of API Recommended Practice 5L1, API Recommended Practice 5LT and API Recommended Practice 5LW.

14.1.5

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

14.2.1

When the manufacturer is responsible for handling or shipping, the shipping procedures with a written method to prevent salt contamination of the pipe at the receiving facility shall be submitted.

14.2.2

When the manufacturer is responsible for handling or shipping, for transoceanic shipping, the ship's log shall be made available for review when the pipe is unloaded.

14.2.3

When the manufacturer is responsible for handling or shipping, the timing to submit loading instructions and diagrams for all pipe shipped shall be agreed during the pre-production meeting.

14.2.4

When the manufacturer is responsible for handling or shipping, all dimensional tolerances and pipe surface conditions specified shall apply to the pipe condition as received at the shipping destination.

14.2.5

When the manufacturer is responsible for handling or shipping, he 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.

14.2.6

No overstowage or deck loads shall be permitted.

Add new section

14.3 Handling

14.3.1

Methods used for handling of the pipe shall not cause damage to the pipe.

14.3.2

Hooks shall only be used to attach to hookable end caps or bevel protectors fitted to the pipe.

14.3.3

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

Add new section

14.4 Storage

14.4.1

The outdoor storage of pipe shall be elevated off the ground.

14.4.2

The outdoor storage of pipe shall prevent accumulation of water.

14.4.3

The outdoor storage of pipe shall not be in contact with other pipe.

14.4.4

Pipe shall not be nested one diameter inside a larger pipe.

14.4.5

Handling, loading and unloading shall avoid magnetization, mechanical damage and 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.

Add to section

MPQT shall be completed prior to the start of production.

Add to section

Performing MPQT as first day production testing shall be subject to approval.

Add to section

When accepted, the MPQT requirements performed during first day production testing shall be at the manufacturer's sole risk.

Add to section

Qualification of HFW pipes shall be in accordance with Figure B.1.

Add to section

When an alternative means of verification of the manufacturing procedure other than MPQT is proposed, this shall be subject to agreement.

B.2 Additional Information to Be Supplied by the Purchaser

Replace section with

B.2.1

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

Add new section

B.2.2

Prior to the start of production, the following documents shall be submitted for acceptance:

a) manufacturing procedure specification in accordance with B.3;

b) inspection and test plan in accordance with B.4.

Add new Figure B.1

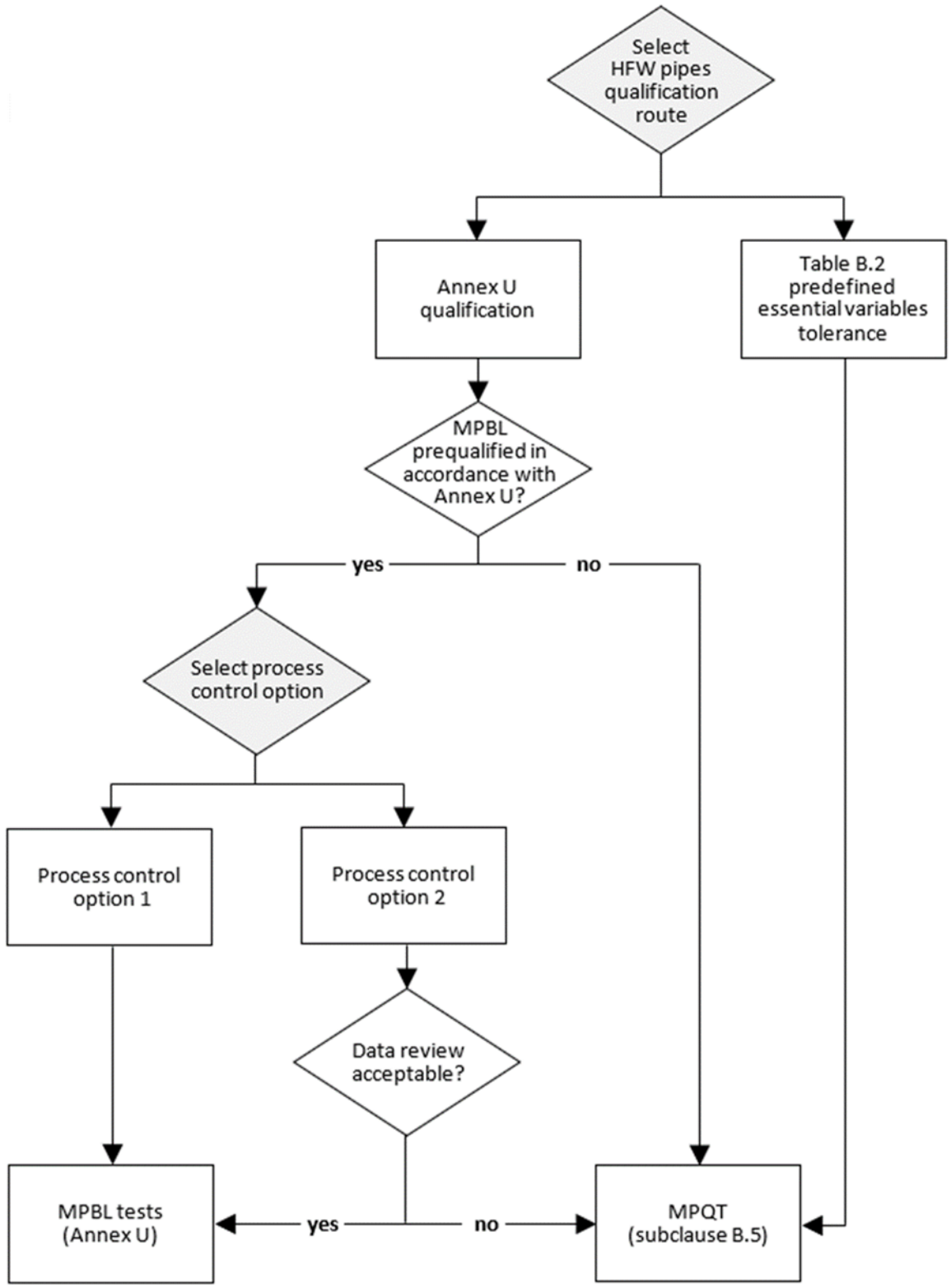


Figure B.1—Qualification of HFW Pipes Flowchart

B.3 Characteristics of the Manufacturing Procedure Specification

Replace first sentence with

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

Replace second sentence with

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

Add to section before list

Before production commences, the manufacturing control documents listed in the IRS (IOGP S-616L) shall be supplied.

Add to section before list

Control documentation shall be for internally and externally sourced processes, products and services.

Add to section before list

Control documentation shall include a lay out, a process flow description/diagram, the information required by Annex B and the following information.

a) Steelmaking and casting—for all pipe:

Add new list item a) 9)

9) procedure for scrap management if steel scrap is used;

Replace list item a) 2) with

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 list item a) 3) with

3) 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 annex specified;

Replace list item a) 5) with

5) hydrogen control practice;

Replace list item a) 8) with

i) steelmaking and casting methods used to mitigate segregation and minimize inclusions;

ii) description of the processes, quality control steps and tests to assure adequate quality of the final pipe;

iii) control of steel cleanliness and centerline segregation, including the acceptance criteria.

Add new list item a) 10)

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

Add to list item a) 6)

Product identification and traceability practices including as a minimum details of the casting sequences (e.g. casting strand, number of heats, tons, scrapping lengths) recorded and available for review;

b) Pipe manufacturing—for all pipe:

Replace list item b) 2) with

2) equipment and process description with diagram showing the process flow for all processes involved in pipe manufacturing, testing, inspection, coating, etc.;

Replace list item b) 3) with

3) hydrostatic testing practices including the specified test pressure to be used, and equipment calibration and verification records;

Replace list item b) 4) with

4) nondestructive inspection methods and practices including standardization practice and records of the test in accordance with Annex T;

Add list items i) and ii) under list item b) 5)

i) product analysis method:

ii) as applicable, detailed mechanical and corrosion test procedures, including:

a) unique identification number for each specimen;

b) drawings of test specimens, size, precise location and orientation (along the length, around the circumference and in the pipe wall thickness); and;

c) procedure for removing, polishing, etching, and notching weld/weld fusion line and HAZ Charpy test specimens.

Replace list item b) 8) with

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

Add to list item b) 9)

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

Replace list item b) 11) with

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

Add new list item b) 12)

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

Add new list item b) 13)

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

Add new list item b) 14)

14) control of final heat treatment process;

Add new list item b) 15)

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

Add new list item b) 16)

16) calibration frequency of the thermocouples;

Add new list item b) 17)

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

Add new list item b) 18)

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 list item b) 19)

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.

c) Hot rolling—for welded pipe:

Replace list item c) 2) with

2) equipment and process description including slab reheating practices, minimum temperature, soaking time at slab reheating stage, rolling schedule, reduction ratio, and cooling practices (cooling method, cooling rate target and range, cooling start and finish temperature target and range), heat treatment if any, and target coiling temperature as applicable;

Add to list item c) 7) after "practices"

and qualified minimum crop lengths

e) Pipe manufacture—for welded pipe:

Add new list item i) under list item 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 list item ii) under list item e) 1)

ii) plate/coil receiving inspection methods and acceptance criteria;

Add new list item c) to list item e) 3) i)

c) weld cap profile dimensions;

Add new list item c) to list item e) 3) ii)

c) description and controls of welding and heat treating processes;

Add new list item d) to list item e) 3) ii)

d) tack welding process and the maximum thickness of the tack weld to be specified within the WPS;

Add new list item 4) to list item e)

5) pWPS or previously qualified WPS if available, including all essential variables from Table B.1 and Table B.2;

Add new list item 6) to list item e)

6) welding equipment, including weld tracking system;

Add new list item 7) to list item e)

7) minimum tab length reported in the MPS and qualified during MPQT.

f) Pipe manufacture—for SMLS pipe:

Add new list item 3) to list item 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 list item 4) to list item f)

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

Add new list item 5) to list item f)

5) end cropping practices.

Replace section B.4 title with

B.4 Characteristics of the Inspection and Test Plan

Add new list item j)

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

Replace section B.5 title with

B.5 Manufacturing Procedure Qualification Testing (MPQT)

B.5.1

Add to beginning of section

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

Add to beginning of section

If a MPQ test fails, retesting shall be subject to approval.

Add to beginning of section

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

Add to beginning of section

If the two new retests meet the acceptance criteria, MPQT shall be considered to meet the requirement.

Add to beginning of section

In cases where the qualification test results do not comply with the requirements, the pipe tested and all pipes produced in accordance with the MPS shall be rejected.

Add to section

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

B.5.2

Replace section with

B.5.2.1 Pipe Sampling

B.5.2.1.1

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

B.5.2.1.2

MPQT pipes shall be subjected to all production applicable inspections.

B.5.2.1.3

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

B.5.2.1.4

The selected MPQT pipes shall be accepted by the inspector.

Add new section

B.5.2.2 Macrographic, Micrographic, and Segregation Analysis on Slabs

B.5.2.2.1

For HFW, the first, middle and last slab from the first casting sequence shall be subjected to macrographic, micrographic and segregation analysis.

B.5.2.2.2

The analysis procedures shall be submitted.

B.5.2.2.3

Macrographic methods shall be by macroetch and magnetic particle testing.

B.5.2.2.4

Micrographic methods shall be by optical microscope on the polished sample.

B.5.2.2.5

Segregation analysis shall be carried out by cross-section chemical analysis at the surface of the slab, ¼ slab thickness and ½ slab thicknesses in the locations as shown in Figure B.2.

B.5.2.2.6

The chemical composition at center line shall be within the tolerance of target chemical composition.

Add new Figure B.2

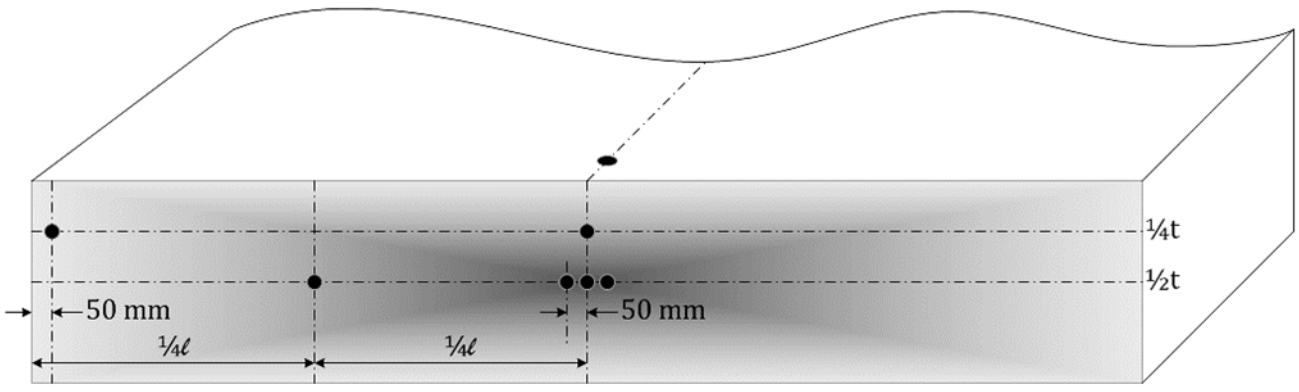


Figure B.2—Slab Macrographic, Micrographic Analysis Sampling

Add new section

B.5.2.3 Charpy Impact Tests

B.5.2.3.1

A 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 in the following locations:

a) for seamless, within the pipe body;

b) for HFW, within the parent material and along the weld centerline within 0.25 mm (0.01 in.) from the fusion line);

c) SAW and COW, within the parent material at 90° from the weld seam, along the weld centerline and on the fusion line.

B.5.2.3.2

If agreed, the temperature range for testing shall cover fully a transition curve showing the transition area.

B.5.2.3.3

Tests at temperatures below the routine test temperature shall be at least 10 °C (18 °F) above the transition temperature.

B.5.2.3.4

For SAW DBTT in terms of shear area, this shall be required in the HAZ [FL +2 mm (0.079 in.)] in accordance with 9.8.3 but not in the weld metal location.

B.5.2.3.5

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

B.5.2.3.6

Ageing shall be performed by heating the specimen to a temperature of 250 +/-5 °C (482 +/-10 °F) with a soaking time of 1 hour.

Add new section

B.5.2.4 Tensile Tests

B.5.2.4.1

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

B.5.2.4.2

Data shall be supplied in native format compatible with spreadsheets.

B.5.2.4.3

For SAW and COW two round bar, two longitudinal all-weld tensile tests, one from inside and one from outside the weld bead, shall be performed.

B.5.2.4.4

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

B.5.2.4.5

If specified, elevated temperature tensile tests shall be performed as follows:

a) in the longitudinal direction for all pipe sizes;

b) in the transverse direction for pipes with an outside diameter greater than 219.1 mm (8.625 in.) if the diameter/thickness allows extraction of minimum diameter round bar specimen allowable by API Specification 5L or unflattened specimen (see Table 20).

Add new section

B.5.2.5 Macrographic, Metallographic, and Hardness Tests on Pipes

B.5.2.5.1

Micrography and hardness tests shall be performed at the two ends of the MPQT pipes as follows:

a) For welded pipes, at the three following positions:

   1) weld seam;

   2) 90° from the weld seam; and

   3) 180° from the weld.

b) For SMLS pipes, at two diametrically opposed locations.

B.5.2.5.2

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

B.5.2.5.3

Photographs of the microstructure shall be supplied at three following locations:

a) below the ID surface;

b) below the OD surface;

c) mid-thickness.

B.5.2.5.4

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

B.5.2.5.5

When not evaluated on the slab (see B.5.2.1), the carbon/carbide segregation level shall be assessed against the Mannesman scale or equivalent, and qualified.

Add new section

B.5.2.6 Ageing Tests

B.5.2.6.1

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.

B.5.2.6.2

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

B.5.2.6.3

The total strain from cold forming shall consider all operations on the steel, including but not limited to, levelling of plate, pipe forming (t/D) and expansion.

B.5.2.6.4

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

B.5.2.6.5

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 Nondestructive Testing

B.5.2.7.1

The weld seam of MPQT shall be radiographically examined throughout the full length for SAW and COW pipes.

B.5.2.7.2

The weld seam of MPQT 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. See 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 in accordance with the following.

a) Three seamless pipes shall be blast cleaned and examined during the manufacturing procedure qualification.

b) Pipes shall be selected at random and heated to a minimum of 70 °C (160 °F).

c) The outside surface of the pipe shall be blast cleaned to a surface finish of SA 2½ and then re-heat the pipe to 250 °C (482 °F).

d) Each pipe shall be examined visually over its entire surface for imperfections that compromise the blast profile of 50 µm to 100 µm (0.002 in. to 0.004 in.).

e) All imperfections detected shall be dressable for no longer than 3 minutes by hand held equipment such as flapper disk or grinder stone grade 100 or above.

Add new section

B.5.2.9 Coating Simulation Effects

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

B.5.3

a) For HFW pipe:

Add to list item a) 1) after "parameters"

within the qualified range in accordance with Annex U

Add to section

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

Add to section

Alternate ranges of essential variables shall be considered with acceptable evidence of suitability for product acceptance.

B.5.4

Replace section with

Weldability test requirements shall be in accordance with 9.15.

If agreed, weldability tests shall be undertaken separately to MPQT.

B.5.6

Replace section with

Change to the essential variables listed in B.5.7 shall require new MPQT.

Add new section

B.5.7 Welding Essential Variables

B.5.7.1

If requested, a preliminary welding procedure shall be submitted.

B.5.7.2

Qualification of the welding procedure specification shall be in advance of each production, from previously qualified procedures or on first day of production, in accordance with B.1.3, if agreed.

B.5.7.3

The WPS and supporting PQR shall be submitted for acceptance.

B.5.7.4

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

B.5.7.5

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

B.5.7.6

Welding records shall be available for review.

B.5.7.7

Information required in ASME IX WPS format shall be listed.

Add new Table B.1

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

Essential Variables	Changes that Require New Qualification	
	GMAW	SAW
Base metal	Change in API Specification 5L steel grade	
	Increase in CE_{PCM} greater than 0.02 as an essential variable	
	Increase in CE_{IIW} greater than 0.03 as an essential variable	
	Change in pipe delivery condition	
	Change in specified wall thickness by more than -10 % / +5 %	
Bevel shape, angle	Change in bevel shape / groove type	
	Change in root face by more than -1.5 mm / +1.5 mm (±0.06 in.)	
	Change in root gap by more than -1.0 mm / +1.0 mm (±0.04 in.)	
	Change in angle by more than -5° / +5°	
Filler metal	Change in number of wires	
	Change in nominal wire diameter	
	Change in brand name	
	Change in wire classification	Change from one flux wire classification to any other flux wire classification
	Change in wire manufacturer	Change in flux or wire manufacturer
Position of welding point (for SAWH pipe)	Change in location and distance between strip-pipe meeting point to ID welding point	Change in location and distance between strip-pipe meeting point to ID welding point
		Change in location for OD welding
Preheat/interpass temperature	Methods 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)	
Equipment	Change in make, type and model of welding equipment	
Electrical characteristics	Change in welding position, type of current and polarity	
	Change of ±10 % in voltage, amperage and wire feed speed for each wire	
	Change of ±10 % in travel speed	
	Change of ±10 % in welding heat input	Change of ±7 % in welding heat input
	Change from constant voltage to constant current output	Change of > 5 mm (0.2 in.) in longitudinal or lateral spacing of the arcs
	Change in the mode of transfer	—
Weld pass	Change in number of weld passes	
Shielding gas	Change in gas composition	—
	Decrease in gas flowrate	—
	Increase in gas flow rate by more than 10 %	—
PWHT	Addition or deletion of PWHT	
	Change in nominal PWHT temperature by more than ±10 °C (18 °F)	
	Change of ≥ 10 % in soaking time	

Add new Table B.2

Table B.2—Welding Essential Variables for HFW Pipes

Essential variables	Changes that Require New Qualification
Base metal	Change in API Specification 5L steel grade
	Increase in CEPCM greater than 0.02 as an essential variable
	Increase in CEIIW greater than 0.03 as an essential variable
	Change in pipe delivery condition
	Change in nominal wall thickness
	Change in nominal pipe diameter
	Change in source of coil
Transfer of welding current and use of impeder	Change in welding current transfer mechanism (either by induction coils or contact tips)
	Change in dimension of induction coils/contact tip, material, coolant type and contact tip force
	Change in use, dimension, material and location of impeder
Equipment	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 temperature of pipe surface and speed of pipe
Induction coil configuration (HFW only)	Any change
Impeder configuration (HFW only)	Any change
Electrical characteristics	Change of ±5 % in qualified frequency (frequency ≥ 100 KHz)
	Change of ±5 % in welding heat coefficient, Q = (amps × volts) / (travel speed × thickness)
Roll pressure on welding/squeezing point, squeeze out and metal flow angle	Change in roll pressure location
	Change below minimum qualified roll pressure
	Decrease in qualified squeeze out
	Metal flow angle range 50° to 80°
Shielding gas and coverage area	Change in gas composition
	Decrease in gas flowrate
	Decrease in coverage area (as a minimum, beveled areas after induction coils/contact tip to be protected)
Weld seam heat treatment and cooling system	Change of > 5 % in qualified frequency
	Decrease in soaking time
	Decrease in qualified exit temperature by more than 20 °C (36 °F) and exit temperature > Ac3 + 30 °C (54 °F)
	Change in cooling system

Add new Table B.3

Table B.3—MPQT Tests in Addition to Table 18

No	Type of Inspection	Type of Pipe
1	Macrographic and metallographic testing of pipe body	All pipes
2	Macrographic, micrographic and segregation analysis of first, middle and last slab	HFW
3	Longitudinal CVN impact testing of pipe body	All pipes
4	If specified, CVN transition curve of the body	All pipes
5	If specified, CVN transition curve of seam weld	Welded pipes
6	If specified, CVN transition curve of HAZ	SAW and COW
7	If specified, CVN transition curve of pipe body, aged condition	All pipes
8	If specified, spring-back test	SAW, COW, HFW
9	If specified, DWT transition curve of pipe body	All pipes
10	If specified, CTOD of base material	All pipes
11	CTOD of weld metal, HAZ (welded pipe only)	Welded pipes
12	AWMT	SAW, COW
13	If specified, tensile test at high temperature	All pipe
14	Root guided bend test	HFW
15	CVN impact testing pipe body after ageing	All pipes with cold forming exceeding 5 %
16	Tensile testing pipe body after ageing	All pipes with cold forming exceeding 5 %
17	Cross section hardness testing after ageing	All pipes with cold forming exceeding 5 %
18	NDT in accordance with B.5.2.7	SAW, COW
19	If specified, surface condition test	SMLS
20	If specified, heating effect tests as per N.3.1.2	Welded pipes
21	Sizing ratio	Cold expanded pipes

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 Table C.1.

Add to section

Transition from dressed area to the contour of the pipe shall have a slope of 1:4 of lower.

Add new Table C.1

Table C.1—Acceptable Grinding Processes

Manufacturing Stage	All Pipe
Before hydrostatic pressure	Grinding wheel or flap wheel
After hydrostatic pressure	Only flap wheels — cosmetic grinding [a]

[a] Cosmetic grinding applies for surface imperfections as defined in 9.10.7 a) and is performed using grain size disk # 100 and above or flap wheels. Wall thickness check is not required after cosmetic grinding.

C.2.3

Replace section with

After grinding, complete removal of defects shall be verified by wet or dry MT in accordance with ASTM E709 or ISO 10893-5.

Add to section

After grinding, complete removal of defects shall be verified by the NDT method that detected the defect (i.e. VT, AUT or EMI).

Add to section

When manual UT is used in lieu of AUT or EMI, the manufacturer shall demonstrate the detection performance of the MUT equipment and procedure for surface defects.

Add to section

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

Add to section

If MT or liquid penetrant cannot be performed on the ID, MUT or AUT and EMI shall be used when applicable.

Add to section

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

Add to section

Wall thickness measurements shall be made by UT in the area of the defects repaired by grinding and the results recorded.

Add to section

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

Add to section

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

Replace first sentence with

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

Replace second sentence with

Multiple repairs shall not exceed more than two consecutive repairs.

Add to section

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

Add to section

Weld seams containing cracks shall not be weld repaired.

Add to section

The section of pipe containing cracks shall be cut off.

Add to section

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

Add to section

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

Add to section

Inside repairs shall be followed by visual inspection.

Add to section

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

C.4.2

Add to section

When required, repairs shall be carried out before cold expansion and hydrostatic testing.

Add to section

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

Add to section

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 after first sentence

Weld repairs shall not exceed four per pipe with a maximum length of 350 mm (13.8 in.) per repair.

C.4.4

Replace first sentence with

Repairs shall be separated by at least 150 mm (5.9 in.).

Replace second sentence with

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

Add to section

Welding repairs shall not be done 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 or helical seam weld.

C.4.6

Replace first sentence with

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

Replace second sentence with

The repaired area shall be 100 % examined as follows:

a) by ultrasonic and MT testing;

b) if specified, by radiographic testing in accordance with Annex E; and

c) if applicable, Annex K.

Annex D
(normative)

Repair Welding Procedure

D.1 General

D.1.2

Delete list 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 ⅔*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) one weld repair of a weld repair if agreed by the manufacturer.

Add to section

If multiple repair qualification is not performed, weld repairs shall not be more than one repair attempt.

Add to section

If multiple repair qualification is performed, a maximum of two weld repairs in a single location shall be permitted.

Add to section

Through thickness repairs shall not be permitted.

Add to section

Repairs shall be preheated at 50 °C (90 °F) above the original weld minimum preheat, unless the qualification test has shown that a higher temperature is necessary.

Add to section

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

c) Welding materials:

Add new list item 7) to list item c)

7) change in batch number of the electrode (each batch shall be individually tested) and if agreed electrode, certificate type 3.1 as per EN 10024 showing actual test results may be issued in lieu of batch testing.

D.2.3 Mechanical Testing

D.2.3.4 Charpy (CVN) Impact Test

Add new section

D.2.3.4.5

D.2.3.4.5.1

Sampling of CVN specimens shall be performed at the locations represented in Figure D.2 for a partial thickness repair.

D.2.3.4.5.2

The manufacturer shall issue a drawing identifying the locations for CVN sampling applicable for the actual repairs to be qualified.

D.2.3.4.5.3

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

Add new section

D.2.3.5 Hardness Testing

D.2.3.5.1

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

D.2.3.5.2

Unless the spacing of the governing testing specification deems otherwise, the number and position of the indentations shall be in accordance with Figure D.3 for partial repair qualification and Figure D.4 for shallow repair qualification.

D.2.3.5.3

Where indentations spacing in accordance with Figure D.3 or Figure D.4 are too small (see ISO 6507-1 or ASTM E92/ASTM E384), the number of indents shall be by agreement.

D.2.3.5.4

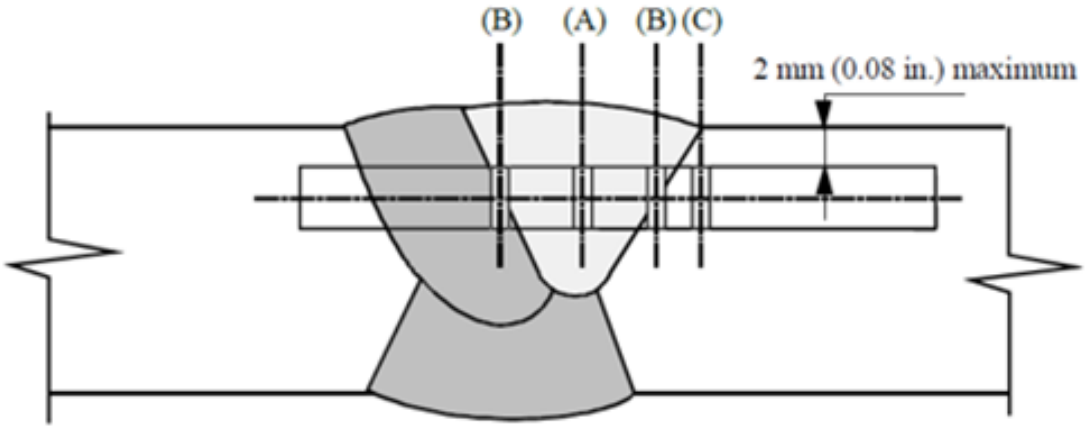
Acceptance criteria shall be in accordance with 9.19 or applicable annexes, if specified.

Add new section

D.2.3.6 CTOD Testing

For the qualification of repair welds when CTOD testing has been specified, tests shall be performed using surface notched specimens (NP) for the repair weld and the repair weld HAZs.

Add new Figure D.2



Key

A weld metal center line

B fusion line of repair weld to base metal and fusion line to repair to original weld

C fusion line +2 mm (0.08 in.)

Figure D.2—Partial Repair Charpy Sampling Location

Add new Figure D.3

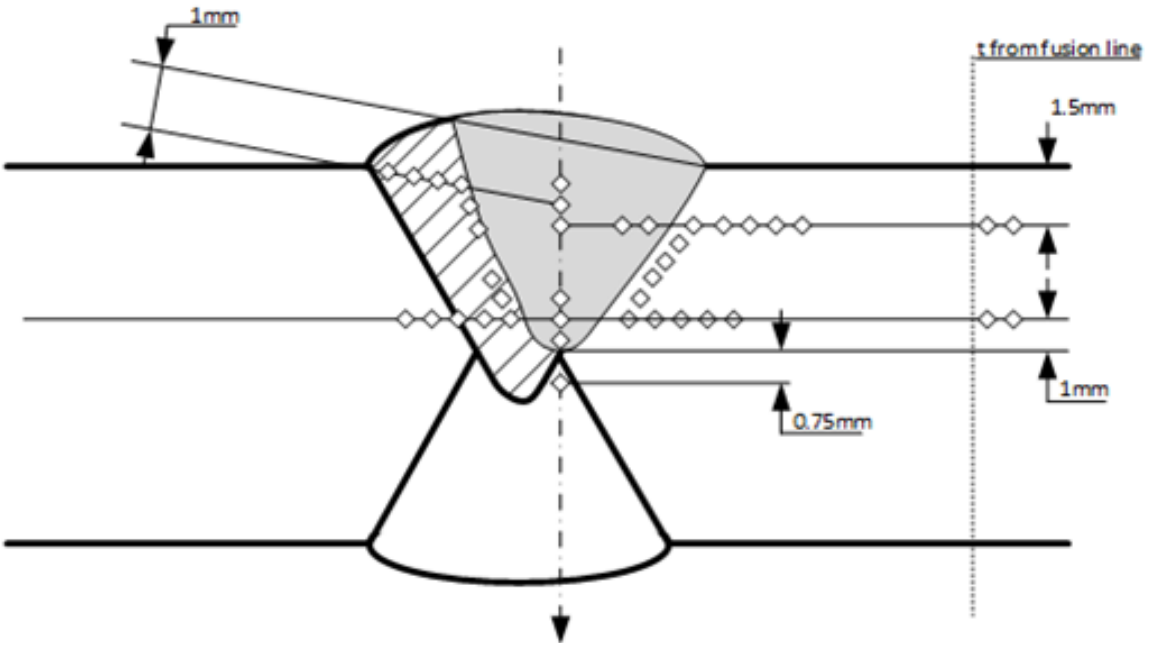


Figure D.3—Partial Repair Hardness Indentation Location

Add new Figure D.4

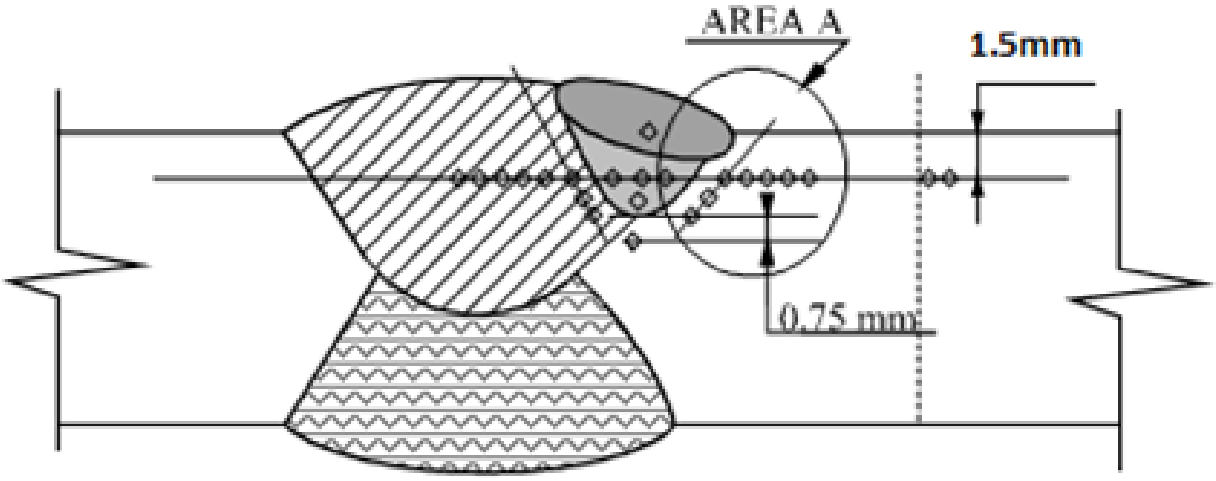


Figure D.4—Shallow Repair Hardness Indentation Location

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.

Add to section

NDT personnel shall be requalified for any method previously qualified if nondestructive inspection in that method has not been performed for a period exceeding 12 months.

Add to section

If specified, the following documents shall be provided:

a) list of NDT personnel showing the scope and dates of qualification;

b) qualifications of personnel performing NDT subject to acceptance;

c) supplemental certification requirements for NDT personnel.

E.1.3

Replace section from

Level 3 personnel shall be responsible for all NDT activities.

Add to section

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

Add to section

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

Add to section

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

Add to section

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

E.3 Methods of Inspection

E.3.1 General

E.3.1.1

Replace first sentence with

The weld seams and HAZs of welded pipes shall be inspected over the complete length (100 %) for the entire thickness for imperfections in accordance with Table E.1 and where applicable with Tables E.7 and E.9.

Replace second sentence with

UT shall be performed in accordance with ISO 10893-11 or ASTM E273, as amended or supplemented by this annex, and using conventional or phased array techniques.

Add to section

Manual or semi-automated UT shall only be used for pipe end inspection, weld end inspection and prove-up.

Add to section

ToFD techniques, EMATs and RTR shall not be used.

Add to section

Acceptance levels shall be in accordance with E.5.5.

Table E.1—Pipe Weld Seam Nondestructive Inspection

Replace Table E.1 with

Weld Seam Type	NDT Method [a]		
	EMI	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 [b]

[a] The weld seam at the pipe ends might require additional inspection as per E.3.2.

[b] Required as a minimum on pipe ends as per E.3.2.2.

E.3.1.2

Replace first sentence with

SMLS pipe shall be subjected to automated NDT over 100 % of the length and circumference for the detection of longitudinal and transverse imperfections in accordance with Table E.2.

Replace second sentence with

Scanning shall be performed in two opposing directions using 38° to 45° nominal angle shear wave probes such that the angle of incidence at the pipe ID targets 45°.

Replace Table E.2 title with

Table E.2—SMLS Pipe Body NDT for PSL 2 Pipe, any Grade

Replace Table E.2 with

Thickness mm (in.)	NDT Method		
	EMI	UT	MT
≤ 6.4 mm (0.25 in.)	Either EMI or UT as specified		If specified
> 6.4 mm (0.25 in.)	If specified	Required	

E.3.1.3

Replace section with

For welded pipe, NDT shall be completed after hydrostatic testing and sizing practice.

E.3.2 Pipe End Inspection—Welded Pipe

Add title to section to E.3.2.1

E.3.2.1 Noninspected Ends

Replace first sentence with

If AUT or EMI inspection is applied to meet the requirements of E.3.1.1, the weld ends that are not covered by the automated inspection, up to 305 mm (12 in.) maximum, shall be inspected by AUT, SAUT or MUT using the same inspection parameters in accordance with E.3.1.1.

Replace second sentence with

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

a) Non-AUT-inspected weld ends shall not to exceed 305 mm (12 in.).

b) Removal of non-AUT-inspected pipe ends shall not remove the obligation to perform radiographic testing (RT) of the weld ends in accordance with E.3.2.2.

c) Removal of non-AUT-inspected pipe ends shall not remove the obligation to perform UT of the pipe ends in accordance with E.3.2.3 and E.3.2.4.

d) Where more critical UT acceptance criteria apply 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

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 in accordance with E.3.2.1.

Add to section

Radiography inspection shall be X-ray.

Add new section

E.3.2.4 SAW & COW Pipe End Circumference

E.3.2.4.1

UT shall be carried out to verify that the 50 mm (2.0 in.) zone at each pipe end is free of axially aligned through thickness cracking.

E.3.2.4.2

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

E.3.2.4.3

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

Add new section

E.3.2.5 MT of End Face

E.3.2.5.1

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.

E.3.2.5.2

The end face shall be free of laminations ≥ 3.2 mm in the circumferential direction.

E.3.3 Pipe End Inspection—SMLS Pipe

Add title to section E.3.3.1

E.3.3.1 Noninspected Ends

Replace first sentence 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 using angle beam probes and the same inspection parameters in accordance with E.3.1.2 by:

a) UT using an alternative AUT system or SAUT system; or

b) MUT.

Replace second sentence with

Scanning shall be performed in two opposing directions using 38° to 45° nominal angle shear wave probes with the angle of incidence at the pipe ID adjacent to 45° as practicable.

Add to section

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

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.4.2.3

Replace section with

The density of the radiographs in the weld seam and parent metal shall be from 2.0 to 3.5.

Add new section

E.4.2.4

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

Add new section

E.4.2.5

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.

Add new section

E.4.2.6

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

E.4.6 Defects Found by Radiographic Inspection

Add to section

For SAW/COW pipe weld seams where an indication has been classified a defect by RT, these shall not be subsequently accepted by UT.

Add new section

E.4.8 Use of Filmless, Computed and Digital Radiography

E.4.8.1

The use of digital methods shall be permitted in accordance with ISO 10893-7 in lieu of conventional film RT of the body weld seam and the weld seam at the pipe ends, provided that the standard of the CR, DDA or DR is at least equal to the requirements for film RT specified in this document.

E.4.8.2

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

E.5 Ultrasonic and Electromagnetic Inspection

E.5.1 Equipment

Add title to section E.5.1.1 heading

E.5.1.1 General Characteristics

Replace section with

NDT equipment shall have the following general characteristics:

a) capable of revealing the defects specified in the applicable acceptance limits in accordance with Table E.8 and qualified in accordance with Annex Q;

b) AUT and EMI scanning equipment to be capable of 100 % coverage of the length and width under inspection, excluding untested edges or ends subsequently inspected using other automated, semi-automated or manual techniques;

c) automated and semi-automated NDT scanning equipment equipped and maintained to comply with Annex Q;

d) AUT and EMI equipment to automatically record indications in terms of their locations and amplitudes on paper charts or retrievable electronic media without any intervention from the operator;

e) all indications recorded by AUT or automated EMI to activate clear acoustic or visual alarms and/or paint spray marking;

f) signal/noise ratio to be at least 12 dB and verified at the beginning of a production run;

g) checks carried out during Annex S qualification (e.g. equipment drift, repeatability, axial consistency and weld seam tracking) performed as part of the mill's documented system of routine quality control checks and maintenance.

Add title to section E.5.1.2 heading

E.5.1.2 Specific Characteristics

Replace section with

E.5.1.2.1 UT Equipment for Plate and Coil

E.5.1.2.1.1

UT equipment used to detect laminar imperfections in plate/coil shall be capable of detecting and recording the minimum sizes of defects over 100 % of the body, 100 % of the edges and the ends, from 3 mm (0.12 in.) below the OD surface to 3 mm (0.12 in.) above the ID surface.

E.5.1.2.1.2

Alternatively, if UT equipment for laminar imperfections is unable to inspect 100 % of the edges and the ends, untested edges or ends shall be removed.

E.5.1.2.1.3

Indications exceeding the recording level shall be displayed in C-Scan format.

E.5.1.2.1.4

If the plate or coil has been fully inspected in accordance with this specification, inspection on the pipe shall not be required.

E.5.1.2.1.5

Scanning of coil may be replaced by full-body AUT of HFW pipe.

E.5.1.2.2 UT Equipment for Pipe Bodies and Pipe Ends

E.5.1.2.2.1 General

E.5.1.2.2.1.1

UT equipment used to detect laminar imperfections in pipe bodies and pipe ends shall detect and record the minimum sizes of defects for all probe types:

a) for pipe over 100 % of the body and 100 % of the pipe ends, from 3 mm (0.12 in.) below the OD surface to 3 mm (0.12 in.) above the ID surface;

b) for weld edges across the full area including at the pipe ends, from 3 mm (0.12 in.) below the OD surface to 3 mm (0.12 in.) above the ID surface.

E.5.1.2.2.1.2

Indications above the recording level shall be displayed in C-Scan format.

E.5.1.2.2.1.3

Scanning equipment for AUT of pipe bodies shall have 100 % coverage in one single uninterrupted pass along the full length and area under inspection (except for pipe ends subjected to separate AUT, SAUT or MUT).

E.5.1.2.2.1.4

For AUT systems incorporating multiple scanning carriages, there shall be overlap between carriages to insure 100 % coverage of the full length and area under inspection.

E.5.1.2.2.2 UT Equipment for Detecting Axially Cracking in Pipe Ends

UT equipment shall detect and record axially-aligned, through-thickness-orientated cracking in CW and CCW circumferential scanning directions, on the ID and OD surfaces for 100 % of a 50 mm (2.0 in.) wide band at both pipe ends.

E.5.1.2.2.3 UT Equipment for SMLS Pipe

UT equipment used to detect though-wall-orientated imperfections in SMLS pipe bodies and pipe ends shall detect and record the minimum sizes of defects required by the applicable acceptance limits on the ID and OD surface, in the axial and circumferential directions.

E.5.1.2.3 UT Equipment for Welded Pipe

E.5.1.2.3.1

Scanning equipment for AUT of the pipe weld seam shall have 100 % coverage in one single uninterrupted pass along the full length under inspection, except for weld ends subjected to separate AUT, SAUT or MUT.

E.5.1.2.3.2

Coverage shall be the full depth and width of the weld seam and HAZs.

E.5.1.2.3.3

HAZs shall be at least 3 mm (0.12 in.) wide on each side of the weld seam.

E.5.1.2.3.4

For AUT systems incorporating multiple scanning carriages, these requirements shall apply to every carriage, with overlap between carriages to assure 100 % coverage.

E.5.1.2.3.5

An automated weld tracking system shall be used with the circumferential positioning of the probes relative to the weld, with a positional accuracy within ±2 mm (0.08 in.).

Add new section

E.5.1.3 MUT and SAUT

E.5.1.3.1

MUT and SAUT equipment shall employ the same probe angles, scanning directions, reference reflectors, standardization, sensitivity and recording levels used for AUT.

E.5.1.3.2

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

Add new section

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

E.5.1.4.1

Ultrasonic probes shall enable the sensitivity and scanning coverage required by this specification.

E.5.1.4.2

Ultrasonic probes shall be provided with probe data sheets stating and illustrating the manufacturer, type, beam angle, dimensions, frequency distribution and beam focusing.

E.5.1.4.3

For ultrasonic probes for angle beam probes used for UT of weld seams, the data sheets shall illustrate the vertical -6 dB beam profile, or for phased array probes, a simulation showing the vertical -6 dB beam profile for each virtual probe.

E.5.1.4.4

If data sheets are generated by the mill rather than the probe manufacturer, the beam profile shall be developed using a series of side-drilled holes in a reference block of representative thickness and material.

Add new section

E.5.1.5 Coupling

E.5.1.5.1

For AUT equipment, coupling shall be monitored for each probe, each probe array or each group of probes contained within a single water-wedge as applicable 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.5.1.5.2

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

E.5.1.5.3

When there is a loss of coupling, the following shall occur:

a) location automatically recorded;

b) clear visible or audible alarms and/or paint marking activated.

E.5.1.5.4

Areas identified with coupling loss during AUT plus one-skip distance adjacent to the areas shall be evaluated by MUT or be reprocessed one time through the same automatic system used for initial inspection.

Add new section

E.5.1.6 Paint Spray Marking Systems

Automated paint spray systems shall be activated during the working shift to verify operation.

E.5.2 Ultrasonic and Electromagnetic Inspection Reference Standards

E.5.2.1

Add to section

Reference standards shall be manufactured from material of the same delivery condition, diameter (for pipe) and thickness as the production run material.

Add to section

Reference standards for pipe shall include additional length for run-on and run-off such that the probes are seated and coupled at the time the probe reach the first and last reference reflectors.

E.5.2.2

Replace section with

Dynamic reference standards shall be the full production length.

Add to section

Static reference standards shall be of a convenient length as determined by the manufacturer.

E.5.2.3

Replace section with

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

a) for HFW seam—Table E.7;

b) for SAW seam—Table E.9;

c) for SMLS pipe—Table E.10;

d) for plate/coil—Table E.11.

Add to section

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

Add to section

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

Add to section

The test standard certification sheet shall include mechanical dimensions of each test notch, hole, and wall reduction (depth, length, width and/or diameter).

Add to section

The test standard certification sheet shall include for SMLS and HFW pipe, acoustical characteristics for each reflector including drilled holes, being a maximum variation of 2 dB from all directions (i.e. left- and right-side and leading and trailing) for each reference reflector.

Add to section

The test standard certification sheet shall include for SAW and COW pipe, acoustical characteristics for each reflector including drilled holes, being a maximum variation of 3 dB from all directions (e.g. left- and right-side and leading and trailing) for each reference reflector.

Add to section

The test standard certification sheet shall include photographs of test notch replicas or molds.

Add to section

The test standard certification sheet shall include remaining thickness measured by MUT 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. FBH, RDH, SDH and N5 Notch).

E.5.2.5

Add to section

The reference standard shall be visually inspected for conformance with dimension requirements.

Add to section

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

Add to section

The following shall 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;

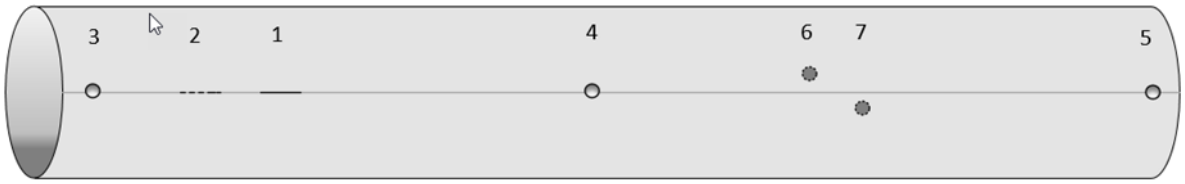
d) FBH (plate/coil)—diameter, drilled depth, depth below surface, angles in two perpendicular planes, and confirmation of flatness and perpendicularity of end;

e) SDH—diameter, drilled length, depth below surface, location, angles in two planes; and

f) RDH—diameter, location, angles in two perpendicular planes.

Table E.7—Reference Reflectors—HFW Seam

Replace Table E.7. with

Reference Reflectors—HFW Seam [a, b]			
Weld Seam Notches [c]		RDH Seam [d, e, f, g]	Radial FBH [a, d]
OD	ID		
Reflector Identification			
1	2	3, 4, 5	6, 7
			

NOTE The drawing is not to scale and is meant for illustration purposes only.

[a] If specified, the lamination check shall be performed with a 6.4 mm (0.25 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, located at the weld centerline and parallel to the weld axis with the following dimensions.

- Depth: 5 %*t*; minimum of 0.3 mm (0.012 in.) with 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.).

[d] Drilled hole dimensions shall be based upon standard drill-bit sizes.

[e] RDH – Seam: One 6 mm (0.063 in.) diameter radially through drilled hole and centered on the fusion line for EMI acceptance criteria.

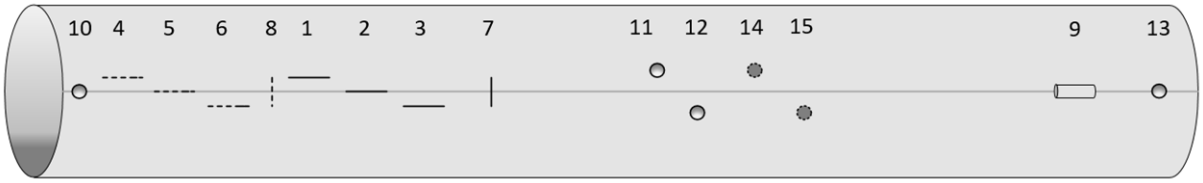
[f] RDH – Seam: Two 3.2 mm (0.125 in.) diameter at pipe ends to represent the maximum extent of automated NDT coverage of the length of the seam (in addition, see E.3.2.1).

[g] For AUT qualification (see Annex Q), 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.

Add new Table E.9

Table E.9—Reference Reflectors—SAW Seam

Reference Reflectors—SAW Seam [a, b]						
Notches [c]				SDH [f, g]	RDH [f, h, i, j]	Radial FBH [a, f]
Longitudinal [d]		Transverse [e]		Longitudinal	Vertical	
OD	ID	OD	ID	Embedded		
Reflector Identification						
1, 2, 3	4, 5, 6	7	8	9	10, 11, 12, 13	14, 15



NOTE The drawing is not to scale and is meant for illustration purposes only.

[a] If specified, lamination check shall be performed with a 6.4 mm (0.25 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 to 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] 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] 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.) diameter, longitudinal, located along the weld centerline drilled parallel to the weld axis within ±1°.

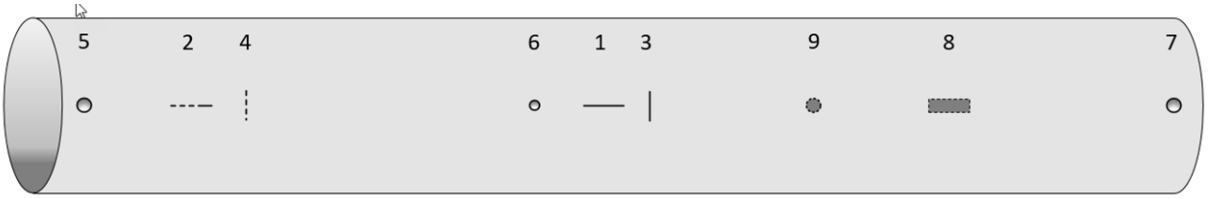
[h] RDH: Two 3.2 mm (0.125 in.) diameter holes located at the weld toes using the widest weld cap (i.e. the reflector should be the farthest away from weld centerline). For setting defect gate lengths/assuring coverage.

[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.

[j] For AUT qualification (see Annex Q), 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.

Add new Table E.10

Table E.10—Reference Reflectors—SMLS Pipe

Reference Reflectors—SMLS Pipe [a, b]						
Notches [c]				RDH [e, f, g, i]	Wall Reduction [h]	FBH [a, e]
Longitudinal [d]		Transverse				
OD	ID	OD	ID			
Reflector Identification						
1	2	3	4	5, 6, 7	8	9
						

NOTE The drawing is not to scale and is meant for illustration purposes only.

[a] If specified, lamination check shall be performed with a 6.4 mm (0.25 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.

[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] Longitudinal notches shall be parallel to the pipe axis.

[e] Drilled hole dimensions shallbased upon standard drill-bit size.

[f] RDH: One 1.6 mm (0.06 in.) maximum diameter hole for EMI.

[g] 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.

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

[i] For AUT qualification (see Annex Q), 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 shall be used to demonstrate the axial consistency of the AUT system.

Add new Table E.11

Table E.11—Reference Reflectors—Plate/Coil

t mm (in.)	**Reference Reflectors—Plate/Coil** [a, b, c]			
	FBH d	**Depths** mm (in.)	**Each Edge Zone** [f]	**Each End Zone** [f]
All	Diameter: 6.4 mm (0.25 in.)	See footnote [e]		

[a] FBHs shall be included in the plate/coil body in line with Table E.7 for HFW pipe and Table E.9 for SAW pipe.

[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] Reference standards for plate or coil shall be of any convenient width (subject to compliance with this specification).

[d] FBH shall be drilled from the back surface, opposite the scanning surface, perpendicular to the surface within ±1°. Drilled hole dimensions are based upon standard drill-bit size.

[e] Full coverage of the plate/coil thickness shall be demonstrated, from 3 mm (0.118 in.) below the scanning surface to 3 mm (0.118 in.) above the backwall, using either the DAC method or DGS method. For DAC and DGS, two FBHs shall be used, drilled from the back surface to 3 mm (0.118 in.) below the scanning surface and 3 mm (0.118 in.) above the back surface. Tolerance ± 0.5 mm (0.02 in.).

[f] Each of the edge and end zones shall be at least 50 mm (2.0 in.) wide. Longer scanning distance may be specified. For continuous coil subjected to in-line AUT before cutting to length, the end zone requirement may be omitted.

E.5.3 Instrument Standardization

Add title to section E.5.3.1 heading

E.5.3.1 General Requirements

Add to section

Standardization shall be performed using the same equipment and the same scans used for production.

Add to section

For UT, the reference reflectors specified in Table E.7, Table E.9, Table E.10 and Table E.11 (as applicable) shall be used to ensure full coverage.

Add to section

For UT, sensitivity shall be in accordance with Table E.12 and be detected under operating conditions.

Add to section

For EMI, the reference reflectors specified in Table E.7 or Table E.10 shall be used to verify full coverage and to establish sensitivity.

Add to section

Coverage of the application shall be demonstrated for all scans by the recording of all applicable reference reflectors.

Add to section

Overlap between consecutive channels or consecutive focal laws shall be demonstrated by the recording of adjacent reflectors.

Add to section

A record of standardizations shall be available and for purchaser's review.

Add title to section E.5.3.2 heading

E.5.3.2 Static Standardization

Add new section

E.5.3.2.1 Static Standardization

E.5.3.2.1.1

The amplitudes of indications from the applicable reference reflector shall be adjusted to a set target reference amplitude between 50 % and 80 % FSH or equivalent dB.

E.5.3.2.1.2

Where more than one reflector (e.g. multiple N5 notches, multiple FBHs or a combination of different types of reflectors) is used to establish PRG for a single probe, probe array, channel or a combined pair of channels, the larger amplitude reference reflector indication shall be set at 50 % to 80 % FSH (or equivalent dB).

E.5.3.2.1.3

A DAC, TCG or multiple recording gates or equivalent, shall be used to record the lower amplitude reference indications.

Add new section

E.5.3.2.2 Dynamic Standardization

E.5.3.2.2.1

Dynamic standardization shall be performed using the same relative speeds between pipe/coil/plate and probe used for production.

E.5.3.2.2.2

Dynamic standardization shall be performed on at least three consecutive runs.

E.5.3.2.2.3

The amplitudes of the applicable reference indications (see E.5.3.3) shall be averaged and adjusted to the set target reference amplitude established during static standardization.

E.5.3.2.2.4

The calibrated gain setting used to achieve this shall become the PRG.

Add new section

E.5.3.2.3 Frequency of Dynamic Standardization

Dynamic standardization shall be performed as follows:

a) at the beginning of the operating shift;

b) every 4 hours of system operation;

c) whenever there is a mechanical malfunction or electrical interruption (e.g. power cut).

Add new section

E.5.3.2.4 System Drift

E.5.3.2.4.1

If for any channel or combined channels, the signal amplitude has drifted by > +2 dB (amplitude increase) since the previous dynamic standardization, static standardization shall be repeated.

E.5.3.2.4.2

If for any channel or combined channels the signal amplitude has drifted by > -2 dB (amplitude decrease) since the previous dynamic standardization, static standardization shall be repeated and all pipes tested since the last satisfactory dynamic standardization retested.

Add new section

E.5.3.2.5 Transfer Correction (TC)

E.5.3.2.5.1

A TC check shall be carried out to determine the acoustic differences between the reference standard and the production plate or pipe.

E.5.3.2.5.2

The TC check shall be performed at the start of the production run and then after every 400 pipes.

E.5.3.2.5.3

The TC check shall be performed using angle beam and/or 0° beam probes as applicable and the result recorded.

E.5.3.2.5.4

A TC shall be made for differences > 2 dB between the reference standard and the production plate or pipe (see Table E.12).

E.5.5 Acceptance Limits

Replace Table E.8 title with

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

Replace Table E.8 with

Application	Acceptance Limit [a]		
	N5 Notch (AUT Only)	**SDH** (AUT Only)	**RDH** (EMI Only)
HFW Seam and HAZs	100 % PRL	—	100 % PRL 1.6 mm (0.063 in.)
SAW Seam and HAZs	100 % PRL	100 % PRL 3.2 mm (0.125 in.)	—
SMLS Pipe	100 % PRL	—	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.

Add new Table E.12

Table E.12—UT Sensitivities

Technique	Application	Scan	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 % reference reflector / DAC / TCG	PRG+ TC	PRL	PRL-6dB (50 % PRL)
	SAW seam and HAZs	Angled beam [c]	N5 Notch				
			3.2 mm (0.125 in.) SDH				
	HFW seam and 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 a DGS system.

[c] N5 notches and 3.2 mm (0.125 in.) SDH to be used to establish sensitivity. For some scans, it may be necessary to establish the DAC/TCG using both types of reflectors.

[d] N5 notches shall be used to establish sensitivity.

[e] For MUT, 6 dB shall be added for scanning but removed prior to evaluation of indications against the acceptance criteria. This requirement does not apply to E.5.8.

E.5.6 Disposition of Indications Found by Ultrasonic and Electromagnetic Inspection

Add to section

For SAW/COW pipe weld seams, indications classified a defect by UT shall not be accepted by RT.

Add new section

E.5.8 Special Requirements for Ultrasonic Inspection for DHC (Chevron Cracking) Detection

E.5.8.1

If specified, AUT or MUT inspection for DHC shall be performed.

E.5.8.2

If AUT is applied instead of MUT, AUT procedures and reference standards shall be agreed.

E.5.8.3

For AUT, probe arrangements, reference reflectors, sensitivity and rejection criteria shall be equivalent to the MUT parameters specified in E.5.8.2 to E.5.8.5.

E.5.8.4

Ultrasonic inspection for delayed hydrogen cracks shall be for SAWH and SAWL pipes.

E.5.8.5 Coverage of the Inspection

E.5.8.5.1

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

E.5.8.5.2

100 % of the weld seam of SAW pipes shall be inspected after final sizing and hydrostatic testing, and at least 48 hours after welding.

E.5.8.5.3

The DHC testing shall sample equally all welding lines.

E.5.8.5.4

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

E.5.8.6 MUT Probe Arrangements

Probe arrangements shall be either of the following:

a) 45° probe in accordance with Figure E.1;

b) by an agreed alternative scanning technique when UT from the weld cap is not practicable due to profile or roughness.

Add new Figure E.1

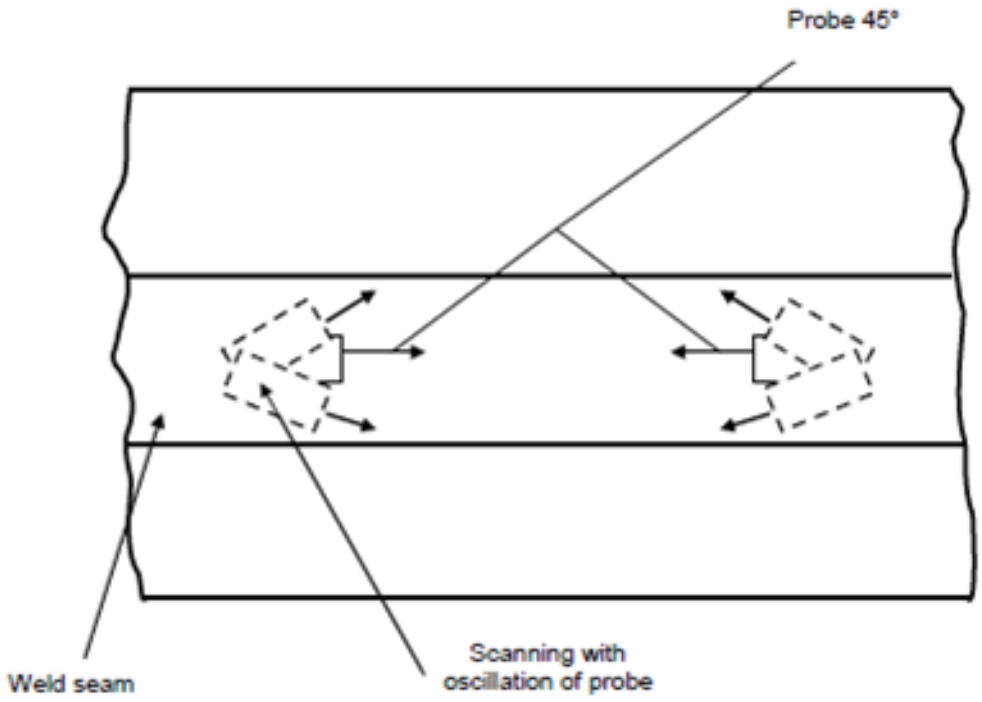


Figure E.1—MUT Probe Arrangements

E.5.8.7 MUT Calibration

E.5.8.7.1

Calibration shall be carried out using three SDH, drilled transverse to the weld seam at hole centerline depths as follows:

a) 4 mm (0.16 in.) from the OD, mid-thickness; and

b) 4 mm (0.16 in.) from the ID.

E.5.8.7.2

The PRL shall be set using DAC or TCG.

E.5.8.7.3

The TCG or the first point of the DAC shall be set at 80 % FSH ± 5 %.

E.5.8.7.4

12 dB shall be added for scanning.

E.5.8.7.5

The orientation of the reflector shall be in accordance with Figure E.1.

E.5.8.7.6

The UT procedure shall be in accordance with ISO 17640.

E.5.8.8 MUT Evaluation and Recording Criteria

E.5.8.8.1

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

E.5.8.8.2

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

E.5.8.9 Discontinuities Rejection Criteria

Cracks shall be rejected regardless of amplitude.

E.5.8.10 Repairs

E.5.8.10.1

Indications classified as DHC shall be reported or communicated to the purchaser within 24 hours of detection.

E.5.8.10.2

A welded joint with indications classified as DHC shall be rejected.

E.5.8.10.3

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

E.6 Magnetic Particle Inspection

E.6.2 Equipment

Add to section

MPI shall be carried out in two directions for pipe bodies and weld seams and in one direction for circumferential defects for finished pipe end faces.

Add to section

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

Add to section

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

Add to section

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

Add to section

If ISO 10893-5 is applied, 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 Special Requirements for MPI for DHCs (Chevron Cracking) Detection

E.6.4.1

For SAW pipes, 100 % of the weld seam of one pipe per shift shall be inspected in accordance with ISO 10893-5 or ASTM E709 after final sizing, hydrostatic testing and 48 hours of welding.

E.6.4.2

The extent of MPI shall be as follows:

a) full length of the exterior surface of the weld seam;

b) full length of the interior surface of the weld seam for nominal pipe diameters, $D \geq 812.8$ mm (32 in.); and

c) at least 406.4 mm (16 in.) from both ends of the interior surface of the weld seam for nominal pipe diameters 406.4 mm (16 in.) ≤ D < 812.8 mm (32 in.).

E.6.4.3

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

E.6.4.4

The DHC testing shall sample all welding lines equally.

E.6.4.5

Indications > 3.2 mm (0.125 in.) in any direction shall be rejected.

E.6.4.6

Cracks and crack-like indications of any size shall be rejected.

E.7 Residual Magnetism

E.7.2

Replace first sentence with

The longitudinal magnetic field shall be measured.

Replace second sentence with

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

Add to section

Measurements shall not be made on pipe in stacks.

E.7.6

Replace first sentence with

The average of the four readings shall be ≤ 2.0 mT (20 Gs).

Replace second sentence with

All individual readings shall be < 2.5 mT (25 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.

Add to section

UT shall be performed in accordance with E.5.1, E.5.2 and either of the following acceptance levels:

a) ISO 10893-9 acceptance level U2 or ASTM A578 acceptance level C if inspection is performed prior to pipe forming; or

b) ISO 10893-8 acceptance level U3 if inspection is performed after seam welding.

E.8.2

Add to section

UT shall be performed in accordance with E.5.1, E.5.2 and either of the following acceptance levels:

a) ISO 10893-9 acceptance level U2 or ASTM A578 acceptance level C if inspection is performed prior to pipe forming; or

b) ISO 10893-8 acceptance level U3 if inspection is performed after seam welding.

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

Replace 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 at least 50 mm (2.0 in.).

Add to section

UT shall be performed in accordance with E.5.1, E.5.2 and either of the following acceptance levels:

a) ISO 10893-9 acceptance level U1 if inspection is performed prior to pipe forming; or

b) ISO 10893-8 acceptance level U1 if inspection is performed after seam welding.

Add new section

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

For SMLS pipes, UT shall be used to verify that the pipe body is free of laminar defects in accordance with ISO 10893-8 acceptance level U1.

Add new section

E.12 Thickness Measurement

E.12.1 Seamless Pipes

E.12.1.1

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

E.12.1.2

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

E.12.1.3

The accuracy of measurements shall be to 0.1 mm (0.004 in.) and recorded to one decimal place for measurements in millimeters and three decimal places for measurements in inches.

E.12.1.4

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

E.12.1.5

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

E.12.1.6

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

E.12.1.7

The records shall be made available for review and included in the final documentation in native format compatible with spreadsheets.

E.12.1.8

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

E.12.1.9

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

Add new Equation (E.1)

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

E.12.1.10

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

a) maximum wall thickness;

b) minimum wall thickness;

c) mean value (M) of wall thickness;

d) STD value;

e) pipe numbers and end sides with t = M + 2 Sd;

f) pipe numbers and end sides with t = M - 2 Sd.

Add new section

E.12.2 Welded Pipes

E.12.2.1 Steel Plate Wall Thickness Measurement

E.12.2.1.1

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

E.12.2.1.2

Minimum and maximum steel plate thickness shall account for changes to thickness during the pipe manufacturing process.

E.12.2.1.3

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

E.12.2.1.4

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

E.12.2.2 Pipe Wall Thickness Measurement

E.12.2.2.1

If specified, pipe suitable for girth weld AUT inspection shall be checked in accordance with E.12.2.2.1 to E.12.2.2.8.

E.12.2.2.2

When the standard deviation (Sd) of the pipe item wall thickness has been found in plate mill in excess of 0.25 mm (0.001 in.), 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.12.2.2.3

The measurements shall not be carried out on ground areas.

E.12.2.2.4

Measurements shall be made using a dial micrometer designed for measuring concave surfaces (e.g. with pointed or convexly rounded contacts).

E.12.2.2.5

The accuracy of measurements shall be to 0.1 mm (0.004 in.) and recorded to one decimal place for measurements in millimetre and three decimal places for measurements in inches.

E.12.2.2.6

The results shall be presented on a histogram that indicates the mean value (M) and the standard deviation (Sd).

E.12.2.2.7

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

E.12.2.2.8

The wall thickness measurements shall be made available for review and be included in the final documentation in native format compatible with spreadsheets.

Add new section

E.13 Qualification of Mill NDT

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

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, two-phase pipelines and dense CO2 phase, an approach in this annex shall be used by the purchaser to determine the required absorbed energy to resist running fractures with the requirements specified.

Add to section

The Charpy test requirements in 9.8 are based on crack initiation principles. For rich gas transmission and two phase pipe lines, higher absorbed energy requirements shall be specified to avoid the risk of running fractures.

Add to section

For rich gas transmission and two phase pipe lines, this annex also provides guidance to the purchaser to determine the required absorbed energy. The outcome requirements specified shall be specified by the purchaser.

G.2 Additional Information to Be Supplied by the Purchaser

G.2.1

Replace section with

The CVN minimum average absorbed energy value, based on full-size test pieces, for each test, shall apply.

G.2.2

Replace section with

The CVN impact test temperature shall be the minimum design temperature in accordance with Table 29 or 0 °C (32 °F), whichever is colder.

Add to section

The DWT test temperature shall be the minimum design temperature or 0 °C (32 °F) whichever is colder.

Add to section

If CVN and DWT testing conducted in accordance with 9.8, 9.9 and 10.2 meet the requirement of this annex, CVN testing shall not be required to be repeated.

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

G.6.1

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.

G.9 Battelle Two-curve Method—Approach 3

Add to section

For CO2, the modified Battelle two-curve model may be used subject to the limitations and requirements of ISO 27913.

NOTE Specialist advice may also be required.

Annex H
(normative)

PSL 2 Pipe Ordered for Sour Service

H.1 Introduction

Add to section

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

Add to section

Material supplied in accordance with this annex shall also comply with NACE MR0175/ISO 15156-1 and NACE MR0175/ISO 15156-2.

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

Add to section

Pipe ordered to this annex shall be manufactured from approved HIC resistant steel source and alloy design.

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 procurement data sheet (IOGP S-616D).

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 and supplemented with additional testing (see Table H.3).

H.3.1.2 MPQT

H.3.1.2.1 Macrographic, Micrographic, and Segregation Analysis on Slabs

Testing in accordance with 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

H.3.2.2

Replace section with

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

Add new Table H.5

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

H.2 List Item Reference	Information Required	Section or Table No	Purchaser's Requirements References
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 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	IOGP S-616D
m)	Deviation from 4 hardness impressions	H.7.3.3.2 c)	IOGP S-616D
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 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 IOGP S-616D
q)	Verification of lamination size/density	K.3.2.2	K.3.2.2
t)	Ultrasonic inspection of SMLS pipe for detection of transverse imperfections	K.3.4.1	K.3.1
y)	Acceptance level U2/U2H for nondestructive inspection of 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
aa)	Ultrasonic inspection of 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 weld for laminar imperfections	K.4.3	K.4.3
dd)	Use of fixed depth notches for equipment standardization	K.5.1.1 c)	—
ee)	Radiographic inspection of pipe ends (noninspected ends) and repaired areas	K.5.3 a)	K.5.3

H.3.3 Pipe Manufacturing

H.3.3.1 SMLS Pipe

Replace section with

SMLS pipe shall be manufactured as follows:

a) from continuously cast (strand cast) steel when accepted once the manufacture has started; or

b) from ingot steel when accepted prior to manufacture.

Add to section

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

H.3.3.2 Welded Pipe

H.3.3.2.1

Replace second sentence with

The pipe shall be SAWL or HFW.

Add to section

SAWH shall not be permitted.

Add to section

SAWL pipe for sour service shall be expanded.

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.

Add to section

Final edge preparation shall not be performed by shearing.

Add to section

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

H.3.3.2.4

Replace section with

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, noncontinuous) of the SAWL groove shall not be permitted.

Add new section

H.3.3.2.7

Welding consumables shall comply with Annex O.

Add new section

H.3.4 Cold Sizing and Cold Expansion

The sizing ratio shall be measured and recorded at a minimum of once per shift.

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.

H.4.1.2

Replace 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 H.1 and modified by Table H.6.

Add to section

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

Add to section

The maximum percentages of residual elements shall be as follows:

a) Sn ≦ 0.020 %;

b) Sb ≦ 0.010 %;

c) Bi ≦ 0.010 %;

d) Pb ≦ 0.010 %;

e) As ≦ 0.020 %.

Add to section

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

Add new section

H.4.1.3

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

H.4.2 Tensile Properties

Replace section with

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

Add to section

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

Add to section

If H.4.2.1 does not apply, within the limits of Table H.2, a maximum range of 100 MPa shall be considered for approval.

Add new Table H.6

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

Element	Weight Percentage	
	Seamless Pipes	Welded Pipes
Carbon (C)	0.04 to 0.11	0.02 to 0.10
Phosphorus (P)	0.018 maximum	0.015 maximum
Sulfur (S)	Table H.1	0.002 maximum
Niobium (Nb)	0.01 maximum	0.04 maximum
Titanium (Ti)	0.025 maximum	0.025 maximum
Manganese (Mn)	1.65 maximum	—
Vanadium (V)	0.02 to 0.06 or Table H.1, whichever is lower	0.08 maximum or Table H.1, whichever is lower
CEPcm	0.19 maximum	0.21 maximum or Table H.1, whichever is lower
Other	Alternative composition limits for niobium (Nb): 0.04 % maximum Alternative composition limits for vanadium (V): 0.01 % maximum Higher limits may be proposed if there is a corresponding reduction in carbon equivalent.	Nb + Ti + V: 0.12 maximum

Add new Table H.7

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

Element	Allowable Range Percentage	
	Welded Pipes %	Seamless Pipes %
Carbon (C)	0.02	0.02
Manganese (Mn)	0.15	0.2
Silicon (Si)	0.1	0.15
Nickel (Ni)	0.1	0.05
Chromium (Cr)	0.1	0.05
Molybdenum (Mo)	0.05	0.05
Copper (Cu)	0.1	0.05
Vanadium (V)	0.015	0.02
Niobium (Nb)	0.01	0.02
Titanium (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 ±0.010.

H.4.3 HIC/SWC Test

Add to section

If specified, crack sensitivity ratio, crack length ratio and crack thickness ratio limits shall apply to each section or face of each specimen.

Add to section

If specified, alternative crack sensitivity ratio, crack length ratio and crack thickness acceptance criteria shall apply.

Add to section

If specified, the CAR shall equal 5 % maximum of the specimen area per specimen.

Add to section

The CAR shall include all cracks and laminations.

Add to section

Damage caused by hydrogen pressure induced cracking related features for example, blistering, straight and stepwise cracks shall be measured by methods including post NDE and reported.

H.4.4 Hardness Test

Replace second paragraph with

Pipes ordered for sour service applications shall satisfy the following hardness requirements:

a) 230 HV10 for base material;

b) 240 HV10 for HAZ and weld metal/weld line;

c) 240 HV0.5 for surface in contact with sour process fluid.

H.4.5 SSC Test

Replace first sentence with

Test results shall be assessed in accordance with NACE TM0316, Section 9.

Replace second sentence with

The metallurgical features shall be documented with photomicrographs.

Add to section

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

Add to section

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

H.4.6.1

If specified, additional CTOD testing shall be performed in the applicable environment.

H.4.6.2

The CTOD testing procedure shall be submitted for review and acceptance.

Add new section

H.4.7 Macrographic and Metallographic Examination

H.4.7.1

Macrographic and metallographic examination shall be documented by macrographs and micrographs at pertinent magnification (e.g. X10, X100 and X400).

H.4.7.2

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

H.4.7.3

If specified, base metal macrographs specimens shall be tested for inclusion ratings in accordance with ASTM E45 method A or D and the severity level reported.

H.4.7.4

If specified, the acceptance criteria for method A shall be as follows:

a) thick (0.5 maximum), thin (0.5 maximum);

b) thick (2 maximum), thin (2 maximum);

c) thick (0.5 maximum), thin (0.5 maximum);

d) thick (2 maximum), thin (2 maximum).

H.4.7.5

For method D, the acceptance criteria shall be 2 maximum.

H.4.7.6

If specified, metallographic examination shall be performed as follows.

a) The mid-thickness area of the base metal and the weld area (i.e. the 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 when qualified.

b) The base metal at location *¼t* and *½t* shall be examined for a banded structure (i.e. ferrite or pearlite/martensite). Acceptance criteria shall be agreed.

Add new section

H.4.8 User Specific Sour Requirements

The user's specific sour requirements, if any, shall be specified and may include the following.

a) A different chemical composition may be specified (with no changes to the limits on CEIIW / CEPcm of this specification).

b) The maximum hardness value may be reduced and different HV load and indentations path may be specified.

c) For 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 the following:

   1) full ring test (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 H_2S is higher than 1 bar (14.5 psi);

   3) for the test method, 4 points bend in accordance with NACE TM0177 Method B or NACE TM0316.

d) For 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 in accordance with 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 provisions of K.6.

Add to section

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

H.7 Inspection

H.7.1 Specific Inspection

Add to section

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

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

Test reports shall identify the specimen location.

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 with 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).

Add to section

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 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.

b) Two sets cut in base material in a direction parallel to the rolling direction, one set at 90° and one set at 180° from the weld, or at agreed locations.

c) For MPQT testing, an additional two sets, one at each pipe end i.e. head and tail of the mother plate shall be tested.

Table H.3—Inspection Frequency

Replace Table H.3 with

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, c]
3	Hardness testing of hard spots in welded pipe	SAWL, HFW	Each hard spot found on the internal or external surface of the pipe
3a	If specified, hard spot / local surface areas with increased hardness inspection	SAWL	Each pipe, plate full surface
4	Hardness testing of 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, c Pipe produced by each welding machine tested at least once a week
5	Pipe diameter and out-of-roundness for pipe	SMLS, SAWL, HFW	First 10 pipes per production run, 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	Nondestructive 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 five heats of steel
9	If agreed, SSC tests	SMLS, SAWL, HFW	If specified, test performed as part of MPQT testing If specified, one test for each of the first 3 heats, then not less than 1 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.7.2.3 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 with 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).

Add to section

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 set at 90° and one set at 180° from the weld.

d) For MPQT testing, two additional sets, one set from a pipe from the start of a mother plate and one set from a pipe from the tail of a mother plate.

H.7.2.3.2

Add to section

Test specimens shall be free of defects.

Add to section

Specimens shall be cut adjacent to the surface in contact with the effluent containing H_2S, with the minimum depth of machining to obtain flat surfaces but leaving the surface to be exposed to the sour media intact.

Add to section

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

Add to section

The test specimens shall have the surface in contact with effluent in the original condition without subsequent surface preparation.

Add to section

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

Add to section

No more than 0.5 mm (0.020 in.) shall be removed from the weld toe area.

Add to section

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

Add to section

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

a) specimen thickness of 15 mm (0.6 in.) or full wall thickness whichever is less;

b) minimum width-to-thickness ratio of 1.5:1; and

c) specimen length to test the area of interest of a minimum of 115 mm (4.53 in.) with the ratio of H/A is to be equal to 4 in accordance with NACE TM0316.

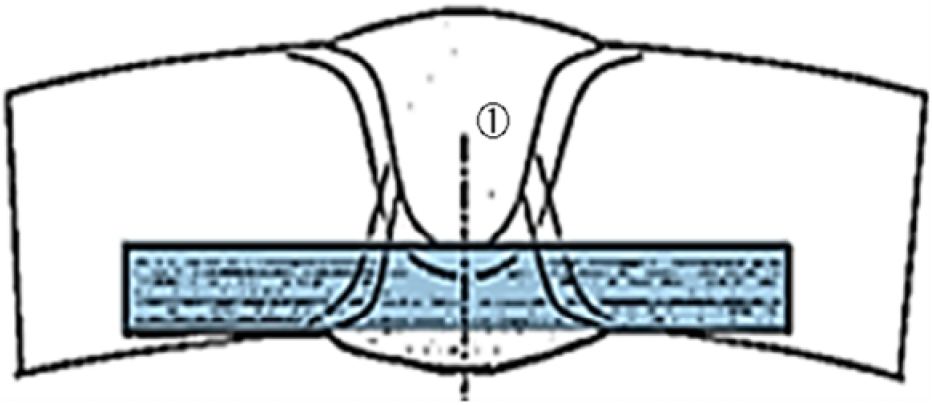
Add to section

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

H.7.2.4 Samples for Hardness Tests

Delete section

Add new Figure H.2



Key

1 center line of specimen for weld

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

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

Replace Table H.4 with

Type of Pipe	Sample Location	Number, Orientation and Location of Tests Pieces [a, b]	
		Specified Outside Diameter *D* mm (in.)	
		< 508 (20.000)	≥ 508 (20.000)
SMLS	Pipe body	1T	1T
SAWL/HFW	Pipe weld	1W	1W
	Pipe body	1T	1T

[a] The test piece shall be from the location of highest hardness as determined in MPQT.

[b] See Figure 5 for an explanation of the symbols used to designate the orientation and location.

H.7.3 Test Methods

H.7.3.1 HIC/SWC Test

H.7.3.1.3

Add new list item d)

d) in an alternative medium as specified.

H.7.3.1.4

Add to section

In addition to the requirements of NACE TM0284, the following data shall be provided in the manufacturer's report for each heat tested, for acceptance:

a) CAR percentage result for each specimen if UT is specified;

b) locations and dimensions of specimens in tested pipe;

c) explanations and concluding comments; and

d) magnified photographs of etched and unetched sections of any reportable crack.

Add to section

Failure shall be analyzed and the cause of failure shall be specified 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.

Add new section

H.7.3.1.6

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

Add new section

H.7.3.1.7

The CAR of scanned surfaces shall be calculated and reported.

Add new section

H.7.3.1.8

Additional sectioning shall be performed at the largest AUT indication.

Add new section

H.7.3.1.9

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

Add new section

H.7.3.1.10

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

Add new section

H.7.3.1.11

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

Add new section

H.7.3.1.12

Laboratory facilities for testing shall be approved.

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 four-point bending test method of NACE TM0316.

Add new section

H.7.3.2.1.2 Tests Required for Determination of Actual Yield Strength

H.7.3.2.1.2.1

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

H.7.3.2.1.2.2

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

H.7.3.2.1.2.3

Flattening shall not be permitted.

H.7.3.2.1.2.4

Tensile testing shall use round bar specimens in accordance with 10.2.3.2.

H.7.3.2.1.2.5

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

H.7.3.2.1.2.6

Tensile test results shall be recorded.

H.7.3.2.1.2.7

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

H.7.3.2.1.3.1

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

H.7.3.2.1.3.2

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.

H.7.3.2.1.3.3

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

H.7.3.2.1.4.1

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

H.7.3.2.1.4.2

Saturation shall be obtained within 1 hour.

H.7.3.2.1.4.3

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

H.7.3.2.1.4.4

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

H.7.3.2.1.4.5

Partial pressure of H_2S shall be 1 bar.

H.7.3.2.1.4.6

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

H.7.3.2.1.4.7

For base metal tests, the measurement of applied stress shall be made using strain gauges or the deflection method with verification by strain gages on the first specimen.

H.7.3.2.1.4.8

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

H.7.3.2.1.4.9

Strain gauges shall be used for SSC test of welds.

H.7.3.2.1.4.10

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

H.7.3.2.1.4.11

Test results shall be described and reported as pass or fail, for information only.

H.7.3.2.1.4.12

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

Add new section

H.7.3.2.1.5 Reporting

H.7.3.2.1.5.1

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 were extracted;

d) testing procedure; and

e) explanations and conclusions.

H.7.3.2.1.5.2

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

Replace first paragraph with

Hardness testing shall be performed using the Vickers test in accordance with ISO 6507-1 or ASTM E92.

Replace second paragraph with

Individual hardness readings exceeding the applicable acceptance limit in accordance with H.4.4 shall be considered acceptable if the average of a minimum of three and a maximum of six additional readings taken within close proximity does not exceed the applicable acceptance limit.

Replace third paragraph with

Individual hardness readings exceeding the applicable acceptance limit in accordance with H.4.4 shall be considered acceptable if an individual reading exceeds the acceptance limit by no more than 10 HV10 units.

Add to section

For pipes formed from thermomechanically controlled processed plates and coils, further to the requirements in H.7.3.3.3, additional hardness indentations shall be performed.

Add to section

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

Add to section

The additional hardness testing shall be performed using Hv0.5 (500 g), 0.25 mm (0.01 in.) from the surface.

Add to section

The additional hardness test acceptance criteria shall be in accordance with H.4.4.

Add to section

Individual hardness readings exceeding the applicable acceptance limit specified in H.4.4 shall be considered acceptable if the average of a minimum of three and a maximum of six additional readings taken within close proximity does not exceed the applicable acceptance limit, and if no such individual reading exceeds the acceptance limit by more than 10 HV units.

H.7.3.3.2

Add new list section d)

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 new list item d)

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

Replace section with

H.7.5.1

H.7.5.1.1

If a HIC/SWC test fails during production, the pipe shall be rejected and retested with one retest to be taken on two different pipes from the same heat/test unit as the failed pipe.

H.7.5.1.2

If a HIC/SWC test fails during production, the pipe shall be rejected and retested providing both these tests give acceptable results, the heat to be considered acceptable.

H.7.5.1.3

If a HIC/SWC test fails during production, the pipe shall be rejected and retested. If either or both pipes fail during retest, the test unit shall be rejected and further testing defined in H.7.5.2 shall be performed.

H.7.5.2

H.7.5.2.1

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 shall be performed for each test unit as follows.

a) Two pipes from every preceding consecutive test unit/heat shall 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 shall be tested until two pipes pass for three consecutive test units/heats.

H.7.5.2.3

When required, reprocessing shall be in accordance with 10.2.11.

H.7.5.2.4

If the RCA required in H.7.3.1.4 points to a raw material issue, the retest frequency based on heat may be more appropriate. In this case, an 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 shall 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 shall be rejected.

Add new section

H.7.7 RCA

H.7.7.1

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

H.7.7.2

The affected slab/billet shall be identified.

H.7.7.3

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

Annex J
(normative)

PSL 2 Pipe Ordered for Offshore Service

J.2 Additional Information to be Supplied by the Purchaser

Add to section

The information to be supplied by the purchaser and options within this specification are covered in Table J.8 and in the procurement data sheet (IOGP S-616D).

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.

Add to section after first sentence

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

Add to section after second sentence

When the process of cold finishing is used, this shall be stated in the MPS and ITP.

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.

Add to section

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.

Add to section

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.

Add new Table J.8

Table J.8—Additional Information to Be Provided by the Purchaser—Offshore Pipe

J.2 List Item Reference	Information Required	Section or Table No	Purchaser's Requirements References
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 and 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	IOGP S-616D
s)	Deviation from location of hardness test	J.8.3.2.2.c)	IOGP S-616D
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 IOGP S-616D
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 nondestructive 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
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)	—
kk)	Radiographic inspection of the pipe ends (noninspected 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
nn)	Alternative hydrostatic test pressure	—	J.8.5

J.4 Acceptance Criteria

J.4.1 Chemical Composition

Add new section

J.4.1.3

Hydrogen content shall be controlled in the ladle so that the final product is no greater than 2 parts per million (ppm).

Add new section

J.4.1.4

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

Add new section

J.4.1.5

The maximum percentages of residual elements shall be as follows:

a) Sn 0.020 %;

b) Sb 0.010 %;

c) Bi 0.010 %;

d) Pb 0.010 %;

e) As 0.020 %.

Add new section

J.4.1.6

Residual elements shall be tested 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

Replace section with

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

a) The maximum yield to tensile (Rt0.5/Rm) ratio in the transverse direction shall be 0.90 for grades up to X56 and 0.92 for grades X60/L415 and above, unless otherwise specified.

b) The (Rt0.5/Rm) ratio in the longitudinal direction shall not exceed 0.93 unless otherwise agreed.

c) Whenever the pipe size allows it, a tensile test shall be performed in the transverse direction and longitudinal direction.

d) The maximum yield strength shall be the specified minimum yield strength + 120 MPa.

e) The actual yield strength range shall be ≤ 100 MPa.

f) For welded pipe, tensile properties in the longitudinal direction shall have the same acceptance criteria as required for the transverse direction, with the exception of the minimum longitudinal tensile strength that shall be 95 % of the specified minimum transverse tensile strength.

Add to section

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

Add to section

The stress-strain curve shall be reported to a minimum of 4 % strain.

Add to section

The data shall be supplied in native format compatible with spreadsheets.

Add to section

The test frequency shall be the same as the transversal test (see Table J.6).

J.4.3 Hardness Test

Replace section with

Hardness testing acceptance criteria shall be in accordance with 9.18.

Add new section

J.4.4

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 and based upon full-size test pieces and a test temperature in accordance with Table 29.

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.

Add to section

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

Add to section

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

Add to section

If specified, out-of-roundness and pipe end diameter shall be measured against the ID.

Add to section

If specified, the actual nominal ID shall be established, with measurements on the first 20 to 100 production pipes.

Add to section

If specified, the OD out-of-roundness requirements at pipe ends shall be maintained.

Add new Table J.9

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

Specified Outside Diameter *D* mm (in.)	**Full-size CVN Absorbed Energy** minimum *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.6.2

Replace section with

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

a) For SMLS pipe, the maximum under tolerance shall be - 0.1*t*.

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

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

Add to section

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

When required, pipe end rectification (e.g. cold end sizing) 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 J.10

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

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

[a] The dimensions of pipe body shall be measured approximately in the middle of the pipe length.

[b] For SMLS pipe, the tolerances shall apply for $t \leq 25.0$ mm (0.98 in.) and the tolerances for heavier wall pipe shall be as agreed with the purchaser.

[c] The pipe end shall include 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 $D \geq 219.1$ mm (8.625 in.) and for nonexpanded 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 (see 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] For level A: Machining to achieve tolerances is acceptable.

Add new Table J.11

Table J.11—Premium Tolerances for Pipe End Wall Thickness

Pipe Type	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)
Welded pipe	> 6.0 (0.236) to 10.0 (0.394)	±0.6 (0.028)	
	> 10.0 (0.394)	±1.0 (0.039)	

Add new section

J.6.5

J.6.5.1

Pitting and imperfections with depth ≥ 0.7 mm (0.028 in.) on the outer surface of the pipe for a distance of 200 mm (8 in.) from each pipe end shall not be permitted.

J.6.5.2

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

J.7 Tolerances for the Weld Seam

Table J.5—Maximum Permissible Radial Offset for SAW Pipe

Replace Table J.5 with

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)

Add new section

J.7.3 SAWL Weld Seam

J.7.3.1

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.

J.7.3.2

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

J.7.3.3

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".

J.8.3 Test Methods

J.8.3.1 CTOD Test

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

J.8.3.2.1

Add to section

Hardness testing shall be in accordance with 10.2.5.5.

Add new section

J.8.3.3 Circumferential Compression Test

J.8.3.3.1

A circumferential compression test in accordance with ASTM E9 shall confirm the specified design αfab value has been achieved. See DNVGL-ST-F101 for αfab definition.

J.8.3.3.2

A compressive stress-strain curve shall be developed.

J.8.3.3.3

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

J.8.3.3.4

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

Add new section

J.8.5 Hydrostatic Test

Hydrostatic testing shall be performed in accordance with 10.2.6 unless an alternative test pressure is specified.

Table J.6—Inspection Frequency

Replace Table J.6 with

No	Type of Inspection	Type of Pipe	Frequency of Inspection
1	Tensile testing of pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio [a]
3	Tensile testing of longitudinal or helical-seam weld of welded pipe	Welded pipes	Once per test unit of pipes with the same cold-expansion ratio [a, b]
6	CVN impact testing of pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio [a]
8	CVN impact testing of longitudinal or helical-seam weld and HAZ of welded pipe	Welded pipes	Once per test unit of pipes with the same cold-expansion ratio [a, b]
11	Hardness testing of pipe body and of 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]
12	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 to be measured If specified, each pipe end measurement to be recorded
14	Nondestructive inspection	All pipes	As per Annex K
15	Wall thickness measurement	All pipes	Each pipe If specified, each pipe end measurement to be recorded
16	Pipe body dimensional testing, squareness and magnetism	All pipes	5 pipes per shift (recorded)
17	Straightness	All pipes	5 pipes per shift (recorded) If specified for fatigue services, straightness to be measured and recorded on 100 % of pipes
18	If specified, circumferential compression test	All pipes	Once per test unit of pipes with the same cold- expansion ratio [a, b]

NOTE Table J.6 modifies the requirements of Table 18.

[a] An 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.

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

Replace Table J.7 with

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 Figure 5 a]	Pipe body	Tensile	1L [b]	1L + 1T	1L + 1T
		CVN	3T+ 3L	3T+ 3L	3T+ 3L
		Hardness	3T	3T	3T
SMLS, cold-expanded [see Figure 5 a]	Pipe body	Tensile	1L [b]	1L + 1T	1L + 1T
		CVN	3T + 3L	3T+ 3L	3T+ 3L
		Hardness	3T	3T	3T
HFW [see Figure 5 b]	Pipe body	Tensile	1L90 [b]	1L90 + 1T180	1L90 + 1T180
		CVN	3T90+ 3L90	3T90+ 3L90	3T90+ 3L90
		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 Figure 6		
SAWL [see Figure 5 b)]	Pipe body	Tensile	1L90 [b]	1L + 1T180	1L + 1T180
		CVN	3T90+ 3L90	3T90+ 3L90	3T90+ 3L90
		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 Figure 5 c)]	Pipe body	Tensile	1L [b]	1L + 1T	1L + 1T
		CVN	3T+ 3L	3T+ 3L	3T+ 3L
		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] See 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 shall 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 Service, and/or Service Requiring Longitudinal Plastic Strain Capacity

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.2.1.2

Delete section

K.2.1.3

Replace section with

For pipe with $t \geq 5.0$ mm (0.197 in.), UT shall be carried out on both pipe ends as per ISO 10893-8 or ASTM E213 to verify freedom from laminar defects.

Add to section

Scanning shall be performed over the entire circumference using AUT, SAUT or MUT for a distance of 100 mm (4.0 in.) from the point where the outside surface meets the pipe end face or bevel.

Add to section

Pipe end UT shall be performed in the delivery condition, including a square end face or from the inside of the pipe if the end has been beveled.

K.2.1.4

Replace first sentence with

The delivery condition end face/bevel at each pipe end shall be magnetic particle inspected for laminations in accordance with ISO 10893-5 or ASTM E709.

Replace second sentence with

The end face shall be free of laminations ≥ 3.2 mm in the circumferential direction.

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 the following tables:

a) Table K.1—UT laminar imperfections (the inspection level shall be specified by the purchaser); and

b) Table K.2—EMI and UT angled beam scans.

K.2.3.2 Reference Standards and Sensitivity

Reference standards shall contain the reference reflectors stated in the following tables:

a) HFW seam—Table K.3;

b) SAW seam—Table K.4;

c) SMLS pipe—Table K.5;

d) plate/coil—Table K.6.

K.2.3.3

Reference reflectors shall be used to establish sensitivity in accordance with Table K.7 and be detected under normal NDT operating conditions.

K.3 Nondestructive Inspection of SMLS Pipe

Replace section K.3.1 title with

K.3.1 Ultrasonic Inspection for Longitudinal, Transverse, and Oblique Imperfections

Replace section with

SMLS pipe shall be subjected to 100 % AUT for longitudinal and transverse imperfections and, if specified, oblique imperfections in accordance with Table K.2, Table K.5 and Table K.7, and ISO 10893-10 or ASTM E213.

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.3.2.2

Add to section

The ultrasonic inspection scanning coverage shall be 100 % of the area of the pipe.

K.4 Nondestructive Inspection of HFW Pipe

K.4.1 Nondestructive Inspection of the Weld Seam

Replace section with

HFW pipe shall be subjected to 100 % AUT for longitudinal imperfections in accordance with Table K.2, Table K.3 and Table K.7 and ISO 10893-10, ISO 10893-11 or ASTM E213.

K.4.2 Laminar Imperfections in the Pipe Body

Replace first sentence with

The pipe or strip/plate body shall be ultrasonically inspected for the detection of laminar imperfections.

Replace second sentence with

Ultrasonic inspection scanning shall be performed on 100 % of the surface area of the plate/coil or pipe body in accordance with Table K.1, Table K.6 and Table K.7, and the following standards:

a) ISO 10893-9 or ASTM A578 if performed prior to pipe forming; or

b) ISO 10893-8 or ASTM E213 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

HFW pipes shall be subjected to 100 % AUT for laminations in accordance with Table K.3 and Table K.7.

Add to section

Ultrasonic inspection shall be done in zones at least 50 mm (1.97 in.) wide and the full length of the pipe (except for AUT-untested ends), along both edges of the coil/plate or on both sides of the weld seam.

Add to section

Ultrasonic inspection shall be performed in accordance with the following standards:

a) ISO 10893-9 or ASTM A578 if prior to pipe forming; or

b) ISO 10893-8 or ASTM E213 if after seam welding.

Add to section

AUT-untested ends shall be subjected to alternative AUT, or to SAUT or MUT.

Add to section

Acceptance criteria shall be in accordance with Table K.1.

K.4.4 Supplementary Nondestructive Inspection

Add to section

If specified, calibration notches shall be N5 and located at least 90° from weld line.

K.3 Nondestructive Inspection of SMLS Pipe

Replace section K.3.1 title with

K.3.1 Ultrasonic Inspection for Longitudinal, Transverse, and Oblique Imperfections

Replace section with

SMLS pipe shall be subjected to 100 % AUT for longitudinal and transverse imperfections and, if specified, oblique imperfections in accordance with Table K.2, Table K.5 and Table K.7, and ISO 10893-10 or ASTM E213.

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.3.2.2

Add to section

The ultrasonic inspection scanning coverage shall be 100 % of the area of the pipe.

Add new Table K.2

Table K.2—Acceptance Limit, Electromagnetic Inspection (EMI), and Ultrasonic Testing (UT) Angled Beam Scans

Technique	Application	Acceptance Limit [a]			
		N5 Notch	**SDH 3.2 mm (0.125 in.) Diameter**	**FBH 3.2 mm (0.125 in.) Diameter**	**RDH 1.6 mm (0.063 in.) Diameter**
UT	HFW seam and HAZs	100 % PRL [b]	—	100 % PRL [b]	—
	SAW seam and HAZs	100 % PRL [b, c]	100 % PRL [b]	100 % PRL [b, c]	100 % PRL [c]
	SMLS pipe	100 % PRL [b, c]	—	—	—
EMI	SMLS pipe	—			100 % PRL
UT and EMI	All	Cracks are unacceptable, irrespective of amplitude.			

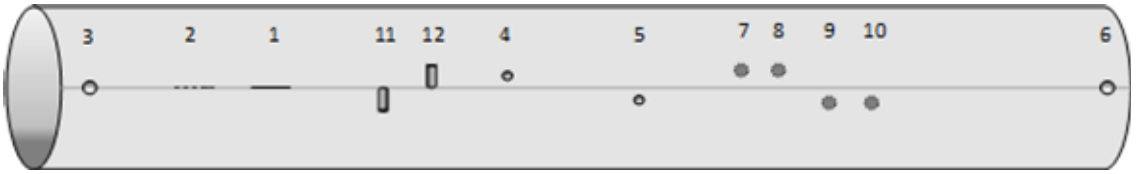
[a] Based upon responses from reference reflectors as defined in Table K.3 (HFW seam), Table K.4 (SAW seam) and Table K.5 (SMLS pipe), as applicable.

[b] Longitudinal defects.

[c] Transverse defects.

Add new Table K.3

Table K.3—Reference Reflectors—HFW Seam

Reference Reflectors—HFW Seam [b]				
Weld Seam N5 Notches [c]		RDH [d, e, f, h]	Radial FBH [a, d]	Longitudinal FBH [d, g]
OD	ID			
Reflector Identification				
1	2	3, 4, 5, 6	7, 8, 9, 10	11, 12
				

NOTE The drawing is not to scale and is meant for illustration purposes only.

[a] Lamination check shall be performed with four 6.4 mm (0.25 in.) diameter FBHs, drilled from the ID in radial direction located in the HAZ and/or parent metal, two on each side of the weld seam. Depths of FBH to be as per Table K.6 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, located at the weld centerline 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 25.4 mm (1.0 in.). Alternative notch length may be specified.
- Width: maximum 1 mm (0.04 in.).

[d] Drilled hole dimensions shall be based upon standard drill-bit sizes.

[e] RDH: Two 1.6 mm (0.063 in.) diameter radially drilled holes, on each side of the weld fusion line, within 3.2 mm of the weld fusion line for gate settings.

[f] RDH – Seam: Two 3.2 mm (0.125 in.) at pipe ends to represent the maximum extent of automated NDT coverage of the length of the seam (in addition, see E.3.2.1).

[g] 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 CW, one of each pair facing CCW. Locations shall be per table below.

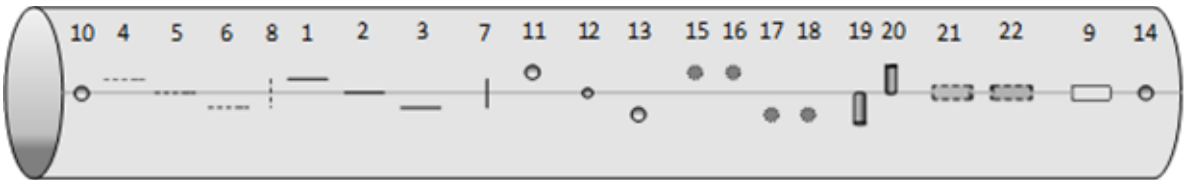
Nominal thickness *t* mm (in.)	**FBH**
$t \leq 12$ (0.47)	None
$12 < t \leq 18$ (0.7)	One pair centered at 50 % of *t*
18 (0.7) < $t \leq 24$ (0.94)	Two pairs centered at 33 % and 66 % of *t*
$t > 24$ (0.94)	To be agreed with the purchaser in advance of NDT

[h] For AUT qualification (see Annex Q), 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 is used to demonstrate the axial consistency of the AUT unit.

Add new Table K.4

Table K.4—Reference Reflectors—SAW Seam

Reference Reflectors—SAW Seam [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
Reflector Identification								
1, 2, 3	4, 5, 6	7	8	9	10, 11, 12, 13, 14	15, 16, 17, 18	19, 20	21, 22



NOTE The drawing is not to scale and is meant for illustration purposes only.

[a] Lamination check shall be performed with four 6.4 mm (0.25 in.) diameter FBHs, drilled from the ID in radial direction located in the HAZ and/or parent metal, two on each side of the weld seam. Depths of FBH to be as per Table K.6 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: One 3.2 mm (0.125 in.) diameter, longitudinal, located at *t*/2 on the weld centerline drilled parallel to the weld axis within ±1°.

[h] RDH: Two 3.2 mm (0.125 in.) diameter holes located at the weld toes using the widest weld 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.

[j] RDH: One 1.6 mm (0.063 in.) diameter, through drilled hole at weld centerline. Used for acceptance criteria for transverse scans.

Table K.4 *(continued)*

Reference Reflectors—SAW Seam [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

[k] FBH: 3.2 mm (0.125 in.) diameter, 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 CW, one of each pair facing CCW. Locations shall be per the following table.

Nominal thickness *t* mm (in.)	FBH
$t \leq 12$ (0.47)	None
12 (0.47) < $t \leq 18$ (0.7)	One pair centered at 50 % of *t*
18 (0.7) < $t \leq 24$ (0.94)	Two pairs centered at 33 % and 66 % of *t*
24 (0.94) < $t \leq 30$ (1.18)	Three pairs centered at 25 %, 50 % and 75 % of *t*
$t > 30$ (1.18)	To be agreed with the purchaser in advance of NDT

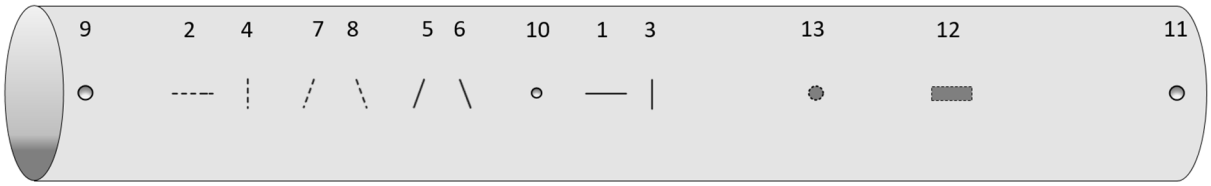
[l] If specified, 3.2 mm (0.125 in.) diameter FBH shall be drilled from the ID at 45° to the weld axis (within ±1° in the radial/axial plane), and one facing forward and one facing backwards. Drilled to 0.5 *t* depth.

[m] For AUT qualification (see Annex Q), 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 i is used to demonstrate the axial consistency of the AUT system.

Add new Table K.5

Table K.5—Reference Reflectors—SMLS Pipe

Reference Reflectors—SMLS Pipe [b]								
N5 Pipe Body Notches [c]						RDH [f, g, h, j]	Wall Reduction [i]	Radial FBH [a, f]
Longitudinal [d]		Transverse		Oblique [e]				
OD	ID	OD	ID	OD	ID			
Reflector Identification								
1	2	3	4	5, 6	7, 8	9, 10, 11	12	13



NOTE The drawing is not to scale and is meant for illustration purposes only.

[a] Lamination check to be performed with two 6.4 mm (0.25 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 with the following dimensions:

— 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 25.4 mm (1.0 in.). Alternative notch length may be specified.

— Width: maximum 1 mm (0.04 in.).

[d] Longitudinal notches shall be parallel to the pipe axis.

[e] For OD and ID oblique pipe body N5 notches, one of each shall be included as follows:

— One oblique angled in the positive direction to the pipe axis by the maximum rolling angle defined by the mill.
— One oblique angled in the negative direction to the pipe axis by the maximum rolling angle defined by the mill.

If specified, the oblique angle to 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 for EMI acceptance criteria.

[h] Two holes with diameter = 3.2 mm (0.125 in.), one at each end representing the maximum extent of automated NDT coverage of the length of the pipe.

[i] The reference standard shall contain an area of known/specified thickness determined by the manufacturer with tolerance ±0.01 mm (0.0003 in.) for the calibration of pipe wall thickness measurement.

[j] For AUT qualification, 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 h shall be used to demonstrate the axial consistency of the AUT system.

Add new Table K.6

Table K.6—Reference Reflectors—Plate/Coil

Reference Reflectors—Plate/Coil [a]					
Item	**FBH [b] Diameter**	**Depths** [c, d, e] mm (in.)	**Each Edge Zone (Typical)** [f]	**Each End Zone (Typical)** [g]	**Body Zone**
Plate	6.4 mm (0.25 in.)	*3* (0.118)	1 [h, i,]	1 [h, i]	[i, j]
		t-3 (0.118*)*	1 [h, i]	1 [h, i]	[i, j]
Coil	6.4 mm (0.25 in.)	*3* (0.118)	1 [h, i]	—	[i, j]
		t-3 (0.118)	1 [h, i]	—	[i, j]

[a] Reference reflectors to 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 to be drilled from the back surface, opposite the scanning surface, perpendicular to the surface within ±1°. Drilled hole dimensions are based upon standard drill-bit size.

[c] Depths are given as those below the UT scanning surface. Tolerance ± 0.5 mm (0.02 in.).

[d] For t > 6 mm (0.236 in.), 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 ≤ 6 mm (0.236 in.), one FBH located at t/2.

[e] Full coverage of the plate/coil thickness to 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.

[f] Each of the two edge zones to run the full length of the plate/coil and from the line of the final edge cut to a distance of 50 mm (2.0 in.) or greater.

[g] Each of the two end zones to run the full width of the plate/coil and from the line of the final cut end to a distance of 100 mm (4.0 in.) or 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 to be used to define the declared uninspected area.

[i] Each ultrasonic probe used to be verified with the detection of a FBH. Probe overlap to also be demonstrated.

[j] In each of at least four positions evenly distributed over the width of the body zone, depth coverage to be demonstrated with FBH at the two specified depths.

[k] For all equipment, the width of the reference standard or the number of scans to be sufficient to comply with footnote i.

[l] Alternative arrangements may only be permitted if agreed in writing by the purchaser at tender stage.

[m] For HFW manufacturing, full-body ultrasonic testing of the pipe for laminar imperfections is acceptable if coil edge ultrasonic inspection is unavailable.

[n] Where AUT is performed on HFW pipe body instead of coil, see K.4.2 and K.4.3.

Add new Table K.7

Table K.7—Ultrasonic Testing (UT) and Electromagnetic Inspection (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 in.) diameter FBH	100 % reference reflector / DAC / TCG	PRG+ TC	PRL	PRL-6 dB (50 % PRL)
	SAW seam and 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 and HAZs	Angled beam [d]	N5 Notch				
			If specified, 3.2 mm (0.125 in.) perpendicular FBH				
	SMLS pipe	Angled beam	N5 Notch				
			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 Table K.1 and Table K.2).

[b] For plate and coil, sensitivity may be established using a 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.

Table K.1—Acceptance Criteria for Laminar Imperfections

Replace Table K.1 with

Service Condition	Maximum Individual Imperfection		Minimum Imperfection Size Considered			Maximum Population Density [a]
	Area mm^2 (in.^{2})	Length mm (in.)	Area mm^2 (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)	—	300 (0.5)	35 (1.4)	8 (0.3)	10 [per 1.0 m (3.3 ft) x 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) x 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) x 500 mm (1.6 ft) square] [c]
Strip/Plate Edges or Areas Adjacent to the Weld Seam [d]						
Level 1 and Level 2 Sour, fatigue, offshore or longitudinal plastic strain capacity	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 considered 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) should 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 are considered as one area.

NOTE 3 The acceptance level should be as specified.

[a] Number of imperfections smaller than the maximum and greater than the minimum imperfection size.

[b] For pipe with D < 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 D < 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.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 and scanning for the detection of transverse imperfections shall be carried out in accordance with Annex E, except that reference standards, sensitivities and acceptance criteria for longitudinal imperfections are in accordance with Annex K.

Add to section

Ultrasonic inspection for transverse imperfections shall be carried out from the weld cap using shear wave probes oriented in forward and reverse axial directions.

Add to section

Where the roughness or profile of the weld cap prevents 100 % scanning coverage, one of the following shall apply.

a) The weld cap shall be dressed flush.

b) Scanning shall be carried out from the parent metal using probes in the K or X configuration.

Add to section

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/Plate 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 ISO 10893-8 or ISO 10893-9 (as applicable), with the following exceptions.

a) Coverage shall be 100 % of the surface area of the plate/coil or pipe body.

b) Reference standards shall comply with Table K.6 (the same requirements apply in pipe form).

c) Sensitivity shall comply with Table K.7.

d) Acceptance limits shall be as given in Table K.1.

K.5.2.2

Replace section with

The pipe or strip/plate shall be ultrasonically inspected for the detection of laminar imperfections on the edges or areas adjacent to the weld seam in accordance with ISO 10893-8 or ISO 10893-9 (as applicable), with the following exceptions.

a) Coverage shall be 100 % of the edges or areas adjacent to the weld seam.

b) The strip/plate edges or areas adjacent to the weld seam shall be at least 50 mm (2.0 in.) wide, the full length of the plate or pipe and on both sides of the weld seam.

c) AUT-untested ends shall be subjected to alternative AUT, SAUT or MUT.

d) Reference standards shall comply with Table K.4 or Table K.6 (as applicable).

e) Sensitivity shall comply with Table K.7.

f) Acceptance limits shall be as given in Table K.1.

K.5.3 Nondestructive Inspection of the Weld Seam at the Pipe Ends/Repaired Areas

Replace first paragraph with

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 the following tests.

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 except radiographic films shall be in accordance with ISO 11699-1, class C4 and used with lead screens.

Replace second paragraph with

For SAW/COW pipe weld seams, disposition of indications shall be in accordance with E.4.6 or E.5.6, as applicable.

Add new section

K.6 Plate Surface Inspection for Hard Surface Layer

K.6.1

If specified, the surface of thermomechanically rolled plates for contact with the sour effluent shall be inspected for the detection of surface hard layers.

K.6.2

Surface hard layer inspection equipment and procedures shall be subjected to pre-production qualification trial that demonstrates the ability to detect hard spots.

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 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.

K.6.3

The procedure shall also address the following:

a) definition of blind zones;

b) inspection of blind zones in a grid pattern, or cropping of blind zones; and

c) grid dimensions.

K.6.4

A hardness increase due to cold forming and ageing, if applicable, shall be considered.

K.6.5

This hardness increase shall be documented by the manufacturer and used to define the plate maximum acceptable hardness value.

K.6.6

The surface hardness value measured on the plate surface shall not exceed 230Hv 10.

Add new section

K.7 Residual Magnetism

K.7.1

The average of the four readings of residual magnetism tests in accordance with E.7 shall be ≤ 1.5 mT (15 Gs).

K.7.2

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

Annex N
(normative)

PSL 2 Pipe Ordered for Applications Requiring Longitudinal Plastic Strain Capacity

N.1 General

Replace first paragraph with

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 after first paragraph

These conditions shall apply to pipelines subjected to high strain, for onshore or offshore.

Add after first paragraph

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 the 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

The information to be supplied by the purchaser and options within this specification shall be in accordance with Table N.8 and in the procurement data sheet (IOGP S-616D).

N.3 Manufacturing

N.3.1 Manufacturing Procedure

Add list section e)

e) If specified, weldability testing in accordance with Annex R shall also include toughness tests of the heat affected zone of girth welds.

NOTE Girth weld HAZ testing after strain and ageing may be considered.

Add new Table N.8

Table N.8—Additional Information Provided by Purchaser—Longitudinal Plastic Strain Capacity

N.2 List Item Reference	Information Required	Section or Table No	Purchaser's Requirements References
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 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 pipe body of seamless, EW and SAW pipe and of seam weld and HAZ of EW and SAW pipe	Table N.6	Table N.6 (see Table J.6)
r)	CTOD testing	N.8.2.2 and Table N.6	J.8.3.1 (see 10.2.3.8 and 10.2.4.10), Table N.6 and 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)	Use of three hardness impressions at each through-thickness location	N.8.3.2.2 c)	IOGP S-616D
v)	Use of alternative distance from weld line for parent metal hardness impressions for welded pipe	N.8.3.2.3 c)	IOGP S-616D
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 pipe ends	K.2.1.3	K.2.1.3
y)	Ultrasonic inspection to verify conformance with applicable requirements given in Table K.1	K.3.2.2	K.3.2.2
bb)	Acceptance level L2/C or L2 for nondestructive inspection of weld seam of HFW pipe	K.4.1	K.4.1
cc)	Ultrasonic inspection of pipe body of HFW pipe for laminar imperfections	K.4.2	K.4.2
dd)	Ultrasonic inspection of strip/plate edges or areas adjacent to 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 pipe ends, noninspected pipe ends and repaired areas	K.5.3 a)	K.5.3

Add new section

N.3.1.1 Welded Pipe

N.3.1.1.2

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.

N.3.1.1.3

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.3.1.2 Strain Cycle Simulation—Application Other than Reeling

N.3.1.2.1

For applications, with the exception of reeling, testing to qualify tensile and compressive strain capacity of the pipe by simulated or full-scale testing shall be part of the qualification.

N.3.1.2.2

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.3.1.3 Strain Cycle Simulation—Reeling

N.3.1.3.1

For reeling applications, the accumulated straining simulation requirements shall be as follows:

a) for strain level 1, two cycles with ±2.5 % plastic strain giving a total accumulated plastic strain of 10.0 %;

b) for strain level 2, two additional cycles, giving a total accumulated plastic strain of 20.0 %.

N.3.1.3.2

Two scenarios, a first one starting in tension and ending in compression and a second one starting in compression and ending in tension, shall be tested independently.

N.3.1.3.3

The first straining cycle (strain level 1 + strain level 2) shall start in tension and end in compression.

N.3.1.3.4

The second straining cycle (strain level 1 + strain level 2) shall start in compression and end in tension.

N.3.1.3.5

The samples shall then be artificially aged at 250 °C (480 °F) for one hour prior to testing.

N.3.1.3.6

Simulation of reeling cycles shall be performed on full scale samples or small scale specimens.

N.3.1.3.7

A detailed procedure for simulation of reeling cycles shall be submitted to the purchaser.

Add new section

N.3.1.4 Additional Testing as per MPQT Pipe

N.3.1.4.1

The tests in N.3.1.4.2 and N.3.1.4.3 shall be applicable only for MPQT.

N.3.1.4.2 Tensile Testing

N.3.1.4.2.1

A longitudinal and a transverse specimen shall be taken from each end of the pipe.

N.3.1.4.2.2

Samples shall be extracted from alternating ends with strain recorded to a minimum of 8 % on the stress-strain curve.

N.3.1.4.3 Hardness Testing

N.3.1.4.3.1

One ring shall be extracted from each pipe end.

N.3.1.4.3.2

Hardness profile testing shall be done on each quadrant of each ring.

Add new section

N.3.1.5 MPQT Additional Testing After Strain and Ageing Simulation

NOTE See N.3.1.2 and N.3.1.3.

The tests in this section shall be applicable for MPQT only.

N.3.1.5.1 Tensile Testing

N.3.1.5.1.1

One AWMT and two longitudinal tests shall be performed.

N.3.1.5.1.2

Longitudinal tensile test samples shall be extracted from alternating ends.

N.3.1.5.1.3

Unless otherwise specified, for base material testing, the following shall apply:

a) minimum yield strength and minimum and maximum tensile strength in accordance with J.4.2;

b) Rt0.5/Rm ratio < 1.0;

c) elongation ≥ 15 % and uniform elongation ≥ 5 %.

N.3.1.5.1.4

Unless otherwise specified, for AWMT testing, the weld metal uniform elongation shall be ≥ 5 % and Rm > Rt0.5 with elongation ≥ 15 %.

N.3.1.5.1.5

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 nonreeled applications, alternative strain levels and/or acceptance criteria based upon pipeline design, may be considered.

N.3.1.5.2 Charpy Testing

N.3.1.5.2.1

Samples for longitudinal Charpy testing in the pipe body shall be extracted from alternating ends.

N.3.1.5.2.2

The seam weld shall be sampled with one set in the weld metal (weld metal / weld line), one set on the FL and one set on the FL2.

N.3.1.5.2.3

The test temperature and acceptance criteria shall be in accordance with the unstrained tests in Annex J.

N.3.1.5.2.4

In the longitudinal direction, acceptance criteria shall be 50 % higher than the specified criteria in the transverse direction.

N.3.1.5.2.5

The shear area shall be recorded for information.

N.3.1.5.3 Hardness Testing

N.3.1.5.3.1

For full scale testing, one ring shall be extracted from each pipe end.

N.3.1.5.3.2

Hardness profile testing shall be performed on each quadrant of each ring, including the weld seam area.

N.3.1.5.3.3

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.

N.3.1.5.3.4

Acceptance criteria shall be in accordance with Table N.9.

Add new Table N.9

Table N.9—Hardness Test Acceptance Criteria in Strained and Aged Condition

Steel Grade	Base Metal, Weld, and HAZ	Cap Area
≤ L450 or X65	270	300
> L450 or X65	300	300
NOTE For sour service, Annex H is applicable.		

N.3.1.5.4 SSC and HIC Tests

If specified, SSC and HIC testing shall be performed in accordance with Annex H.

N.3.1.5.5 Fracture Toughness Test

CTOD testing shall be performed in accordance with 10.2.3.8 and 10.2.4.10.

N.3.1.5.6 Weld Seam Repairs

N.3.1.5.6.1

Repair welds in accordance with Annex D shall be qualified in the strained and aged condition.

N.3.1.5.6.2

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

N.3.3.2.2

Replace section with

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.

Add to section

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

N.3.3.2.5

Replace section with

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 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

N.4.1.1

Add to section

Amendments in J.4.1. shall apply to Table N.1.

N.4.2 Tensile Properties

Add to section

N.4.2.1

Add to section

The tensile properties requirements of J.4.2 shall apply for the tensile tests.

Add to section

The additional requirements for longitudinal tensile properties specified in this annex shall apply.

N.4.2.2

Replace section with

Additional requirements for longitudinal tensile properties shall be in accordance with all of the following.

a) The maximum yield strength minus the minimum yield strength shall be ≤ 100 MPa.

b) The maximum tensile strength shall be the specified minimum tensile strength plus 150 MPa.

c) The maximum ratio of Rt0.5/Rm in the longitudinal direction shall not exceed 0.90.

d) The minimum UEL shall be 5 % and the minimum total elongation shall be 18 % for pipe body and weld metal tests.

N.4.2.3

Replace section with

MPQT shall be in accordance with N.3.1.2 and N.3.1.3.

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 Annex J for nonsour service or with 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, the CTOD value of pipes shall be 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

N.5.2 Outer Diameter Grinding

N.5.2.1 General

N.5.2.1.1

Grinding shall be performed in accordance with the submitted and accepted procedures.

N.5.2.1.2

Repair by stone wheel grinding shall not exceed 15 % of the pipe order.

N.5.2.1.3

Cosmetic repairs shall not be included in the repair percentage calculation.

N.5.2.2 Ground areas

N.5.2.2.1

Ground areas shall not exceed more than 45 % of the circumference of a cross-sectional plane.

N.5.2.2.2

Ground areas shall be smoothly contoured to the surface of the pipe at a minimum 4:1 slope.

N.5.2.2.3

Ground areas shall not exceed an area of 10 % of the total surface area of each pipe.

N.5.2.2.4

For ground areas after grinding, the remaining wall thickness shall conform to the thickness tolerance requirements of this specification.

N.5.2.2.5

Ground areas shall have the final wall thickness measured by UT and be recorded (i.e. wall thickness and joint number).

N.5.2.2.6

Ground areas shall not interfere with nondestructive testing at the pipe mill.

N.5.2.2.7

Ground areas at pipe ends shall comply with the requirements of C.2.2.

N.5.2.2.8

Ground areas shall not result in loss-of-signal or otherwise impede inspection verification required by C.2.3.

N.5.2.3

Pipe ends shall not be internally or externally machined or ground by stone without prior acceptance.

N.5.2.4

Pipes that are repaired by grinding shall be identified with a green paint band, die stamped with the letter "R" on the square cut face, and noted on the pipe tally list.

Add new section

N.5.3 Dents

N.5.3.1

Pipes shall not contain dents on a surface that cause visible distortion on the opposite surface.

N.5.3.2

Pipes 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

When the pipe surface quality rejection rate exceeds 15 %, billets/plates 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/plate quality.

N.6 Tolerances for Diameter, Wall Thickness, and Straightness

N.6.1

Replace first sentence with

The diameter and out-of-roundness shall be within the tolerances specified in Table J.3 or Table J.10 for "premium" level A or "premium" level B.

Replace second sentence with

The tolerance shall refer to the internal diameter.

Add to section

Actual nominal ID shall be established, with measurements on the first 20 to 100 production pipes.

Add to section

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.11 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) that exceed the lesser of the following measurements shall be considered a defect and treated in accordance with C.3 b) or C.3 c).

a) 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

b) 25 % of pipe diameter in any direction with a maximum length of 300 mm (11.8 in.).

N.6.4

Replace section with

For seamless pipes, the eccentricity for pipe ends shall be as follows:

a) with an eccentricity tolerance ≤ 18 %;

b) with measurements to be made around the circumference on the same cross-sectional plane using callipers, laser or by other equivalent methods; and

c) with an eccentricity within 152 mm (6 in.) of each end defined in Equation (N.1):

Add new Equation N.1

$$Eccentricity = \frac{t_{max} - t_{min}}{t_{max}} \times 100 \qquad \text{(N.1)}$$

where

t_{max} is maximum wall thickness

t_{min} is minimum wall thickness

N.8 Inspection

N.8.1 Specific Inspection

Replace section with

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".

Add NOTE

NOTE Table N.6 modifies the requirements of Table 18.

Table N.6—Inspection Frequency

Replace Table N.6 with

No	Type of Inspection	Type of Pipe	Frequency of Inspection
1	Tensile testing of pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio [a, e]
3	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]
5	Tensile testing of strip/plate end weld of SAW pipe with $D \geq 219.1$ mm (8.625 in.)	SAWH	Once per test unit with the same cold-expansion ratio [a, b, d]
6	CVN impact testing of pipe body	All pipes	Once per test unit of pipes with the same cold-expansion ratio [a]
8	CVN impact testing of longitudinal or helical-seam weld and HAZ of welded pipe	Welded pipes	Once per test unit of pipes with the same cold-expansion ratio [a, b, c]
11	Hardness testing of pipe body and of 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, c]
12	Pipe end diameter and out of roundness	SMLS, SAWL or SAWH	Each pipe If specified, each pipe end measurement to be recorded
13	Pipe end peaking	SAWL or SAWH	Each pipe
14	Pipe end diameter, pipe end out-of-roundness and pipe end peaking	HFW	Two pipes per coil
15	Pipe body diameter and out-of-roundness for pipe with $D \leq 168.3$ mm (6.625 in.)	SMLS, HFW, SAWL or SAWH	Once per test unit of not more than 50 lengths of pipe
16	Pipe body diameter and out-of-roundness for pipe with $D > 168.3$ mm (6.625 in.)	SMLS, HFW, SAWL or SAWH	Once per test unit of not more than 20 lengths of pipe
17	Nondestructive inspection	All pipes	As per Annex K
18	CTOD testing	All Pipes	MPQT joints
19	Wall thickness measurement	All pipes	Each pipe If specified, each pipe end measurement to be recorded
20	Pipe body dimensional testing, squareness and magnetism	All pipes	5 pipes per shift (recorded)
21	Straightness	All pipes	5 pipes per shift (recorded) If specified for fatigue services, straightness to 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.

[c] For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.

[d] Applies only to finished helical seam pipe containing strip/plate end welds.

[e] Where Table N.7 requires more than one specimen orientation, one of each orientation shall be taken at the frequency indicated.

N.8.2 Samples and Test Pieces for Mechanical and Technological Tests

N.8.2.3 Samples for Hardness Tests

Replace section with

Samples for hardness tests shall be taken from a ring from the end of selected pipes, and for welded pipe.

Add to section

Each hardness test sample shall contain a section of the longitudinal or a helical seam at its center (see Figure N.1).

Add to section

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

N.8.2.4.1

Samples for Charpy testing shall be extracted from alternating ends.

N.8.2.4.2

The sample for Chary testing location shall be in accordance with 10.2.3.3.

N.8.3 Test Methods

N.8.3.3 Longitudinal Tensile Tests

Add to section

The procurement data sheet (IOGP S-616D) shall specify the tensile test specimen type.

Add to section

For nonproportional tensile specimens, 50 mm (2 in.) gauge length shall be used.

Add to section

For the proportional type in accordance with ISO 6892-1, the gauge length shall be equal to $5.65\sqrt{S0}$, where S0 is the original cross-sectional area of the specimen.

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

Replace Table N.7 with

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 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 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 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 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 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 shall be as per 10.2.3.3 (additional set required depending on wall thickness).

Add new Annex Q

Annex Q
(normative)

Welding Consumables

Q.1 General

Q.1.1

The manufacturer shall submit for review and acceptance the procedures concerning storing, handling, drying, recycling and traceability of consumables.

Q.1.2

The manufacturer shall provide evidence of successful use of the proposed combination of welding consumables on comparable applications.

Q.1.3

Welding consumables shall be stored and handled in accordance with the supplier's written recommendations.

Q.1.4

The welding consumables shall be procured in accordance with AWS A5.01 or ASME *BPVC,* Section II, Part C SFA A5.01.

Q.1.5

The level of testing shall be in accordance with Schedule I of AWS A5.01.

Q.1.6

Unless otherwise specified, welding consumables shall be supplied with an inspection certificate type 3.1 in accordance with EN 10204, obtained for the same batch.

Q.1.7

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.

Q.1.8

The hydrogen content test and value shall be performed during packing and recorded in the certified material test report.

Q.1.9

If specified, welding consumables and procedures shall not produce a weld deposit containing more than 1.0 % mass fraction nickel.

Q.1.10

Welding consumable shall be in compliance with NACE MR0175/ISO 15156-1 and NACE MR0175/ISO 15156-2 for pipes ordered for sour service applications.

Q.2 Consumables for GMAW

Q.2.1

The solid electrode shall conform to the requirements of AWS A5.18 or AWS A5.28 and produced in accordance with Lot Class S3 of AWS A5.01.

Q.2.2

The gas shielding shall conform to the requirements of AWS A5.32.

Q.3 Consumables for SAW

Q.3.1

The SAW consumables shall conform to the requirements of AWS A5.17 or AWS A5.23 and produced in accordance with lot class S3 and lot class F2 of AWS A5.01 for solid electrode and flux, respectively.

Q.3.2

The manufacturer shall provide a dedicated procedure for flux management, covering the steps from flux purchasing to the "ready-to-use" step (welding heads).

Q.3.3 Procurement of flux

Q.3.3.1

At the time of packing the flux, the diffusible hydrogen content in the SAW weld deposit shall be < 5 ml/100 g of weld deposit, taken from a sample of the batch of flux.

Q.3.3.2

Flux grain size shall be checked per batch when the flux is first received and comply with the recommendation of the flux supplier.

Q.3.3.3

Acceptable flux packing shall be one of the following methods:

a) metallic / stiff plastic drums with a rubber gasket for top tightness;

b) double polymer top welded bags;

c) HDPE-aluminium-HDPE top welded bags.

Q.3.3.4

An alternative packing proposal shall be submitted for acceptance provided protection of the flux from moisture pickup within requirements for a period of one year is demonstrated.

Q.3.3.5

Packing shall not permit humidity absorption when stored in the manufacturer's recommended conditions for one year or the time period specified by the manufacturer, whichever is less.

Q.3.4 Diffusible Hydrogen and Moisture Content Test

Q.3.4.1

As required in Q.3.3 and Q.3.6, diffusible hydrogen measurement of deposited weld metal shall be performed.

Q.3.4.2

When evidence of correlation is provided by the flux supplier, previously established data is acceptable, indirect diffusible hydrogen assessment done through moisture content measurement shall be acceptable.

Q.3.4.3

The maximum moisture content shall be 0.03 % unless a higher figure is justified via the correlation curves based upon comparative tests of diffusible hydrogen versus flux moisture content.

Q.3.4.4 Test Condition

Q.3.4.4.1

The moisture content shall be measured in accordance with AWS A4.4M by the "Karl Fisher" method or equivalent.

Q.3.4.4.2

For diffusible hydrogen testing or for moisture measurement, pre-drying or pre-heating of the flux sample shall not be carried out before testing.

Q.3.4.4.3

The moisture measurement test shall be carried out at ≥ 982 °C (1800 °F).

Q.3.4.4.4

The carrier gas shall contain ≥ 10 % oxygen.

Q.3.4.5 Test Results

Q.3.4.5.1

Results of diffusible hydrogen or moisture measurement shall be reported on the 3.1 flux certificate for each batch.

Q.3.4.5.2

Results of diffusible hydrogen or moisture measurement testing conditions as per this annex shall be confirmed on the certificate.

Q.3.5 Flux Storage

Q.3.5.1

Flux shall be stored in a room with controlled hygrometry and temperature.

Q.3.5.2

Hygrometry and temperature shall be in accordance with the supplier's recommendation.

Q.3.5.3

A check of the diffusible hydrogen / moisture content shall be required for material stored more than one year or the storage time period as specified by the manufacturer, whichever is less.

Q.3.5.4

Flux that has been wet or damp shall not be used.

Q.3.6 Flux Handling and Transfer System

Q.3.6.1

Drums/bags shall be checked before using the flux and be undamaged.

Q.3.6.2

Unless the manufacturer demonstrates an ability to maintain flux residual moisture below critical level, flux shall be dried before use and poured in the welding machine hopper.

Q.3.6.3

Unless otherwise demonstrated, the temperature of the hopper shall be maintained between 120 °C (248 °F) and 150 °C (302 °F).

Q.3.6.4

Flux residual moisture demonstration shall include the flux manufacturer's recommended temperature range and the moisture content meets the requirements in Q.3.2 and Q.3.5.2.

Q.3.6.5

Flux feeding shall be from:

a) hopper by gravity; or

b) flux conveying, using dry and oil-free pressurized air.

Q.3.6.6

The manufacturer shall document the flux management procedure in case of an interruption or pause in welding. Unless the manufacturer can justify otherwise, in case of welding interruption, the following shall be carried out.

a) In case of welding interruption of more than two hours, the system of feeding downstream of the hoppers shall be drained off before recommencing welding.

b) In case of welding interruption of more than 12 hours, the remaining flux stored in the hoppers shall be scrapped.

Q.3.7 Flux Recycling

Q.3.7.1

When recycling flux, the manufacturer shall demonstrate that the mill has an appropriate flux recycling system.

a) The flux recovery system shall be equipped with vacuum suction to collect the excess unfused flux from the weld seam.

b) The recovered flux shall be processed with sieving and a magnetic separator.

c) The size distribution of recovered flux shall be within the specified defined tolerance range of the fresh batch.

d) The frequency of flux size testing shall be aligned with the moisture content check.

e) The use of crushed or recycled slag, or blending crushed or recycled slag with fresh flux shall not be permitted.

Q.3.7.2 Moisture Content Check

Q.3.7.2.1

The manufacturer shall confirm the supply of dry flux at the welding point.

Q.3.7.2.2

Flux shall be sampled at every welding point at the start of production.

Q.3.7.2.3

Flux shall then be sampled at every welding point at least once per week for inside and outside welding.

Q.3.7.2.4

If moisture content exceeds the permitted limit in accordance with Q.3.2, sampling frequency shall be increased to once per shift per machine.

Q.3.7.2.5

The procedure shall include a flowchart of flux management and temperature details of the ovens used for re-drying, if applicable.

Q.4 Consumables for SMAW

Q.4.1

The covered electrodes shall conform to the requirements of AWS A5.1 or AWS A5.5, produced in accordance with Lot Class C5 of AWS A5.01 and is supplied in hermetically sealed containers.

Q.4.2

Cellulose coated electrodes shall not be used.

Q.5 Consumables for FCAW

Q.5.1

The flux cored electrode shall conform to the requirements of AWS A5.20 and produced according to Lot Class T3 of AWS A5.01.

Q.5.2

The gas shielding shall conform to the requirements of AWS A5.32.

Add new Annex R

Annex R
(normative)

Weldability Test

R.1 Introduction

R.1.1

The intent of the weldability test is to verify acceptable properties in the girth weld HAZ. The manufacturer shall note that weldability tests are acceptance tests for pipes and that pipes are not accepted until these tests have been successfully completed.

R.1.2

Weldability tests shall be performed by the pipe manufacturer or by a purchaser approved supplier under the manufacturer's responsibility.

R.1.3

Previously performed weldability trials to be used in lieu of testing shall include variances in chemistry, grade, size and manufacturing process.

R.2 Material for Weldability Test

R.2.1

The pipe material shall be qualified in accordance with the manufacturing procedure qualification (see Annex B) and within the limits specified (see B.5.).

R.2.2

Weldability tests shall be conducted for each steel grade, pipe size and steel source on pipes to be produced.

R.2.3

When pipe size grouping of dimensions is permitted and subject to approval, the greatest wall thickness in the group shall be tested.

R.2.4

The material shall be taken from finished production pipes.

R.2.5

Selected pipes shall be subject to approval.

R.3 Welding Procedure Specification (WPS)

R.3.1

Prior to welding, a pWPS shall be submitted and include the following:

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 with the proposed groove profile such that the welding results in a straight HAZ on one side of the bevel (i.e. half–V bevel or narrow gap bevel to be used);

d) welds to be single sided from the outer surface of pipe;

e) welding positions, heat input range.

R.3.2

Welding test shall not be carried out till the manufacturer's pWPS is accepted.

R.3.3 Test Welds

R.3.3.1

At least one full butt weld shall be produced for each trial.

R.3.3.2

The welding processes for weldability tests, proposed by the manufacturer shall be in accordance with recognized methods for pipe laying (e.g. GTAW, P-GTAW, P-GMAW, m-GMAW, STT, CMT, SMAW and SAW).

R.3.3.3

Test coupons shall be prepared with a single V-groove.

R.3.3.4

Test coupons shall have one side with 0° bevel angle.

R.3.3.5

The tests shall be carried out with two welding heat inputs as follows:

a) low welding heat inputs (0.45 KJ/mm ≤ HI ≤ 0.75 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 KJ/mm ≤ HI ≤ 3 KJ/mm) with a preheat temperature and inter-pass temperature not lower than 250 °C (482 °F).

R.3.3.6

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 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 the percentage of HAZ sampled.

R.3.3.7

The time lapse between the root and hot pass shall not exceed 15 minutes without maintaining preheating during that time.

NOTE 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 grove is unrefined-columnar weld metal.

R.3.4 Testing and Inspection

R.3.4.1 Nondestructive Testing

R.3.4.1.1

The test weld shall be inspected by visual, magnetic particle and UT or X-ray radiography testing.

R.3.4.1.2

The weld shall satisfy the acceptance criteria of the specific project fabrication code prior to being sent for sampling.

R.3.4.1.3

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.

R.3.4.1.4

The project fabrication code shall be specified.

R.3.4.2 Mechanical Testing

R.3.4.2.1

The test specimen failing due to welding defects shall be declared as invalid and retesting is permitted upon the purchaser's acceptance.

R.3.4.2.2 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.

R.3.4.2.3 Charpy Testing

R.3.4.2.3.1

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.

R.3.4.2.3.2

For alternative welding position (i.e. 1G or 2G), a sample of specimens shall be taken from two opposite locations.

R.3.4.2.3.3

A set shall consist of three specimens.

R.3.4.2.3.4

The notches shall be located at mid-thickness of the welded side with 0° bevel in accordance with Figure R.1.

R.3.4.2.3.5

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.

R.3.4.2.3.6

The impact test temperature and acceptance criteria shall be in accordance with 9.8. Alternative test conditions and acceptance criteria may be specified.

R.3.4.2.3.7

If specified, a transition curve shall be performed for each test location.

R.3.4.2.4 CTOD Test

R.3.4.2.4.1

CTOD specimens shall be taken from the low and high welding heat input test coupons.

R.3.4.2.4.2

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.

R.3.4.2.4.3

For each set, three specimens shall be cut and tested.

R.3.4.2.4.4

For alternative welding positions (i.e. 1G or 2G), a sample of CTOD specimens shall be taken from one location only.

R.3.4.2.4.5

Specimens shall be as follows:

a) SENB B*2B full thickness specimens if dimensions permit; or

b) B*B if pipe dimensions do not permit B*2B.

R.3.4.2.4.6

The notches shall be located on the welded side with 0° bevel in accordance with Figure R.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.

R.3.4.2.4.7

Following testing, sectioned CTOD samples shall be sampled with pre and post-testing macrographs to document that sampling requirements have been met.

R.3.4.2.4.8

CTOD testing shall be carried out in accordance with ISO 15653.

R.3.4.2.4.9

Test specimens for the HAZ areas shall have orientation NP in accordance with Figure R.1.

R.3.4.2.4.10

The CTOD test temperature and acceptance criteria shall be as specified.

R.3.4.2.5 Macrography and Vickers Hardness Survey

R.3.4.2.5.1

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.

R.3.4.2.5.2

For alternative welding positions (i.e. 1G or 2G), a sample of macrography specimens shall be taken from two locations:

a) one location at 180° apart for pipe;

b) one location at a minimum distance of 300 mm (12 in.) apart for plate.

R.3.4.2.5.3

Macrographic cross-sections for R.3.4.2.5.1 and R.3.4.2.5.2 shall have the following:

a) HV10 hardness survey in accordance with Figure R.2;

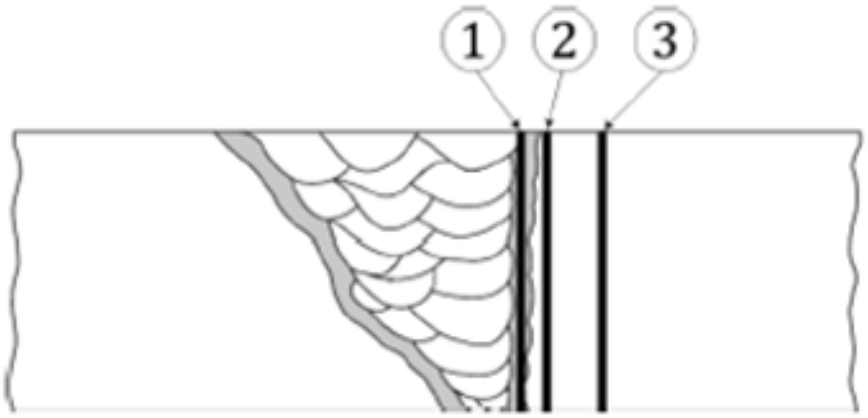
b) indent spacing of the top and bottom row of indents at 1.5 mm (0.059 in.) center-to-specimen edge, but not closer than a distance equal to 2.5 times the mean of the impression's diagonals;

c) indent spacing as shown in Figure R.2 is defined as center-to-center, but not closer than a distance equal to 3 times the mean of the impressions' diagonals.

R.3.4.2.5.4

If not specified, the acceptance criteria shall be in accordance with Annex H, Annex J or Annex N as applicable.

Add new Figure R.1



Key

1 in the CGHAZ

2 at 2 mm (0.079 in.) from fusion line

3 at 5 mm (0.197 in.) from fusion line

NOTE CGHAZ to be determined by metallography.

Figure R.1—Charpy Testing Locations

Add new Figure R.2

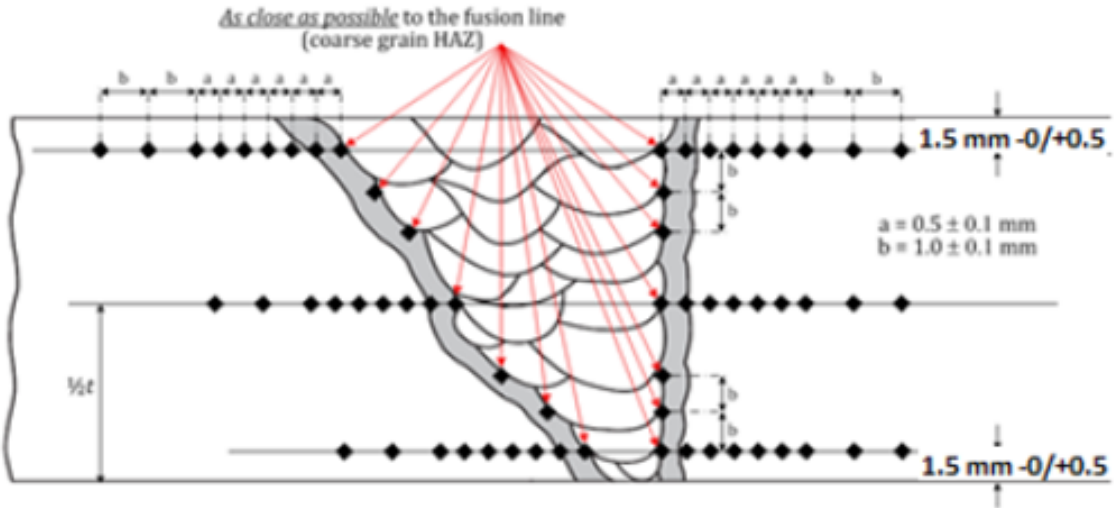


Figure R.2—Hardness Indents Location

R.4 Reporting

R.4.1

Following completion of the test program, the results and a final report from the manufacturer shall be submitted to the purchaser.

R.4.2

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) interpretation of the results and the conclusions of the manufacturer, including the recommendations for welding the pipes at the installation site.

Add new Annex S

Annex S
(normative)

Qualification of Nondestructive Testing (NDT) at Plate/Coil and Pipe Mills

S.1

Qualification shall be subject to demonstration of the capability of the mill to satisfy the requirements of this specification and all standards referenced herein.

S.2

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.

S.3

The process for the qualification of pipe mill NDT equipment and practices shall be as follows.

S.4 Prior to the Qualification Audit

The following information shall be submitted to the auditor(s) 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 Annex T 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 S.4.1 c);

e) Detailed description of the equipment design and any capability studies that the mill may have performed on the equipment.

S.5 NDT Method-specific Requirements During the Qualification Audit

S.5.1 General Requirements

The qualification audit shall include the following:

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.

S.5.2 Practical Demonstrations

S.5.2.1

For automated NDT systems, each carriage, combination of carriages and configuration used for production shall be documented in standard operating procedures and qualified individually.

S.5.2.2

For HFW mills that perform full-body AUT, the coil AUT system shall be exempt from qualification.

S.5.2.3

Responses from each of the reference reflectors shall be recorded.

S.5.3 AUT of Plate/Coil

S.5.3.1

The practical demonstration shall be carried out on one or more reference standards as agreed covering the manufacturing thickness range capability and 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.

S.5.3.2 Repeatability Trials

S.5.3.2.1

The repeatability trial shall be carried out as follows.

a) The repeatability trial is carried out dynamically, using the same conveyor assembly, the same AUT equipment and at the maximum scanning speeds (travel and/or cross-head) to be used during production. Where multiple scanning carriages are available on the same conveyor assembly, the carriages are subjected to repeatability trials separately and in combination.

b) Indications from all reference reflectors to be set at a suitable amplitude to enable recording and subsequent amplitude measurement, typically 50 % to 80 % FSH (or equivalent dB). All indications are to be below the saturation level (e.g. where an AUT system can only measure amplitudes up to 100 % FSH, any indication greater than 100 % shall be invalid).

c) Ten test runs shall be carried out.

d) The result of a repeatability trial is acceptable when no reference reflector indication amplitude deviates from the average of the ten indications from that reference reflector by more than ±25 % (+2.0 dB, -2.5 dB). For AUT equipment using the DGS/AVG system and measuring FBH area, the equivalent diameters are calculated using the formula dB = 40 x log10 (D1/D2) e.g. for 6 mm (0.236 in.) diameter FBHs, the equivalent measured diameter limits would be 5.19 mm (0.0204 in.) to 6.73 mm (0.265 in.).

S.5.3.2.2

The following data shall be recorded:

a) written procedure;

b) reference standard details and dimensions;

c) equipment used, including probe types, frequencies and dimensions;

d) C-scan record, either paper or digital as applicable;

e) for each channel, the probes used, scanning direction, reference reflector identities and locations, indication amplitudes (digitally recorded);

f) 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 %, is not rounded up to 82 %);

g) indication amplitudes for all channels and all reference reflectors that are entered into a spreadsheet agreed upon with the auditor and the manufacturer for the calculation of the average values and the minimum and maximum deviations from the average values; and

h) equipment drift.

S.5.4 AUT of HFW, SAW, and SMLS Pipe

S.5.4.1

The practical demonstration shall be carried out on reference standards covering the manufacturing thickness and diameter range to include:

a) equipment set-up;

b) dynamic standardization on full production length reference standards and (when applicable) static standardization on reference standards of any convenient length, as determined by the manufacturer;

c) gate positions for defects and coupling;

d) S/N ratio;

f) repeatability trial;

g) extent of coverage;

h) axial consistency;

i) accuracy and consistency of seam tracking system;

j) documented threshold settings;

k) equipment drift.

S.5.4.2

Reference standards for each carriage configuration shall be full production length (see E.5.2.2) and in accordance with the tables in Annex E or Annex K, as applicable [see S.1 a) 2)]. The number, wall thickness and diameter shall be as follows:

a) for wall thickness ≤ 12 mm (0.47 in.), one reference standard having the lowest wall thickness to be qualified;

b) for wall thickness > 12 mm (0.47 in.), one reference standard having the highest wall thickness to be qualified;

c) where more than one reference standard is required for qualification in accordance with S.2.2.2.2 a) and S.2.2.2.2 b), the diameters of the reference standards shall cover the range of production as widely as practicable.

S.5.4.3

The repeatability trial shall be carried out as follows.

a) The repeatability trial shall be carried out dynamically, using the same conveyor assembly, the same AUT equipment and at the maximum scanning speeds (travel and/or circumferential) to be used during production. Where multiple scanning carriages are available on the same conveyor assembly, the carriages shall be subjected to repeatability trials separately and in combination.

b) Indications from all reference reflectors shall 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 % is invalid).

c) Ten uninterrupted test runs, shall be run in the normal carriage/conveyor direction, without any adjustment of equipment or settings. Any interruption or adjustment shall 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 circumferentially after each series of five runs.

e) The result of a repeatability trial shall be acceptable when, for each channel or probe array, no reference reflector indication amplitude deviates from the average of the ten indications from that reference reflector by more than ±25 % (+2.0 dB, -2.5 dB). For each channel used in pulse-echo, each combination of channels used in pitch-catch, each probe array, the indications from each applicable reference reflector to be averaged over 10 runs.

NOTE This is neither the average of all reference reflectors, nor the average of the same reflector detected by different channels, etc.

f) 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 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 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.

S.5.5 EMI of Welded or SMLS Pipe

S.5.5.1

The practical demonstration shall be carried out on the reference standards to include the following.

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; and

j) equipment drift.

S.5.5.2

Two reference standard representatives of the smallest and largest diameter, and of the maximum wall thickness range shall be qualified.

S.5.5.3

The repeatability trial shall be carried out as follows.

a) The repeatability trial shall be carried out dynamically, using the same conveyor assembly, the same EMI equipment and at the maximum scanning speeds (travel and/or circumferential) 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 % is invalid).

c) Where EMI systems utilize voltage or alternative signal responses, readings above the vertical calibrated range shall not be permitted.

d) Ten uninterrupted tests shall be run without any adjustment of equipment or settings. Any interruption or adjustment shall invalidate the results.

e) 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 % (+2.0 dB, -2.5 dB).

f) 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 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 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 Annex T

Annex T
(normative)

Procedure Requirements for Nondestructive Testing (NDT)

T.1

For each NDT technique, written procedures describing the inspection equipment and processes to be applied shall be submitted.

T.2

Multiple NDT techniques shall not be combined within one procedure.

T.3

The procedures shall contain, as a minimum, the details stated in Table T.1, Table T.2, Table T.3, Table T.4 and Table T.5.

The procedures shall be written in English, for review and acceptance prior to production NDT.

Add new Table T.1

Table T.1—Ultrasonic Testing (UT)

UT Requirement	UT Requirement Description
Scope (application)	Product form (e.g. plate/coil, pipe, pipe end, weld)
	Material grade and specification
	Dimensions (plate/coil: length, width, thickness and 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-scanning , gap-scanning 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
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

Table T.1 *(continued)*

UT Requirement	UT Requirement Description
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 -6 dB 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	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

Add new Table T.2

Table T.2—Penetrant Testing (PT)

UT Requirement	UT Requirement Description
Scope (application)	Product form (e.g. weld, pipe end bevel)
	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	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

Add new Table T.3

Table T.3—Magnetic Particle Testing (MT)

MT Requirement	MT Requirement Description
Scope (application)	Product form (e.g. weld, pipe end bevel)
	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, wet or dry magnetic particles, 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

Table T.3 *(continued)*

MT Requirement	MT Requirement Description
Reporting	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

Add new Table T.4

Table T.4—Electromagnetic Inspection (EMI)

EMI Requirement	EMI Requirement Description
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	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

Add new Table T.5

Table T.5—Radiographic Inspection (RT)

RT Requirement	RT Requirement Description
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. after hydrotest for longitudinally welded pipe seams)
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

Table T.5 *(continued)*

RT Requirement	RT Requirement Description
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
	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	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

Add new Annex U

Annex U
(normative)

HFW Welding Qualification

When HFW weld qualification is selected to be in accordance with this annex, one of the two following options shall be selected:

a) Option 1—Manufacturer proprietary process control procedures and limits;

b) Option 2—Manufacturing process boundary limits qualification.

U.1 Option 1—Manufacturer Proprietary Process Control Procedures and Limits

U.1.1

The manufacturer shall submit their own proprietary process control procedures for review.

U.1.2

The proprietary process control system shall meet the intent of this specification to define the process variables, relate these variables to production of acceptable pipe and maintain process control during production.

U.1.3

Supporting information including production data and test results for statistical analysis shall be submitted for acceptance.

U.2 Option 2—Manufacturing Process Boundary Limits Qualification

U.2.1

Welding essential variables shall be in accordance with Table U.1.

U.2.2

The qualification of the essential variable range shall include the following steps.

a) The manufacturer shall define nominal settings for voltage current (and/or power), line speed, and squeeze roll force identify.

b) The manufacturer shall calculate the maximum and minimum limits for each combination of Q parameter and constructs the preliminary process limits (see Figure U.1).

c) Pipes shall be manufactured from 5 coils representing the nominal conditions and the 4 extreme points of Figure U.1 envelope.

d) All pipes shall be inspected in accordance with Annex E and/or Annex K as applicable for the intended application qualification.

e) 3 pipes per coil are tested: first and last pipe of the coil and a pipe from approximately half of the coil length. The total number of pipes to be tested is 15.

f) Unless otherwise agreed, all MPQT tests are performed as per Annex B on all 15 pipes.

g) Determine the metal flow angle in accordance with 9.19 and Figure 11 for all 5 welding conditions.

h) Choose, at random, one additional pipe from the coil at nominal welding condition of point A in Figure U.1 and remove at least 10 samples, at least one meter apart, for determination of the metal flow angle in accordance with 9.19 and Figure 11.

U.2.3

Essential variables shall be recorded.

U.2.4

If a set of specimens fails to meet the acceptance criteria, the manufacturer shall adjust the variable settings and produce an additional coil for each welding condition that failed.

U.2.5

If a pipe fails to meet the NDT acceptance criteria, the manufacturer shall adjust the variable settings accordingly and produce another coil for each welding condition that failed.

U.2.6

The manufacturer shall perform the following calculations with the measurements made in in accordance with 9.19 and Figure 11 for all five test coils as follows.

a) Determine the average overall metal flow angle for all OD. angles combined. This calculated value is defined as X-barQOD.

b) Determine the standard deviation for all OD. angles combined. This calculated value is defined as SQOD. If SQOD > 3.0, the process shall be requalified after process improvements have been made.

c) Determine the average overall metal distortion angle for all ID angles combined. This calculated value is defined as X-barQID.

d) Determine the standard deviation for all ID angles combined. This calculated value is defined as SQID. If SQID > 3.0, the process shall be requalified after process improvements have been made.

e) Determine, for the additional single pipe from coil A, the average OD and ID angles with their associated standard deviations. These values (X-barAOD, X-barAID, SAOD, and SAID) are defined as approximations of the true process means and standard deviations and shall appear in the qualification report. If SAOD or SAID are greater than SQOD or SQID respectively, requalification shall be required after significant process improvement.

U.2.7

The qualified process limits for the manufacturing procedure and combination of essential welding variables shall be in accordance with the final manufacturing process boundary limit of Figure U.1.

U.2.8

An operation shown to be outside of the qualified process limits shall require requalification.

U.2.9

Pipe produced outside this qualified boundary shall be rejected or held for further evaluation.

U.2.10

The pipes used for qualification may be included in the production order provided said qualification is successful.

Add new Figure U.1

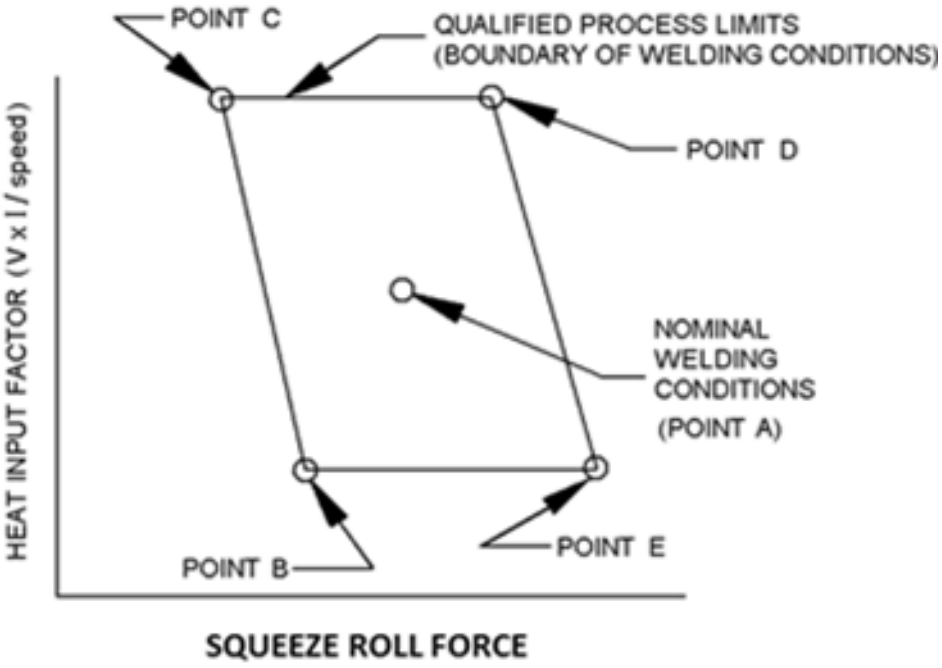


Figure U.1—Manufacturing Process Boundary Limits Qualification

Add new Table U.1

Table U.1—HFW Welding Essential Variables

No	Essential Variables	Changes Requiring New Qualification
1	Base metal	Change in API Specification 5L steel grade
		Increase in CEPCM greater than 0.02 as an essential variable
		Increase in CEIIW greater than 0.03 as an essential variable
		Change in pipe delivery condition
		Change in nominal wall thickness
		Change in nominal pipe diameter
		Change in coil width after edge milling outside of qualified range
		Change in the source of coil
2	Transfer of welding current and the use of impeder	Change in welding current transfer mechanism (either by induction coils or contact tips)
		Change in dimension of induction coils/contact tip, material, coolant type and the contact tip force
		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	Change in qualified frequency (frequency-^{3} 100 KHz) outside qualified range as per Figure U.1
		A in welding heat coefficient, Q = (amps × volts) / (travel speed × thickness) outside qualified range as per Figure U.1
7	Roll pressure on welding/squeezing point, squeeze out and metal flow angle	A change in roll pressure location.
		Roll pressure outside qualified range as per Figure U.1
		Metal flow angle outside qualified range as per Figure U.1
		Change in girth reduction
8	Shielding gas and coverage area	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	Change of > 5 % in qualified frequency
		Change of heat treatment type
		Decrease in soaking time
		Decrease in qualified exit temperature by more than 20°C (36 °F) and exit temperature > Ac3+30 °C (86 °F).
		Change in cooling system

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