

**API Ballot id# 6451
SC5 TG LP**

Work Item Number	4256
Title of Work Item	Tensile Testing near Weld Strain Capacity
Ballot Revision Level	1
Type of Ballot (Initial, Comment, Comment resolution (reference API ballot#), 1 st Re-ballot, 2 nd Re-ballot, etc.)	Initial
Submitter Name(s)	Fred Myschuk
API Document Modified	5L_e46
Revision Key	Current/unchanged content in BLACK; Track Changes as: 1) Additions in RED 2) Deletions in strikethrough BLUE

Work Item Charge: Investigate possible changes to tensile testing methods, validations, frequencies, and criteria as they relate to improvements in processes to better measure properties, and consider additional tests and criteria to address strain localization in the field girth weld region.

Ballot Rationale: To approve the proposed revisions.

Ballot Text: Draft document attached.

NOTE: This proposed Addendum for 5L_e46 WI 4256 will be combined with the revisions in WI 4246.

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

Line Pipe

API SPECIFICATION 5L
FORTY-SIXTH EDITION, APRIL 2018

API MONOGRAM PROGRAM EFFECTIVE DATE: MAY 1, 2019

ERRATA 1, MAY 2018



AMERICAN PETROLEUM INSTITUTE

7 Information to Be Supplied by the Purchaser

7.1 General Information

7.2 Additional Information

The purchase order shall indicate which of the following provisions apply for the specific order item:

- a) Items that are subject to mandatory agreement, if applicable:
- b) Items that apply as prescribed, unless otherwise agreed:
- c) Items that apply, if agreed:
 - 1) delivery condition (see 6.2 and Table 1);
 - 2) supply of quenched and tempered PSL 1 Grade L245 or B SMLS pipe (see Table 1);
 - 3) supply of intermediate grades [see Table 2, footnote a)];
 - 4) supply of double-seam SAWL pipe [see Table 2, footnote c)];
 - 5) alternative to specified seam heat treatment for PSL 1 pipe (see 8.8.1);
 - 6) supply of SAWH pipe with coil/plate end welds at the pipe ends (see 8.10.3);
 - 7) supply of jointers (see 8.11);
 - 8) CVN impact test temperature lower than 0 °C (32 °F) (see 9.8.2.1, 9.8.2.2, 9.8.3, and D.2.3.4.4);
 - 9) CVN impact test of the pipe body of PSL 2 welded pipe with $D < 508$ mm (20.000 in.) for shear fracture area (see 9.8.2.2 and Table 18);
 - 10) CVN impact test of the longitudinal seam weld of PSL 2 HFW pipe (see 9.8.3 and Table 18),
 - 11) drop-weight tear (DWT) test of the pipe body of PSL 2 welded pipe with $D \geq 508$ mm (20.000 in.) (see 9.9.1 and Table 18);
 - 12) DWT test temperature lower than 0 °C (32 °F) (see 9.9.1);
 - 13) fraction jointers comprising two or three pieces for 12 m (40 ft) nominal or 24 m (80 ft) nominal, respectively [see 9.11.3.3 c), d), and e)];
 - 14) power-tight make-up of couplings (see 9.12.2.3 and 10.2.6.1);
 - 15) special bevel configuration (see 9.12.5.3);
 - 16) removal of outside weld bead at pipe ends of SAW or COW pipe [see 9.13.2.2 e)];
 - 17) weldability data or tests for PSL 2 pipe (see 9.15);
 - 18) type of inspection document for PSL 1 pipe (see 10.1.2.1);

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

19) manufacturing information for PSL 1 pipe (see 10.1.2.2);

20) alternative type of inspection document for PSL 2 pipe (see 10.1.3.1);

~~21) use of transverse test pieces for tensile tests of SMLS pipe, not cold expanded [see Table 20, footnote c)];~~

21) use of alternative to full-thickness strip specimens for longitudinal tensile test specimens (see 10.2.3.2);

22) use of the ring expansion test for transverse yield strength determinations [see 10.2.3.2, Table 19 footnote c), and Table 20 footnote d)];

23) use of an alternative to macrographic examination (see 10.2.5.2);

24) hardness test during production of EW and LW pipe (see 10.2.5.3);

25) application of the API Monogram, in which case the requirements of Annex A and Annex O apply.

Draft - For Committee Review

Table 7—Requirements for the Results of Tensile Tests for PSL 2 Pipe

Pipe Grade	Pipe Body of Seamless and Welded Pipe						Weld Seam of HFW, SAW and COW Pipe
	Yield Strength ^{a, e}		Tensile Strength ^{a, e}		Ratio ^{a, c, e}	Elongation ^e	Tensile Strength ^d
	$R_{10.5}$ MPa (psi)		R_m MPa (psi)		$R_{10.5}/R_m$	(on 50 mm or 2 in.) A_f %	R_m MPa (psi)
	min	max	min	max	max	min	min
L245R or BR L245N or BN L245Q or BQ L245M or BM	245 (35,500)	450 (65,300) ^{e f}	415 (60,200)	655 (95,000)	0.93	f g	415 (60,200)
L290R or X42R L290N or X42N L290Q or X42Q L290M or X42M	290 (42,100)	495 (71,800)	415 (60,200)	655 (95,000)	0.93	f g	415 (60,200)
L320N or X46N L320Q or X46Q L320M or X46M	320 (46,400)	525 (76,100)	435 (63,100)	655 (95,000)	0.93	f g	435 (63,100)
L360N or X52N L360Q or X52Q L360M or X52M	360 (52,200)	530 (76,900)	460 (66,700)	760 (110,200)	0.93	f g	460 (66,700)
L390N or X56N L390Q or X56Q L390M or X56M	390 (56,600)	545 (79,000)	490 (71,100)	760 (110,200)	0.93	f g	490 (71,100)
L415N or X60N L415Q or X60Q L415M or X60M	415 (60,200)	565 (81,900)	520 (75,400)	760 (110,200)	0.93	f g	520 (75,400)
L450Q or X65Q L450M or X65M	450 (65,300)	600 (87,000)	535 (77,600)	760 (110,200)	0.93	f g	535 (77,600)
L485Q or X70Q L485M or X70M	485 (70,300)	635 (92,100)	570 (82,700)	760 (110,200)	0.93	f g	570 (82,700)
L555Q or X80Q L555M or X80M	555 (80,500)	705 (102,300)	625 (90,600)	825 (119,700)	0.93	f g	625 (90,600)
L625M or X90M	625 (90,600)	775 (112,400)	695 (100,800)	915 (132,700)	0.95	f g	695 (100,800)
L625Q or X90Q	625 (90,600)	775 (112,400)	695 (100,800)	915 (132,700)	0.97 ^g	f g	—
L690M or X100M	690 (100,100) ^b	840 (121,800) ^b	760 (110,200)	990 (143,600)	0.97 ^h	f g	760 (110,200)
L690Q or X100Q	690 (100,100) ^b	840 (121,800) ^b	760 (110,200)	990 (143,600)	0.97 ^h	f g	—
L830M or X120M	830 (120,400) ^b	1050 (152,300) ^b	915 (132,700)	1145 (166,100)	0.99 ^h	f g	915 (132,700)

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

^a For intermediate grades, the difference between the specified maximum yield strength and the specified minimum yield strength shall be as given in the table for the next higher grade, and the difference between the specified minimum tensile strength and the specified minimum yield strength shall be as given in the table for the next higher grade; for intermediate grades up to Grade L320 or X46, the tensile strength shall be ≤ 655 MPa (95,000 psi); for intermediate grades greater than Grade L320 or X46 and lower than Grade L555 or X80, the tensile strength shall be ≤ 760 MPa (110,200 psi); for intermediate grades higher than Grade L555 or X80, the maximum permissible tensile strength shall be obtained by interpolation; for SI units, the calculated value shall be rounded to the nearest 5 MPa; for USC units, the calculated value shall be rounded to the nearest 100 psi.

^b For grades $> L625$ or X90, $R_{p0.2}$ applies.

^c This limit applies for pipe with $D > 323.9$ mm (12.750 in.).

^d For intermediate grades, the specified minimum tensile strength for the weld seam shall be the same value as was determined for the pipe body using footnote a).

^e Where longitudinal tensiles are specified in addition to transverse tensiles, the longitudinal results for yield strength, tensile strength, ratio, and elongation shall be reported for information purposes.

^{e f} For pipe requiring longitudinal testing, the maximum yield strength shall be ≤ 495 MPa (71,800 psi).

^{f g} The specified minimum elongation, A_f , shall be as determined using the following equation:

$$A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$$

where

C is 1940 for calculations using SI units and 625,000 for calculations using USC units;

A_{xc} is the applicable tensile test piece cross-sectional area, expressed in square millimeters (square inches), as follows:

- 1) for circular cross-section test pieces, 130 mm^2 (0.20 in.²) for 12.7 mm (0.500 in.) and 8.9 mm (0.350 in.) diameter test pieces; 65 mm^2 (0.10 in.²) for 6.4 mm (0.250 in.) diameter test pieces;
- 2) for full-section test pieces, the lesser of a) 485 mm^2 (0.75 in.²) and b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm^2 (0.01 in.²);
- 3) for strip test pieces, the lesser of a) 485 mm^2 (0.75 in.²) and b) the cross-sectional area of the test piece, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm^2 (0.01 in.²);

U is the specified minimum tensile strength, expressed in megapascals (pounds per square inch).

^{g h} Lower values of $R_{t0.5}/R_m$ may be specified by agreement.

^{h i} For grades $> L625$ or X90, $R_{p0.2}/R_m$ applies. Lower values of $R_{p0.2}/R_m$ may be specified by agreement.

10.1.3 Inspection Documents for PSL 2 Pipe

10.1.3.1 The manufacturer shall issue an Inspection Certificate 3.1.B in accordance with ISO 10474:1991 or an Inspection Certificate 3.1 in accordance with EN 10204:2004. Alternatively, if specified in the purchase order, an Inspection Certificate 3.1.A or 3.1.C in accordance with ISO 10474:1991 or an Inspection Certificate 3.2 in accordance with EN 10204:2004 shall be issued.

10.1.3.2 The following information, as applicable, shall be provided for each order item:

- a) specified outside diameter, specified wall thickness, pipe grade, PSL, type of pipe, and the delivery condition;
- b) chemical composition (heat and product) and carbon equivalent (product analysis and acceptance criterion);
- c) tensile test results (excluding measured modulus values) and the type, size, location, and orientation of the test pieces;
- d) CVN impact test results; the size, orientation, and location of the test pieces; the test temperature; and the acceptance criteria for the specific test piece sizes used;
- e) for welded pipe, DWT test results (individual and average test results for each test);
- f) specified minimum hydrostatic test pressure and specified test duration;
- g) for welded pipe, the method of nondestructive weld inspection (radiological, ultrasonic, or electromagnetic) used and the type and size of reference indicator or IQI used;
- h) for SMLS pipe, the method of nondestructive inspection (ultrasonic, electromagnetic, or magnetic particle) used and the type and size of the reference indicator used;
- i) for HFW pipe, the minimum temperature for heat treatment of the weld seam;
- j) for pipe with welded jointer and/or TFL pipe, certification that the product meets the requirements of Annexes M and/or I, as applicable;
- k) name and location of facilities used for pipe manufacturing, plate/coil rolling, and steelmaking;
- l) results of any supplementary testing specified in the purchase order.

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

10.2.3 Samples and Test Pieces for Mechanical Tests

10.2.3.1 General

For tensile tests, CVN impact tests, DWT tests, bend tests, guided-bend tests, and flattening tests, the samples shall be taken and the corresponding test pieces prepared, in accordance with the applicable reference standard.

Samples and test pieces for the various test types shall be taken from locations as shown in Figure 5 and Figure 6 and as given in Table 19 or Table 20, whichever is applicable, taking into account the supplementary details in 10.2.3.2 to 10.2.3.7 and in 10.2.4.

All mechanical test pieces shall be taken from pipe in the final bare pipe delivery condition (see Table 3) and cold expansion ratio. Test pieces may be removed prior to cold end sizing. Each test piece shall be prepared in a manner that does not intentionally enhance or decrease mechanical properties.

For any of the mechanical tests specified in Section 9, any test piece that shows defective preparation or material imperfections unrelated to the intent of the particular mechanical test, whether observed before or after testing, may be discarded and replaced by another test piece from the same length of pipe.

10.2.3.2 Test Pieces for the Tensile Test

Rectangular test pieces, representing the full wall thickness of the pipe, shall be taken in accordance with ISO 6892-1 or ASTM A370 and as shown in Figure 5. A standard sampling location along the coil or plate length shall be selected according to a documented practice.

For hot worked and heat-treated seamless pipe, transverse test pieces shall have a round cross-section and shall be obtained from nonflattened samples.

For other pipe, transverse test pieces shall either have a rectangular or round cross-section. Rectangular cross-section test pieces shall be from flattened samples, whereas round cross-section test shall be from nonflattened samples.

Flattening of test pieces shall be carried out according to documented procedures. ~~Flattening of the test pieces shall be performed at room temperature. The maximum residual curvature of the flattened test piece shall be measured with a taper gauge or similar method having a maximum width of 12.7 mm (0.5 in.). For specimens with an overall length of 300 mm (12 in.), the residual curvature shall not exceed 1.5 mm (0.060 in.) as measured at any location along the test piece. The residual curvature requirements shall be extrapolated for specimens with an alternate overall length. Weld beads may be ground flush, alternately a groove may be machined into the measuring surface to facilitate accurate measurement of the test piece flatness. Local imperfections may be removed.~~

For transverse tensile tests using round cross-section test pieces, the diameter of such test pieces shall be as given in Table 21, except that the next larger diameter may be used at the option of the manufacturer. For longitudinal tensile tests of pipe with $t \geq 19.0$ mm (0.748 in.), such test pieces shall be 12.7 mm (0.500 in.) in diameter.

~~Unless otherwise agreed, longitudinal tensile test specimens for welded pipe shall be full-thickness strip specimens. Longitudinal specimens for seamless pipe shall be either full-thickness strip specimens or round bar specimens. No flattening of longitudinal tensile test specimens is permitted, except for the grip area.~~

For testing pipe with $D < 219.1$ mm (8.625 in.), full-section longitudinal test pieces may be used at the option of the manufacturer.

~~If agreed, r~~ Ring expansion test pieces may be used for the determination of transverse yield strength.

~~Weld beads may be ground flush, and local imperfections may be removed.~~

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

Table 19—Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests for PSL 1 Pipe

Type of Pipe	Sample Location	Type of Test	Number, Orientation, and Location of Test Pieces per Sample ^a			
			Specified Outside Diameter <i>D</i> mm (in.)			
			< 219.1 (8.625)	219.1 (8.625) to < 323.9 (12.750)	323.9 (12.750) to < 508 (20.000)	≥ 508 (20.000)
SMLS, not cold-expanded [see Figure 5 a)]	Pipe body	Tensile	1L ^b	1L	1L	1L
	Pipe body	Tensile	1L ^b	1T ^c	1T ^c	1T ^c
CW [see Figure 5 b)]	Pipe body	Tensile	1L90 ^b	—	—	—
	Pipe body and weld	Bend	1 ^e	—	—	—
	Pipe body and weld	Flattening	As shown in Figure 6			
LW [see Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1T180 ^c	1T180 ^c	1T180 ^c
	Seam weld	Tensile	—	1W	1W	1W
	Seam weld	Guided-bend	—	—	2W	2W
	Pipe body and weld	Flattening	As shown in Figure 6			
LFW or HFW [see Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1T180 ^c	1T180 ^c	1T180 ^c
	Seam weld	Tensile	—	1W	1W	1W
	Pipe body and weld	Bend	1 ^e	—	—	—
	Pipe body and weld	Flattening	As shown in Figure 6			
SAWL or COWL [see Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1T180 ^c	1T180 ^c	1T180 ^c
	Seam weld	Tensile	—	1W	1W	1W ^d
	Seam weld	Guided-bend	2W	2W	2W	2W ^d
SAWH or COWH [see Figure 5 c)]	Pipe body	Tensile	1L ^b	1T ^c	1T ^c	1T ^c
	Seam weld	Tensile	—	1W	1W	1W
	Seam weld	Guided-bend	2W	2W	2W	2W
	Coil/plate end weld	Guided-bend	2WS	2WS	2WS	2WS

- a See Figure 5 for an explanation of the symbols used to designate orientation and location of samples and test pieces.
- b Full-section longitudinal test pieces may be used at the option of the manufacturer.
- c ~~If agreed, a~~ Annular test pieces may be used for the determination of transverse yield strength by the hydraulic ring expansion test in accordance with ASTM A370.
- d For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.
- e Testing limited to pipe of $D \leq 60.3$ mm (2.375 in.).

Draft - For Committee Review

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

Table 20—Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests for PSL 2 Pipe

Type of Pipe	Sample Location	Type of Test	Number, Orientation, and Location of Test Pieces per Sample ^a			
			Specified Outside Diameter			
			<i>D</i> mm (in.)			
			< 219.1 (8.625)	219.1 (8.625) to < 323.9 (12.750)	323.9 (12.750) to < 508 (20.000)	≥ 508 (20.000)
SMLS, not cold-expanded [see Figure 5 a)]	Pipe body	Tensile	1L ^b	1L ^{c,d}	1L ^{c,d}	1L ^{c,d}
		CVN	3T	3T	3T	3T
SMLS, cold-expanded [see Figure 5 a)]	Pipe body	Tensile	1L ^b	1T ^d 1L90	1T ^d 1L90	1T ^d 1L90
		CVN	3T	3T	3T	3T
HFW [see Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1T180 ^d 1L90	1T180 ^d 1L90	1T180 ^d 1L90
		CVN	3T90	3T90	3T90	3T90
		DWT	—	—	—	2T90
	Seam weld	Tensile	—	1W	1W	1W
		CVN	3W	3W	3W	3W
	Pipe body and weld	Flattening	As shown in Figure 6			
SAWL or COWL [see Figure 5 b)]	Pipe body	Tensile	1L90 ^b	1T180 ^d 1L90	1T180 ^d 1L90	1T180 ^d 1L90
		CVN	3T90	3T90	3T90	3T90
		DWT	—	—	—	2T90
	Seam weld	Tensile	—	1W	1W	1W ^e
		CVN	3W and 3HAZ	3W and 3HAZ	3W and 3HAZ	3W ^e and 3HAZ ^e
		Guided-bend	2W ^f	2W ^f	2W ^f	2W ^{e,f}
SAWH or COWH [see Figure 5 c)]	Pipe body	Tensile	1L ^b	1T ^d 1L	1T ^d 1L	1T ^d 1L
		CVN	3T	3T	3T	3T
		DWT	—	—	—	2T
	Seam weld	Tensile	—	1W	1W	1W
		CVN	3W and 3HAZ	3W and 3HAZ	3W and 3HAZ	3W and 3HAZ
		Guided-bend	2W ^f	2W ^f	2W ^f	2W ^f
	Coil/plate end weld	Tensile	—	1WS	1WS	1WS
		CVN	3WS and 3HAZ	3WS and 3HAZ	3WS and 3HAZ	3WS and 3HAZ
		Guided-bend	2WS ^f	2WS ^f	2WS ^f	2WS ^f

^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 If agreed, transverse test pieces may be used.

^d If agreed, ^aAnnular test pieces may be used for the determination of transverse yield strength by the hydraulic ring expansion test in accordance with ASTM A370.

^e For double-seam pipe, both longitudinal-weld seams in the pipe selected to represent the test unit shall be tested.

^f For pipe with *t* > 19.0 mm (0.748 in.), the test pieces may be machined to provide a rectangular cross-section having a thickness of 18.0 mm (0.709 in.).

10.2.4 Test Methods

10.2.4.1 Product Analysis

10.2.4.2 Tensile Test

The tensile test shall be carried out in accordance with ISO 6892-1 or ASTM A370.

For pipe body tests, the yield strength, the tensile strength, the yield ratio (as appropriate), and the percentage elongation after fracture shall be determined. For pipe weld tests, the tensile strength shall be determined.

For nominal wall thickness less than 25.4 mm (1.0 in.), the measured modulus value shall be used to assess test validity. The measured modulus value obtained from the stress-percentage extension curve (Stress-strain curve) shall be 207 GPa \pm 20% (166 – 248 GPa) (30.0 x10⁶ psi \pm 20%) [24.0 x 10⁶ – 36.0 x 10⁶ psi]. Tensile tests with a measured modulus value failing to conform to the specified requirements shall be considered invalid and shall be subject to a replacement test.

Stress-strain curve evaluation shall include compensation for deviations from the ideal yielding behavior, as detailed in ASTM E8/E8M Appendix X5.

The percentage elongation after fracture shall be reported with reference to a gauge length of 50 mm (2 in.). For test pieces having a gauge length less than 50 mm (2 in.), the measured elongation after fracture shall be converted to a percentage elongation in 50 mm (2 in.) in accordance with ISO 2566-1 or ASTM A370.

Table H.2—Requirements for the Results of Tensile Tests

Pipe Steel Grade	Pipe Body of SMLS and Welded Pipe						Weld Seam of HFW and SAW Pipe
	Yield Strength ^{a, d}		Tensile Strength ^{a, d}		Ratio ^{b, d}	Elongation ^d (on 50 mm or 2 in.)	Tensile Strength ^c
	$R_{t0.5}$ MPa (psi)		R_m MPa (psi)		$R_{t0.5}/R_m$	A_f %	R_m MPa (psi)
	min	max	min	max	max	min	min
L245NS or BNS L245QS or BQS L245MS or BMS	245 (35,500)	450 (65,300) ^{d e}	415 (60,200)	655 (95,000)	0.93	^{e f}	415 (60,200)
L290NS or X42NS L290QS or X42QS L290MS or X42MS	290 (42,100)	495 (71,800)	415 (60,200)	655 (95,000)	0.93	^{e f}	415 (60,200)
L320NS or X46NS L320QS or X46QS L320MS or X46MS	320 (46,400)	525 (76,100)	435 (63,100)	655 (95,000)	0.93	^{e f}	435 (63,100)
L360NS or X52NS L360QS or X52QS L360MS or X52MS	360 (52,200)	530 (76,900)	460 (66,700)	760 (110,200)	0.93	^{e f}	460 (66,700)
L390QS or X56QS L390MS or X56MS	390 (56,600)	545 (79,000)	490 (71,100)	760 (110,200)	0.93	^{e f}	490 (71,100)
L415QS or X60QS L415MS or X60MS	415 (60,200)	565 (81,900)	520 (75,400)	760 (110,200)	0.93	^{e f}	520 (75,400)
L450QS or X65QS L450MS or X65MS	450 (65,300)	600 (87,000)	535 (77,600)	760 (110,200)	0.93	^{e f}	535 (77,600)
L485QS or X70QS L485MS or X70MS	485 (70,300)	635 (92,100)	570 (82,700)	760 (110,200)	0.93	^{e f}	570 (82,700)

Draft - For Comment

a For intermediate grades, the difference between the specified maximum yield strength and the specified minimum yield strength shall be as given in the table for the next higher grade, and the difference between the specified minimum tensile strength and the specified minimum yield strength shall be as given in the table for the next higher grade; for intermediate grades, the tensile strength shall be ≤ 760 MPa (110,200 psi).

b This limit applies for pipe with $D > 323.9$ mm (12.750 in.).

c For intermediate grades, the specified minimum tensile strength for the weld seam shall be the same value as was determined for the pipe body using footnote a).

d Where longitudinal tensiles are specified in addition to transverse tensiles, the longitudinal results for yield strength, tensile strength, ratio, and elongation shall be reported for information purposes.

e For pipe requiring longitudinal testing, the maximum yield strength shall be ≤ 495 MPa (71,800 psi).

f The specified minimum elongation, A_f , on 50 mm or 2 in., expressed in percent and rounded to the nearest percent, shall be as determined using the following equation:

$$A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$$

where

C is 1940 for calculations using SI units and 625,000 for calculations using USC units;

A_{xc} is the applicable tensile test piece cross-sectional area, expressed in square millimeters (square inches) as follows:

- 1) for circular cross-section test pieces, 130 mm² (0.20 in.²) for 12.7 mm (0.500 in.) and 8.9 mm (0.350 in.) diameter test pieces, and 65 mm² (0.10 in.²) for 6.4 mm (0.250 in.) diameter test pieces;
- 2) for full-section test pieces, the lesser of a) 485 mm² (0.75 in.²) and b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in.²);
- 3) for strip test pieces, the lesser of a) 485 mm² (0.75 in.²) and b) the cross-sectional area of the test piece, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in.²);

U is the specified minimum tensile strength, expressed in megapascals (pounds per square inch).

Annex J (normative)

PSL 2 Pipe Ordered for Offshore Service

J.1 Introduction

This annex specifies additional provisions that apply for PSL 2 pipe that is ordered for offshore service [see 7.2. c) 58)].

NOTE This annex does not include requirements for specialized tests for pipe intended for applications such as pipe reeling or for pipe that will experience high ($> 0.5\%$) total, single event strain during installation; for such applications, additional testing can be necessary to prove the suitability of the pipe and the purchaser might need to supplement the requirements of this specification with other appropriate provisions (e.g. see Annex N and DNV-OS-F101 **Error! Reference source not found.**).

J.2 Additional Information to Be Supplied by the Purchaser

The purchase order shall indicate which of the following provisions apply for the specific order item:

- a) steel casting method for strip or plate used for the manufacture of welded pipe (see J.3.3.2.1);
- b) ultrasonic inspection of strip or plate for laminar imperfections (see J.3.3.2.4);
- c) supply of helical seam pipe containing coil/plate end welds (see J.3.3.2.5);
- d) chemical composition for intermediate grades (see J.4.1.1);
- e) chemical composition for pipe with $t > 25.0$ mm (0.984 in.) (see J.4.1.2);
- f) carbon equivalent limit for steel Grade L555QO or X80QO, L625QO or X90QO, and L690QO or X100QO (see Table J.1);
- g) chemical composition limits [see Table J.1, footnote d)];
- h) acceptance criteria for tensile properties if determined at other than room temperature (see J.4.2.2);
- i) for grades equal to or greater than Grade L555 or X80, a lower maximum tensile strength limit may be agreed [see Table J.2, footnote b)];
- j) minimum average length other than 12.1 m (39.7 ft) and/or different range (see J.6.3);
- k) diameter and out-of-roundness tolerances for SMLS pipe with $t > 25.0$ mm (0.984 in.) [see Table J.3, footnote b)];
- l) use of inside diameter to determine diameter and out-of-roundness tolerances for nonexpanded pipe with $D \geq 219.1$ mm (8.625 in.) [see Table J.3, footnote c)];
- m) hardness test of the pipe body seam weld and HAZ of EW and SAW pipe (see Table J.7);
- n) hardness testing of pipe body for SMLS pipe (see Table J.7);

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

o) crack tip opening displacement (CTOD) testing (see J.8.2.2 and Table J.6);

~~p) use of the ring expansion test for transverse yield strength determinations [see Table J.7, footnote c)];~~

~~q) p) additional longitudinal tensile testing for deep-water pipelay [see Table J.7, footnote d)];~~

~~r) q) deviation from hardness test [see J.8.3.2.2 c) and J.8.3.2.3];~~

~~s) r) deviation from location of hardness test [J.8.3.2.2.c)];~~

~~t) s) 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 (see K.2.1.3);~~

~~u) t) supplementary end NDT lamination criteria (see K.2.1.3 and K.2.1.4);~~

~~v) u) magnetic particle inspection for laminar imperfections at each pipe end face/bevel (see K.2.1.4);~~

~~w) v) ultrasonic inspection to verify conformance with the applicable requirements given in Table K.1 (see K.3.2.2);~~

~~x) w) verification of lamination size/density (see K.3.2.2);~~

~~y) x) increased coverage for ultrasonic thickness measurements for SMLS pipe (see K.3.3);~~

~~z) y) application of one or more of the supplementary nondestructive inspection operations for SMLS pipe (see K.3.4);~~

~~aa) z) ultrasonic inspection of SMLS pipe for the detection of transverse imperfections (see K.3.4.1);~~

~~bb) aa) full-body inspection of SMLS pipe using the flux leakage method for the detection of longitudinal and transverse imperfections (see K.3.4.2);~~

~~cc) bb) full-body inspection of SMLS pipe by the eddy current method (see K.3.4.3);~~

~~dd) cc) full-body magnetic particle inspection of pipe (see K.3.4.4);~~

~~ee) dd) acceptance Level U2/U2H for nondestructive inspection of the weld seam of HFW pipe (see K.4.1);~~

~~ff) ee) alternate ISO 10893-10 HFW weld seam UT acceptance criteria [see K.4.1 b)];~~

~~gg) ff) ultrasonic inspection of the pipe body of HFW pipe for laminar imperfections (see K.4.2);~~

~~hh) gg) ultrasonic inspection of the strip/plate edges or areas adjacent to the weld for laminar imperfections (see K.4.3);~~

~~ii) hh) nondestructive inspection of the pipe body of HFW pipe using the ultrasonic or flux-leakage method (see K.4.4);~~

~~jj) ii) use of fixed-depth notches for equipment standardization [see K.5.1.1 c)];~~

~~kk) jj) radiographic inspection of the pipe ends (noninspected pipe ends) and repaired areas [see K.5.3 a)];~~

~~ll) kk) magnetic particle inspection of the weld seam at the pipe ends of SAW pipe (see K.5.4);~~

~~mm)~~ II) for grades L625QO or X90QO, and L690QO or X100QO, a lower $R_{t0.5}/R_m$ (see Table J.2).

Draft - For Committee Review

Table J.2—Requirements for the Results of Tensile Tests

Pipe Grade	Pipe Body of SMLS and Welded Pipe						Weld Seam of HFW and SAW Pipe	
	Yield Strength ^{a, e}		Tensile Strength ^{a, e}		Ratio ^{a, c, e}	Elongation ^e (on 50 mm or 2 in.)		Tensile Strength ^d
	$R_{t0.5}$ MPa (psi)		R_m MPa (psi)		$R_{t0.5}/R_m$	A_f %		R_m MPa (psi)
	min	max	min	max	max	min		min
L245NO or BNO L245QO or BQO L245MO or BMO	245 (35,500)	450 (65,300) ^{ef}	415 (60,200)	655 (95,000)	0.93	f g	415 (60,200)	
L290NO or X42NO L290QO or X42QO L290MO or X42MO	290 (42,100)	495 (71,800)	415 (60,200)	655 (95,000)	0.93	f g	415 (60,200)	
L320NO or X46NO L320QO or X46QO L320MO or X46MO	320 (46,400)	520 (75,000)	435 (63,100)	655 (95,000)	0.93	f g	435 (63,100)	
L360NO or X52NO L360QO or X52QO L360MO or X52MO	360 (52,200)	525 (76,000)	460 (66,700)	760 (110,200)	0.93	f g	460 (66,700)	
L390QO or X56QO L390MO or X56MO	390 (56,600)	540 (78,300)	490 (71,100)	760 (110,200)	0.93	f g	490 (71,100)	
L415QO or X60QO L415MO or X60MO	415 (60,200)	565 (81,900)	520 (75,400)	760 (110,200)	0.93	f g	520 (75,400)	
L450QO or X65QO L450MO or X65MO	450 (65,300)	570 (82,700)	535 (77,600)	760 (110,200)	0.93	f g	535 (77,600)	
L485QO or X70QO L485MO or X70MO	485 (70,300)	605 (87,700)	570 (82,700)	760 (110,200)	0.93	f g	570 (82,700)	
L555QO or X80QO L555MO or X80MO	555 (80,500)	675 (97,900)	625 (90,600)	825 (119,700) ^b	0.93	f g	625 (90,600)	
L625QO or X90QO	625 (90,600)	745 (108,000)	695 (100,800)	895 (129,800) ^b	0.97 ^h	f g	—	
L690QO or X100QO	690 (100,100) ^{gh}	810 (117,500) ^{gh}	760 (110,200)	960 (139,200) ^b	0.97 ⁱ	f g	—	

Draft - For Review

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

^a For intermediate grades, the difference between the specified maximum yield strength and the specified minimum yield strength shall be as given in the table for the next higher grade, and the difference between the specified minimum tensile strength and the specified minimum yield strength shall be as given in the table for the next higher grade; for intermediate grades up to Grade L320 or X46, the tensile strength shall be ≤ 655 MPa (95,000 psi); for intermediate grades greater than Grade L320 or X46 and less than Grade L555 or X80, the tensile strength shall be ≤ 760 MPa (110,200 psi); for intermediate grades higher than Grade L555 or X80, the maximum permissible tensile strength shall be obtained by interpolation; for SI units, the calculated value shall be rounded to the nearest 5 MPa; for USC units, the calculated value shall be rounded to the nearest 100 psi.

^b If agreed, for pipe in grades equal to or greater than Grade L555 or X80, more stringent maximum tensile strength limits may apply.

^c This limit applies for pipe with $D > 323.9$ mm (12.750 in.).

^d For intermediate grades, the specified minimum tensile strength for the weld seam shall be the same value as was determined for the pipe body using footnote a).

^e Where longitudinal tensiles are specified in addition to transverse tensiles, the longitudinal results for yield strength, tensile strength, ratio, and elongation shall be reported for information purposes.

^{e f} For pipe requiring longitudinal testing the yield strength shall be ≤ 495 MPa (71,800 psi).

^{f g} The specified minimum elongation, A_f , on 50 mm (2 in.), expressed in percent and rounded to the nearest percent, shall be as determined using the following equation:

$$A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$$

where

C is 1940 for calculations using SI units and 625,000 for calculations using USC units;

A_{xc} is the applicable tensile test piece cross-sectional area, expressed in square millimeters (square inches), as follows:

- 1) for circular cross-section test pieces, 130 mm² (0.20 in.²) for 12.7 mm (0.500 in.) and 8.9 mm (0.350 in.) diameter test pieces; and 65 mm² (0.10 in.²) for 6.4 mm (0.250 in.) diameter test pieces;
- 2) for full-section test pieces, the lesser of a) 485 mm² (0.75 in.²) and b) the cross-sectional area of the test piece, derived using the specified outside diameter and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in.²);
- 3) for strip test pieces, the lesser of a) 485 mm² (0.75 in.²) and b) the cross-sectional area of the test piece, derived using the specified width of the test piece and the specified wall thickness of the pipe, rounded to the nearest 10 mm² (0.01 in.²);

U is the specified minimum tensile strength, expressed in megapascals (pounds per square inch).

^{g h} For grades > L625QO or X90QO, $R_{p0.2}$ applies.

^{h i} Lower $R_{10.5}/R_m$ ratio values may be specified by agreement for L625 or X90.

^{i j} For grades > L625 or X90, $R_{p0.2}/R_m$ applies; lower $R_{p0.2}/R_m$ ratio values may be specified by agreement.

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

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

^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 ~~If agreed,~~ ^aAnnular test pieces may be used for the determination of transverse yield strength by the hydraulic ring expansion test in accordance with ASTM A370.

^d For deep-water pipelay, additional longitudinal tests might be specified, with the requirements and test frequency being as agreed.

^e For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.

Annex N (normative)

PSL 2 Pipe Ordered for Applications Requiring Longitudinal Plastic Strain Capacity

N.1 General

This annex specifies additional provisions that apply for PSL 2 pipe that is ordered for applications with designs requiring longitudinal plastic strain capacity (strains > 0.5 %) [see 7.2.c) 59)].

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, this annex does not prescribe specific values for required properties; the required properties are to be determined by the designer of the pipeline and to be specified by the purchaser of the pipe; this annex provides a format for the purchaser of the pipe to specify properties that are known to affect the longitudinal strain capacity of pipelines.

N.2 Additional Information to Be Supplied by the Purchaser

The purchase order shall indicate which of the following provisions apply for the specific order item:

- a) steel casting method for strip or plate used for the manufacture of welded pipe (see N.3.3.2.1);
- b) ultrasonic inspection of strip or plate for laminar imperfections (see N.3.3.2.4);
- c) the delivery of jointers (see N.3.3.3);
- d) chemical composition for intermediate grades (see N.4.1.1);
- e) chemical composition for pipe with $t > 25.0$ mm (0.984 in.) (see N.4.1.2);
- f) carbon equivalent limit for steel Grade L555QP or X80QP (see Table N.1);
- g) chemical composition limits [see Table N.1, footnote d)];
- h) requirements for longitudinal tensile properties (see N.4.2.2);
- i) aging conditions for longitudinal tensile test pieces and method of heating the sample (see N.4.2.3);
- j) requirement for fully rounded stress-strain curve shape (see N.4.2.4);
- k) additional requirements on stress-strain curve shape (see N.4.2.5);
- l) limit on the difference between the maximum and minimum values of actual longitudinal yield strength (see N.4.2.6);
- m) more stringent out-of-roundness tolerances (see N.6.1);
- n) more stringent wall thickness tolerances (see N.6.2);
- o) diameter and out-of-roundness tolerances for SMLS pipe with $t > 25.0$ mm (0.984 in.) [see Table N.2, footnote b)];

- p) use of inside diameter to determine diameter and out-of-roundness tolerances with $D \geq 219.1$ mm (8.625 in.) [see Table N.2, footnote c)];
- q) hardness test of the pipe body of seamless, EW, and SAW pipe and of the seam weld and HAZ of EW and SAW pipe (see Table N.6);
- r) CTOD testing (see N.8.2.2 and Table N.6);
- ~~s) use of the ring expansion test for transverse yield strength determinations [see Table N.7, footnote c)];~~
- ~~t) s) alternatives to full-thickness strip test pieces for longitudinal testing of welded pipe (see N.8.3.1);~~
- ~~u) t) the use of three hardness impressions at each through-thickness location [see N.8.3.3.2 c)];~~
- ~~v) u) 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 (see K.2.1.3);~~
- ~~w) v) magnetic particle inspection for laminar imperfections at each pipe end face/bevel (see K.2.1.4);~~
- ~~x) w) inspection to verify conformance with the applicable requirements given in Table K.1 (see K.3.2.2);~~
- ~~y) x) increased coverage for ultrasonic thickness measurements for SMLS pipe (see K.3.3);~~
- ~~z) y) application of one or more of the supplementary nondestructive inspection operations for SMLS pipe (see K.3.4);~~
- ~~aa) z) acceptance Level L2/C or L2 for nondestructive inspection of the weld seam of HFW pipe (see K.4.1);~~
- ~~bb) aa) ultrasonic inspection of the strip/plate edges or areas adjacent to the weld for laminar imperfections (see K.4.3);~~
- ~~cc) bb) nondestructive inspection of the pipe body of HFW pipe using the ultrasonic or flux-leakage method (see K.4.4);~~
- ~~dd) cc) use of fixed-depth notches for equipment standardization [see K.5.1.1 c)];~~
- ~~ee) dd) radiographic inspection of the pipe ends (noninspected pipe ends) and repaired areas [see K.5.3 a)];~~
- ~~ff) ee) magnetic particle inspection of the weld seam at the pipe ends of SAW pipe (see K.5.4).~~

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

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

This document is not an API Standard; it is under consideration within an API technical committee but has not received all approvals required to become an API Standard. It shall not be reproduced or circulated or quoted, in whole or in part, outside of API committee activities except with the approval of the Chairman of the committee having jurisdiction and staff of the API Standards Dept. Copyright API. All rights reserved.

- 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 ~~If agreed, a~~ Annular test pieces may be used for the determination of transverse yield strength by the hydraulic ring expansion test in accordance with ASTM A370.
- d If aged longitudinal tensile tests are agreed, two specimens shall be taken, with one aged and one not aged; the unaged specimen shall be tested to meet the requirements of the main body of the standard.
- e For double-seam pipe, both longitudinal weld seams in the pipe selected to represent the test unit shall be tested.

Draft - For Committee Review