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Errata 1

Page 60, Table 22:

The top five rows of the table shall read like below. Cells surrounded by a red box contain updated values:

114.3 (4.500) to < 141.3 (5.563)	≥ 12.6 (0.495)	11.3 (0.445) to < 12.6 (0.495)	10.9 (0.429) to < 11.3 (0.445)	10.1 (0.396) to < 10.9 (0.429)
141.3 (5.563) to < 168.3 (6.625)	≥ 11.9 (0.469)	9.8 (0.387) to < 11.9 (0.469)	9.4 (0.370) to < 9.8 (0.387)	8.6 (0.338) to < 9.4 (0.370)
168.3 (6.625) to < 219.1 (8.625)	≥ 11.7 (0.460)	9.2 (0.361) to < 11.7 (0.460)	8.5 (0.333) to < 9.2 (0.361)	7.6 (0.301) to < 8.6 (0.333)
219.1 (8.625) to < 273.1 (10.750)	≥ 11.4 (0.449)	8.9 (0.350) to < 11.4 (0.449)	8.1 (0.317) to < 8.9 (0.350)	6.5 (0.257) to < 8.1 (0.317)
273.1 (10.750) to < 323.9 (12.750)	≥ 11.2 (0.442)	8.7 (0.343) to < 11.2 (0.442)	7.9 (0.310) to < 8.7 (0.343)	6.2 (0.245) to < 7.9 (0.310)

Line Pipe

API SPECIFICATION 5L
FORTY-SIXTH EDITION, APRIL 2018

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ERRATA 1, MAY 2018



AMERICAN PETROLEUM INSTITUTE

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Contents

1	Scope	1
1.1	Coverage	1
1.2	Application of the API Monogram	1
2	Normative References	1
3	Terms, Definitions, Symbols, and Abbreviations	4
3.1	Terms and Definitions	4
3.2	Symbols	11
3.3	Abbreviations	13
4	Conformity	14
4.1	Units of Measurement	14
4.2	Rounding	14
5	Compliance to This Specification	14
5.1	Quality	14
5.2	Other Terms and Definitions	15
5.3	References to Annexes	15
6	Pipe Grades and Steel Grades, and Delivery Condition	16
6.1	Pipe Grades and Steel Grades	16
6.2	Delivery Condition	16
7	Information to Be Supplied by the Purchaser	18
7.1	General Information	18
7.2	Additional Information	18
8	Manufacturing	22
8.1	Process of Manufacture	22
8.2	Processes Requiring Validation	24
8.3	Starting Material	24
8.4	Tack Welds	25
8.5	Weld Seams in COW Pipe	26
8.6	Weld Seams in SAW Pipe	26
8.7	Weld Seams in Double-seam Pipe	26
8.8	Treatment of Weld Seams in EW and LW Pipe	26
8.9	Cold Sizing and Cold Expansion	26
8.10	Coil/Plate End Welds	27
8.11	Jointers	27
8.12	Heat Treatment	27
8.13	Traceability	27
9	Acceptance Criteria	28
9.1	General	28
9.2	Chemical Composition	28
9.3	Tensile Properties	31
9.4	Hydrostatic Test	33
9.5	Bend Test	33
9.6	Flattening Test	33
9.7	Guided-bend Test	33
9.8	CVN Impact Test for PSL 2 Pipe	34
9.9	DWT Test for PSL 2 Welded Pipe	35

Contents

9.10 Surface Conditions, Imperfections, and Defects	36
9.11 Dimensions, Mass, and Tolerances.	37
9.12 Finish of Pipe Ends	42
9.13 Tolerances for the Weld Seam	44
9.14 Tolerances for Mass	47
9.15 Weldability of PSL 2 Pipe	48
10 Inspection	48
10.1 Types of Inspection and Inspection Documents	48
10.2 Specific Inspection	49
11 Marking	74
11.1 General	74
11.2 Pipe Markings	75
11.3 Coupling Markings	77
11.4 Marking of Pipe to Multiple Grades.	78
11.5 Thread Identification and Certification	78
11.6 Pipe Processor Markings	78
12 Coatings and Thread Protectors	79
12.1 Coatings and Linings	79
12.2 Thread Protectors	79
13 Retention of Records	79
14 Pipe Loading	80
Annex A (informative) API Monogram Program: Use of the API Monogram by Licensees.	81
Annex B (normative) Manufacturing Procedure Qualification for PSL 2 Pipe	85
Annex C (normative) Treatment of Surface Imperfections and Defects	90
Annex D (normative) Repair Welding Procedure.	92
Annex E (normative) Nondestructive Inspection for Pipe Not Required to Meet Annex H, J, or N	99
Annex F (normative) Requirements for Couplings (PSL 1 Only)	112
Annex G (normative) PSL 2 Pipe with Resistance to Ductile Fracture Propagation	115
Annex H (normative) PSL 2 Pipe Ordered for Sour Service	122
Annex I (normative) Pipe Ordered as TFL Pipe	136
Annex J (normative) PSL 2 Pipe Ordered for Offshore Service	138
Annex K (normative) Nondestructive Inspection for Pipe Ordered for Sour Service, Offshore Service, and/or Service Requiring Longitudinal Plastic Strain Capacity.	153
Annex L (informative) Steel Designations.	158
Annex M (normative) Specification for Welded Jointers	160
Annex N (normative) PSL 2 Pipe Ordered for Applications Requiring Longitudinal Plastic Strain Capacity.	162
Annex O (informative) Additional Information for Use of the API Monogram by Licensees.	179

Contents

Annex P (informative) Equations for Threaded and Coupled Pipe and Background Equations for Guided-bend and CVN Test Specimens	181
Bibliography	192

Figures

1 Measuring Full-length Straightness	41
2 Measuring End Straightness	42
3 Reference When Using a Fixed Square Measurement	44
4 Dimensional Deviations of the Weld Seam	44
5 Sample and Test Piece Orientation and Locations	53
6 Flattening Tests	54
7 Location of Charpy Test Specimens	59
8 Guided-bend Test Pieces	60
9 Jigs for Guided-bend Test	64
C.1 Resultant Cavity of Weld Repair (PSL 2 Only)	91
D.1 Guided-bend Test Piece	96
F.1 Line Pipe and Coupling	114
H.1 Location of Hardness Tests	133
J.1 Location of Hardness Tests	150
M.1 Segment Identification Marking Sequence Example	161
N.1 Location of Hardness Tests	177
P.1 Threaded and Coupled Pipe	182
P.2 Pipe Coupling	183
P.3 Determination of Minimum Wall Thickness for Charpy Standard V-Notch Specimens	189
P.4 Determination of Minimum Wall Thickness for Tapered CVN Specimens	190

Tables

1 Pipe Grade and Steel Grades, and Acceptable Delivery Conditions	17
2 Acceptable Process of Manufacture and PSLs	22
3 Acceptable Manufacturing Routes for PSL 2 Pipe	23
4 Chemical Composition for PSL 1 Pipe with $t \leq 25.0$ mm (0.984 in.)	29
5 Chemical Composition for PSL 2 Pipe with $t \leq 25.0$ mm (0.984 in.)	30
6 Requirements for the Results of Tensile Tests for PSL 1 Pipe	31
7 Requirements for the Results of Tensile Tests for PSL 2 Pipe	32
8 CVN Absorbed Energy Requirements for Pipe Body of PSL 2 Pipe	35
9 Permissible Specified Outside Diameter and Specified Wall Thickness	38
10 Tolerances for Diameter and Out-of-roundness	39
11 Tolerances for Wall Thickness	40
12 Tolerances for Random Length Pipe	41
13 Maximum Angle of Internal Taper for SMLS Pipe	43
14 Maximum Permissible Radial Offset for SAW and COW Pipe	46
15 Maximum Permissible Depth of Groove for EW and LW Pipe	46
16 Maximum Permissible Weld Bead Height for SAW and COW Pipe (Except at Pipe Ends)	47
17 Inspection Frequency for PSL 1 Pipe	50
18 Inspection Frequency for PSL 2 Pipe	51
19 Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests for PSL 1 Pipe	55
20 Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests for PSL 2 Pipe	56
21 Relationship between Pipe Dimensions and Round Bar Test Piece Diameter for Transverse Tensile Tests	57

Contents

22	Relationship between Pipe Dimensions and Required Impact Test Piece for PSL 2 Pipe	60
23	Strain Values for Guided-bend Test	65
24	Test Pressures for Light-wall Threaded Pipe	67
25	Test Pressures for Heavy-wall Threaded Pipe	68
26	Percentage of Specified Minimum Yield Strength for Determination of S	69
27	Paint Color	77
D.1	Guided-bend Test Jig Dimensions	97
E.1	Pipe Weld Seam Nondestructive Inspection	100
E.2	SMLS Pipe Body Nondestructive Inspection	100
E.3	ISO Wire-type IQI for Radiographic Inspection	102
E.4	ASTM Wire-type IQI for Radiographic Inspection	102
E.5	Elongated Slag-inclusion-type Imperfections	104
E.6	Circular Slag-inclusion-type and Gas-pocket-type Imperfections	104
E.7	Reference Indicators	106
E.8	Acceptance Limit.	108
F.1	Coupling Dimensions, Masses, and Tolerances	113
G.1	Minimum CVN Absorbed Energy Requirements for a Design Factor of 0.625	118
G.2	Minimum CVN Absorbed Energy Requirements for a Design Factor of 0.72.	119
G.3	Minimum CVN Absorbed Energy Requirements for a Design Factor of 0.80.	120
H.1	Chemical Composition for Pipe with $t \leq 25.0$ mm (0.984 in.)	126
H.2	Requirements for the Results of Tensile Tests	127
H.3	Inspection Frequency	129
H.4	Number, Orientation, and Location of Test Pieces per Sample for Hardness Tests	130
I.1	Dimensions, Masses per Unit Length, and Test Pressures for TFL Pipe	137
I.2	Drift Mandrel Dimensions.	137
J.1	Chemical Composition for Pipe with $t \leq 25.0$ mm (0.984 in.)	142
J.2	Requirements for the Results of Tensile Tests	143
J.3	Tolerances for Diameter and Out-of-roundness	145
J.4	Tolerances for Wall Thickness	146
J.5	Maximum Permissible Radial Offset for SAW Pipe	147
J.6	Inspection Frequency	148
J.7	Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests	149
K.1	Acceptance Criteria for Laminar Imperfections.	155
L.1	List of Corresponding Additional Steel Designations (Steel Numbers) for Use in Europe	159
N.1	Chemical Composition for Pipe with $t \leq 25.0$ mm (0.984 in.)	166
N.2	Tolerances for Diameter and Out-of-roundness	169
N.3	Tolerances for Wall Thickness	170
N.4	Eccentricity at Pipe Ends for Seamless Pipe.	170
N.5	Maximum Permissible Radial Offset for SAW Pipe	171
N.6	Inspection Frequency	172
N.7	Number, Orientation, and Location of Test Pieces per Sample for Mechanical Tests	174

Introduction

This specification is based on API Spec 5L, 45th Edition.

In the preparation of this document, the technical committee maintained the concept of two basic levels of standard technical requirements for line pipe expressed as two product specification levels (PSL 1 and PSL 2). Level PSL 1 provides a standard quality level for line pipe. Level PSL 2 has additional mandatory requirements for chemical composition, notch toughness and strength properties, and additional nondestructive testing. Requirements that apply to only PSL 1 or to only PSL 2 are so designated. Requirements that are not designated to a specific PSL designation apply to both PSL 1 and PSL 2 pipes.

The technical committee also recognized that the petroleum and natural gas industries often specify additional requirements for particular applications. In order to accommodate such needs, optional additional requirements for special applications are available, as follows:

- PSL 2 pipe ordered with a qualified manufacturing procedure (Annex B), the requirements of which have been enhanced to include verification detail of critical processes in the production of feedstock material, line pipe manufacture, and product testing and inspection;
- PSL 2 pipe ordered with resistance to ductile fracture propagation in gas pipelines (Annex G);
- PSL 2 pipe ordered for sour service (Annex H);
- pipe ordered as “through the flowline” pipe (Annex I);
- PSL 2 pipe ordered for offshore service (Annex J).

The following new annex has been added to this specification:

- PSL 2 Pipe Ordered for Applications Requiring Longitudinal Plastic Strain Capacity (Annex N).

The requirements of the annex apply only when specified on the purchase order.

When pipe is ordered for dual or multiple applications, the requirements of more than one annex for special applications can be invoked. In such instances, if a technical conflict arises due to applying the requirements of more than one annex for special applications, the most stringent requirement applicable to the intended service shall apply.

This specification does not provide guidance on when it is necessary to specify the above supplementary requirements. Instead, it is the responsibility of the purchaser to specify, based on the intended use and design requirements, which, if any, of the supplementary requirements apply for a particular purchase order.

Consideration has been given to traditional symbols (denoting mechanical or physical properties or their values, dimensions, or test parameters) and the format of equations that have been widely used and which (in their traditional format) maintain strong links with other widely used standards and specifications, and with the original scientific work that led to their derivation. Accordingly, some symbols and equations, most specifically those in 9.2 and Table F.1 and Annex P, have been retained in their traditional form to avoid causing confusion. Where changes have been made, care has been taken to ensure that the new symbol replacing the traditional one has been fully and clearly defined.

Line Pipe

1 Scope

1.1 Coverage

This specification specifies requirements for the manufacture of two product specification levels (PSL 1 and PSL 2) of seamless and welded steel pipe for use in pipeline transportation systems in the petroleum and natural gas industries.

This specification is not applicable to cast pipe.

1.2 Application of the API Monogram

If the product is manufactured at a facility licensed by the American Petroleum Institute (API) and is intended to be supplied bearing the API Monogram, the requirements of Annex A apply.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda or errata) applies.

[API Recommended Practice 5A3](#), *Thread Compounds for Casing, Tubing, and Line Pipe*

[API Recommended Practice 5L3](#), *Drop-Weight Tear Tests on Line Pipe*

[API Specification 5B](#), *Threading, Gauging, and Thread Inspection of Casing, Tubing, and Line Pipe Threads*

[API Standard 5T1](#), *Imperfection Terminology*

ASNT SNT-TC-1A ¹, *Recommended Practice No. SNT-TC-1A — Non-Destructive Testing*

[ASTM A370](#) ², *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

[ASTM A435](#), *Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates*

[ASTM A578](#), *Standard Specification for Straight-Beam Ultrasonic Examination of Plain and Clad Steel Plates for Special Applications*

[ASTM A751](#), *Standard Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products*

[ASTM A941](#), *Standard Terminology Relating to Steel, Stainless Steel, Related Alloys, and Ferroalloys*

[ASTM A956](#), *Standard Test Method for Leeb Hardness Testing of Steel Products*

¹ American Society for Nondestructive Testing, 1711 Arlingate Lane, Columbus, Ohio 43228, <https://www.asnt.org>.

² ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, <https://www.astm.org>.

[ASTM A1038](#), *Standard Practice for Portable Hardness Testing by the Ultrasonic Contact Impedance Method*

[ASTM E18](#), *Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials*

[ASTM E92](#), *Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials*

[ASTM E94](#), *Standard Guide for Radiographic Examination*

[ASTM E110](#), *Standard Test Method for Indentation Hardness of Metallic Materials by Portable Hardness Testers*

[ASTM E114](#), *Standard Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method*

[ASTM E164](#), *Standard Practice for Contact Ultrasonic Testing of Weldments*

[ASTM E165](#), *Standard Test Method for Liquid Penetrant Examination*

[ASTM E213](#), *Standard Practice for Ultrasonic Examination of Metal Pipe and Tubing*

[ASTM E273](#), *Standard Practice for Ultrasonic Examination of the Weld Zone of Welded Pipe and Tubing*

[ASTM E309](#), *Standard Practice for Eddy-Current Examination of Steel Tubular Products Using Magnetic Saturation*

[ASTM E570](#), *Standard Practice for Flux Leakage Examination of Ferromagnetic Steel Tubular Products*

[ASTM E587](#), *Standard Practice for Ultrasonic Angle-Beam Contact Testing*

[ASTM E709](#), *Standard Guide for Magnetic Particle Examination*

[ASTM E747](#), *Standard Practice for Design, Manufacture and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology*

[ASTM E1806](#), *Standard Practice for Sampling Steel and Iron for Determination of Chemical Composition*

[ASTM E1815-08](#), *Standard Test Method for Classification of Film Systems for Industrial Radiography*

[ASTM E1820](#), *Standard Test Method for Measurement of Fracture Toughness*

[ASTM E2033](#), *Standard Practice for Computed Radiology (Photostimulable Luminescence Method)*

[ASTM E2698](#), *Standard Practice for Radiological Examination Using Digital Detector Arrays*

[ASTM G39](#), *Standard Practice for Preparation and Use of Bent-Beam Stress-Corrosion Test Specimens*

BS 7448-1³, *Fracture mechanics toughness tests — Method for determination of K_{Ic} , critical CTOD and critical J values of metallic materials*

EN 10168⁴, *Steel products — Inspection documents — List of information and description*

³ BSI, 389 Chiswick High Road, London, W4 4AL, United Kingdom, <https://www.bsigroup.com>.

⁴ European Committee for Standardization (CEN), Management Centre, Rue de la Science 23, B - 1040 Brussels, Belgium, <https://www.cen.eu>.

EN 10204:2004, *Metallic products — Types of inspection documents*

ISO 148-1⁵, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 404, *Steel and steel products — General technical delivery requirements*

ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels*

ISO 4885, *Ferrous products — Heat treatments — Vocabulary*

ISO 5173, *Destructive tests on welds in metallic materials — Bend tests — Third Edition*

ISO 6506 (all parts), *Metallic materials — Brinell hardness test*

ISO 6507 (all parts), *Metallic materials — Vickers hardness test*

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature*

ISO 6929, *Steel products — Definitions and classification*

ISO 7539-2, *Corrosion of metals and alloys — Stress corrosion testing — Part 2: Preparation and use of bent-beam specimens*

ISO 8491, *Metallic materials — Tube (in full section) — Bend test*

ISO 8492, *Metallic materials — Tube — Flattening test*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 9712, *Non-destructive testing — Qualification and certification of personnel*

ISO 9769, *Steel and iron — Review of available methods of analysis*

ISO 10474:1991, *Steel and steel products — Inspection documents*

ISO 10893-2, *Non-destructive testing of steel tubes — Part 2: Automated eddy current testing of seamless and welded (except submerged arc welded) steel tubes for the detection of imperfections*

ISO 10893-3, *Non-destructive testing of steel tubes — Part 3: Automated full peripheral flux leakage testing of seamless and welded (except submerged arc welded) ferromagnetic steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 10893-4, *Non-destructive testing of steel tubes — Part 4: Liquid penetrant inspection of seamless and welded steel tubes for the detection of surface imperfections*

ISO 10893-5, *Non-destructive testing of steel tubes — Part 5: Magnetic particle inspection of seamless and welded steel tubes for the detection of surface imperfections*

ISO 10893-6, *Non-destructive testing of steel tubes — Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

⁵ International Organization for Standardization, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, www.iso.org.

ISO 10893-7, *Non-destructive testing of steel tubes — Part 7: Digital radiographic testing of the weld seam of welded steel tubes for the detection of imperfections*

ISO 10893-8, *Non-destructive testing of steel tubes — Part 8: Automated ultrasonic testing of seamless and welded steel tubes for the detection of laminar imperfections*

ISO 10893-9, *Non-destructive testing of steel tubes — Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for manufacture of welded steel tubes*

ISO 10893-10, *Non-destructive testing of steel tubes — Part 10: Automated full peripheral ultrasonic testing of seamless and welded (except submerged arc welded) steel tubes for the detection of longitudinal flash and/or transverse imperfections*

ISO 10893-11, *Non-destructive testing of steel tubes — Part 11: Automated ultrasonic testing of the weld seam of welded steel tubes for the detection of longitudinal and/or transverse imperfections*

ISO 10893-12, *Non-destructive testing of steel tubes — Part 12: Automated full peripheral ultrasonic thickness testing of seamless and welded (except submerged arc welded) steel tubes*

ISO 11484, *Steel products — Employer's qualification system for non-destructive testing (NDT) personnel*

ISO 11699-1:2008, *Non-destructive testing — Industrial radiographic films — Part 1: Classification of film systems for industrial radiography*

ISO 12135, *Metallic materials — Unified method of test for the determination of quasistatic fracture toughness*

ISO 12737, *Metallic materials — Determination of plane-strain fracture toughness*

ISO 13678, *Petroleum and natural gas industries — Evaluation and testing of thread compounds for use with casing, tubing and line pipe*

ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*

ISO 15653, *Metallic materials—Method of test for the determination of quasistatic fracture toughness of welds*

ISO 19232-1:2004, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) — Determination of image quality value*

ISO 80000-1:2009/Cor 1:2011, *Quantities and units — Part 1: General*

NACE TM0177⁶, *Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H₂S Environments*

NACE TM0284, *Standard Test Method — Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking*

3 Terms, Definitions, Symbols, and Abbreviations

3.1 Terms and Definitions

For the purposes of this specification, the following terms and definitions apply.

⁶ NACE International, 15835 Park Ten Place, Houston, Texas 77084, <https://www.nace.org>.

3.1.1**as agreed**

Requirement to be as agreed upon by the manufacturer and the purchaser, and specified in the purchase order.

NOTE Associated, for example, with items covered by 7.2 a).

3.1.2**as-rolled**

Delivery condition without any special rolling and/or heat treatment.

3.1.3**coil/plate end weld**

Weld that joins coil or plate ends together.

3.1.4**cold-expanded pipe**

Pipe that, while at ambient mill temperature, has received a permanent increase in outside diameter or circumference throughout its length, by internal hydrostatic pressure in closed dies or by an internal expanding mechanical device.

3.1.5**cold-sized pipe**

Pipe that, after forming (including sizing on EW), while at ambient mill temperature, has received a permanent increase in outside diameter or circumference for all or part of its length, or permanent decrease in outside diameter or circumference for all or part of its length.

3.1.6**cold finishing**

Cold-working operation (normally cold drawing) with a permanent strain greater than 1.5 %.

NOTE The amount of permanent strain generally differentiates it from cold expansion and cold sizing.

3.1.7**cold forming**

Process in which a strip or plate is formed into a pipe without heating.

3.1.8**continuous welding****CW**

Process of forming a seam by heating the strip in a furnace and mechanically pressing the formed edges together, wherein successive coils of strip had been joined together to provide a continuous flow of strip for the welding mill.

3.1.9**COW pipe****combination welded pipe**

Tubular product having one or two longitudinal seams or one helical seam, produced by a combination of gas metal arc and submerged arc welding, wherein the gas metal arc weld bead is not completely removed by the submerged arc welding passes.

3.1.10**COWH pipe****combination helical welded pipe**

Tubular product having one helical seam produced by a combination of gas metal arc and submerged arc welding, wherein the gas metal arc weld bead is not completely removed by the submerged arc welding passes.

3.1.11**COWL pipe****combination longitudinal welded pipe**

Tubular product having one or two longitudinal seams produced by a combination of gas metal arc and submerged arc welding, wherein the gas metal arc weld bead is not completely removed by the submerged arc welding passes.

3.1.12**COW seam****combination welding seam**

Longitudinal or helical seam produced by a combination of gas metal arc and submerged arc welding, wherein the gas metal arc weld bead is not completely removed by the submerged arc welding passes.

3.1.13**CW pipe****continuous welded pipe**

Tubular product having one longitudinal seam produced by continuous welding.

3.1.14**daughter coil**

Portion of steel removed via slitting, cutting, or shearing from the mother coil that is used to produce one or more pieces of pipe.

3.1.15**daughter plate**

Portion of steel removed via slitting, cutting, or shearing from the mother plate that is used to produce one or more pieces of pipe.

3.1.16**defect**

Imperfection of a size and/or population density greater than the acceptance criteria specified in this specification.

3.1.17**electric welded pipe****EW pipe**

Tubular product having one longitudinal seam produced by low- or high-frequency electric welding.

3.1.18**electric welded seam****EW seam**

Longitudinal seam produced by electric welding.

3.1.19**electric welding****EW**

Process of forming a seam by electric resistance welding, wherein the edges to be welded are mechanically pressed together and the heat for welding is generated by the resistance to flow of electric current applied by induction or conduction.

3.1.20**flux core arc welding**

Welding process that produces melting and coalescence of metals by heating them with an arc between a continuous filler metal electrode and the work-piece, wherein the arc and molten metal are shielded by a flux contained within the tubular electrode.

NOTE In some cases, additional shielding is obtained from an externally supplied gas or gas mixture.

3.1.21**gas metal arc welding****GMAW**

Welding process that produces melting and coalescence of metals by heating them with an arc or arcs between a continuous consumable electrode and the work, wherein the arc and molten metal are shielded by an externally supplied gas or gas mixture.

NOTE Contact pressure is not used, and the filler metal is obtained from the electrode.

3.1.22**heat**

The metal produced by a single cycle of a batch melting process.

3.1.23**high-frequency welded pipe****HFW pipe**

EW pipe produced with a welding current frequency equal to or greater than 70 kHz.

3.1.24**if agreed**

Requirement to be as prescribed, or more stringent than is prescribed, if agreed upon by the manufacturer and the purchaser and specified in the purchase order.

NOTE Associated, for example, with items covered by 7.2 c).

3.1.25**imperfection**

Discontinuity or irregularity in the product wall or on the product surface that is detectable by inspection methods outlined in this specification.

3.1.26**indication**

Evidence obtained by nondestructive inspection.

3.1.27**inspection**

Activities, such as measuring, examining, testing, weighing, or gauging one or more characteristics of a product and comparing the results of such activities with the specified requirements in order to determine conformity.

3.1.28**instrument standardization**

Adjustment of a nondestructive inspection instrument to an arbitrary reference value.

3.1.29**jointer**

Two or three lengths of pipe coupled or welded together by the manufacturer.

3.1.30**ladle refining**

A post steelmaking secondary process, performed prior to casting to improve the steel quality, of which some examples may include degassing, desulfurization, and various methods for the removal of nonmetallic inclusions and for inclusion shape control.

3.1.31**lamination**

Internal metal separation that creates layers, generally parallel to the pipe surface.

3.1.32**laser welded pipe****LW pipe**

Tubular product having one longitudinal seam produced by laser welding.

3.1.33**laser welding****LW**

Process of forming a seam by using a laser-beam keyhole welding technique to produce melting and coalescence of the edges to be welded, with or without preheating of the edges, wherein shielding is obtained from an externally supplied gas or gas mixture.

3.1.34**low-frequency electric welded pipe****LFW pipe**

EW pipe produced with a welding current frequency less than 70 kHz.

3.1.35**manufacturer**

Firm, company, or corporation responsible for making and marking the product in accordance with the requirements of this specification.

NOTE The manufacturer is, as applicable, a pipe mill, processor, maker of couplings or threader.

3.1.36**mother coil**

Hot-rolled coil of steel processed from a single reheated slab that is used to produce one or more pieces of pipe.

3.1.37**mother plate**

Hot-rolled plate of steel processed from a single reheated slab that is used to produce one or more pieces of pipe.

3.1.38**nondestructive inspection****nondestructive testing****NDT**

Inspection of pipe to reveal imperfections, using radiographic, ultrasonic, or other methods specified in this specification that do not involve disturbance, stressing, or breaking of the materials.

3.1.39**normalizing formed**

Pipe delivery condition resulting from the forming process in which the final deformation is carried out within a certain temperature range, leading to a material condition equivalent to that obtained after normalizing, such that the specified mechanical properties would still be met in the event of any subsequent normalizing.

3.1.40**normalizing rolled**

Pipe delivery condition resulting from the rolling process in which the final deformation is carried out within a certain temperature range, leading to a material condition equivalent to that obtained after normalizing,

such that the specified mechanical properties would still be met in the event of any subsequent normalizing.

3.1.41**pipe body**

<SMLS pipe> the entire pipe.

3.1.42**pipe body**

<Welded pipe> the entire pipe, excluding the weld(s) and heat-affected zone.

3.1.43**pipe grade**

Designation of pipe strength level.

NOTE Chemical composition and/or heat treatment condition of a pipe grade may differ.

3.1.44**pipe mill**

Firm, company, or corporation that operates pipe-making facilities.

3.1.45**processor**

Firm, company, or corporation that operates facilities capable of heat treating pipe made by a pipe mill.

3.1.46**product analysis**

Chemical analysis of the pipe, plate, or coil.

3.1.47**purchaser**

Party responsible for both the definition of requirements for a product order and for payment of that order.

3.1.48**quenching and tempering**

Heat treatment consisting of quench hardening followed by tempering.

3.1.49**sample**

Quantity of material taken from the product to be tested for the purpose of producing one or more test pieces.

3.1.50**SAW pipe****submerged arc welded pipe**

Tubular product having one or two longitudinal seams, or one helical seam, produced by the submerged arc welding process.

3.1.51**SAWH pipe****submerged arc helical welded pipe**

Tubular product having one helical seam produced by the submerged arc welding process.

3.1.52**SAWL pipe****submerged arc longitudinal welded pipe**

Tubular product having one or two longitudinal seams produced by submerged arc welding.

3.1.53**SAW seam****submerged arc welding seam**

Longitudinal or helical seam produced by submerged arc welding.

3.1.54**seamless pipe****SMLS pipe**

Pipe without a welded seam, produced by a hot forming process, which can be followed by cold sizing or cold finishing to produce the desired shape, dimensions, and properties.

3.1.55**service condition**

Condition of use that is specified by the purchaser in the purchase order.

NOTE In this specification, the terms "sour service" and "offshore service" are service conditions.

3.1.56**shielded metal arc welding****SMAW**

Welding process that produces melting and coalescence of metals by heating them with an arc between a covered metal electrode and the work, wherein the arc and molten metal are shielded by decomposition of the electrode covering.

NOTE Contact pressure is not used, and the decomposition is obtained from the electrode.

3.1.57**submerged arc welding****SAW**

Welding process that produces melting and coalescence of metals by heating them with an arc or arcs between a bare metal consumable electrode or electrodes and the work-piece, wherein the arc and molten metal are shielded by a blanket of granular flux.

NOTE Contact pressure is not used, and part or all of the filler metal is obtained from the electrodes.

3.1.58**tack weld**

Intermittent or continuous seam weld used to maintain the alignment of the abutting edges until the final seam weld is produced.

3.1.59**test piece**

Part of a sample with specified dimensions, machined or un-machined, brought to a required condition for submission to a given test.

3.1.60**test unit**

Prescribed quantity of pipe that is made to the same specified outside diameter and specified wall thickness, from coils/plates produced by the same hot rolling practice (as applicable to welded pipe), by the same pipe-manufacturing process from the same heat and under the same pipe-manufacturing conditions.

3.1.61**thermomechanical forming**

Hot forming process for manufacture of pipe, in which the final deformation is carried out in a certain temperature range, leading to a material condition with certain properties that cannot be achieved or repeated by heat treatment alone, and such deformation is followed by cooling, possibly with increased cooling rates, with or without tempering, self-tempering included.

CAUTION—Subsequent heating above 580 °C (1075 °F) typically can lower the strength values.

3.1.62**thermomechanical rolled**

Pipe delivery condition resulting from the hot rolling process for coil or plate, in which the final deformation is carried out in a certain temperature range, leading to a material condition with certain properties that cannot be achieved or repeated by heat treatment alone, and such deformation is followed by cooling, possibly with increased cooling rates, with or without tempering, self-tempering included.

CAUTION—Subsequent heating above 580 °C (1075 °F) typically can lower the strength values.

3.1.63**undercut**

Groove melted into the parent metal adjacent to the weld toe and left unfilled by the deposited weld metal.

3.1.64**unless otherwise agreed**

Requirement that applies, unless an alternative requirement is agreed upon between the manufacturer and the purchaser and specified in the purchase order.

NOTE Associated, for example, with items covered by 7.2 b) and 7.2 c).

3.1.65**welded pipe**

CW, COWH, COWL, EW, HFW, LFW, LW, SAWH, or SAWL pipe

3.2 Symbols

a	length of coil/plate end weld
A_f	elongation after fracture, expressed in percent and rounded to the nearest percent
A_{gb}	breadth diameter of guided bend test mandrel/roll, expressed in millimeters (inches)
A_I	internal cross-sectional area of pipe, expressed in square millimeters (square inches)
A_P	cross-sectional area of pipe wall, expressed in square millimeters (square inches)
A_R	cross-sectional area of end-sealing ram, expressed in square millimeters (square inches)
A_{xc}	applicable tensile test piece cross-sectional area, expressed in square millimeters (square inches)
b	specified width of bearing face, expressed in millimeters (inches)
B	distance of the die walls or distance of the supports in the guided-bend test, expressed in millimeters (inches)
C	constant, which is dependent upon the system of units used
CE_{IIW}	carbon equivalent, based on the International Institute of Welding equation

CE_{Pcm}	carbon equivalent, based on the chemical portion of the Ito-Bessyo carbon equivalent equation
d	calculated inside diameter of pipe, expressed in millimeters (inches)
D_a	manufacturer-designated outside diameter after sizing, expressed in millimeters (inches)
D_b	manufacturer-designated outside diameter before sizing, expressed in millimeters (inches)
D	specified outside diameter of pipe, expressed in millimeters (inches)
A	tangential dimension from the OD to the intersection of the exposed OD Charpy shoulder and the end of the specimen, expressed in millimeters (inches)
δ	machined depth from the OD to the Charpy surface at mid-specimen length, expressed in millimeters (inches)
f	frequency, expressed in hertz (cycles per second)
K_V	full-size Charpy V-notch absorbed energy, expressed in joules (foot-pounds force)
L	length of pipe, expressed in meters (feet)
N_L	specified minimum length, coupling dimension, expressed in millimeters (inches)
P	hydrostatic test pressure, expressed in megapascals (pounds per square inch)
P_R	internal pressure on end-sealing ram, expressed in megapascals (pounds per square inch)
Q	specified diameter of recess coupling dimension, expressed in millimeters (inches)
r	radius, expressed in millimeters (inches)
r_a	radius of the mandrel for the guided bend test, expressed in millimeters (inches)
r_b	radius of the die for the guided bend test, expressed in millimeters (inches)
r_o	pipe outside radius, expressed in millimeters (inches)
R_m	tensile strength, expressed in megapascals (pounds per square inch)
$R_{p0.2}$	yield strength (0.2 % nonproportional extension), expressed in megapascals (pounds per square inch)
$R_{t0.5}$	yield strength (0.5 % total extension), expressed in megapascals (pounds per square inch)
s_r	sizing ratio
S	hoop stress for the hydrostatic test, expressed in megapascals (pounds per square inch)
t	specified wall thickness of pipe, expressed in millimeters (inches)
t_{min}	minimum permissible wall thickness of pipe, expressed in millimeters (inches)
U	specified minimum tensile strength, expressed in megapascals (pounds per square inch)
U_{EL}	uniform elongation, expressed in percent
V_t	transverse ultrasonic velocity, expressed in meters per second (feet per second)
W	specified outside diameter, coupling dimension, expressed in millimeters (inches)
ε	strain

λ	wavelength, expressed in meters (feet)
ρ_l	mass per unit length of plain-end pipe, expressed in kilograms per meter (pounds per foot)
σ_h	design hoop stress for the pipeline, expressed in megapascals (pounds per square inch)

3.3 Abbreviations

API	American Petroleum Institute
AISI	American Iron and Steel Institute
COW	combination welding process for pipe during manufacturing
COWH	combination helical welding process for pipe during manufacturing
COWL	combination longitudinal welding process for pipe during manufacturing
CTOD	crack tip opening displacement
CVN	Charpy V-notch
CW	continuous welding process for pipe during manufacturing
DWT	drop-weight tear
EDI	electronic data interchange
EPRG	European Pipeline Research Group
EW	electric resistance or electric induction welding process for pipe during manufacturing
GMAW	gas metal arc welding
HAZ	heat-affected zone
HBW	Brinell hardness with tungsten ball
HFV	high-frequency electric welding process for pipe during manufacturing
HIC	hydrogen-induced cracking
HRC	Rockwell hardness, C scale
HV	Vickers hardness
IQI	image quality indicator
LFW	low-frequency electric welding process for pipe during manufacturing
LW	laser welding process for pipe during manufacturing
MT	magnetic particle testing
NDT	nondestructive testing
PSL	product specification level
PT	penetrant testing
SAW	submerged arc welding process for pipe during manufacture

SAWH	submerged arc helical welding process for pipe during manufacture
SAWL	submerged arc longitudinal welding process for pipe during manufacture
SI	International System of Units
SMAW	shielded metal arc welding for pipe during manufacture
SMLS	seamless pipe
SSC	sulfide stress cracking
SWC	stepwise cracking
TFL	through the flowline
USC	United States customary
UT	ultrasonic testing
WPQT/PQR	welding procedure qualification test record
WPS	welding procedure specification

4 Conformity

4.1 Units of Measurement

In this specification, data are expressed in both the International System of Units (SI) and the United States customary (USC) units. For a specific order item, only one system of units shall be used, without combining data expressed in the other system. Data values expressed in SI and USC units shall not be combined on the same inspection document or in the same required pipe marking sequence.

Where product is tested and verified against requirements using one measurement system (USC or SI), and an inspection document is issued, with data reported in the alternate measurement system units, a statement shall appear on the inspection document indicating that the data presented were converted from the measurement system used for the original inspection.

The purchaser shall specify whether data, drawings, and maintenance dimensions of pipe shall be in the SI or USC system of measurements. Use of an SI data sheet indicates that the SI measurements shall be used. Use of a USC data sheet indicates the USC system of measurements shall be used.

4.2 Rounding

Unless otherwise stated in this specification, to determine conformance with the specified requirements, observed or calculated values shall be rounded to the nearest unit in the last right-hand place of figures used in expressing the limiting value, in accordance with ISO 80000-1:2009/Cor 1:2011, Annex B, Rule A.

NOTE For the purposes of this provision, the rounding method of [ASTM E29-04](#) ^[1] is equivalent to ISO 80000-1:2009/Cor 1:2011, Annex B, Rule A.

5 Compliance to This Specification

5.1 Quality

A documented quality system shall be applied to assist compliance with the requirements of this specification.

NOTE 1 Documentation of a quality system does not require certification by a third-party certification body; only the creation or adoption of a written quality system is necessary to meet the requirement of this standard. API defers to the expertise of responsible quality management personnel to create or adopt the system that best reflects the need of each company.

NOTE 2 There are many existing quality management systems to which personnel can refer to for guidance in the development of an appropriate quality system, including ISO/TS 29001 [2] and [API Q1](#) [3], which contain provisions specific to the oil and gas industry, or ISO 9001 [4], which contains general requirements for quality management systems that are auditable. This list is not exhaustive and is provided for information only.

A contract can specify that the manufacturer shall be responsible for complying with all of the applicable requirements of this specification, which may include terms for it to be permissible for the purchaser to investigate as necessary in order to be assured of compliance by the manufacturer and to reject any material that does not comply.

5.2 Other Terms and Definitions

For the purposes of this document, the terms and definitions in the following documents, except as given in 3.1, shall apply:

- a) ISO 6929 or [ASTM A941](#) for steel products;
- b) [API 5T1](#) for imperfection terminology;
- c) ISO 404, ISO 10474, or [ASTM A370](#), whichever is applicable, for the types of sampling procedures, inspection, and inspection documents.

5.3 References to Annexes

For additional requirements or information concerning the manufacturing of line pipe, as referenced, see the following for:

- PSL 2 manufacturing procedure qualification, see Annex B (normative);
- treating surface imperfections and defects, see Annex C (normative);
- welding repair procedure, see Annex D (normative);
- nondestructive testing (NDT) for nonsour service, or nonoffshore service, or nonlongitudinal plastic strain capacity, see Annex E (normative);
- PSL 1 coupling requirements, see Annex F (normative);
- PSL 2 ductile fracture propagation resistance, see Annex G (normative);
- PSL 2 pipe for sour service, see Annex H (normative);
- through the flowline (TFL) pipe, see Annex I (normative);
- PSL 2 pipe for offshore service, see Annex J (normative);
- NDT for sour service, offshore service, or longitudinal plastic strain capacity, see Annex K (normative);
- steel designations, see Annex L (informative);

- welded jointers, see Annex M (normative);
- PSL 2 pipe for longitudinal plastic strain capacity, see Annex N (normative);
- Monogram licensee additional information (other than Annex A), see Annex O (informative);
- equations for pipe, guided bend, and Charpy V-notch (CVN) test specimens, see Annex P (informative).

6 Pipe Grades and Steel Grades, and Delivery Condition

6.1 Pipe Grades and Steel Grades

6.1.1 The pipe grade for PSL 1 pipe is identical to the steel grade (designated by a steel name) and shall be as given in Table 1. It consists of an alpha or alphanumeric designation that identifies the strength level of the pipe and is linked to the chemical composition of the steel.

NOTE 1 The designations for Grade A and Grade B do not contain any reference to the specified minimum yield strength; however, the numerical portion of other designations corresponds with the specified minimum yield strength in SI units or with the upward-rounded specified minimum yield strength, expressed in 1000 psi for USC units.

NOTE 2 The suffix “P” indicates that the steel has a specified phosphorus range.

6.1.2 The pipe grade for PSL 2 pipe shall be as given in Table 1 and consists of an alpha or alphanumeric designation that identifies the strength level of the pipe. The steel name (designating a steel grade), linked to the chemical composition of the steel, additionally includes a suffix that consists of a single letter (R, N, Q, or M) that identifies the delivery condition (see Table 3).

NOTE 1 The designation for Grade B does not contain any reference to the specified minimum yield strength; however, the numerical portion of other designations corresponds with the specified minimum yield strength in SI units or USC units.

NOTE 2 For sour service, see H.4.1.1.

NOTE 3 For offshore service, see J.4.1.1.

NOTE 4 For pipe requiring longitudinal plastic strain capacity, see N.4.1.1.

6.1.3 Other steel grade designations (steel numbers) that are used in addition to the steel name in Europe are given for guidance in Table L.1.

6.2 Delivery Condition

6.2.1 For each order item, the delivery condition for PSL 1 pipe shall be at the option of the manufacturer unless a specific delivery condition is specified in the purchase order. Delivery conditions for PSL 1 and PSL 2 pipes are given in Table 1 with additional information for PSL 2 pipe in Table 3.

6.2.2 For PSL 2 pipe, the delivery condition shall be in accordance with the purchase order as specified in the steel name.

Table 1—Pipe Grade and Steel Grades, and Acceptable Delivery Conditions

PSL	Delivery Condition	Pipe Grade/Steel Grade ^{a,b}
PSL 1	As-rolled, normalizing rolled, normalized, or normalizing formed	L 175 or A25
		L 175P or A25P
		L210 or A
	As-rolled, normalizing rolled, thermomechanical rolled, thermomechanical formed, normalizing formed, normalized, normalized and tempered; or, if agreed, quenched and tempered for SMLS pipe only	L245 or B
	As-rolled, normalizing rolled, thermomechanical rolled, thermomechanical formed, normalizing formed, normalized, normalized and tempered or quenched and tempered	L290 or X42
		L320 or X46
		L360 or X52
		L390 or X56
		L415 or X60
		L450 or X65
		L485 or X70
PSL 2	As-rolled	L245R or BR
		L290R or X42R
	Normalizing rolled, normalizing formed, normalized, or normalized and tempered	L245N or BN
		L290N or X42N
		L320N or X46N
		L360N or X52N
		L390N or X56N
		L415N or X60N
	Quenched and tempered	L245Q or BQ
		L290Q or X42Q
		L320Q or X46Q
		L360Q or X52Q
		L390Q or X56Q
		L415Q or X60Q
		L450Q or X65Q
		L485Q or X70Q
		L555Q or X80Q
		L625Q or X90Q ^c
		L690Q or X100Q ^c
PSL 2	Thermomechanical rolled or thermomechanical formed	L245M or BM
		L290M or X42M
		L320M or X46M
		L360M or X52M
		L390M or X56M
		L415M or X60M
		L450M or X65M
		L485M or X70M
		L555M or X80M
	Thermomechanical rolled	L625M or X90M
		L690M or X100M
		L830M or X120M
^a For intermediate grades, the steel grade shall be in one of the following formats: (1) the letter L followed by the specified minimum yield strength in MPa and, for PSL 2 pipe, the letter describing the delivery condition (R, N, Q, or M) consistent with the above formats; (2) the letter X followed by a two- or three-digit number equal to the specified minimum yield strength in 1000 psi rounded down to the nearest integer and, for PSL 2 pipe, the letter describing the delivery condition (R, N, Q, or M) consistent with the above formats.		
^b The suffix (R, N, Q, or M) for PSL 2 grades belongs to the steel grade.		
^c Seamless only.		

7 Information to Be Supplied by the Purchaser

7.1 General Information

The purchase order shall include the following information:

- a) quantity (e.g. total mass or total length of pipe);
- b) PSL (1 or 2);
- c) type of pipe (see Table 2);
- d) reference to API 5L;
- e) steel grade (see 6.1, H.4.1.1, or J.4.1.1, whichever is applicable);
- f) outside diameter and wall thickness (see 9.11.1.2);
- g) length and type of length (random or approximate) (see 9.11.1.3, 9.11.3.3, and Table 12);
- h) confirmation of applicability of individual annexes.

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:
 - 1) pipe designation for intermediate grades [see Table 1, footnote a)];
 - 2) chemical composition for intermediate grades (see 9.2.1 and 9.2.2);
 - 3) chemical composition for pipe with $t > 25.0$ mm (0.984 in.) (see 9.2.3);
 - 4) carbon equivalent limits for PSL 2 pipe in Grade L415N or X60N (see Table 5);
 - 5) carbon equivalent limits for PSL 2 pipe in Grade L555Q or X80Q, L625Q or X90Q, and L690Q or X100Q (see Table 5);
 - 6) carbon equivalent limits for PSL 2 SMLS pipe with $t > 20.0$ mm (0.787 in.) [see Table 5, footnote a)];
 - 7) diameter and out-of-roundness tolerances for pipe with $D > 1422$ mm (56.000 in.) (see Table 10);
 - 8) diameter and out-of-roundness tolerances for the ends of SMLS pipe with $t > 25.0$ mm (0.984 in.) [see Table 10, footnote b)];
 - 9) standard applicable to jointer welds (see M.1.4).
- b) Items that apply as prescribed, unless otherwise agreed:
 - 1) range of sizing ratio for cold-expanded pipe (see 8.9.2);
 - 2) equation for sizing ratio (see 8.9.3);

- 3) chemical composition limits for PSL 1 pipe [see Table 4, footnotes c), e), and f)];
 - 4) chemical composition limits for PSL 2 pipe [see Table 5, footnotes c), e), f), g), h), i), k), and l)];
 - 5) yield/tensile ratio for grades L625Q or X90Q, L690 or X100, and L830 or X120 [see Table 7, footnotes g) and h) or Table J.2, footnotes h) and i)];
 - 6) estimation and reporting of Charpy shear area (see 9.8.2.3);
 - 7) tolerances for random length pipe [see 9.11.3.3 a)];
 - 8) type of thread compound (see 9.12.2.4);
 - 9) type of end face (see 9.12.5.1 or 9.12.5.2);
 - 10) international standard applicable to Charpy testing (see 10.2.3.3, 10.2.4.3, D.2.3.4.2, and D.2.3.4.3);
 - 11) product analysis method (see 10.2.4.1);
 - 12) alternate method for diameter measurement for $D \geq 508$ mm (20.000 in.) (see 10.2.8.1);
 - 13) jointer welding type (see M.1.2);
 - 14) offset of longitudinal pipe weld seams at jointer welds (see M.3.5);
 - 15) repairs in cold-expanded pipe (see C.4.2);
 - 16) alternate image quality indicator (IQI) type (see E.4.3.1).
- 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);
- 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)];
- 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) specific condition to be used for hydrostatic tests for threaded and coupled pipe (see 10.2.6.1);
- 26) alternate hydrotest pressure (see Table 26);
- 27) use of minimum permissible wall thickness to determine hydrostatic test pressure (see 10.2.6.7);
- 28) specific method to be used for determining pipe diameter (see 10.2.8.1);
- 29) use of inside diameter measurements to determine diameter and out-of-roundness for expanded pipe with $D \geq 219.1$ mm (8.625 in.) and for nonexpanded pipe [see 10.2.8.3 and Table 10, footnote c)];
- 30) specific method to be used for determining other pipe dimensions (see 10.2.8.7);
- 31) paint-stenciled markings for couplings (see 11.1.2);
- 32) additional markings specified by the purchaser (see 11.1.4);
- 33) dual unit marking [see 11.2.1 e)];
- 34) specific surface or location for pipe markings [see 11.2.3 b) and 11.2.7 b)];
- 35) die-stamping or vibro-etching of pipe (see 11.2.4);
- 36) alternative location for marking the pipe (see 11.2.5);

- 37) alternative format for pipe length marking locations (see 11.2.7 a);
- 38) color identification for pipe (see 11.2.8);
- 39) multiple grade marking (see 11.4.1);
- 40) temporary external coating (see 12.1.2);
- 41) special coating (see 12.1.3);
- 42) lining (see 12.1.4);
- 43) manufacturing procedure qualification for PSL 2 pipe, in which case Annex B shall apply (see B.1.1);
- 44) radiographic inspection of SAW seam or coil/plate end weld (see Table E.1);
- 45) nondestructive inspection of PSL 1 SMLS pipe (see E.3.1.2);
- 46) NDT of EW seam welds after hydrotest [see E.3.1.3 b)];
- 47) ultrasonic inspection of welded pipe for laminar imperfections at pipe ends (see E.3.2.3);
- 48) ultrasonic inspection of SMLS pipe for laminar imperfections at pipe ends (see E.3.3.2);
- 49) radiographic inspection in accordance with E.4;
- 50) use of both holes and notches in ultrasonic reference standard (see Table E.7);
- 51) alternative re-inspection technique for COW seams (see E.5.5.5);
- 52) ultrasonic inspection for laminar imperfections in the pipe body of EW, SAW, or COW pipe (see E.8);
- 53) ultrasonic inspection for laminar imperfections along the coil/plate edges or the weld seam of EW, SAW, or COW pipe (see E.9);
- 54) supply of welded couplings on pipe with $D \geq 355.6$ mm (14.000 in.) (see F.1.4);
- 55) application of Annex G to PSL 2 pipe where purchaser shall specify the toughness test temperature, the minimum energy for each test, and the minimum average energy value required for the order (see G.2);
- 56) PSL 2 pipe for sour service, in which case, Annex H shall apply (see H.2);
- 57) TFL pipe, in which case Annex I shall apply (see I.2);
- 58) pipe for offshore service, in which case Annex J shall apply (see J.2);
- 59) pipe for longitudinal plastic strain capacity, in which case Annex N shall apply when specified (see N.2);
- 60) other additional or more stringent requirements;
- 61) application of the API Monogram, in which case the requirements of Annex A and Annex O apply.

8 Manufacturing

8.1 Process of Manufacture

Pipe furnished to this specification shall be manufactured in accordance with the applicable requirements and limitations given in Tables 2 and 3.

Table 2—Acceptable Process of Manufacture and PSLs

Type of Pipe or Pipe End	PSL 1 Pipe Grade ^a					PSL 2 Pipe Grade ^a		
	L175 or A25 ^b	L175P or A25P ^b	L210 or A	L245 or B	L290 or X42 to L485 or X70	L245 or B to L555 or X80	> L555 or X80 to L690 or X100	> L690 or X100 to L830 or X120
Type of Pipe								
SMLS	X	X	X	X	X	X	X	—
CW	X	X	—	—	—	—	—	—
LFW	X	—	X	X	X	—	—	—
HFW	X	—	X	X	X	X	—	—
LW	—	—	—	—	X	—	—	—
SAWL ^c	—	—	X	X	X	X	X	X
SAWH ^d	—	—	X	X	X	X	X	X
COWL ^c	—	—	X	X	X	X	—	—
COWH ^d	—	—	X	X	X	X	—	—
Type of Pipe End								
Belled end ^e	X	—	X	X	X	—	—	—
Plain end	X	—	X	X	X	X	X	X
Plain end for special coupling	X	—	X	X	—	—	—	—
Threaded end ^f	X	X	X	X	—	—	—	—
^a Intermediate grades are available if agreed, but limited to grades higher than Grade L290 or X42. ^b Grades L175, L175P, A25, and A25P are limited to pipe with $D \leq 141.3$ mm (5.563 in.). ^c Double-seam pipe is available if agreed, but limited to pipe with $D \geq 914$ mm (36.000 in.). ^d Helical seam pipe is limited to pipe with $D \geq 114.3$ mm (4.500 in.). ^e Belled-end pipe is limited to pipe with $D \leq 219.1$ mm (8.625 in.) and $t \leq 3.6$ mm (0.141 in.). ^f Threaded-end pipe is limited to SMLS and longitudinal seam welded pipe with $D \leq 508$ mm (20.000 in.).								

Table 3—Acceptable Manufacturing Routes for PSL 2 Pipe

Type of Pipe	Starting Material	Pipe Forming	Pipe Heat Treatment	Delivery Condition
SMLS	Ingot, bloom, or billet	As-rolled	—	R
		Normalizing forming	—	N
		Hot forming	Normalizing	N
			Quenching and tempering	Q
		Hot forming and cold finishing	Normalizing	N
			Quenching and tempering	Q
HFW	Normalizing-rolled coil	Cold forming	Heat treating ^a of weld area only	N
	Thermomechanical-rolled coil	Cold forming	Heat treating ^a of weld area only	M
			Heat treating ^a of weld area and stress relieving of entire pipe	M
	As-rolled or thermomechanical-rolled coil	Cold forming	Normalizing	N
			Quenching and tempering	Q
		Cold forming followed by hot reducing under controlled temperature resulting in a normalized condition	—	N
		Cold forming followed by thermomechanical forming of pipe	—	M
SAW or COW pipe	Normalized or normalizing-rolled coil or plate	Cold forming	—	N
	As-rolled, thermomechanical-rolled, normalizing-rolled, or normalized	Cold forming	Normalizing	N
	Thermomechanical-rolled coil or plate	Cold forming	—	M
	Quenched and tempered plate	Cold forming	—	Q
	As-rolled, thermomechanical-rolled, normalizing-rolled, or normalized coil or plate	Cold forming	Quenching and tempering	Q
	As-rolled, thermomechanical-rolled, normalizing-rolled, or normalized coil or plate	Normalizing forming	—	N

^a See 8.8 for applicable heat treatments.

8.2 Processes Requiring Validation

Final operations performed during pipe manufacturing that affect attribute compliance as required in this specification (except chemical composition and dimensions) shall have their processes validated.

Those processes requiring validation are the following:

- | | |
|--|--|
| a) for seamless, as-rolled pipe: | final reheating practice and hot sizing or stretch reducing; if applicable, upsetting, cold finishing; |
| b) for seamless, heat-treated pipe: | heat treatment; |
| c) for electric welded, as-rolled pipe: | sizing and seam welding; if applicable, seam heat treatment and upsetting; |
| d) for electric welded, heat-treated pipe: | seam welding and full-body heat treatment; |
| e) for SAW and COW pipe, nonexpanded: | pipe forming, seam welding, repair welding; if applicable, heat treatment; |
| f) for SAW and COW pipe, expanded: | pipe forming, seam welding, repair welding, expansion. |

8.3 Starting Material

8.3.1 The supplying steel and rolling mill(s) shall have a documented quality management system.

NOTE 1 Documentation of a quality system does not require certification by a third-party certification body. Only the creation or adoption of a written quality system is necessary to meet the requirement of this specification. API defers to the expertise of responsible quality management personnel to create or adopt the system that best reflects the need of each company.

NOTE 2 There are many existing quality management systems to which personnel can refer for guidance in the development of an appropriate quality system, including ISO/TS 29001 and [API Q1](#), which contain provisions specific to the oil and gas industry, or ISO 9001, which contains general requirements for quality management systems that are auditable. This list is not exhaustive and is provided for information only.

8.3.2 The ingots, blooms, billets, coils, or plates used as starting material for the manufacture of pipe shall be made from steel made by:

- a) basic oxygen process,
- b) electric furnace process, or
- c) open hearth process only in combination with a ladle refining process.

8.3.3 For PSL 2 pipe, the steel shall be killed and made according to fine grain practice.

8.3.4 The coil or plate used for the manufacture of PSL 2 pipe shall not contain any repair welds.

8.3.5 The width of the coil or plate used for the manufacture of helical seam pipe shall not be less than 0.8 times or more than 3.0 times the specified outside diameter of the pipe.

8.3.6 Any lubricant that contaminates the weld bevel or the surrounding areas shall be removed before making the longitudinal seam welds of SAWL or COWL pipe or the helical seam welds of SAWH or COWH pipe.

8.3.7 For welded pipe with delivery condition M, critical variables of the coil/plate rolling practice (e.g. reheating, rolling and cooling temperatures, times, and tolerances) shall be defined and controlled to ensure that the mechanical properties throughout the pipe are suitably uniform considering:

- a) coil/plate characteristics and variability,
- b) sensitivity of properties to rolling practice,
- c) appropriate coil/plate cropping distances, and
- d) tensile property changes inherent in pipe forming.

The permissible ranges of critical variables for coil/plate rolling practice shall be documented.

8.3.8 For welded pipe with delivery condition M, the ability of the coil/plate rolling practice to achieve planned results consistent with 8.3.7 shall be verified as follows.

- a) Representative coil/plate and pipe manufacturing trials or historical data of coil/plate and/or pipe properties and processing conditions that demonstrate, within the ranges permitted by documented limits of the rolling practice, the consistent achievement of required pipe properties.
- b) For grades higher than L360M or X52M, the pipe manufacturer shall conduct or shall have previously conducted an on-site technical audit of the coil/plate mill and periodic on-site or remote confirmation that the coil/plate rolling practice continues to achieve the planned results. Coil/plate rolling practice validation criteria shall be verified as part of the audit.

8.3.9 Hot rolling practice process deviations from the manufacturer's documented limits shall be qualified through documented practices either in the hot rolled material by mechanical testing to defined limits and/or in the pipe form by designating that material as a new test unit.

8.4 Tack Welds

8.4.1 Tack welds shall be made by:

- a) semi-automatic submerged arc welding,
- b) electric welding,
- c) gas metal arc welding (GMAW),
- d) flux-cored arc welding,
- e) shielded metal arc welding using a low hydrogen electrode, or
- f) laser welding.

8.4.2 Tack welds shall be:

- a) melted and coalesced into the final weld seam,
- b) removed by machining, or
- c) treated in accordance with C.2.

8.5 Weld Seams in COW Pipe

For the production of weld seams in COW pipe, the first pass shall be continuous and made by gas metal arc welding followed by submerged arc welding, with at least one submerged arc welding pass made on the inside of the pipe and at least one submerged arc welding pass made on the outside of the pipe, wherein the gas metal arc weld bead is not completely removed by the submerged arc welding passes.

8.6 Weld Seams in SAW Pipe

For the production of weld seams in SAW pipe, at least one submerged arc welding pass shall be made on the inside of the pipe and at least one submerged arc welding pass shall be made on the outside of the pipe.

8.7 Weld Seams in Double-seam Pipe

The seams of double-seam pipe shall be approximately 180° apart.

8.8 Treatment of Weld Seams in EW and LW Pipe

8.8.1 PSL 1 EW Pipe

For grades higher than Grade L290 or X42, the weld seam and the heat-affected zone (HAZ) shall be heat treated so as to simulate a normalizing heat treatment, except that, if agreed, alternative heat treatments may be substituted. If such substitutions are made, the manufacturer shall demonstrate the effectiveness of the method selected using an agreed procedure. Such a procedure may include, but is not necessarily limited to, hardness testing, microstructural evaluation, or mechanical testing.

For grades equal to or lower than Grade L290 or X42, the weld seam shall be heat treated so as to simulate a normalizing heat treatment, or the pipe shall be processed in such a manner that no untempered martensite remains.

8.8.2 LW Pipe and PSL 2 HFW Pipe

For each grade not subjected to quench and temper processing, the weld seam and the entire HAZ shall be heat treated so as to simulate a normalizing heat treatment.

8.9 Cold Sizing and Cold Expansion

8.9.1 Except as allowed by 8.9.2, the sizing ratio for cold-sized pipe shall not be more than 0.015, unless:

- a) the pipe is subsequently normalized or quenched and tempered, or
- b) the entire part of the pipe that is cold sized is subsequently stress relieved.

8.9.2 Unless otherwise agreed, the sizing ratio for cold-expanded pipe shall not be less than 0.003 or more than 0.015.

8.9.3 Unless otherwise agreed, the sizing ratio, s_r , shall be derived using Equation (1):

$$s_r = \frac{|D_a - D_b|}{D_b} \quad (1)$$

where

D_a is the manufacturer-designated outside diameter after sizing, expressed in millimeters (inches);

D_b is the manufacturer-designated outside diameter before sizing, expressed in millimeters (inches);

$|D_a - D_b|$ is the absolute value of the outside diameter difference, expressed in millimeters (inches).

8.10 Coil/Plate End Welds

8.10.1 Coil/plate end welds shall not be present in finished longitudinal seam pipe.

8.10.2 For finished helical seam pipe, junctions of coil/plate end welds, and helical seam welds shall be at least 300 mm (12.0 in.) from the pipe ends.

8.10.3 If agreed, coil/plate end welds in helical seam pipe may be present at the pipe ends, provided that there is a circumferential separation of at least 150 mm (6.0 in.) between the coil/plate end weld and the helical seam at the applicable pipe ends.

8.10.4 Coil/plate end welds in finished helical seam pipe shall have been:

- a) made by submerged arc welding or a combination of submerged-arc welding and GMAW;
- b) inspected to the same acceptance criteria as specified for the helical seam weld.

8.11 Jointers

8.11.1 Jointers may be furnished if agreed.

8.11.2 Welded jointers shall be made in accordance with the requirements of Annex M.

8.11.3 No pipe used in making a jointer shall be less than 1.5 m (5.0 ft) long.

8.11.4 Portions of pipe used in the making of jointers shall have passed inspection, including hydrostatic testing. Alternatively the completed jointer may be hydrostatically tested.

8.12 Heat Treatment

Heat treatments shall be performed in accordance with documented procedures.

8.13 Traceability

8.13.1 For PSL 1 pipe, the manufacturer shall establish and follow documented procedures for maintaining:

- a) the heat identity until each related chemical tests is performed and conformance with the specified requirements is shown;
- b) the test-unit identity until each related mechanical tests is performed and conformance with the specified requirements is shown.

8.13.2 For PSL 2 pipe, the manufacturer shall establish and follow documented procedures for maintaining the heat identity and the test-unit identity for such pipe. Such procedures shall provide means for tracing any length of pipe to the proper test unit and the related chemical and mechanical test results.

9 Acceptance Criteria

9.1 General

9.1.1 The general technical delivery requirements shall be in accordance with ISO 404.

9.1.2 Pipe manufactured as Grade L415 or X60 or higher shall not be substituted for pipe ordered as Grade L360 or X52 or a lower grade, without the purchaser's approval.

9.2 Chemical Composition

9.2.1 For PSL 1 pipe with $t \leq 25.0$ mm (0.984 in.), the chemical composition for standard grades shall be as given in Table 4, and the chemical composition for intermediate grades shall be as agreed, but consistent with those given in Table 4.

NOTE Grade L175P or A25P is re-phosphorized and, therefore, has better threading properties than Grade L175 or A25; however, it can be more difficult to bend.

9.2.2 For PSL 2 pipe with $t \leq 25.0$ mm (0.984 in.), the chemical composition for standard grades shall be as given in Table 5, and the chemical composition for intermediate grades shall be as agreed, but consistent with those given in Table 5.

9.2.3 For PSL 1 or PSL 2 pipe with $t > 25.0$ mm (0.984 in.), the chemical composition shall be as agreed, with the requirements of Tables 4 and 5 being amended as appropriate.

9.2.4 For PSL 2 pipe with a product analysis carbon mass fraction equal to or less than 0.12 %, the carbon equivalent, CE_{Pcm} , shall be determined using Equation (2):

$$CE_{Pcm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B \quad (2)$$

where the symbols for the chemical elements represent the mass fraction in percent (see Table 5).

If the heat analysis for boron is less than 0.0005 %, then it is not necessary for the product analysis to include boron, and the boron content may be considered to be zero for the CE_{Pcm} calculation.

9.2.5 For PSL 2 pipe with a product analysis carbon mass fraction greater than 0.12 %, the carbon equivalent, CE_{IIW} , shall be determined using Equation (3):

$$CE_{IIW} = C + \frac{Mn}{6} + \frac{(Cr + Mo + V)}{5} + \frac{(Ni + Cu)}{15} \quad (3)$$

where the symbols for the chemical elements represent the mass fraction in percent (see Table 5).

Table 4—Chemical Composition for PSL 1 Pipe with $t \leq 25.0$ mm (0.984 in.)

Steel Grade (Steel Name)	Mass Fraction, Based on Heat and Product Analyses ^{a,g}							
	%							
	C	Mn	P		S	V	Nb	Ti
	max ^b	max ^b	min	max	max	max	max	max
Seamless Pipe								
L175 or A25	0.21	0.60	—	0.030	0.030	—	—	—
L175P or A25P	0.21	0.60	0.045	0.080	0.030	—	—	—
L210 or A	0.22	0.90	—	0.030	0.030	—	—	—
L245 or B	0.28	1.20	—	0.030	0.030	c,d	c,d	d
L290 or X42	0.28	1.30	—	0.030	0.030	d	d	d
L320 or X46	0.28	1.40	—	0.030	0.030	d	d	d
L360 or X52	0.28	1.40	—	0.030	0.030	d	d	d
L390 or X56	0.28	1.40	—	0.030	0.030	d	d	d
L415 or X60	0.28 ^e	1.40 ^e	—	0.030	0.030	f	f	f
L450 or X65	0.28 ^e	1.40 ^e	—	0.030	0.030	f	f	f
L485 or X70	0.28 ^e	1.40 ^e	—	0.030	0.030	f	f	f
Welded Pipe								
L175 or A25	0.21	0.60	—	0.030	0.030	—	—	—
L175P or A25P	0.21	0.60	0.045	0.080	0.030	—	—	—
L210 or A	0.22	0.90	—	0.030	0.030	—	—	—
L245 or B	0.26	1.20	—	0.030	0.030	c,d	c,d	d
L290 or X42	0.26	1.30	—	0.030	0.030	d	d	d
L320 or X46	0.26	1.40	—	0.030	0.030	d	d	d
L360 or X52	0.26	1.40	—	0.030	0.030	d	d	d
L390 or X56	0.26	1.40	—	0.030	0.030	d	d	d
L415 or X60	0.26 ^e	1.40 ^e	—	0.030	0.030	f	f	f
L450 or X65	0.26 ^e	1.45 ^e	—	0.030	0.030	f	f	f
L485 or X70	0.26 ^e	1.65 ^e	—	0.030	0.030	f	f	f
^a Cu $\leq$ 0.50 %; Ni $\leq$ 0.50 %; Cr $\leq$ 0.50 % and Mo $\leq$ 0.15 %. ^b For each reduction of 0.01 % below the specified maximum concentration for carbon, an increase of 0.05 % above the specified maximum concentration for Mn is permissible, up to a maximum of 1.65 % for grades $\geq$ L245 or B, but $\leq$ L360 or X52; up to a maximum of 1.75 % for grades $>$ L360 or X52, but $<$ L485 or X70; and up to a maximum of 2.00 % for Grade L485 or X70. ^c Unless otherwise agreed, Nb + V $\leq$ 0.06 %. ^d Nb + V + Ti $\leq$ 0.15 %. ^e Unless otherwise agreed. ^f Unless otherwise agreed, Nb + V + Ti $\leq$ 0.15 %. ^g No deliberate addition of B is permitted and the residual B $\leq$ 0.001 %.								

Table 5—Chemical Composition for PSL 2 Pipe with *t* ≤ 25.0 mm (0.984 in.)

Steel Grade (Steel Name)	Mass Fraction, Based on Heat and Product Analyses									Carbon Equivalent ^a	
	% max									% max	
	C ^b	Si	Mn ^b	P	S	V	Nb	Ti	Other	CE _{IIW}	CE _{Pcm}
Seamless and Welded Pipe											
L245R or BR	0.24	0.40	1.20	0.025	0.015	c	c	0.04	e,l	0.43	0.25
L290R or X42R	0.24	0.40	1.20	0.025	0.015	0.06	0.05	0.04	e,l	0.43	0.25
L245N or BN	0.24	0.40	1.20	0.025	0.015	c	c	0.04	e,l	0.43	0.25
L290N or X42N	0.24	0.40	1.20	0.025	0.015	0.06	0.05	0.04	e,l	0.43	0.25
L320N or X46N	0.24	0.40	1.40	0.025	0.015	0.07	0.05	0.04	d,e,l	0.43	0.25
L360N or X52N	0.24	0.45	1.40	0.025	0.015	0.10	0.05	0.04	d,e,l	0.43	0.25
L390N or X56N	0.24	0.45	1.40	0.025	0.015	0.10 ^f	0.05	0.04	d,e,l	0.43	0.25
L415N or X60N	0.24 ^f	0.45 ^f	1.40 ^f	0.025	0.015	0.10 ^f	0.05 ^f	0.04 ^f	g,h,l	As agreed	
L245Q or BQ	0.18	0.45	1.40	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L290Q or X42Q	0.18	0.45	1.40	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L320Q or X46Q	0.18	0.45	1.40	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L360Q or X52Q	0.18	0.45	1.50	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L390Q or X56Q	0.18	0.45	1.50	0.025	0.015	0.07	0.05	0.04	d,e,l	0.43	0.25
L415Q or X60Q	0.18 ^f	0.45 ^f	1.70 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
L450Q or X65Q	0.18 ^f	0.45 ^f	1.70 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
L485Q or X70Q	0.18 ^f	0.45 ^f	1.80 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
L555Q or X80Q	0.18 ^f	0.45 ^f	1.90 ^f	0.025	0.015	g	g	g	i,j	As agreed	
L625Q or X90Q	0.16 ^f	0.45 ^f	1.90	0.020	0.010	g	g	g	j,k	As agreed	
L690Q or X100Q	0.16 ^f	0.45 ^f	1.90	0.020	0.010	g	g	g	j,k	As agreed	
Welded Pipe											
L245M or BM	0.22	0.45	1.20	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L290M or X42M	0.22	0.45	1.30	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L320M or X46M	0.22	0.45	1.30	0.025	0.015	0.05	0.05	0.04	e,l	0.43	0.25
L360M or X52M	0.22	0.45	1.40	0.025	0.015	d	d	d	e,l	0.43	0.25
L390M or X56M	0.22	0.45	1.40	0.025	0.015	d	d	d	e,l	0.43	0.25
L415M or X60M	0.12 ^f	0.45 ^f	1.60 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
L450M or X65M	0.12 ^f	0.45 ^f	1.60 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
L485M or X70M	0.12 ^f	0.45 ^f	1.70 ^f	0.025	0.015	g	g	g	h,l	0.43	0.25
L555M or X80M	0.12 ^f	0.45 ^f	1.85 ^f	0.025	0.015	g	g	g	i,l	0.43 ^f	0.25
L625M or X90M	0.10	0.55 ^f	2.10 ^f	0.020	0.010	g	g	g	i,l	—	0.25
L690M or X100M	0.10	0.55 ^f	2.10 ^f	0.020	0.010	g	g	g	i,j		0.25
L830M or X120M	0.10	0.55 ^f	2.10 ^f	0.020	0.010	g	g	g	i,j		0.25
^a Based on product analysis, for seamless pipe with <i>t</i> > 20.0 mm (0.787 in.), the CE limits shall be as agreed; the CE _{IIW} limits apply if C > 0.12 % and the CE _{Pcm} limits apply if C ≤ 0.12 %.											
^b For each reduction of 0.01 % below the specified maximum for C, an increase of 0.05 % above the specified maximum for Mn is permissible, up to a maximum of 1.65 % for grades ≥ L245 or B, but ≤ L360 or X52; up to a maximum of 1.75 % for grades > L360 or X52, but < L485 or X70; up to a maximum of 2.00 % for grades ≥ L485 or X70, but ≤ L555 or X80; and up to a maximum of 2.20 % for grades > L555 or X80.											
^c Unless otherwise agreed, Nb + V ≤ 0.06 %.											
^d Nb + V + Ti ≤ 0.15 %.											
^e Unless otherwise agreed, Cu ≤ 0.50 %; Ni ≤ 0.30 %; Cr ≤ 0.30 % and Mo ≤ 0.15 %.											
^f Unless otherwise agreed.											
^g Unless otherwise agreed, Nb + V + Ti ≤ 0.15 %.											
^h Unless otherwise agreed, Cu ≤ 0.50 %; Ni ≤ 0.50 %; Cr ≤ 0.50 % and Mo ≤ 0.50 %.											
ⁱ Unless otherwise agreed, Cu ≤ 0.50 %; Ni ≤ 1.00 %; Cr ≤ 0.50 % and Mo ≤ 0.50 %.											
^j B ≤ 0.004 %.											
^k Unless otherwise agreed, Cu ≤ 0.50 %; Ni ≤ 1.00 %; Cr ≤ 0.55 % and Mo ≤ 0.80 %.											
^l For PSL 2 pipe grades except those grades to which footnote j) already applies, the following applies: unless otherwise agreed no intentional addition of B is permitted and residual B ≤ 0.001 %.											

9.3 Tensile Properties

9.3.1 For PSL 1 pipe, the tensile properties shall be as given in Table 6.

9.3.2 For PSL 2 pipe, the tensile properties shall be as given in Table 7.

Table 6—Requirements for the Results of Tensile Tests for PSL 1 Pipe

Pipe Grade	Pipe Body of Seamless and Welded Pipe			Weld Seam of EW, LW, SAW, and COW Pipe
	Yield Strength ^a	Tensile Strength ^a	Elongation (on 50 mm or 2 in.)	Tensile Strength ^b
	$R_{10.5}$	R_m	A_f	R_m
	MPa (psi)	MPa (psi)	%	MPa (psi)
	min	min	min	min
L175 or A25	175 (25,400)	310 (45,000)	c	310 (45,000)
L175P or A25P	175 (25,400)	310 (45,000)	c	310 (45,000)
L210 or A	210 (30,500)	335 (48,600)	c	335 (48,600)
L245 or B	245 (35,500)	415 (60,200)	c	415 (60,200)
L290 or X42	290 (42,100)	415 (60,200)	c	415 (60,200)
L320 or X46	320 (46,400)	435 (63,100)	c	435 (63,100)
L360 or X52	360 (52,200)	460 (66,700)	c	460 (66,700)
L390 or X56	390 (56,600)	490 (71,100)	c	490 (71,100)
L415 or X60	415 (60,200)	520 (75,400)	c	520 (75,400)
L450 or X65	450 (65,300)	535 (77,600)	c	535 (77,600)
L485 or X70	485 (70,300)	570 (82,700)	c	570 (82,700)

^a For intermediate grades, the difference between the specified minimum tensile strength and the specified minimum yield strength for the pipe body shall be as given in the table for the next higher grade.

^b 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).

^c The specified minimum elongation, A_f , 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; 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).

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		Tensile Strength ^a		Ratio ^{a,c}	Elongation (on 50 mm or 2 in.) <i>A_f</i> %	Tensile Strength ^d
	<i>R_{t0.5}</i> MPa (psi)		<i>R_m</i> MPa (psi)		<i>R_{t0.5}/R_m</i>		<i>R_m</i> 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	415 (60,200)	655 (95,000)	0.93	f	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	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	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	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	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	520 (75,400)
L450Q or X65Q L450M or X65M	450 (65,300)	600 (87,000)	535 (77,600)	760 (110,200)	0.93	f	535 (77,600)
L485Q or X70Q L485M or X70M	485 (70,300)	635 (92,100)	570 (82,700)	760 (110,200)	0.93	f	570 (82,700)
L555Q or X80Q L555M or X80M	555 (80,500)	705 (102,300)	625 (90,600)	825 (119,700)	0.93	f	625 (90,600)
L625M or X90M	625 (90,600)	775 (112,400)	695 (100,800)	915 (132,700)	0.95	f	695 (100,800)
L625Q or X90Q	625 (90,600)	775 (112,400)	695 (100,800)	915 (132,700)	0.97 ^g	f	—
L690M or X100M	690 (100,100) ^b	840 (121,800) ^b	760 (110,200)	990 (143,600)	0.97 ^h	f	760 (110,200)
L690Q or X100Q	690 (100,100) ^b	840 (121,800) ^b	760 (110,200)	990 (143,600)	0.97 ^h	f	—
L830M or X120M	830 (120,400) ^b	1050 (152,300) ^b	915 (132,700)	1145 (166,100)	0.99 ^h	f	915 (132,700)
^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, <i>R_{p0.2}</i> applies. ^c This limit applies for pipe with <i>D</i> > 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 For pipe requiring longitudinal testing, the maximum yield strength shall be ≤ 495 MPa (71,800 psi). ^f The specified minimum elongation, <i>A_f</i>, shall be as determined using the following equation: $A_f = C \frac{A_{xc}^{0.2}}{U^{0.9}}$ where <i>C</i> is 1940 for calculations using SI units and 625,000 for calculations using USC units; <i>A_{xc}</i> 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; 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); <i>U</i> is the specified minimum tensile strength, expressed in megapascals (pounds per square inch). ^g Lower values of <i>R_{t0.5}/R_m</i> may be specified by agreement. ^h For grades > L625 or X90, <i>R_{p0.2}/R_m</i> applies. Lower values of <i>R_{p0.2}/R_m</i> may be specified by agreement.							

9.4 Hydrostatic Test

9.4.1 Except as allowed by 9.4.2, the pipe shall withstand the hydrostatic test without leakage through the weld seam or the pipe body.

9.4.2 Jointers need not be hydrostatically tested, provided that the portions of pipe used in making the jointers were successfully hydrostatically tested prior to the joining operation.

9.5 Bend Test

No cracks shall occur in any portion of the test piece, and no opening of the weld shall occur.

NOTE For bend tests, the weld extends to a distance of 6.4 mm (0.25 in.) on each side of the fusion line.

9.6 Flattening Test

Acceptance criteria for flattening tests shall be as follows.

- a) EW pipe in grades $\geq$ L210 or A and LW pipe with $D < 323.9$ mm (12.750 in.).
 - 1) For grades $\geq$ L415 or X60 with $t \geq 12.7$ mm (0.500 in.), there shall be no opening of the weld before the distance between the plates is less than 66 % of the original outside diameter. For all other combinations of pipe grade and specified wall thickness, there shall be no opening of the weld before the distance between the plates is less than 50 % of the original outside diameter.
 - 2) For pipe with a $D/t > 10$, there shall be no cracks or breaks other than in the weld before the distance between the plates is less than 33 % of the original outside diameter.
 - 3) There shall be no evidence of lamination or burnt metal during the entire test before opposite walls of the pipe meet.
- b) EW and CW pipe in Grade L175, L175P, A25, or A25P.
 - 1) There shall be no opening of the weld before the distance between the plates is less than 75 % of the original outside diameter.
 - 2) There shall be no cracks or breaks other than in the weld before the distance between the plates is less than 60 % of the original outside diameter.

NOTE 1 The weld extends to a distance, on each side of the weld line, of 6.4 mm (0.25 in.) for $D < 60.3$ mm (2.375 in.) and 13 mm (0.5 in.) for $D \geq 60.3$ mm (2.375 in.).

NOTE 2 For EW pipe that is processed through a hot-stretch mill and is flattened prior to such treatment, the original outside diameter is as designated by the manufacturer; for all other cases, the original outside diameter is the specified outside diameter.

NOTE 3 The term "opening of the weld" includes any cracks, breaks, or tears that become visible during the flattening test but does not include incipient cracking at the test piece edges.

9.7 Guided-bend Test

9.7.1 Except as allowed by 9.7.2, the test pieces shall not:

- a) fracture completely;
- b) reveal any cracks or ruptures in the weld metal longer than 3.2 mm (0.125 in.), regardless of depth;
- c) reveal any cracks or ruptures in the parent metal, HAZ, or fusion line longer than 3.2 mm (0.125 in.) or deeper than 12.5 % of the specified wall thickness.

9.7.2 Cracks that occur at the edges of the test piece during testing shall not be cause for rejection, provided that they are not longer than 6.4 mm (0.250 in.).

9.8 CVN Impact Test for PSL 2 Pipe

9.8.1 General

9.8.1.1 If subsize test pieces are used, the required minimum average (of a set of three test pieces) absorbed energy values shall be the required values for full-size test pieces times the ratio of the specified width of the subsize test piece to the specified width of the full-size test piece, with such derived values rounded to the nearest joule (foot-pound force).

9.8.1.2 Individual test values for any test piece shall be ≥ 75 % of the required minimum average (of a set of three test pieces) absorbed energy values.

9.8.1.3 Tests conducted at temperatures lower than the specified test temperature shall be acceptable if the applicable requirements for energy absorption and shear fracture area are met at such lower temperatures.

9.8.2 Pipe Body Tests

9.8.2.1 The minimum average (of a set of three test pieces) absorbed energy for each pipe body test shall be as given in Table 8, based on full-size test pieces and a test temperature of 0 °C (32 °F) or, if agreed, a lower test temperature.

NOTE The energy values specified in Table 8 provide sufficient fracture-initiation resistance for most pipeline designs.

9.8.2.2 For welded pipe with $D < 508$ mm (20.000 in.), if agreed, the minimum average (of a set of three test pieces) shear fracture area for each test shall be at least 85 %, based on a test temperature of 0 °C (32 °F) or, if agreed, a lower test temperature.

NOTE This percentage of shear fracture area ensures sufficiently ductile fracture at or above the test temperature.

9.8.2.3 If 9.8.2.2 does not apply for the order item, the shear fracture area on the CVN specimen shall be estimated and reported for information purposes for all grades and sizes of pipe that have been CVN tested, unless otherwise agreed.

Table 8—CVN Absorbed Energy Requirements for Pipe Body of PSL 2 Pipe

Specified Outside Diameter <i>D</i> mm (in.)	Full-size CVN Absorbed Energy min K_V 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)	27 (20)	27 (20)	27 (20)	40 (30)	40 (30)	40 (30)	40 (30)
> 508 (20.000) to 762 (30.000)	27 (20)	27 (20)	27 (20)	40 (30)	40 (30)	40 (30)	40 (30)
> 762 (30.000) to 914 (36.000)	40 (30)	40 (30)	40 (30)	40 (30)	40 (30)	54 (40)	54 (40)
> 914 (36.000) to 1219 (48.000)	40 (30)	40 (30)	40 (30)	40 (30)	40 (30)	54 (40)	68 (50)
> 1219 (48.000) to 1422 (56.000)	40 (30)	54 (40)	54 (40)	54 (40)	54 (40)	68 (50)	81 (60)
> 1422 (56.000) to 2134 (84.000)	40 (30)	54 (40)	68 (50)	68 (50)	81 (60)	95 (70)	108 (80)

9.8.3 Pipe Weld and HAZ Tests

The minimum average (of a set of three test pieces) absorbed energy for each pipe weld and HAZ test, based on full-size test pieces and a test temperature of 0 °C (32 °F) or, if agreed, a lower test temperature, shall be as follows:

- a) 27 J (20 ft·lbf) for pipe with $D < 1422$ mm (56.000 in.) in grades ≤ L555 or X80;
- b) 40 J (30 ft·lbf) for pipe with $D \geq 1422$ mm (56.000 in.);
- c) 40 J (30 ft·lbf) for pipe in grades > L555 or X80.

9.9 DWT Test for PSL 2 Welded Pipe

9.9.1 For each test (of a set of two test pieces), the average shear fracture area shall be ≥ 85 %, based on a test temperature of 0 °C (32 °F) or, if agreed, a lower test temperature. For wall thickness > 25.4 mm (1.000 in.), DWT test acceptance requirements shall be by agreement.

NOTE 1 Such shear-fracture area ensures a sufficiently ductile fracture at or above the test temperature.

NOTE 2 A sufficient combination of shear-fracture area and CVN absorbed energy is an essential pipe-body property to ensure the avoidance of brittle fracture propagation and the control of ductile fracture propagation in gas pipelines (see Annex G and Table 20).

9.9.2 Tests conducted at temperatures lower than the specified test temperature shall be acceptable if the applicable requirements for shear fracture area are met at such lower temperatures.

9.10 Surface Conditions, Imperfections, and Defects

9.10.1 General

9.10.1.1 All pipe shall be free from defects in the finished condition.

9.10.1.2 All pipe shall be free from cracks, sweats, and leaks.

9.10.1.3 The acceptance criteria for imperfections found by nondestructive inspection shall be in accordance with Annex E.

9.10.2 Undercuts

Undercuts in SAW and COW pipe shall be investigated, classified, and treated as follows.

- a) Undercuts that have a depth ≤ 0.4 mm (0.016 in.) are acceptable, regardless of length, and shall be treated in accordance with C.1.
- b) Undercuts that have a depth > 0.4 mm (0.016 in.) but ≤ 0.8 mm (0.031 in.) are acceptable provided they are treated in accordance with C.2 and provided that:
 - 1) their individual lengths are $\leq 0.5t$,
 - 2) their individual depths are $\leq 0.1t$, and
 - 3) there are no more than two such undercuts in any 300 mm (12.0 in.) length of weld.
- c) Undercuts that exceed the limits specified in item b) shall be classified as defects and shall be treated in accordance with C.3.

NOTE Undercuts can best be located visually.

9.10.3 Arc Burns

9.10.3.1 Arc burns shall be classified as defects.

NOTE 1 Arc burns are localized points of surface melting caused by arcing between the electrode or ground and the pipe surface.

NOTE 2 Contact marks, which are intermittent marks adjacent to the weld line of EW pipe resulting from electrical contact between the electrodes supplying the welding current and the pipe surface, are treated in accordance with 9.10.7.

9.10.3.2 Arc burns shall be treated in accordance with C.2, C.3 b), or C.3 c), except that they may be removed by grinding, chipping, or machining, provided that the resultant cavity is thoroughly cleaned and checked for complete removal of damaged material by etching with a 10 % solution of ammonium persulfate or a 5 % solution of nital.

9.10.4 Laminations

Laminations or inclusions extending into the face or bevel of the pipe and having a visually determined length in the circumferential direction > 6.4 mm (0.250 in.) shall be classified as defects. Pipes that contain such defects shall be rejected or cut back until no such lamination or inclusion is present at the pipe ends.

9.10.5 Geometric Deviations

9.10.5.1 For other than dents, geometric deviations from the normal cylindrical contour of the pipe (e.g. flat spots and peaks) that occur as a result of the pipe forming process or manufacturing operations and that exceed 3.2 mm (0.125 in.) in depth, measured as the gap between the extreme point of the deviation

and the prolongation of the normal contour of the pipe, shall be considered defects and shall be treated in accordance with C.3 b) or C.3 c).

9.10.5.2 For dents, the length in any direction shall be $\leq 0.5D$ and the depth, measured as the gap between the extreme point of the dent and the prolongation of the normal contour of the pipe, shall not exceed the following:

- a) 3.2 mm (0.125 in.) for cold-formed dents with sharp-bottom gouges;
- b) 6.4 mm (0.250 in.) for other dents.

Dents that exceed the specified limits shall be considered defects and shall be treated in accordance with C.3 b) or C.3 c).

9.10.6 Hard Spots

Any hard spot larger than 50 mm (2.0 in.) in any direction shall be classified as a defect if its hardness exceeds 35 HRC, 345 HV10, or 327 HBW, based on individual indentations. Pipes that contain such defects shall be treated in accordance with C.3 b) or C.3 c).

9.10.7 Other Surface Imperfections

Other surface imperfections found by visual inspection shall be investigated, classified, and treated as follows.

- a) Imperfections that have a depth $\leq 0.125t$ and do not encroach on the minimum permissible wall thickness shall be classified as acceptable imperfections and shall be treated in accordance with C.1.
- b) Imperfections that have a depth $> 0.125t$ and do not encroach on the minimum permissible wall thickness shall be classified as defects and shall be dressed-out by grinding in accordance with C.2 or shall be treated in accordance with C.3.
- c) Imperfections that encroach on the minimum permissible wall thickness shall be classified as defects and shall be treated in accordance with C.3.

NOTE "Imperfections that encroach on the minimum permissible wall thickness" implies that the portion of the wall thickness that is beneath the surface imperfection is less than the minimum permissible wall thickness.

9.11 Dimensions, Mass, and Tolerances

9.11.1 Dimensions

9.11.1.1 The pipe shall be delivered to the dimensions specified in the purchase order, subject to the applicable tolerances.

9.11.1.2 The specified outside diameter and specified wall thickness shall be within the applicable limits given in Table 9.

9.11.1.3 The pipe shall be delivered in random lengths or approximate length, as specified in the purchase order.

9.11.2 Mass per Unit Length

The mass per unit length, ρ_l , expressed in kilograms per meter (pounds per foot), shall be calculated using Equation (4):

$$\rho_l = t(D - t) \times C \quad (4)$$

where

D is the specified outside diameter, expressed in millimeters (inches);

t is the specified wall thickness, expressed in millimeters (inches);

C is 0.02466 for calculations in SI units and 10.69 for calculations in USC units.

For threaded-and-coupled pipe, the weights determined as described above shall conform to the calculated weights or adjusted calculated weights within the tolerances specified in 9.14.

NOTE The nominal mass of a pipe is the product of its length and its mass per unit length.

Table 9—Permissible Specified Outside Diameter and Specified Wall Thickness

Specified Outside Diameter D mm (in.)	Specified Wall Thickness t mm (in.)	
	Special Light Sizes ^a	Regular Sizes
≥ 10.3 (0.405) to < 13.7 (0.540)	—	≥ 1.7 (0.068) to ≤ 2.4 (0.094)
≥ 13.7 (0.540) to < 17.1 (0.675)	—	≥ 2.2 (0.088) to ≤ 3.0 (0.118)
≥ 17.1 (0.675) to < 21.3 (0.840)	—	≥ 2.3 (0.091) to ≤ 3.2 (0.125)
≥ 21.3 (0.840) to < 26.7 (1.050)	—	≥ 2.1 (0.083) to ≤ 7.5 (0.294)
≥ 26.7 (1.050) to < 33.4 (1.315)	—	≥ 2.1 (0.083) to ≤ 7.8 (0.308)
≥ 33.4 (1.315) to < 48.3 (1.900)	—	≥ 2.1 (0.083) to ≤ 10.0 (0.394)
≥ 48.3 (1.900) to < 60.3 (2.375)	—	≥ 2.1 (0.083) to ≤ 12.5 (0.492)
≥ 60.3 (2.375) to < 73.0 (2.875)	≥ 2.1 (0.083) to ≤ 3.6 (0.141)	> 3.6 (0.141) to ≤ 14.2 (0.559)
≥ 73.0 (2.875) to < 88.9 (3.500)	≥ 2.1 (0.083) to ≤ 3.6 (0.141)	> 3.6 (0.141) to ≤ 20.0 (0.787)
≥ 88.9 (3.500) to < 101.6 (4.000)	≥ 2.1 (0.083) to ≤ 4.0 (0.156)	> 4.0 (0.156) to ≤ 22.0 (0.866)
≥ 101.6 (4.000) to < 168.3 (6.625)	≥ 2.1 (0.083) to ≤ 4.0 (0.156)	> 4.0 (0.156) to ≤ 25.0 (0.984)
≥ 168.3 (6.625) to < 219.1 (8.625)	≥ 2.1 (0.083) to ≤ 4.0 (0.156)	> 4.0 (0.156) to ≤ 40.0 (1.575)
≥ 219.1 (8.625) to < 273.1 (10.750)	≥ 3.2 (0.125) to ≤ 4.0 (0.156)	> 4.0 (0.156) to ≤ 40.0 (1.575)
≥ 273.1 (10.750) to < 323.9 (12.750)	≥ 3.6 (0.141) to ≤ 5.2 (0.203)	> 5.2 (0.203) to ≤ 45.0 (1.771)
≥ 323.9 (12.750) to < 355.6 (14.000)	≥ 4.0 (0.156) to ≤ 5.6 (0.219)	> 5.6 (0.219) to ≤ 45.0 (1.771)
≥ 355.6 (14.000) to < 457 (18.000)	≥ 4.5 (0.177) to ≤ 7.1 (0.281)	> 7.1 (0.281) to ≤ 45.0 (1.771)
≥ 457 (18.000) to < 559 (22.000)	≥ 4.8 (0.188) to ≤ 7.1 (0.281)	> 7.1 (0.281) to ≤ 45.0 (1.771)
≥ 559 (22.000) to < 711 (28.000)	≥ 5.6 (0.219) to ≤ 7.1 (0.281)	> 7.1 (0.281) to ≤ 45.0 (1.771)
≥ 711 (28.000) to < 864 (34.000)	≥ 5.6 (0.219) to ≤ 7.1 (0.281)	> 7.1 (0.281) to ≤ 52.0 (2.050)
≥ 864 (34.000) to < 965 (38.000)	—	≥ 5.6 (0.219) to ≤ 52.0 (2.050)
≥ 965 (38.000) to < 1422 (56.000)	—	≥ 6.4 (0.250) to ≤ 52.0 (2.050)
≥ 1422 (56.000) to < 1829 (72.000)	—	≥ 9.5 (0.375) to ≤ 52.0 (2.050)
≥ 1829 (72.000) to < 2134 (84.000)	—	≥ 10.3 (0.406) to ≤ 52.0 (2.050)

NOTE Standardized values for specified outside diameter and specified wall thickness of pipe are given in ISO 4200 ^[7] and ASME B36.10M ^[8].

^a Pipe having the combination of specified outside diameter and specified wall thickness is defined as special light size pipe; other combinations given in this table are defined as regular size pipe.

9.11.3 Tolerances for Diameter, Wall Thickness, Length, and Straightness

9.11.3.1 Except as allowed by C.2.3, the diameter and out-of-roundness shall be within the tolerances given in Table 10 (see 10.2.8.2).

9.11.3.2 The tolerances for wall thickness shall be as given in Table 11.

Table 10—Tolerances for Diameter and Out-of-roundness

Specified Outside Diameter <i>D</i> mm (in.)	Diameter Tolerances ^d mm (in.)				Out-of-roundness Tolerances mm (in.)	
	Pipe Except the End ^a		Pipe End ^{a,b,c}		Pipe Except the End ^a	Pipe End ^{a,b,c}
	SMLS Pipe	Welded Pipe	SMLS Pipe	Welded Pipe		
< 60.3 (2.375)	−0.8 (0.031) to +0.4 (0.016)		−0.8 (0.031) to +0.4 (0.016)		1.2 (0.048)	0.9 (0.036)
≥ 60.3 (2.375) to 168.3 (6.625)	±0.0075 <i>D</i>		−0.4 (0.016) to +1.6 (0.063)		0.020 <i>D</i> for $\frac{D}{t} \leq 75$; by agreement for $\frac{D}{t} > 75$	0.015 <i>D</i> for $\frac{D}{t} \leq 75$; by agreement for $\frac{D}{t} > 75$
> 168.3 (6.625) to 610 (24.000)	±0.0075 <i>D</i>	±0.0075 <i>D</i> , but maximum of ±3.2 (0.125)	±0.005 <i>D</i> , but maximum of ±1.6 (0.063)		0.020 <i>D</i>	0.015 <i>D</i>
> 610 (24.000) to 1422 (56.000)	±0.01 <i>D</i>	±0.005 <i>D</i> , but maximum of ±4.0 (0.160)	±2.0 (0.079)	±1.6 (0.063)	0.015 <i>D</i> , but maximum of 15 (0.6) for $\frac{D}{t} \leq 75$; by agreement for $\frac{D}{t} > 75$	0.01 <i>D</i> , but maximum of 13 (0.5) for $\frac{D}{t} \leq 75$; by agreement for $\frac{D}{t} > 75$
> 1422 (56.000)	As agreed					

^a The pipe end includes a length of 100 mm (4.0 in.) at each of the pipe extremities.

^b For SMLS pipe, the tolerances apply for *t* ≤ 25.0 mm (0.984 in.), and the tolerances for thicker pipe shall be as agreed.

^c For expanded pipe with *D* ≥ 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).

^d For determining compliance to diameter tolerances, the pipe diameter is defined as the circumference of the pipe in any circumferential plane divided by pi (π).

Table 11—Tolerances for Wall Thickness

Wall Thickness t mm (in.)	Tolerances ^a mm (in.)
SMLS Pipe ^b	
≤ 4.0 (0.157)	+0.6 (0.024) −0.5 (0.020)
> 4.0 (0.157) to < 25.0 (0.984)	+0.150 t −0.125 t
≥ 25.0 (0.984)	+3.7 (0.146) or +0.1 t , whichever is the greater −3.0 (0.120) or −0.1 t , whichever is the greater
Welded Pipe ^{c,d}	
≤ 5.0 (0.197)	± 0.5 (0.020)
> 5.0 (0.197) to < 15.0 (0.591)	$\pm 0.1t$
≥ 15.0 (0.591)	± 1.5 (0.060)
^a If the purchase order specifies a minus tolerance for wall thickness smaller than the applicable value given in this table, the plus tolerance for wall thickness shall be increased by an amount sufficient to maintain the applicable tolerance range. ^b For pipe with $D \geq 355.6$ mm (14.000 in.) and $t \geq 25.0$ mm (0.984 in.), the wall thickness tolerance locally may exceed the plus tolerance for wall thickness by an additional 0.05 t , provided that the plus tolerance for mass (see 9.14) is not exceeded. ^c The plus tolerance for wall thickness does not apply to the weld area. ^d See 9.13.2 for additional restrictions.	

9.11.3.3 The tolerances for length shall be as follows.

- Unless otherwise agreed, random lengths shall be delivered within the tolerances given in Table 12.
- Approximate lengths shall be delivered within a tolerance of ± 500 mm (20 in.).
- If the supply of jointers is agreed, jointers comprising two pieces welded together to make a length shorter than 15.0 m (49.2 ft) may be furnished to a maximum of 5 % of the order item, or as agreed.
- If the supply of jointers is agreed, jointers comprising two pieces welded together to make a length 15.0 m (49.2 ft) or longer may be furnished for the entire order item or any portion thereof.
- If the supply of jointers is agreed, jointers comprising three pieces welded together to make a length 15.0 m (49.2 ft) or longer may be furnished to a maximum of 5 % of the order item, or as agreed.